APNGA
AMERICAN PORTABLE NUCLEAR GAUGE ASSOCIATION

Manual

(For easy navigation of this manual, you can "show" or "hide" the Quick Table of Contents by clicking on the "Bookmarks" icon to the left.)

Note: Your Web browser's security settings may not allow you to follow the links in PDF documents. If the links in this manual do not work on your computer, the information is also contained on the APNGA website (www.apnga.com) under the Industry column.

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Table of Contents

Foreword

The American Portable Nuclear Gauge Association (APNGA) was established to serve portable nuclear gauge (moisture density gauge) owners and users. This web based association is designed to assist members on regulatory and industry issues and training. It also strives to strengthen the communications bridge between regulatory agencies and licensees and to liaise with the media and federal and state officials (politicians) to provide a better understanding of the benefits of moisture density gauges.

Goals of the association are to provide information, resources, communications, guidance and clarification to both industry and non-industry interested parties. There are sections available on the APNGA website designed to educate the media, the public, Emergency Response and Law Enforcement. For industry, information on gauge product and service options will help guide buying decisions.

The depth and breadth of regulations and information related to portable nuclear gauges renders it virtually impossible to gather everything that could be covered. One must realize that there are too many variations of regulations between federal and state regulations to offer one definitive version. So while we don't purport to have 100% of the answers we will do our best to cover the main issues. And for those answers we don't have we offer the "Ask A Question" post as well as links to regulatory agencies and other pertinent providers of portable nuclear gauge related information.

One should not consider the materials on the APNGA website to be definitive or authoritative. This material is intended to be complementary to the regulatory agencies and their regulations. The Gauge Safety Course is fully accepted by most states while all other courses and tutorials, including the USDOT HAZMAT Refresher, RSO Class, Annual Employee Refresher and the Do It Yourself Annual Audit, can be used in all 50 states. A full list of classes and the states that accept these classes can be viewed on the apnga.com home page.

It is also the goal of APNGA is to use this training material and website to better acquaint and direct you to the regulatory agencies and their websites and materials. Remember, your regulatory agency is there to help you. You should never hesitate to contact them. They know the regulatory responsibility can at times be cumbersome and confusing. They will help you.

The APNGA courses, tutorials and materials allow the worker to better prepare, learn, absorb and revisit the materials while the "Ask A Question" and "FAQ's" sections will serve to clarify or answer additional questions you may have.

Because access is available on any terminal or laptop the viewer can train in their actual work setting and directly relate the training materials to their workplace, including the storage area, security, posters, procedural documents, forms, dosimetry locations and service facilities. They can directly interact with the RSO, senior staff and operators for help in clarifying the materials. This includes direct guidance and observation of the gauge(s) and methodologies in use by the company. APNGA courses require and allow the RSO to be more interactive with their authorized users.

APNGA training materials are more comprehensive than other classes, but that does not mean it is more difficult to understand. The writing is designed to communicate to all viewers and much of the material can be translated into numerous foreign languages with a click of the mouse.

A key goal of APNGA is to help reduce the number of violations associated with the portable nuclear gauge industry. By doing so it may serve to prevent further restrictions on gauge licensing and use.

You can do your part in educating the media and public, especially after an incidence of gauge damage or theft, by directing these individuals to the informative free materials on the website. There are Media Information Sheets available on the website that can be printed for distribution to reporters or the local press. You can likewise notify APNGA so we might respond to any exaggerated coverage of these incidents.

Remember, your radiation safety program is only as good as your least trained individual.

George Marshall
APNGA Director
gmarshall@apnga.com

Acknowledgements

A big thank you goes out to my web development team. If you ever need someone to develop a website you can't go wrong in contacting Tom, Melodi and Chasity at webdrafter.com.

Special thanks go out for all the assistance and support from my APNGA team, Caren, Mike, Jenna and Alex.

And also to everyone's favorite S.O.B. ("Sweet 'Ole Bern").

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Disclaimer

APNGA provides access to the information, training and material on this site as a service to portable nuclear gauge owners and users, the public, the media and others interested in portable nuclear gauges. The use and/or implementation of this information are solely the responsibility of the user.

The links on this website are provided solely as a reference for the convenience of the user. The links are not under the control of APNGA and therefore APNGA is not responsible for link contents. APNGA cannot and does not guarantee the authenticity of information obtained at other websites nor does a provided link imply endorsement of, or responsibility for, the opinions, data, or products available at linked websites. It is the responsibility of the user to take precautionary steps to ensure that information accessed at or downloaded from these other websites is free of viruses, worms or other destructive software programs.

The information provided and contained on the APNGA website should be considered complementary and subservient to that provided by official regulatory agencies. Opinions and interpretations on the website do not create legally enforceable rights or obligations and are listed as an aide to greater awareness and understanding for the user.

This website does not purport to address all of the safety concerns associated with portable nuclear gauges. It is the responsibility of the user to establish adequate health and safety procedures and practices and determine the applicability of regulatory limitations prior to use.

Proper training is required under federal and state regulations to handle portable nuclear gauges. All persons and entities are required to comply with stated federal and state regulations. The information contained in the APNGA website in no way alters or influences federal or state regulations.

The enclosed training materials are based on the criteria for NUREG 1556 and Agreement State gauge operator training as well as 49 CFR 172 Subpart H training. The licensee RSO must provide additional guidance and training as described by the materials and training certificates. The licensee must verify that portable nuclear gauge safety training provided by APNGA materials is accepted by any state where portable nuclear gauge operations are performed.

APNGA shall not be held responsible for any harm, loss, injury or damage caused by omissions, misrepresentations, misprints or errors of the contents of APNGA materials. It is the responsibility of the user to verify the accuracy of any material or information contained within the APNGA website.

U.S. Code of Federal Regulations & Agreement State Regulations

All regulations pertaining to portable nuclear gauges are derived from the United States Code of Federal Regulations (CFR) listed below. The Agreement States follow these regulations but are at liberty to institute further regulations provided the new regulations do not compromise CFR regulations.

NRC States (non-Agreement States) licensees should have a copy of the regulations listed below. **Agreement State** licensees should acquire a copy of regulations for their state. Contact information for each state can be found on the "**View My State**" section of the APNGA website home page.

The NRC and Agreement State Regulations should always be your final and authoritative reference for all portable nuclear gauge licensing and regulatory guidance.

The CFR's

All NRC & Agreement States must comply with the U.S. DOT requirements found in 49 CFR Parts 170-189. These are the regulations that form the basis for HAZMAT training:
http://www.access.gpo.gov/nara/cfr/waisidx_99/49cfrv2_99.html

The following Parts of 10 CFR Chapter I contain regulations applicable to portable gauging devices:

_ 10 CFR Part 2, "Rules of Practice for Domestic Licensing Proceedings and Issuance of Orders"; http://www.nrc.gov/reading-rm/doc-collections/cfr/part002/

_ 10 CFR Part 19, "Notices, Instructions and Reports to Workers: Inspection and Investigations"; http://www.nrc.gov/reading-rm/doc-collections/cfr/part019/

_ 10 CFR Part 20, "Standards for Protection Against Radiation"; http://www.nrc.gov/reading-rm/doc-collections/cfr/part020/

_ 10 CFR Part 21, "Reporting of Defects and Noncompliance"; http://www.nrc.gov/reading-rm/doc-collections/cfr/part021/

_ 10 CFR Part 30, "Rules of General Applicability to Domestic Licensing of Byproduct Material"; http://www.nrc.gov/reading-rm/doc-collections/cfr/part030/

_ 10 CFR Part 71, "Packaging and Transportation of Radioactive Material";
Part 71 requires that licensees or applicants 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. http://www.nrc.gov/reading-rm/doc-collections/cfr/part071/

_ 10 CFR Part 150, “Exemptions and Continued Regulatory Authority in Agreement States and in Offshore Waters under Section 274”; http://www.nrc.gov/reading-rm/doc-collections/cfr/part150/

_ 10 CFR Part 170, “Fees for Facilities, Materials, Import and Export Licenses, and Other Regulatory Services Under the Atomic Energy Act of 1954, as Amended”; http://www.nrc.gov/reading-rm/doc-collections/cfr/part170/

_ 10 CFR Part 171, “Annual Fees for Reactor Operating Licenses, and Fuel Cycle Licenses and Materials Licenses, Including Holders of Certificates of Compliance, Registrations, and Quality Assurance Program Approvals and Government Agencies Licensed by NRC.” http://www.nrc.gov/reading-rm/doc-collections/cfr/part171/

To request copies of the above documents, call GPO’s order desk in Washington, DC at (202) 512-1800. You may also contact GPO electronically at < http://www.gpo.gov >. Electronic copies of all documents are available at this site. Single copies of the above NRC regulations may be requested from NRC’s Regional Offices. Note that the NRC publishes amendments to its regulations in the *Federal Register*.

NRC regulations and amendments can also be accessed on the NRC web page at < http://www.nrc.gov >.

It is the applicant’s or licensee’s responsibility to have up-to-date copies of applicable NRC or Agreement State regulations, read them, and abide by each applicable regulation.

A guide for gauge license holders is the NRC NUREG 1556 Volume 1 “Consolidated Guidance about Materials Licenses” Guide. This guide is used to prepare and apply for a NRC license but it has helpful information for all gauge licensees. Go to nrc.gov and search for NUREG 1556 Vol. 1 or click this link.

Some Agreement States have also prepared excellent gauge guidance and use guides. The majority of gauge regulations, regardless of which state you are licensed in, are very similar. Although you must abide by the regulations established in your state you will find that perusing the information from other states can be very helpful in understanding the regulations in your state. Go to the “View My State” section to access licensing information for all NRC and Agreement States.

NRC Training Course Content Requirements

NRC and Agreement States require gauge users to complete a gauge certification class before using a gauge. This class includes a test that requires a 70% passing grade. The test must be closed-book and the person taking the test must be monitored by the RSO. Those passing the test must review incorrect answers and acknowledge correct answers. It is a vital role of the RSO to monitor this process and make sure the student successfully completes the training. As with all requirements of a licensee the integrity of the RSO and the Radiation Safety Program, including training, must be maintained.

The Gauge Safety Certification Class has been recognized and fully accepted by most states – check the apnga.com home page to see if it has been accepted by your state. The USDOT HAZMAT (includes IATA requirements) class meets the 49 CFR 172 Subpart H criteria and is valid in all states to meet refresher requirements. The RSO Class, Employee Annual Refresher and Do It Yourself Annual Refresher can be used to help meet regulatory requirements in all states. You should always check for state specific requirements that are in addition to the material covered in these courses.

Other helpful instruction includes the “Gauge Operations Photo Tutorial”, “Step-by-Step” Tutorial, and “How To” tutorials.

Regulations require that all of the following topics be covered. Although not in the same sequence, all of this material is covered in the APNGA training classes.

Course Content - NUREG 1556, Volume 1 - Radiation Safety & Regulatory Requirements

Safe Use of the Gauge

Radiation vs. Contamination

Internal vs. External Exposure

ALARA and the concepts of time, distance & shielding

Control & surveillance of gauges

Location of sealed sources within the gauge

Inventory

Recordkeeping

Incidents

Licensing & Inspection

Complete & accurate information

Employee protection

Deliberate misconduct

Portable Gauge Theory & Operation

Operating procedures

Emergency procedures

Maintenance

Transportation

Field training emphasizing radiation safety (Generic gauge instruction covered in the APNGA courses and actual field hands-on instruction of the gauge in use by the licensee conducted by the RSO or senior gauge operator)

Setting up & making measurements with the gauge in use by the company

Controlling & maintaining gauge surveillance

Familiarizing the Gauge Worker with the Licensee's Regulatory Agency

Every current and prospective gauge worker should be familiar with the regulatory agency that issued the company's portable nuclear gauge license. The RSO should introduce the worker to the regulatory agency by way of the agency's website, regulations and materials.

Links and contact information for all states can be found on the APNGA website home page.

Familiarizing the Gauge Worker with the Gauge Manufacturer's Website

Every current and prospective gauge worker should be familiar with the manufacturer's website and materials. These websites have important information regarding safety, security and gauge use.

Contact information for the manufacturer's can be found on the APNGA website home page under "Industry".

A Tour of the Licensee's Facility

The RSO should escort the gauge worker on a tour of the building and storage area, pointing out security measures, postings, forms and their role in maintaining control of the gauges.

A Trip to the Worksite

The RSO or senior gauge operator should escort the gauge worker on a trip to the worksite, pointing out shipping and control measures while transporting a gauge. Further gauge operating and surveillance procedures instruction should be covered at the worksite.

Note: "Live classes" have severe limitations because of time constraints. There has always been too much material to be taught in one sitting. The typical live class is more of a "certificate mill" than a course that prepares and qualifies the individual to carry out the responsibilities of a gauge operator.

These limitations manifest themselves in violations recorded during inspections and in incidents of damage and theft. Some regulatory agencies have found that upwards of 84% of all inspections have violations and that poor training is responsible for most cases of gauge theft and damage. Recent NRC findings show that gauge thefts have remained at an unacceptable level.

APNGA promotes a "total training" concept, giving the gauge worker and RSO an association and website dedicated to improving gauge safety, security and compliance. The association gives a voice, a meeting place and a ready resource and reference for regulatory information and issues.

The APNGA website training materials gives the current and prospective worker the time to fully study, absorb and understand the many requirements necessary to become a responsible gauge operator, and because the training can be carried out on any computer or laptop, the prospective gauge operator can learn at the licensee facility and directly relate the materials to his or her surroundings.

This "total training" concept not only offers the worker an in-depth and comprehensive look at the key gauge safety principles, but enhances the experience with the "Ask a Question" feature, tutorials and 'How To" guides.

There is a wealth of information available on Agreement State and gauge manufacturer websites that are helpful regardless of which state you reside. The APNGA "View My State" listings give quick and easy access to these sites. (Remember to always adhere to the applications, forms, guides and material provided by your state).

The “Total Training” concept enlists the company RSO to become more involved in the training process. By working more closely with company workers the RSO will ensure that the worker is completely familiar with the procedures and gauge in use at the company.

The NRC, USDOT and most Agreement states accept the APNGA internet Gauge Safety Certification Class. Check the Gauge Safety Certification Class approval list to see if your state has accepted the class. All other APNGA classes, tutorials and materials can be used in all states.

Other key benefits of internet training are the reductions in travel costs and lost man-hours. Tighter budgets make it difficult and expensive for companies to pull their employees off the job and send them to an off-site class. The ever growing infrequency of live classes leads to inordinate delays in the training of new employees, which leads to under-utilization of the workforce.

Many states never have “live” classes scheduled in their state, forcing the gauge licensees to send their workers out of state for training. Internet classes allow immediate training and in the environment where the worker will be carrying out their everyday activities.

“Live” instructors know, because of reciprocity fees, that the use of a live gauge in class is cost prohibitive. Most now resort to power point presentations, which are in fact more effective, descriptive and safer than a live gauge. Power point presentations show cut-a-way views and step-by-step methods of using a gauge and are just as effective on the internet.

Gauge owners can save thousands of dollars by using internet classes, and because of APNGA membership, they will find that the material offered on the website can be used as an everyday resource and reference to gauge regulations and guidance.

The RSO must do their part by working with the individual in showing safe methods of using the gauge. As mentioned, one important requirement of gauge certification is the need to familiarize the worker with the gauge model in use by the company. There are over 20 different model gauges in use today and no practical way to demonstrate all 20+ gauges during a “live” class. And even if there was, there is no practical way for every participant to receive “hands-on” with the gauges – there are not enough hours in the day.

Gauge training class certificates will now include a statement and signature line that the company RSO must sign to confirm that their gauge worker has been given hands-on gauge instruction by the RSO or a senior gauge operator. They are also required to monitor the attendee during the closed book test.

Senior Management Commitment

Your portable nuclear gauge license requires a solid commitment from the company's senior management in overseeing the radiation safety program. In fact, it is frequently determined that the reason for safety and compliance violations is ineffective senior management.

Senior management is required to be involved and sign the original license application. Although senior management assigns a Radiation Safety Officer (RSO) to run and oversee the gauge safety program, it is senior management that is ultimately responsible for violations of the program. Senior management should not take this commitment lightly. They are responsible for:

- Radiation safety, security and control of radioactive materials and compliance with the regulations.
- Completeness and accuracy of the radiation safety records and all information provided to the regulatory agency.
- Knowledge about the contents of the license and its conditions.
- The need to commit adequate money and resources, including space, equipment, personnel, time, training, and, if necessary, contractors, to the radiation safety program to ensure that public and worker safety is protected from radiation hazards and that compliance with regulations is maintained.
- Selecting and assigning a qualified individual to serve as the RSO for their licensed duties. This person is to be given the necessary authority to manage and train gauge workers and, if necessary, shut down any questionable activities.

Senior management should ensure that the RSO receives proper training and refresher training as well as initial and refresher training for gauge workers.

Many companies opt to have an assistant RSO on staff. If allowable, this individual should also be listed on the license. This individual can assist the RSO and be in position to assume the RSO role in the event the current RSO departs.

Let the regulatory agency know as soon as possible of any change in RSO personnel.

Senior management should take initial gauge safety and RSO training, even if they are not involved in gauge operation. They should also work with and oversee the RSO during the annual audit.

The Radiation Safety Officer (RSO)

Your license requires that senior management designate an individual as Radiation Safety Officer (RSO). This individual will establish, maintain, enforce and control the company gauge radiation safety program and act as the contact person for the regulatory agency. When the company is contacted or inspected by the regulatory agency they will want to speak with the RSO.

Senior management is required to supply the RSO with the necessary means, including training, to carry out the position of RSO and should work with the RSO to make sure that all conditions and compliance of the license are met.

The RSO will maintain complete, accurate and organized records. The RSO is responsible for making necessary amendments and notifying the regulatory agency of these amendments. The RSO will keep the safety program updated as to any changes in the regulations.

When a new RSO is designated the licensee must immediately notify the regulatory agency. If allowable, the company should also designate an assistant RSO. This person should be readily trained and authorized to speak for the company as well as carry out all RSO responsibilities.

Do you really want to be the RSO?

You must ask yourself that question before you accept the responsibilities of the position. The spotlight will be on you. You cannot cut corners or attempt regulatory “end-arounds”. The regulatory agency is delegating the responsibility of “protecting public and property” to your shoulders. Your actions will be viewed and scrutinized by everyone around you. The “Notice to Employees” poster tells your workers about their rights and how to notify the regulatory agency if they see you or your radiation safety program in violation of the regulations. If you let them see you skimp on a rule or regulation today you may regret it in the future. Today’s happy employee may be tomorrow’s disgruntled employee, one who is looking to get back at you or the company at a later date. Don’t give them a reason to “exercise” their employee rights.

You must also not let senior management compromise your duties and authority. The following article gives a reality check to those considering the RSO position.

So You're the New RSO!

Dr. Carl J. Paperillo

What is a Radiation Safety Officer (RSO) and what are his/her duties?

The RSO is the person responsible for radiological safety in conjunction with the use, handling, and storage of radioactive materials in a program licensed by the Nuclear Regulatory Commission (NRC) or Agreement State. It is the duty of the RSO to ensure that all licensed activities are carried out in compliance with the requirements of the license and the applicable rules and regulations.

The following excerpts of an article written by Dr. Carl J. Paperillo, former Deputy Regional Administrator of NRC Region III, offers insight into what the NRC or Agreement State expects of an RSO. (From the March 1993 issue of Nuclear Material Safety and Safeguards (NMSS) Licensee Newsletter)

What does it mean, if you agree to be named as the new Radiation Safety Officer (RSO) on an NRC or Agreement State license?

It means you have the knowledge and skill, the resources and time, the will, and the clout in your organization to ensure that activities involving radiation and radioactive materials are conducted safely, and all license requirements, both in the regulations and those specific to your license, are being met. Although you can delegate tasks, you have the ultimate responsibility.

How much knowledge do you have to have?

It depends. You don't need an advanced degree in nuclear physics if your responsibility is limited to sealed sources contained in devices like portable nuclear gauges. On the other hand, an RSO for a major broad-scope university, medical center, or manufacturer will probably need a fairly good scientific background, including substantial knowledge of radiation characteristics and methods of detection.

There is a skill set frequently overlooked in the selection of an RSO: **Can you manage?** If there is a large program under your license (i.e., a lot of users, diverse places of use, and/or branch offices) can you establish a management system that ensures you know everything that has to be done is being done?

For example, if your license involves a lot of gauges at diverse locations used by numerous employees, the knowledge of dose calculations, shielding or biological effects is not much help if you don't know if your users are properly trained, wearing the proper dosimetry, and transporting and storing gauges correctly.

Most of the civil penalty enforcement actions with which I have been involved result from a failure of a licensee to manage the radiation safety program correctly. The major management failure is the failure to know whether activities are being conducted in accordance with NRC and Agreement State requirements. I fail to understand why a business that knows how to audit its financial activities does not conduct an annual audit of its Radiation Safety Program and safety and operating procedures.

Do you have the time and resources to be an RSO?

This can be a problem, particularly if the RSO function is an ancillary assignment. It can generally work well for a small program in which the RSO is a user and has day-to-day contact with the other users. One geotechnical office with a few gauge operators is such an example. Others might include a small paving operations company with one office and several gauge operators, or a small testing services company. Problems usually arise when a small business grows, particularly when it adds branch offices, and the part-time RSO can no longer keep track of activities at other locations.

Do you want to be an RSO?

An RSO can be unpopular. You have to be a cop. Sometimes you have to say no. Don't let your name get on the license just because you have a Ph.D. and a desire to teach or do research but not to be a snoop! I know the feeling. I originally wanted to teach, too. I suppose, in a way, that is what I am doing now, by writing this article. As an RSO, you are a regulator just like me. A regulator has to have the will to regulate.

Do you have the clout in your organization?

Or, are you so low in your organization that no one listens to you? Does the senior gauge operator or job foreman write your performance appraisal or control your salary bonus? If so, you may have a problem. You must have the authority to stop an unsafe activity or an activity in violation of NRC or Agreement State requirements. Or you must at least have ready access to someone who can stop it. Organizations that prevent an RSO from doing his or her job are in violation of NRC or Agreement State regulations.

A listing of RSO requirements and responsibilities can be found in the “Agencies, Licensing, Regulations and Recordkeeping” section.

The ALARA Philosophy and the Commitment by Senior Management and the RSO

Every company must make a commitment to adhere to the ALARA principles of keeping occupational and public doses of radiation to a minimum. ALARA principles will be covered in depth in this training manual. The following is an example of a commitment statement. Check with your regulatory agency for their version of this commitment and keep a copy on file.

The ALARA Philosophy and Commitment

Regulations establish standards for protection against radiation hazards. Procedures and engineering controls are based upon sound radiation protection principles that seek to achieve occupational and public doses that are as low as reasonably achievable (ALARA). Management, the radiation safety officer (RSO) and all authorized gauge users must participate in the establishment, implementation and operation of a radiation protection program that applies the ALARA philosophy of minimizing exposures to radiation.

The primary concept of the ALARA philosophy is that unnecessary exposure to radiation should be avoided, even though current occupational exposure limits provide a very low risk of harm. The objective is to reduce occupational exposures (both individual and collective) as far below regulatory limits as is reasonably achievable by means of good radiation protection planning and practice.

MANAGEMENT COMMITMENT

We, the management of _____ are committed to the ALARA philosophy of maintaining occupational and public radiation doses as low as reasonably achievable.

A. Management is committed to the ALARA philosophy of maintaining occupational and public radiation doses as low as reasonably achievable. It is a management priority for all personnel using radioactive materials to be aware of our commitment to the ALARA philosophy and for them to be instructed in the procedures used to keep their exposures as low as possible.

B. Management has delegated authority to our RSO to ensure adherence to ALARA principles. Management will support the RSO in instances where this authority must be asserted.

C. Management will make all reasonable modifications to procedures, equipment and facilities to reduce exposures, unless the cost is considered to be unjustified. We will be prepared to describe the reasons for not implementing modifications that have been recommended.

WORKER COMMITMENT

All personnel working with portable gauging devices will adhere strictly to policies and procedures applicable to activities involving ionizing radiation sources, and will apply ALARA principles and good work practices to minimize their occupational radiation exposures. Time, distance and shielding will be used to keep exposures ALARA. When working with sources of radiation, minimize the time spent near the gauge, maximize the distance from the gauge, and make use of available radiation shielding. Workers must report to the RSO any conditions in the workplace that have the potential for causing unnecessary exposures.

RADIATION SAFETY OFFICER RESPONSIBILITIES

A. The RSO will emphasize the ALARA philosophy to workers, instruct personnel on current procedures and provide guidance on relevant changes to reduce exposures.

B. The RSO will review dosimetry reports for all monitored personnel to determine if unnecessary exposures are being received. The RSO will investigate within 30 days the cause of any dose considered to be excessive. If warranted, the RSO will take corrective actions to prevent recurrence. A report of each investigation and the actions taken, if any, will be recorded and maintained for inspection purposes.

C. At least annually, the RSO will conduct a formal review of the radiation protection program's content and implementation. The review will include an evaluation of equipment, procedures, dosimetry records, inspection findings, and incidents. The RSO will assess trends in occupational exposures as an index of the program's success and determine if any modifications to the program are needed. A summary of the results of each annual review, including a description of actions proposed and taken (if any) will be documented by the RSO, discussed with management, and signed and dated by both. A report on each audit will be maintained on file for 3 years from the date of the review.

D. The RSO will provide written notifications of annual radiation exposures to all monitored personnel and will be available to respond to any questions regarding the exposure reports.

The undersigned certify that the commitments set forth above have been implemented

_____	_____
Signature – RSO	Signature – Senior Management
_____	_____
Print name and title	Print name and title

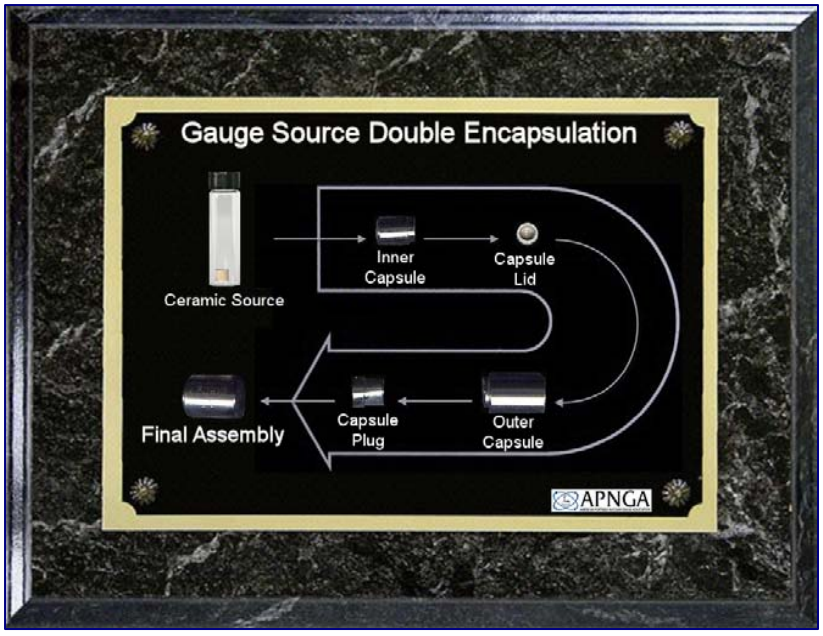
A stand alone copy of this document can be found in the attachments/forms section at the end of this training manual.

Introduction to Moisture Density Gauges and How Radiation Makes Them Work

Nuclear moisture density gauges have been in use for over thirty years. They offer the user a quick and accurate means of determining density and moisture content of soils, asphalt, rooftops and concrete and they all essentially use the same design and basic approach to determining these measurements.

Double Encapsulation Board

All moisture density gauges use two different radioactive sources to produce two different types of radiation. One of the radioactive sources, Cesium 137, emits gamma ray photon radiation to determine density, while the other radioactive source, Americium 241 (combined with non-radioactive Beryllium), emits neutron radiation to determine moisture content.



As seen in the above depiction these sources are double encapsulated before being installed inside the gauge. This double encapsulation undergoes extensive integrity testing and is virtually impenetrable, forming a solid core of metal around the sources. The encapsulated source is then fused at the base of the metal source rod or embedded in the base of the gauge, giving the operator three levels of distinct metal shielding from the source.

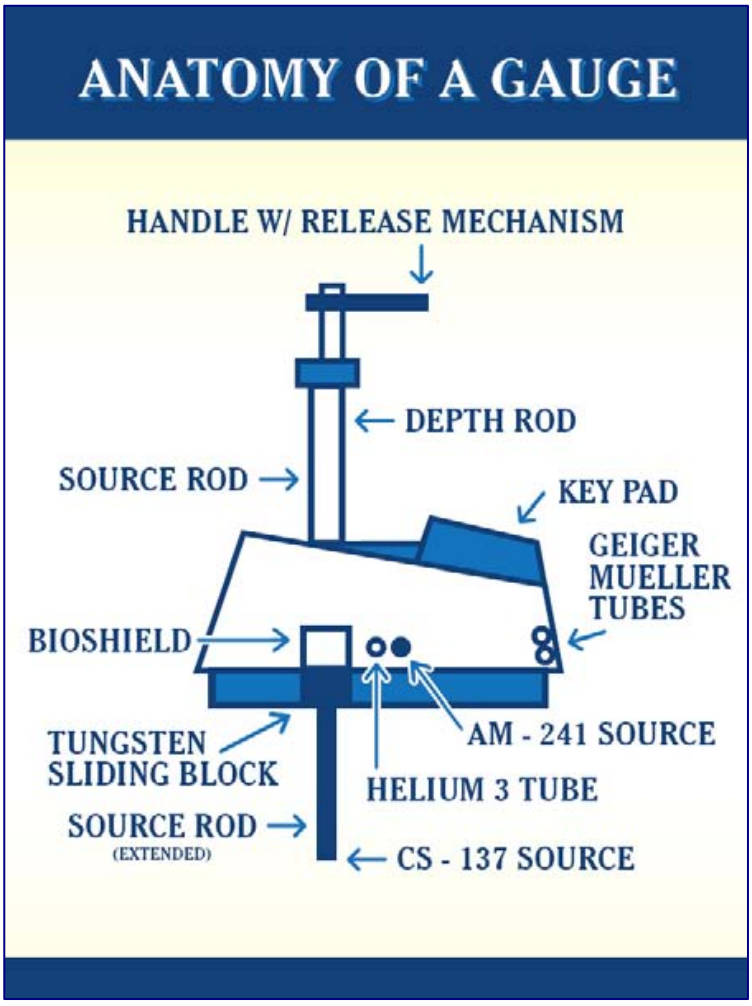
The sources themselves have been solidified in a way that prevents them from powdering or leaking. Note the physical size of the density source bead – it is approximately half the size of a piece of rice. The moisture pellet is smaller than a baby aspirin. The final double encapsulated metal housing around these sources is about the size of a pencil eraser.

Both sources have been laser fused inside the gauge, leaving no way to gain access.

Anatomy of a Gauge

As seen in the depiction, the gauges all have a handle at the top of metal rods. These long rods are called source rods and depth rods. Some models house these rods in an enclosed tower.

The handle at the top of the rods has a release mechanism that is depressed or triggered to allow the source rod to be lowered out of the gauge into positions starting at the base of the gauge and continuing at predetermined notched positions below the surface. These notched positions can be readily seen along the spine of the depth rod (gauges with a tower assembly will have a ruler-like strip along the side showing rod position). The notches are usually spaced 1-2 inches apart along an 8-12 inch rod, allowing the operator to choose the notch that matches the depth of the desired measurement.



Radiation Measurement: The Invisible Property

A gauge uses nuclear radiation to determine density and moisture. Radiation can be described as numerous disintegrations from unstable elements ejecting sub-atomic energy or particles from the element's nucleus. Density and/or moisture measurements are achieved by counting the amount of radiation that can pass through matter to the gauge's detector tubes.

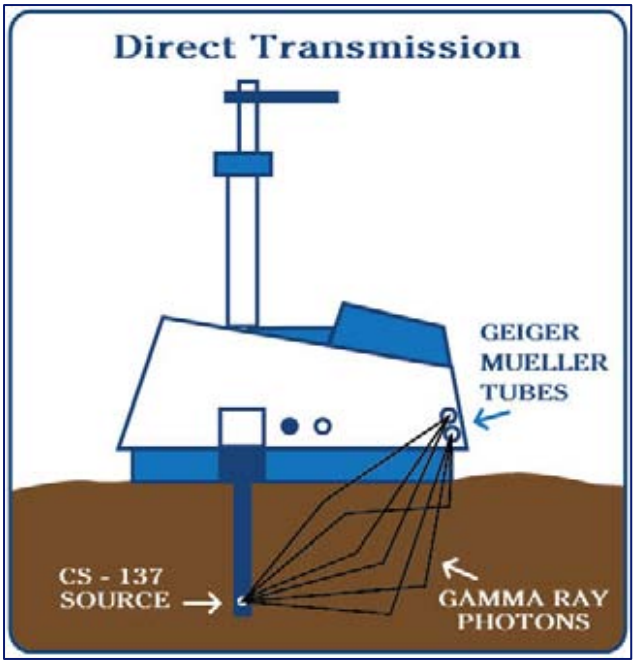
The density source is sending out a constant and steady level of radiation. The detector tubes are receiving and counting this constant and steady level. Any material between the source and the detector tube will reduce the amount of radiation received. As the material (soil or asphalt) becomes more compacted, more and more of the radiation is stopped by the material. You end up with fewer counts, which is interpreted as a higher density of the material.

The moisture source sends out a different type of radiation that must be slowed down before it can be counted. The hydrogen in moisture acts to slow down this radiation, which results in higher counts. The gauge interprets higher counts as a higher level of moisture under the gauge.

You can't see or feel these types of radiation. But you must realize that the radiation is present and take precautionary steps to ensure that you keep yours, and everyone else's, exposure to radiation at a minimum.

Gamma Ray Photon Radiation

The Cesium 137 (Cs137) density source, also known as the emitter, resides at the bottom of the source rod. Cs137 releases gamma ray photon radiation, which is used to measure density. When the operator pushes the start key the gauge detector tubes begin measuring the amount of radiation that is moving from the Cs137 source to the Geiger Muller tubes, at the opposite end of the gauge. As compaction of the material under the gauge increases, more of the gamma ray radiation will be absorbed, unable to make it to the detector tubes to be counted. The gauge interprets lower counts as a higher density.

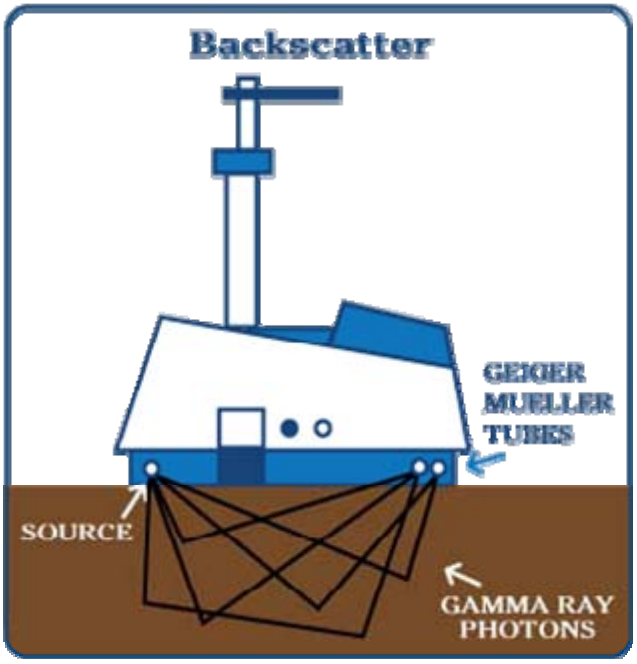


While in the safe (retracted) position inside the gauge, the Cs137 source is surrounded by a tungsten bio-shield that offers optimum shielding that gives extra protection to the operator. A tungsten spring loaded sliding block closes shut below the source rod whenever it is retracted after a test. This completes the bio-shield around the source rod.

When a test is completed the operator should immediately lift the gauge by the handle. The handle features a safety design that retracts the source rod into the safe position before the gauge can be lifted off the ground.

If you ever lift the gauge by the handle and the source rod does not retract it is a sure sign that the gauge needs maintenance. If this happens, position the source rod back into the hole. Place your foot on the gauge to keep it anchored to the ground, grab the handle and pull the rod back into the gauge. Don't use it again until it can be cleaned.

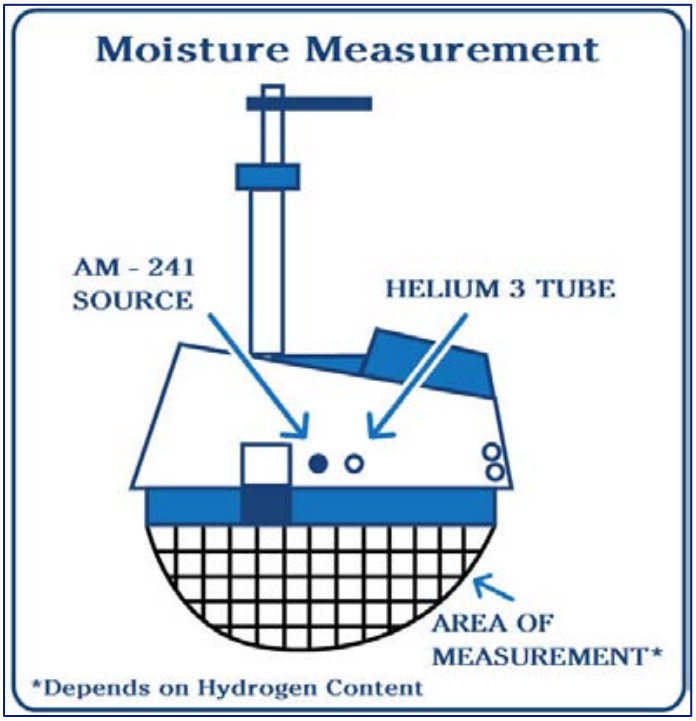
Direct transmission refers to a test where an access hole has been made with the drill rod and the source rod lowered to a predetermined depth (up to 12 inches). Direct transmission is typically used for a soils/aggregate application.



Backscatter transmission is typically used for an asphalt test. The first depth notch on the gauge is the backscatter position. This will open the sliding block and place the source rod at the base of the gauge and at the top of the testing surface (No access hole is drilled for a backscatter test). The gamma ray photons will penetrate the material to a maximum depth of 3 – 4 inches before making their way to the Geiger-Mueller detector tubes at the far side of the gauge.

Some gauges offer a “thin lift mode”. The thin lift mode is a version of a backscatter test – the source rod should be placed in the same depth position as an ordinary backscatter test (the 1st notch).

Neutron Radiation



The Americium 241 (Am241) source permanently resides in the base of the gauge and is surrounded by additional shielding. Unlike the Cs137 in the source rod, it never releases out of the gauge. The Am241 source releases neutron radiation to measure moisture. The neutron is emitted in a form known as a “fast neutron”.

The Helium 3 detector tube resides next to the source. But the detector tube can only count a “slow” neutron. The fast neutron must be slowed. The best way to slow a fast neutron is for it to collide with the single proton in the nucleus of hydrogen. Hydrogen happens to be a key component of moisture and its role in slowing the fast neutron gives a representative indication of moisture under the gauge.

This process is called thermalization. When the operator presses the start key the detector tubes count the thermalized neutrons that have collided and slowed from the hydrogen present under the gauge.

Safety Record

Gauges have a virtually spotless safety record. Considering that gauges have been used on millions of tests it is a very impressive record.

There has likewise never been a known case where a gauge has been stolen and used to make a weapon (dirty bomb) or harm anyone. You may be surprised to find that there has never been a “dirty bomb” of any kind exploded in the history of the planet.

The safety record of the nuclear moisture density gauge is something the gauge industry is very proud of – let’s keep it that way.

Radiation Basics

Atoms, Elements, Isotopes & the Periodic Table

Radioactivity, Contamination & Radiation Decay

The Four Types of Radiation Emitted by the Gauge

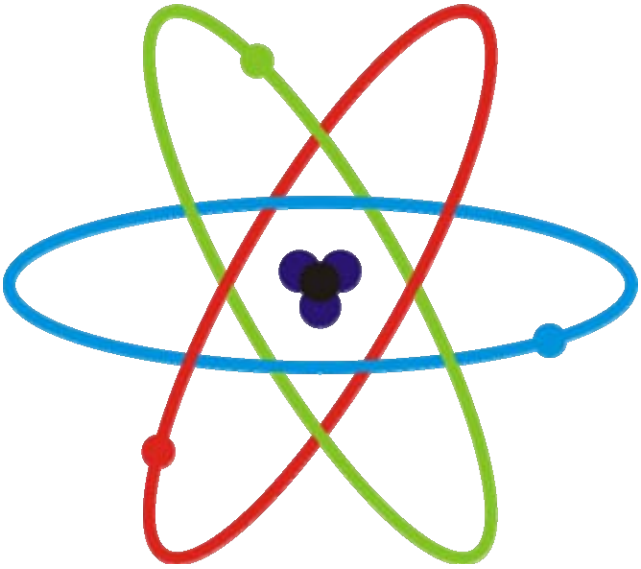
Radiation Decay and the Half-Life Measurement

Ionizing Radiation

Radiation Measuring Units

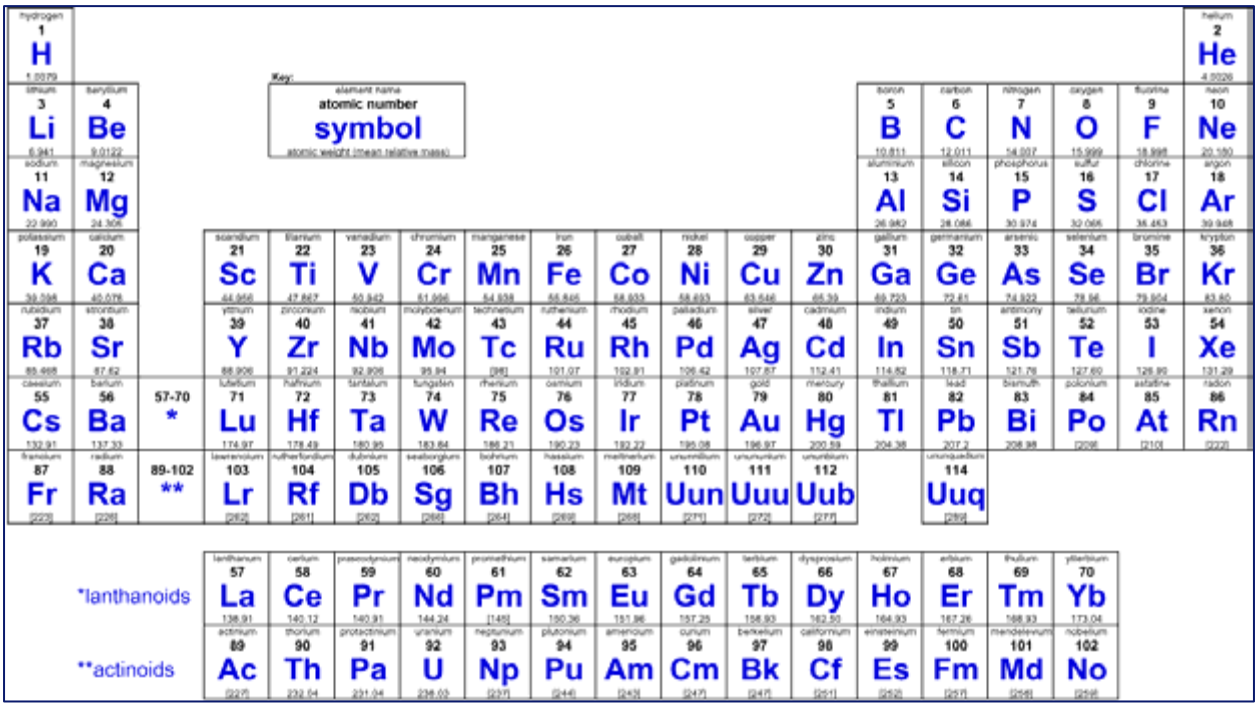
Atoms, Elements, Isotopes and the Periodic Table

To understand how radiation makes your gauge work you must first understand basic atomic structure. The universe and everything in it, including us, is made up of elements. That includes all solids, gases and liquids. The atom is the smallest unit of an element. One atom consists of an electron, a proton and a neutron. Elements are a greater mixture of atoms, with more electrons, protons and neutrons.

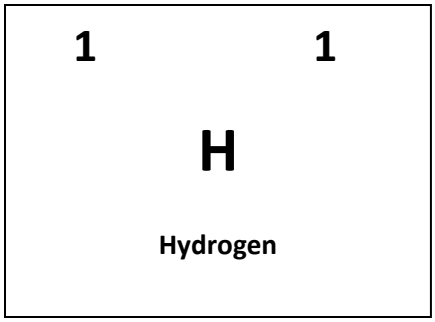


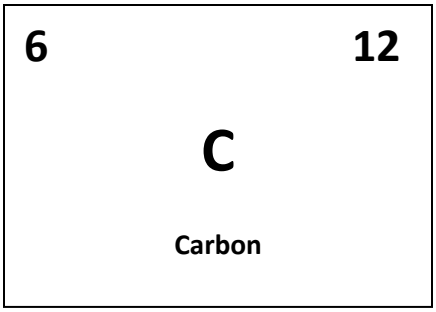
The “heart” or center of an atom is the nucleus, which makes up about 1/8000 of the atom. Atoms are mostly open space. It holds the sub-atomic protons and neutrons. Sub-atomic electrons “orbit” the nucleus in what is known as an electron cloud. Protons have a positive charge and electrons have a negative charge. As long as you have the same number of protons as electrons the atom is considered to be electrically neutral. Neutrons have no charge.

The Periodic Table of the Elements



An element, also known as a chemical element, is a type of atom that is defined by its **atomic number**. The atomic number is determined by the number of **protons** in the nucleus. All of the elements that we know of are listed on the **Periodic Table**. Each "box" on the periodic table shows a different element and includes some basic information about that element: Its name or abbreviation – Hydrogen – "H", its atomic number – "1" and its mass number – "1". Carbon would be: "C", "6" & "12".





A full depiction of the Periodic Table of the Elements can be found in the appendices/attachments.

The **atomic number**, also known as the chemical number, represents the number of protons in an element and is the number that you see running sequentially through the periodic table, from #1 Hydrogen to #118 Ununoctium (Elements 1 – 92 are naturally

occurring, everything above 92 can be considered man-made). If you could physically count the number of protons in a given element you could match that number to the atomic number on the periodic table to determine which element you are looking at. But atoms are tiny. There are more atoms in a single glass of water than there are glasses of water from all the oceans on earth. You can put a trillion of them on the head of a pin. One strand of your hair is one million atoms thick.

If the number of protons in the nucleus were to change, the element would change.

The other number in the “box” is the mass number. Virtually all the mass of an element comes from the protons and neutrons – electrons consist of energy and contain virtually no mass. Conveniently, the mass number for one proton or one neutron is approximately one. The mass number tells you the number of protons and neutrons an element has in its nucleus. If you could all you need to do is count the total number of protons and neutrons in the nucleus to approximate its mass number. The periodic table already tells you the atomic number (# of protons) and mass number (total number). To determine the number of neutrons just subtract the atomic number from the mass number.

Elements are generally referred to by their mass number. For example, #6 Carbon, in its natural, stable state, is referred to as Carbon 12.

More stable elements are those that have an equal number of electrons, protons and neutrons. Carbon, #6 on the periodic table, has 6 electrons, 6 protons and 6 neutrons – relatively nice and stable.

But there are versions of a given element that are not so completely balanced. These variations of a given element are known as **isotopes**. Isotopes of a given element all have the same number of electrons and protons, but the number of neutrons vary. For example Carbon can have variations such as Carbon 13, Carbon 14, etc. Carbon 13 has an extra neutron while Carbon 14 has two extra neutrons. They are still Carbon, just not as balanced as Carbon 12. All elements have these variations.

The balance between the number of protons and neutrons in the nucleus is very important. All atoms seek to be perfectly stable. Iron, #26, is the most stable of all elements, which is why it is not only strong, but also in great abundance. There are two forces present inside a nucleus, the “electro-magnetic force” and “strong nuclear force”. Iron not only has an equal number of sub-atomic particles, it also has the most stable balance between the two forces. In terms of stability, all lighter and heavier elements dream of being as stable as Iron.

Lighter elements typically need fusion to combine with other elements to create a new element that is more Iron-like. Heavier elements can be so unstable in proton/neutron

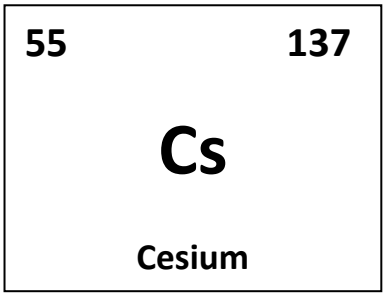
ratios that they will tend to fall about on their own, becoming new, lighter elements in the process. Many of these unstable heavier elements will eventually change into Iron.

Elements that become too unstable are classified as **radioactive**. When it becomes too unstable the nucleus releases energy and/or sub-atomic (protons/neutrons) portions of itself in order to get to a more stable condition. This release of energy and matter is known as radioactive decay, better known as **radiation**.

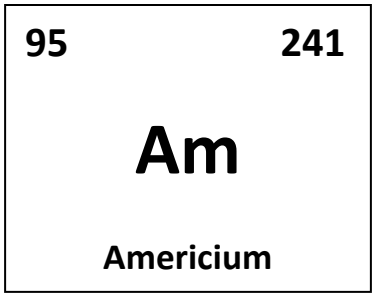
Radioactive elements, and the radiation they release, have been used for thousands of beneficial applications. Radiation is a unique property that is used for energy production, non-destructive industrial measurements, medical observations (x-rays), as well as a cancer treatment.

Moisture density gauges use two different types of radioactive elements to produce the radiation necessary to determine density and moisture content.

Cesium 137, an unstable radioactive ***isotope*** of Cesium (#55 on the periodic table), is used to measure density.



Americium 241 (#95 on the table), also an unstable radioactive ***isotope***, is used to determine the moisture content under the gauge.



Radioactivity, Contamination, Radiation and Decay

People sometimes have a difficult time understanding the difference between radioactivity and radiation. Radioactivity refers to an element that has a significant imbalance between neutrons, protons and forces. It results in the element throwing off energy and portions of its self during the decay process. Although the matter and energy that are emitted is coming from a radioactive source, the matter and energy themselves are not radioactive. They carry a charge that can change the electrical balance of an element in our body, thereby causing cell damage, but it does not make you radioactive.

As mentioned, radioactivity is an element that is decaying. But there is nothing that can happen to the radioactive element in the gauge that will cause it to explode, catch fire, ooze or seep. No accident, including being struck by heavy construction equipment, getting wet, or being struck by lightning will cause it to detonate into a destructive mushroom cloud.

These elements can only decay, getting weaker with every second. Over time they will decay to a negligible level.

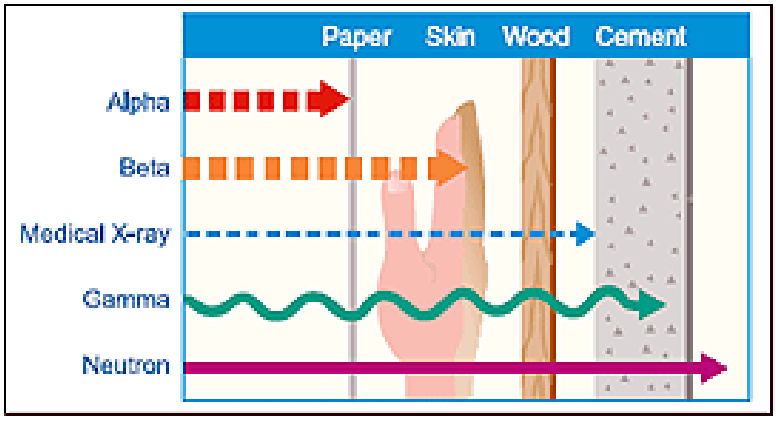
The radiation, or decay, it gives off is non-radioactive sub-atomic particles or energy that can have an effect on the balanced cells in our body. It does not turn you radioactive – you're not going to glow after working all day with a gauge. The radiation amount you receive from a gauge is so small it is generally considered to be in the "**background**" range of the radiation that humans naturally absorb in a year. A further discussion of the effects of radiation on humans will be discussed in the next chapter.

To clarify, radiation is non-radioactive matter or energy that is emitted by a radioactive element, passes through space and collides with or is absorbed by matter.

If you were to be impacted by the actual physical radioactive material, you would be considered to be **contaminated.** You would have to go through a physical cleansing to remove the radioactive material.

Consider the x-rays that you receive at the doctor or dentist or the way they x-ray your luggage at the airport. X-ray radiation is essentially the same type of radiation the gauge uses to determine density. Do you ever consider yourself or your luggage to be contaminated or radioactive after getting x-rayed? Well, you're not – nor will you be after using the gauge. But you do want to limit your exposure to radiation as best you can (ALARA).

The Four Types of Radiation Emitted by the Gauge



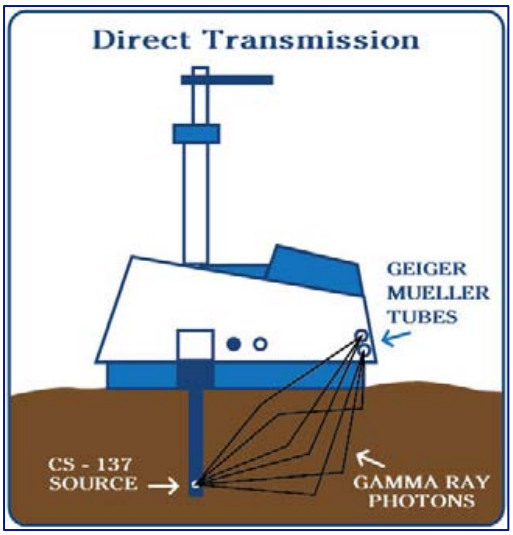
Although there are four types of radiation emitted by the sources in a moisture density gauge, the gauge only uses two types to measure density and moisture. The shielding around the sources permanently absorbs the other two types. The four types are:

Alpha Radiation Decay – Alpha decay is a particle that consists of two protons & two neutrons. Relatively speaking, two protons & two neutrons make for a big chunk of radiation. It is emitted by the Americium 241 moisture source and only travels a very short distance. It is easily stopped - a single sheet of paper or the top layer of human skin will stop it. The protective double encapsulated metal housing around the material permanently absorbs this radiation. The gauge does not use it to make measurements. You are never exposed to the gauge's alpha radiation. Note: The common household smoke detector uses Americium 241.

Beta Radiation Decay – Beta radiation typically consists of a very low mass electron that travels very fast. But its negative charge will only penetrate matter to a short distance. The heavy shielding around the sources in the gauge absorbs all beta decay. The gauge does not use beta radiation for measurements. You are never exposed to the gauge's beta radiation.

Gamma Ray Photon Radiation – Gamma Ray Photons are very similar to x-rays. They are a form of pure energy that is very penetrating. People think of lead as a good shield for radiation. It is as long as it is alpha, beta, x-ray or gamma ray photon radiation. Regarding human interaction, gamma ray photons can either be absorbed by the body, deflect the photon in a process called the Compton Effect, or the photon can pass completely through the body with no interaction.

The gauge uses the gamma ray photons emitted by the Cesium 137 source to measure density. The more you roll and compact the material, the more gamma ray photons will be absorbed and prevented from making their way to be counted by the detector tubes. The gauge interprets lower counts as a higher density. It is an indirect relationship – the fewer the counts – the higher the density.



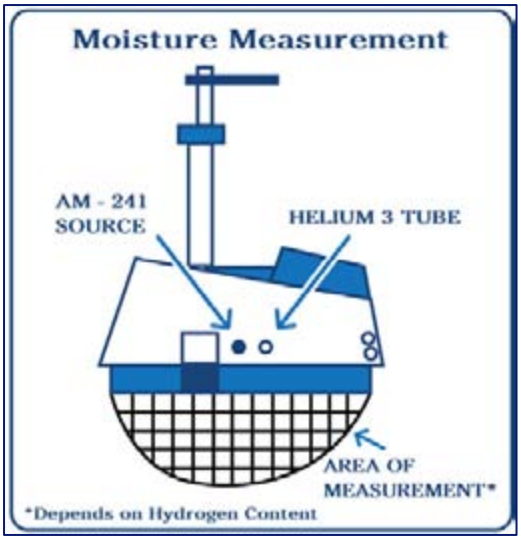
Neutron Radiation

The Americium 241 in the gauge does not directly produce neutron radiation. It is combined with and utilizes non-radioactive Beryllium to produce the neutrons.

Neutron radiation has no charge and is therefore highly penetrating into matter, including humans.

It is best shielded by anything loaded with hydrogen, like a plastic, and it is this characteristic that makes it effective in measuring moisture, which is loaded with hydrogen.

The radiation emitted by the moisture source in the gauge takes the form of a “fast” neutron. The detector tubes used in the gauge to measure neutron radiation cannot detect a fast neutron, only slow ones. The fast neutron must go through an interaction called thermalization before it slows down enough to be detected and counted.



Thermalization occurs when the neutron collides with a nucleus, ideally one that is equivalent in mass to its self. The element that best meets that requirement is the nucleus of hydrogen, which consists of just one proton and is approximately the same size as the neutron. Each interaction with a hydrogen nucleus transfers a portion of the neutron’s energy

and slows it down. It takes 19 of these collisions to sufficiently slow the neutron to a state where it can be counted by the Helium 3 detector tube.

It is a very direct relationship. The more moisture under the gauge, the more neutrons will be thermalized and counted by the detector tube.

Radiation Decay & the Half Life

Radiation is the decay of the radioactive material in your gauge. It is unlikely the radioactive material will decay to a level that will make your gauge inoperative. Typically, the rest of the gauge will wear out before the radioactive material.

Of more importance is the understanding that the radioactive material in the gauge will remain active for hundreds or thousands of years. For this reason, you must properly dispose of the gauge. You can't just throw it in a dumpster or a scrap yard.

Radiation decay is measured by the half-life. The half-life for most radioactive materials is known. For Cesium 137, the half-life is 30 years. For Americium 241, it is 432 years.

A brand new moisture density gauge, depending on the model, will have 8-10 millicuries of Cesium 137 and 40-50 millicuries of Americium 241. Each half-life will see a reduction of ½ of that material, so the 8-10 millicuries of Cesium 137 will decay to 4-5 millicuries in 30 years, while the 40-50 millicuries of Americium 241 will take 432 years to decay to 20-25 millicuries.

The second 30 year half-life of Cesium 137 will see the material decay to 2-2.5 millicuries while the second 432 year half-life of Americium will see the material decay to 10-12.5 millicuries. It takes 10 half-life periods for any radioactive material, regardless of the half-life period, to decay down to a negligible level.

So, for Cesium 137 it will take 300 years and, for Americium 241, it will take 4,320 years. That seems like a long time but there are many natural radioactive materials that take billions of years to completely decay.

Ionizing Radiation

The two types of radiation used by the gauge to measure density and moisture are known as ionizing radiation. Ionizing radiation has the ability to detach (ionize) an electron from an atom or molecule in the human cell structure. This can damage or eventually kill the cell, but because the body repairs or replaces about a billion cells a

day, the likelihood of harm is virtually non-existent. It typically takes huge exposures of ionizing radiation to cause harm or a cancer.

Humans have no senses capable of detecting exposure to ionizing radiation. But radiation survey meters, also known as Geiger Counters, are quite capable of detecting and measuring ionizing radiation and are one the primary reasons that your licensing agency wants you to be in possession of one.

Radiation Measuring Units

Although it has been present since the beginning of time, it has been only a little over a hundred years since humans first became aware of radiation. We had to first understand it and also quantify it by giving it a measuring unit.

Today, we measure radiation in curies (Ci), in honor of Madame Curie, and becquerels (Bq), in honor of Henri Becquerel, two of the early pioneers in radiation physics. The strength or quantity property of radiation that is measured is its activity. Activity is defined as the number of disintegrations that occur per second of a given radioactive element.

One curie equates to 37,000,000,000 disintegrations per second. That's a lot of activity and too large for measuring the strength of the sources in a gauge. The Cesium 137 (Cs137) in moisture density gauges is in the 8 – 10 millicurie range. The Americium 241 (Am241) source is in the 40-50 millicurie (mCi) range. A millicurie is 1/1000 of a curie.

The SI international measurement is becquerel unit. You can think of the Becquerel as the metric equivalent. A becquerel is equivalent to one disintegration per second, which is very small. Becquerel measurements for the gauge are expressed in megabecquerels and gigabecquerels. All documents must have radiation measurements listed in the SI equivalent.

For conversion purposes: 1mCi = 37 MBq

Introduction to SI Units

SI (Systeme International) units comprise the primary measurement system for most countries. The system is also finding increasing use in the United States. State and federal regulatory agencies, including the U.S. Nuclear Regulatory Commission, have adopted SI units for radiation measurements; other agencies (e.g., the U.S. Department of Transportation) require their use.

Common Radiological Unit Prefixes

Submultiples				Multiples			
m	milli	10^{-3}	thousandth	k	kilo	10^{3}	thousand
µ	micro	10^{-6}	millionth	M	mega	10^{6}	million
n	nano	10^{-9}	thousand millionth	G	giga	10^{9}	thousand million
p	pico	10^{-12}	million millionth	T	tera	10^{12}	million million

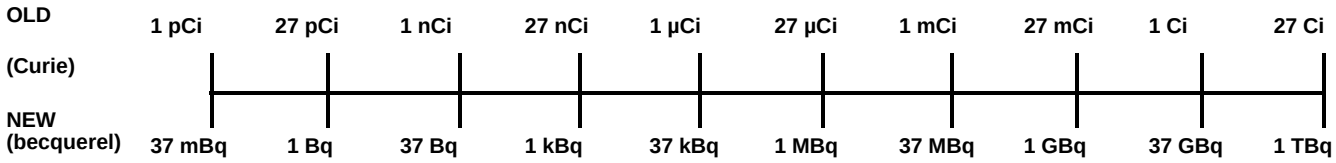
Activity

The traditional unit is the Curie (Ci); the SI unit is the Becquerel (Bq)

1 Ci = 3.7 x 10^{10} Bq = 37 GBq **1 Bq = 1 disintegration per second = 2.7027 x 10^{-11} Ci or ≅ 27 pCi**

To convert Bq to Ci, divide the Bq figure by 37 x 10^{9} (or multiply the Bq figure by 2.7027 x 10^{-11})

To convert Ci to Bq, multiply the Ci figure by 37 x 10^{9}



Examples: **9 mCi = 333 MBq = 0.333 GBq** **10 mCi = 370 MBq = 0.37 GBq**
44 mCi = 1628 MBq = 1.63 GBq **50 mCi = 1850 MBq = 1.85 GBq**

Table A

Curie Units	Becquerel Units
Ci	kBq
mCi	MBq
Ci	GBq
0.1	3.7
0.25	9.25
0.5	18.5
0.75	27.75
1	37
2	74
3	111
5	185
7	259
10	370
20	740
25	925.

From Table A: 0.1 mCi = 3.7 MBq
0.1 Ci = 3.7 GBq

Table B

Curie Units	Becquerel Units
Ci	MBq
mCi	GBq
Ci	TBq
50	1.85
60	2.22
100	3.7
200	7.4
250	9.25
500	18.5
800	29.6
1000	37

From Table B: 50 mCi = 1.85 GBq
3.7 MBq = 100 Ci

To convert from one unit to another, read across from one column to the other, ensuring the units are in the same line of the column headings.

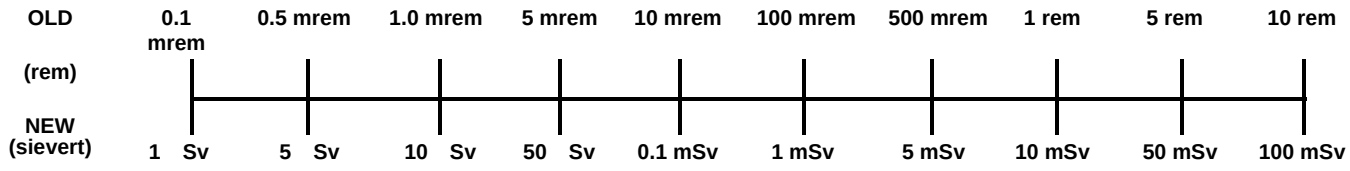
Radiation Dose Equivalent

The traditional unit is the rem; the SI unit is the sievert (Sv).

1 rem = 0.01 sievert (Sv) = 10 mSv **100 rem = 1 Sv** **500 rem = 5 Sv**

1 rad = 0.01 gray (Gy) = 10 mGy **100 rads = 1 Gy** **500 rads = 5 Gy**

The working SI unit is the sievert (Sv)



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Biological Effects of Radiation

Putting Radiation Exposure in Perspective

There is a big difference between radioactivity and radiation. A radioactive material releases radiation, but that radiation is not radioactive and will not turn you radioactive.

Nuclear radiation has been present since the beginning of time. We absorb nuclear radiation every day of our lives. It has always been there and it will always be there. There is nothing you can do to hide from it nor is there a reason to. Harm from radiation would generally only come from a huge exposure. There are literally thousands of other potential contaminants we encounter in everyday life that could likewise harm or kill you if delivered in a large dose.

The air you breathe and the water you drink are loaded with trace amounts of lethal contaminants. The trace amounts of pesticides, solvents, diesel exhaust, and paint vapors we breathe in every day would all be killers if delivered in large quantity. Factories, landfills, dry cleaners, gas stations, incinerators, mining operations, locomotives, farms boats, ATVs, body shops, auto interiors, plastics plants, bug spray, furniture cleaners, window washer fluids, etc…… are all emitting noxious and poisonous fumes capable of causing harm or a cancer.

Cigarettes release over a thousand contaminants with every puff – and those contaminants are being ingested by many non-smokers (2^{nd} hand smoke). Alcohol is another major offender. Even the oxygen in the air you breathe, if ingested in higher concentrations, would get you.

Although not an exact analogy, the same rule that applies to radiation. It is typically only harmful in extreme exposures. But you are far more likely to receive harmful or cancer-causing exposures to other contaminants than radiation. The strictly enforced regulations regarding radioactive materials make it highly unlikely that you ever will be subject to high exposures of radiation.

Your own genetics are far more likely to get you than radiation. Matter of fact, radiation, in the form of cancer killing medical treatments, is far more likely to save you than kill you.

Everyday activities are far more lethal to humans than radiation. Driving a car, flying in an airplane, bee stings, snake bites, lightning strikes, bike riding, falling off the roof, or a thousand other calamities rank higher than radiation on the mortality hit list. Virtually any other industry is more lethal to humans than the nuclear industry.

Humans do have one major thing going for them – their bodies. The human body is an incredibly resilient machine. We average a 70+ year lifespan, even with all the evil nasties that invade our bodies every day. Our bodies replace over a billion dead or damaged cells every day. As long as we're not overwhelmed by any particular toxin we have remarkable built-in recuperative abilities. It is ultimately the failure of our aging brain and organs that will eventually do us in.

To put things in perspective consider the following - In your lifetime:

If you smoke a pack of cigarettes a day you will cut your life short by	2250 days
If you are 30% overweight	1300 days
Drinking alcohol - U.S. average	365 days
If you are a teacher	30 days
Using a gauge for 70 yrs & receiving twice the annual average dose	7 days
Drink coffee every day	6 days

Background Exposure vs. Occupational Exposure

Exposure to radiation can be put into two categories; background exposure and occupational exposure.

Background radiation is any exposure to radiation that is not part of your job. Natural exposures include the cosmic radiation that makes it through our atmosphere and terrestrial sources such as radon and radioactive elements imbedded in the ground or stone (marble). Other natural radioactive elements (Carbon 14 & Potassium 40) enter and are stored in our bodies by way of the food we eat and water we drink. These trace internal amounts give off and expose an individual to more radiation than is typically received working around a gauge for a year. Medical x-ray exposures are also included in the total. The average background radiation exposure dosage for a U.S. citizen is 360 **millirem**.

Occupational radiation exposure is that which is received while working around a gauge. A worker that is taking reasonable steps (ALARA) to keep their gauge exposure to a minimum can expect an annual exposure dosage around 1/10 of the average **background** exposure – somewhere in the 25-50 millirem range. That means you can work around a gauge every day of the year and still receive a very low exposure.

Measuring Your Exposure

The measuring unit (REM or Sievert) used to determine how much exposure a person has received is determined by measuring the volume (rad or gray) of exposure multiplied by the type of radiation (Q - Quality Factor).

The **radiation absorbed dose (rad)** measures the volume of radiation an individual is exposed to. The SI International equivalent for a rad is the **gray.** A gray is equal to 100 rad. The volume must be multiplied by a **quality factor**, which is based on the type of radiation the individual is exposed:

A rad of x-ray, gamma or beta radiation has a quality factor of	1 (1 x 1 =1 rem)
A rad of fast neutron radiation has a quality factor multiplier of	10 (1 x 10 = 10 rem)
A rad of alpha radiation has a quality factor multiplier of	20 (1 x 20 = 20 rem)

REM is an exposure measurement that measures the volume and type of radiation. The SI International unit for REM is the **sievert**. One sievert is equal to 100rem.

An equal volume exposure of fast neutron radiation is 10 times more potent than that of x-ray, gamma or beta. Alpha would be twice as potent as fast neutron and 20 times as potent as x-ray, gamma or beta.

In Defense of the Nuclear World

There is much debate about the uses and threats of radioactive material and radiation. Nuclear physics is not easily understood, which has lead to many misconceptions and an easy target for the “gloom and doom” crowd.

If one were to take the time to analyze the safety and benefits history of the nuclear industry one might come away with a very positive view. Consider the last 50 years. What other industry has a safer record than nuclear? Outside of the Chernobyl mishap that killed 30+ plant workers and exposed the local population, can you name another nuclear incident that has harmed a group of people? Can you name another industry that has that safe a record?

The portable nuclear moisture density gauge record has an immaculate record. No one has been contaminated by gauge source material nor has anyone required medical treatment for an exposure.

The media, environmental groups and Hollywood have done an injustice to the nuclear industry. A study of the benefits of nuclear medicine would show that radiation treatment

has saved countless numbers of individuals and has been a benefit to billions of medical and dental patients.

Where would we be without medical and dental x-rays for broken bones, mammograms, cavities, etc? How would you like a doctor take his “best shot” at setting a broken bone because he didn’t have an x-ray to show him the location and severity of the break?

Construction and manufacturing industries use radiation gauges and measuring devices to ensure the quality of virtually every product and job in use today.

X-rays and industrial gauges do subject you to a dose of radiation but the rates are far below anything that is considered dangerous.

You also constantly hear fears about the potential of using radioactive materials as a weapon. How many times have you heard the term “**dirty-bomb**” since 9/11? While we now live in a never-say-never world, the fact of the matter is that there has never been a dirty-bomb exploded in the history the planet.

External vs. Internal Exposure

The only way to discuss the potential harm of radiation is to put exposures in perspective with levels that would be harmful to humans. Only then can we understand how little the potential harm of moisture density gauge radiation exposure is to the gauge operator.

When discussing the potential of radiation to harm our bodies we are most concerned about exposure to our vital organs. They are the machines that keep you in a healthy state.

External Exposures

External exposures are those that penetrate our bodies from the outside, through our skin to our vital organs.

The previous chapter discussed the four types of radiation that are emitted by the radioactive sources in the gauge. The encapsulation around the sources permanently shields alpha and beta radiation. Even if they were unshielded they do not have the ability to penetrate our bodies deep enough to reach our vital organs. Gamma ray photon and neutron ionizing radiation can penetrate our bodies enough to cause cell damage to our organs, but it would take a huge exposure to cause acute radiation sickness or permanent damage.

Internal Exposures

Internal exposures come from radiation or radioactive materials ingested into our bodies. Internal exposures directly impact our vital organs and are much harder to remediate.

Internal or external contamination from moisture density gauges has never occurred nor has a significant external radiation exposure.

Chronic and Acute Exposures

Radiation exposure to humans can be divided into two categories; long term chronic exposure and short term acute exposure.

Long term **chronic exposure** is exposure that takes place over a longer period of time. Your annual average of 360millirem per year of background radiation is an example of long term chronic exposure. Cell damage from long term chronic exposure does not overwhelm the body's recuperative ability. Damaged cells are replaced or repaired by the body.

Acute exposures are those of greater quantities that generally happen all at once or in a very short time frame. This type of exposure can cause extensive damage to the body's vital organs and overwhelm the recuperative abilities of the body. The only examples of events that caused widespread acute exposures were the atomic bombs dropped on Japan and the incident at Chernobyl.

Acute exposures can cause radiation sickness. Higher exposure doses with likely effects are:

• 100rem (100,000mrem)	Slight blood lymphocyte reduction – lymphocytes are beneficial in fighting infections.
• 150rem (150,000mrem)	Flu like symptoms including nausea with vomiting and fatigue
• 250rem (250,000mrem)	Severe flu like symptoms. Can take up to 2 weeks to occur and up to 3 months to recover.
• 400+rem (400,000+mrem)	Severe flu-like symptoms, loss of hair, hemorrhaging, purpura, inflammation & emaciation. Typically fatal to 50% of those exposed over the next 4-6 weeks.
• 600+rem (600,000+mrem)	All of the above symptoms. Survival is unlikely.

It is highly unlikely you will ever encounter acute exposure levels and certainly not from the gauge.

Your Occupational Exposure Limits

The NRC and Agreement States have placed a 5,000mrem limit on the amount of radiation a worker can receive in any cumulative year. Any worker exceeding that level will have to be reassigned to a job free of exposure to occupational radiation exposure. Note: There has never been a case where a moisture density gauge user has received their annual limit.

Declared pregnant women will be limited to 500mrem for the term of the pregnancy. A pregnant woman should make her declaration in writing. She cannot be forced to relinquish her position unless she voluntarily declares.

Individuals under the age of 18 are limited to 500mrem per year (50 in some states).

Realistic Annual Average Exposures

Most workers can expect an annual exposure to radiation from a gauge to be less than 100mrem. Exposures are tracked by the use of personnel dosimetry, such as film badges and TLD's. Any unusual amounts of exposure should be investigated and any inappropriate activities should be corrected.

ALARA – As Low As Reasonably Achievable and How to Limit Your Exposure

"Any Unnecessary Exposure is Considered to be an Excessive Exposure"

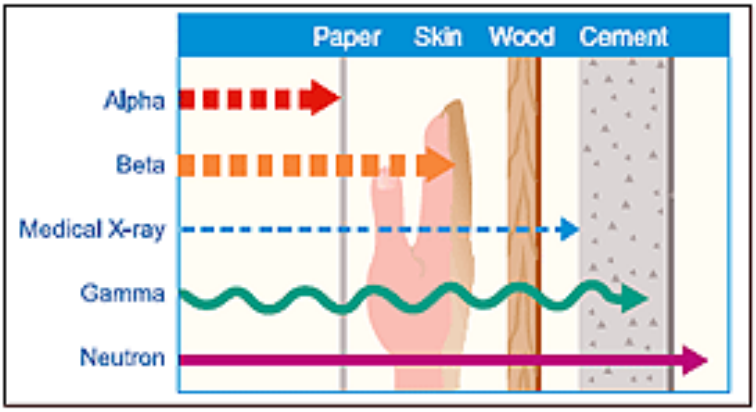
There is nothing more important as a condition of your license then for you and your program to understand and practice good **ALARA**. ALARA stands for "As Low As Reasonable Achievable". It is a concept and a way of life while operating a nuclear gauge.

The purpose of ALARA is to protect you and the general public from radiation exposure. The idea behind ALARA is for you to minimize the radiation exposure you receive from a gauge down to a level that is as low as possible, within reason. ALARA states that "any unnecessary exposure is considered an excessive exposure".

There are four ways to make sure your and everyone else's exposure is kept to a minimum, **shielding**, **time**, **containment** and **distance**:

1) **Shielding** – Moisture density gauges are heavy, usually 30-40 lbs. One reason for all this weight is the shielding built into the gauge. The base of the gauge is made of lead, a good shield for radiation. An even better shield, tungsten, is

typically used to create a bio-shield directly around the radioactive sources in the gauge. The safe position for a source rod is when the rod is fully retracted into the gauge. In the safe position the shielding will absorb most of the radiation released by the sources.



Let the shielding do its job. Always keep the source rod retracted into the safe position when the gauge is not in use. Once a test is completed, and before you record the results, retract the source rod into the safe position.

To give you an idea as to how effective the shielding is, consider the **transport index** of the gauge. The transport index of the gauge, also known as T.I., is a measurement of the radiation dose at one meter away from the gauge per hour. Typically, a T.I. for a moisture density gauge is 0.2mrem – 0.7mrem (safe position). Let's say your gauge has a T.I. of 0.5. That means for every hour you sit one meter away from the gauge you are absorbing 0.5mrem radiation. At that rate you could sit one meter away from the gauge for a year and never achieve your allowable 5,000mrem dose for the year.

But, if you did sit unnecessarily and intentionally next to your gauge, you would be in violation of the ALARA principle. It doesn't matter that you are under your annual limit – it matters that this type of exposure is unnecessary and therefore excessive.

2) **Time** – You always want to limit your time around a gauge. When preparing the test area keep the gauge locked in the vehicle. When taking a test push the start button and then back away from the gauge (10 feet is usually sufficient). When the test is complete lock the gauge back in the vehicle. When transporting a gauge always store the gauge in the rear most part of the vehicle.

Your time spent near a gauge should result in exposures that can be measured in seconds, not minutes.

3) **Containment** – When not in use, gauges should be confined and secured in a manner that restricts access by, and limits exposure to, the general public and anyone not actively using the gauge – that pretty much means everyone. A gauge in storage, be it the licensed or approved temporary storage area (including a vehicle), should always be restricted by four levels of locked security:

A) A lock on the gauge handle – this prevents release of the source rod
B) A lock on the gauge case – this limits access to the gauge itself.
C) A lock on the door of the storage closet or an additional lock securing the case and gauge to a vehicle.
D) A lock restricting access to the storage closet or entry into the vehicle or trunk. Gauges in the back of an open bed vehicle must have an additional locked chain, cable or enclosure.

4) Distance – Distance may be the most important and effective component of ALARA. Telling you to maintain your distance whenever possible from a radioactive source is the easy way to obey the distance component of ALARA. Explaining the reason is a little more difficult.

A law of physics called the **inverse-square law** explains that some physical quantity or strength is inversely proportional to the square of the distance from the source of that physical quantity. In a nutshell it means that your exposure to the radiation coming off a radioactive source is reduced by 3/4 every time you

double your distance away from that source. That's because the radiation release is a constant that is being spread over an ever increasing area as you move away from it and it therefore quickly loses its intensity.

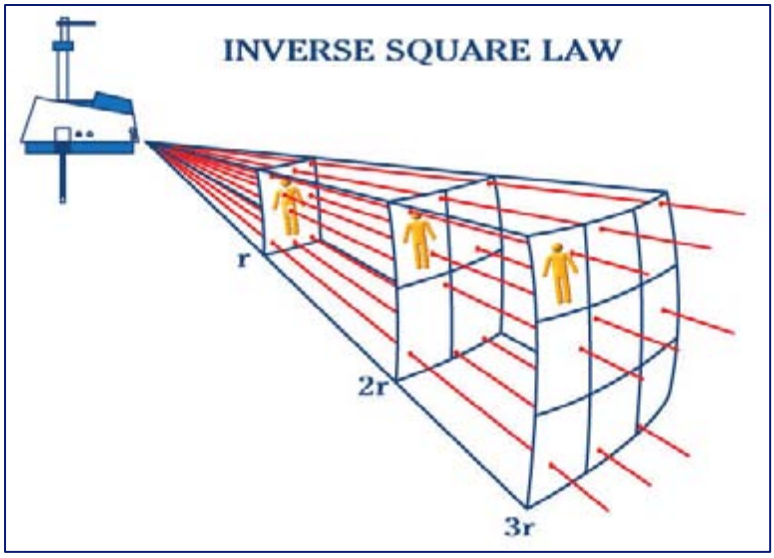
Inverse Square Law: $I_2 = \frac{I_1 R_1^2}{R_2^2}$

Where: I_1 = intensity (radiation dose rate) at distance R_1

I_2 = intensity (radiation dose rate) at distance R_2.

R_1 = distance from RAM with dose rate I_1

R_2 = distance from RAM where dose rate I_2 is calculated



The same holds true with gauge radiation. It quickly drops off as you move away from the gauge. When you push the start button for a test you should move away as the gauge completes the test, typically one minute. Ten feet should be enough – you will want to stay close enough to move the gauge out of harm's way (heavy construction vehicles) or to limit access to the gauge by unauthorized individuals.

By practicing effective ALARA you can ensure that your exposure will be kept to a minimum.

Tracking Your Exposure – Personnel Dosimeters: Film Badges, TLD's & OSL's

Licensees must "provide **dosimetry** processed and evaluated by a NVLAP (National Voluntary Laboratory Accreditation Program) approved processor that is exchanged at a frequency recommended by the processor". A dosimeter is a device, such as a film badge or **TLD** (Thermoluminescent Dosimeter) that measures the amount of radiation that an individual absorbs over a given period of time. Dosimetry options are:

Film badges: A small piece of x-ray film that darkens in proportion to the amount of radiation received. Film badges are exchanged on a monthly basis.

TLD's contain small crystals that are capable of storing some of the energy from radiation. When heated to a specific temperature they release the energy in the form of light that can be measured to determine the dose. TLD's are exchanged every 3 months.

OSLD's are optically stimulated by a laser, causing it to be luminescent in proportion to the amount of radiation exposure.

The dosimeter should be able to detect and measure beta, gamma and neutron radiation.

Having employees wear a dosimeter is the best way to track how much radiation they are exposed to while in the presence of a gauge. It is an important requirement of the license to know this information and likewise important to keep this information on file.

Dosimetry is a service provided by a NVLAP approved provider. Most licensees use dosimeters by Global Dosimetry and Landauer, primarily through third party providers,

such as gauge manufacturers and gauge service facilities. Since all of these dosimeters are NVLAP accredited you can be assured that the devices and the analyses have solid integrity.

See the Dosimeter/TLD section under the APNGA homepage “Industry” column for providers.

Every licensee must provide a dosimeter to every individual that works around a gauge. The dosimeters, usually a clip-on device, must be assigned to workers at the beginning of each period, typically quarterly.

A delivery of dosimeters from the provider should include a “control” dosimeter. This dosimeter is identical to the dosimeter that workers wear but it is to be placed at a location within the licensee’s location that is free from any exposure to gauges (at least 30 feet away). This control dosimeter will monitor the typical background radiation normally present at the location. It will be returned with the workers’ dosimeters and the measurement from the control dosimeter will be subtracted from the workers’ dosimeter readings, leaving only the occupational dose for each worker. When workers return from the job each day their dosimeters should be stored with the control dosimeter.

Note: Some licensees use an extra dosimeter to monitor the radiation zone around the gauge storage area. An extra dosimeter or two can also be stored to provide immediate use for a new worker or lost dosimeter.

Every worker must be wearing a dosimeter on any day they encounter a gauge:

a) No dosimeter = no gauge use.
b) Dosimeters cannot be shared.
c) Dosimeters are easy to forget but don’t store them with the gauge. Radiation is always present.
d) Don’t wear dosimeters to the dentist or doctor because x-rays will be recorded.
e) A belt loop or shirt pocket is a good place to wear a dosimeter.
f) Return the dosimeter to the RSO or control dosimeter area upon return to the office.

At the end of each quarter return the dosimeters to the provider for analyses (the dosimeters for the next quarter should arrive about 2 weeks beforehand). Dosimeter reports show readings for the most recent quarter, year to date, and lifetime exposures for each employee. They must be kept on file permanently. Make copies available to the employees.

If a report for any employee shows an unusually high exposure an investigation should be conducted to determine the reason for the increase. Document the increase, the

investigation, the reason found (if any), and what steps will be taken to remedy the situation. Follow the procedures of your regulatory agency.

The NRC states and many Agreement States have a provision that allow licensees to forgo dosimetry requirements. If you can document, over a 1-2 year period, that annual gauge exposures for all employees are less than 500mrem per person (check with the agency regarding levels for minors or declared pregnant women) you can forgo dosimeters. Although this can save a lot of money and paperwork, many licensees still prefer the service. Dosimetry programs act as an insurance policy against future employee legal actions. Check with your agency to determine if this option is available and what requirements may be necessary.

Examples of Personnel Dosimetry forms can be found in the appendices under "Attachments/Forms".

A full list of NVLAP approved providers can be found at http://ts.nist.gov/Standards/scopes/dosim.htm.

Radiation Survey Meters

A radiation detection device, also known as a radiation survey meter or handheld Geiger Counter, is the best instrument a gauge user can have for determining the presence and intensity of radiation. These meters measure in millirem or microsievert per hour. You should acquire a model that detects alpha, beta, gamma and x-ray. These meters can also locate neutron sources by detecting the small amount of gamma ray photons released by the Am241 source.

Remember that humans have no senses to detect the presence of radiation and the small size of the encapsulated source will make it very difficult to visually locate in the unlikely event of separation from the source rod.

Your regulatory agency requires that you own or have access to a radiation survey meter. Make sure to provide the model and range, typically 0-50mr/hr or 0-200mr/hr, and the annual calibration service provider that you will use, including their name, address, license number and agency that issued the license.

The survey meter is useful in detecting a damaged or malfunctioning source rod sliding block.

There are numerous models of survey meters consisting of a detector with an analog or digital display. Some models have a LED and audio click that enact when in the presence of radiation. A basic model will allow you to survey your gauge storage area, as well as the radiation zone around the storage area, ensuring that you are providing a safe work environment.

A list of providers can be found on the APNGA home page under the “Industry” listings.

Agencies, Licensing, Regulations, and Recordkeeping

The Regulatory Agencies

The possession and use of a moisture density gauge requires a license issued by the Nuclear Regulatory Commission or Agreement State.

You must follow the conditions that were originally established in your license application. Any changes to these conditions will more than likely require an amendment to your license.

Check the “View My State” listings on the APNGA homepage to determine whether you are regulated by the NRC or an Agreement State and to access their licensing and application materials.

The regulations associated with owning a portable nuclear gauge (moisture density gauge) were established in the Code of Federal Regulations (CFR’s), which have been adopted by and are also in use by the Agreement States. You should have a copy of your license and the regulations on file.

Protecting the General Public, Property and Your Employees

The mission of the regulatory agencies is to protect persons and property from any harmful effects of radioactive materials. That includes your employees. The agencies will conduct inspections and issue penalties to assure their mission is met. You will be charged fees, including those for licensing, amendments, inspections, reciprocity and penalties, to help fund these agencies.

Another mission of the regulatory agencies is to help you run an effective and successful gauge radiation safety program. You should become familiar with the regulatory agency organization, personnel, materials and website (a listing for each state can be found on the AGNGA homepage under “View My State”).

Your NRC or Agreement State license will allow you to use your gauge in any of the 50 states and U.S. Territory’s, although the state you are visiting will require you to obtain reciprocity (permission) before you enter with your gauge. Likewise, the NRC still maintains jurisdiction over many federal properties, typically military bases, in Agreement States and you will need NRC reciprocity to enter those areas.

The application timeframe for obtaining a license can take up to four months, so plan accordingly.

The CFR's and Agreement State Regulations

The Agreement States were required to adopt the federal regulations, also known as the Code of Federal Regulations (CFR's), pertaining to the ownership, transport and use of portable nuclear gauges. Most have changed the regulation numbers and in some cases have added additional regulations. If you are licensed in an Agreement State you must have a copy of their regulations. Follow their regulations and use their forms.

Go to the "View Your State" listing on the APNGA homepage to link to your state and download or request a copy of regulations. Many state websites have excellent materials and guidance regarding the ownership of gauges. Most also make available the forms you will need to stay in compliance with your license. The APNGA website provides examples of these forms, but whenever possible, use the forms provided by your state.

Your company or organization can also add their own regulations provided they do not compromise the regulations of your agency. You must follow the established instructions of your RSO.

It is the applicant's or licensee's responsibility to have up-to-date copies of applicable NRC or Agreement State regulations, read them, and abide by each applicable regulation.

A guide for gauge license holders is the NRC NUREG 1556 Volume 1 "Consolidated Guidance about Materials Licenses" Guide. This guide is used to prepare and apply for a NRC license but it has useful and helpful information for all gauge licensees. Go to nrc.gov and search for NUREG 1556 Vol. 1.

Some gauge manufacturers supply a licensing guide that is tailored towards their gauges. Go to their website to obtain one.

The Specific License

Moisture density gauge owners are required to have a "**Specific License**". A specific license allows for the use of a device with sealed sources and places the responsibility of protecting the general public and environment in the hands of the licensee. The sealed sources must only be used in the device and for the purposes intended as described in the license and the gauge SSD (Sealed Source &Device) sheet.

The specific license identifies the radioactive material in its chemical and physical form, maximum activity and the purposes for which it may be used. A specific license requires

the licensee to have appropriately trained and qualified personnel, appropriate facilities, equipment and procedures to ensure safe operations.

The NRC application for a specific license is NRC Form 313. Agreement States will likewise have a designated license application form. A copy of NRC Form 313 application can be viewed at www.nrc.gov or in the appendices under "Attachments/Forms".

Enforcement

The regulations and the conditions of your license can be enforced by the NRC, Agreement States, the U.S. DOT (including divisions such as the FAA), the EPA, law enforcement (including the FBI), fire and rescue, and other federal, state and local agencies.

The Radiation Safety Officer (RSO)

Your license requires that senior management designate an individual as Radiation Safety Officer (RSO). This individual will establish, maintain, enforce and control the company gauge radiation safety program and act as the contact person for the regulatory agency. When the company is contacted or inspected by the regulatory agency they will want to speak with the RSO.

Senior management is required to supply the RSO with the necessary means, including training, to carry out the position of RSO and should work with the RSO to make sure that all conditions and compliance of the license are met.

The RSO will maintain complete, accurate and organized records. The RSO is responsible for making necessary amendments and notifying the regulatory agency of these amendments. The RSO will keep the safety program updated as to any changes in the regulations.

When a new RSO is designated the licensee must immediately notify the regulatory agency. If allowable, the company should also designate an assistant RSO. This person should be readily trained and authorized to speak for the company as well as carry out all RSO responsibilities.

RSO Requirements and Responsibilities

Recordkeeping File

Designate a file drawer for maintaining all of the documents required for the license. This file drawer should hold all of the original documents and be kept under lock and key.

RSO Training and Your License

The RSO should have the proper training and experience to carry out the position. A minimum training requirement is the completion of the Gauge Safety Certification Class. This class should qualify the individual to perform the duties of the RSO. Your APNGA membership includes the Gauge Safety Certification Class as well as a RSO class. The RSO class will include more in-depth analyses of RSO responsibilities.

Training

The RSO must have practical experience in operating gauges and must introduce and instruct workers to the safety and operational aspects of the gauge.

All gauge workers must pass the Gauge Safety Certification Class. APNGA recommends that all gauge workers also complete the RSO class. It is included in every member's annual dues and completion of this class will aid the RSO and further the understanding of safety, security and compliance requirements for every person in the organization. Remember, your gauge safety program is only as good as your least trained person.

The RSO will oversee the training and monitor the test that is required of company employees and will ensure that he/she has received training. The RSO must be available 24/7/365, providing employees the RSO contact telephone numbers including, office number, cell number, pager and home number. Company employees should be trained in all safety and emergency procedures and possess a copy of the company radiation safety program.

Training for the employees should include:

- Gauge safety training
- HAZMAT training
- Annual refreshers

Topics of training include:

- Principles and practices of radiation protection
- Radiation measurement and monitoring
- Biological effects of radiation

It is important for the RSO or a senior gauge operator to spend time with new workers in the basics of gauge safety and operation.

The certificate issued for APNGA Gauge Safety Training will include a confirmation and signature line for the RSO to acknowledge that the employee has received hands on training with the gauge in use by the company. The APNGA training course covers the safe use of gauges. Virtually all gauges use the same mechanics of measurement, specifically, an adjustable source rod that can be lowered for measuring density, and an internal, stationary source for measuring moisture. The only differing aspects of various models are the keypad and software. The RSO must familiarize the worker with the gauge, as well as the custom gauge methodology and applications in use by the company.

The RSO will authorize and ensure that only properly trained individuals will operate the gauges and prepare and transport gauges. All training certificates are to be kept on file.

Personnel Monitoring/Dose Rates

The RSO will ensure that all gauge workers wear a dosimeter for monitoring occupational radiation exposure. Typical annual exposure is less than 100mRem. Train and practice the concepts of ALARA (As Low As Reasonably Achievable) to ensure minimal exposures. When not in use all employee dosimeters should be kept with the control badge, at a distance free from gauge exposure. Store badges in a temperate environment.

The annual dose limit for workers is 5,000mRem. Declared (in writing) pregnant workers are typically limited to 500mRem (check with your state for limits and forms) for the term of the pregnancy. Workers under the age of 18 are limited to 500mRem/yr (some states limit their exposure to 50mRem).

Storage areas should have limited access to the general public and ensure that public exposure is less than 100mRem/yr or is less than 2mRem/hr. A general rule of 15 feet from a full-time work station should ensure compliance but areas with multiple gauges will need to be evaluated.

Reciprocity

Gauges can only be used within the state you are licensed in. The gauge will be kept at the licensed storage area or approved work site temporary storage. Use outside of your state will require reciprocity (permission from the NRC or Agreement State).

Storage/Security

When not in use gauges will be stored behind double-locked security that prevents unauthorized access or removal. The RSO must authorize and approve any operators before they can remove gauges from storage. Any gauge and case removed from storage must be inspected and logged out with the operator's name, date, gauge serial number and place of use.

Gauges can never be left unattended at the work site. Gauges left in vehicles should be double-locked and concealed with appropriate bill of lading and emergency response sheets left on the driver's seat.

Gauges cannot be left unsupervised with 3rd party gauge service personnel. If you have an individual from a gauge service company visit your facility to calibrate, service or repair your gauges you must have one of your authorized gauge operators accompany the individual at all times. They cannot be left alone with your gauges nor can they be left alone in the secured storage areas of the gauges. The service individual is not employed by your company and you have not transferred the gauge to their ownership. The service person must have a license and that license must specify the exact gauge model that they are to service. They must also have a special license to remove the source rod from the gauge **(some mobile 3rd party gauge service and calibration individuals are not licensed but will tell you that they can work on your gauge as long as a company individual is present – this is illegal and a violation of your license if you let them perform maintenance on your gauge. Others do not have the proper license to remove the source rod and will therefore bypass important source rod inspections and other critical gauge maintenance).**

You cannot let the individual remove a gauge to take to their vehicle without supervision. If a gauge is removed from storage you must adhere to all requirements of the radiation safety program.

If you are in possession of radionuclide quantities of concern you are not allowed to let 3rd party individuals access storage areas and the gauges unless they have regulatory background clearance. A copy of the NRC background clearance notice can be viewed in the appendices/attachments.

Leak Testing

Gauges should be leak tested for contamination every 6 months and documentation placed on file.

Inventory

Hands on gauge inventory will be taken every 6 months and documentation kept on file.

Gauge maintenance

Typically, licenses only allow for general maintenance on gauges, including removal of dirt, clays and debris from the area directly inside the base plate and from the source rod. You must have a special license to remove a source rod. Removal can only be performed by a licensed service facility.

Gauge transport

Gauges transported in a vehicle must be by a trained and authorized company employee. Gauges must be properly double-locked, blocked and braced from movement, and concealed. The driver should have immediate access to a bill of lading and emergency response sheet.

Gauges turned over to a common carrier will include the properly completed documents. Always check the identification of common carrier personnel.

Gauges prepared and turned over to an air cargo company must have the required dangerous goods documentation.

Operating Procedures

The RSO or senior gauge user should spend time familiarizing each worker with each type of gauge in use.

The RSO should also familiarize the worker with all aspects of the company **Gauge Operating Safety Procedures.**

Only users authorized by the company RSO can operate a gauge.

Of utmost importance is a solid understanding of and commitment to the ALARA (As Low as Reasonably Achievable) Principle. The objective is to reduce occupational and public exposures as far below regulatory limits as possible by means of good work practices.

Where provided, always wear a personnel monitoring film badge or TLD when handling, transporting or operating a gauge.

Company Operating Procedures should include instruction in all aspects of:

- Storage and Security
- Constant Surveillance
- Transporting the Gauge
- Operational Procedures at the Worksite
- Gauge Maintenance – if authorized

Emergency procedures

Gauge workers will be trained in aspects of emergency precautions and emergency response. In the event of damage at the work site the gauge operator will respond in the following order:

a. Attend to anyone that may have been injured.
b. Determine the location of radioactive sources (typically the source rod)
c. Take control and deny access to the area (15 feet in all directions)
d. If a vehicle is involved keep it on site until it is determined that it is not contaminated
e. Gather details about accident and damage – if possible, perform radiation survey
f. Stay at the site but contact RSO with details
g. If necessary, the RSO will contact the regulatory agency, manufacturer and police
h. The RSO will give guidance on whether to move the gauge or;
i. The RSO should travel to the site with a radiation survey meter

In the event of damage in an auto accident:

a. Attend to injuries
b. Deny access
c. Gather details, document actions and take photos
d. Contact the RSO and/or emergency response number
e. Wait for instructions or arrival of emergency response

In the event of theft:

a. Contact the RSO
b. Call the regulatory agency
c. Immediately contact the police
d. Consider issuing a reward through the media

Investigations and corrections

Investigate all unusual occurrences involving the gauge (accident, damage, theft, oversights), determine the cause, identify corrective actions and implement such actions.

Enforcement actions and employee misconduct

Enforce all requirements of the license and stop any activities that are considered unsafe or illegal. Misconduct by any employee should be documented and corrective actions taken.

Self-Reporting

An important requirement of your license is for the RSO to self-report any violations of the gauge safety program or conditions of the license. No one is perfect and your regulatory agency understands this. Self corrections are an important learning tool.

Self corrections will show the regulatory agency that you conscientious and committed towards the gauge safety program. Self corrections rarely subject you to a fine, whereas “hidden” violations are far more likely to result in a fine.

Self corrections should include a report of the violation and corrective steps to ensure that the violation will not be repeated.

Recordkeeping, and the Need for Complete and Accurate Records

The File Drawer and Original Copies

The RSO should designate a file drawer for maintaining all of the documents required for the license. This file drawer should hold all of the original documents and be kept under lock and key. If you have to remove an original, make a photocopy and immediately return the original to the file.

There is nothing more helpful during an inspection than a neat, tidy, complete and accurate file of all of your records and it will go a long way towards a successful inspection.

Recordkeeping Checklist

Specific Gauge License – The original and up to date license. Make all the copies you want but keep the original in the file. A **copy** of the license can be placed in every gauge case and emergency procedure packet. Send a **copy** whenever you need reciprocity. Keep a **copy** with your bill of lading and emergency response sheet transport documents. Know and review the conditions of the license on a regular basis.

The Regulations – A copy of the NRC or Agreement State regulations. NRC regulations are contained in the Code of Federal Regulation (CFR) Vol. 10, Parts 1-50 & 51-199 and Vol. 49, Parts 100-185. If you are licensed by an Agreement State contact them or view their website (see the "View My State" listings on the APNGA homepage) for a copy. Regulations should be reviewed on a regular basis. The NRC NUREG 1556 Vol.1, Revision 1, licensing guide is a useful guide. To obtain a copy, visit:

http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1556/v1/r1/

Employee Training Records

Employees working with a moisture density gauge must have appropriate training and certificates documenting their successful participation in these classes. These certificates must be kept on file (distribute a **copy** of each certificate to the employee):

Gauge Safety Class Certification – This class educates the employee about all safety and security aspects associated with using a gauge and qualifies the attendee to be a RSO. This certificate is good for life but employees should receive annual refreshers on the content. The Hazardous Materials (HAZMAT) portion of the class requires a minimum three year refresher.

A closed book, 25+ question test must be taken and passed (70% passing grade). Incorrect answers must be reviewed, including a discussion of the correct response. The RSO must observe and enforce the conditions of the test.

Gauge Field Training – A requirement of the gauge safety class is an understanding of the mechanical aspects of a gauge. There are 20+ different models of moisture density gauges on the market and many different approaches to field applications, making it virtually impossible to cover all aspects of each gauge in a class setting.

All moisture density gauges use the same basic mechanical approach to operating a gauge, which is covered in the APNGA gauge safety course.

But it is still required that the employee see and operate the actual gauge in use by the company. The RSO or senior gauge operator must introduce the gauge to the employee and familiarize them with the software and unique field applications used by the company.

The RSO will be required to sign the training certificate acknowledging that the employee has completed this requirement. Only then will the certificate be valid.

U.S. DOT Hazardous Materials (HAZMAT) Training – Included in the Gauge Safety Certification Class is a section required by CFR 49, Parts 100-185, on safe and knowledgeable transport of a moisture density gauge. This certificate does expire after three years and the employee must be given a HAZMAT refresher. The certificate must be kept on file, but it also a good idea to include a copy with the bill of lading and emergency response sheet. This will show any regulatory, law enforcement or emergency response individual that the employee has received such training.

If you are contacted by a DOT organization, such as the FAA, about gauge air shipments they will want to see that the employee(s) involved in the preparation of paperwork and subsequent transport has been properly trained.

RSO Training – Although the Gauge Safety Certification Class qualifies the individual to be a RSO, many individuals opt to take a more in-depth course. Some Agreement Sates make this a requirement. Keep these certificates on file.

Annual Refresher – Every gauge worker should receive an annual refresher that covers the basics of gauge safety and conditions of the license.

Note: An annual APNGA membership includes a free participation in each of the above classes. Even if the employee has already taken the initial gauge safety class or is not the presiding RSO, it is highly beneficial to review the material and take each of the tests. They're included, take advantage of them.

Your membership also includes free "How To" and "Daily Step-by-Step" tutorials.

Notice to Employees Poster

Go to the NRC website or your Agreement State website to download a copy of the "Notice to Employees" poster. This poster needs to be placed in a location where all employees can see it – typically a break room or perhaps at the time clock. The poster informs the employee as to their rights regarding a company that utilizes radioactive devices. It contains contact information of the regulatory agency for the employee to use if inappropriate actions are observed. Always keep a copy in the main file drawer. Click or copy & paste here to view an example of the poster: http://www.nrc.gov/reading-rm/doc-collections/forms/form3_us.pdf. A copy can also be found in the appendices/attachments.

If you are licensed in a NRC state you can print and use this poster. Agreement State licensees should go to their state website for the appropriate copy.

Personnel Gauge Radiation Exposure Records – Dosimetry Records

When used, employee dosimetry records must be kept on file permanently. You should also give employees a copy of their report. These are the quarterly records that are generated by the film badge or TLD that employees wear. Your dosimetry provider will supply you with a report for each individual's as well as a company-wide report. NRC Forms can be viewed in the appendices/attachments.

Inventory and Gauge Receipt Records

You must keep a "cradle-to-grave" accountability of your gauges. Cradle to grave starts with the day you first take possession of a gauge and ends on the day you permanently transfer it to another party. An inventory sheet example can be viewed in the appendices/attachments.

Gauge Receipts

When you first take possession of a gauge you need to formally enter that gauge into your inventory. The documentation provided with the gauge, including the receipt or bill of sale, transfer sheet and current leak test should be kept on file. Remember, before you purchase a gauge you first need to make sure that gauge is listed on your license, including the make, model, and radioactive source quantities.

All manufacturers will provide a package of information with the gauge. Sometimes called a gauge certificate, this document will show the model, serial numbers for the gauge and each source, leak test report, transfer date and calibration data. File this information but also make a copy to put in the gauge case information packet.

If you obtain your gauge via other means, such as a reseller or another gauge licensee, make sure that all of this information is included. Remember that no gauge can change ownership without a current leak test.

If you are selling a gauge make sure to check the buyer's license to see if the gauge you are selling is listed, including the quantity amounts. Make an adjustment to your inventory and maintain documents of the sale.

You should also have a copy of the gauge manual. If one is not included you should be able to download a copy through the manufacturer's website.

If you ever have questions about a buyer or seller it is always wise to contact their licensing agency.

Inventory

Create a physical inventory sheet to track and record your gauges. Inventories are to be made every six months. Keep a copy in your file for three years. Some have found that keeping an inventory sheet on a clipboard at the storage area serves as a good reminder of when to take the next inventory. Many also coincide the inventory date with the leak test date.

An example of an inventory sheet can be viewed in the appendices/attachments.

Leak Test Reports

A requirement of your license is to perform a “leak” or “wipe” test on your gauges, either every 6 or 12 months. The time interval is determined by what is stated on your license. This test assures that your gauge is not releasing any of the radioactive source material through the double encapsulated shielding. On-time leak tests are very important, mandatory, and enforced.

Gauges cannot be transported or transferred without a current leak test. Always check to make sure a gauge has a current leak test before you remove it from storage.

If you forget to perform a leak test on time you should self-report the violation and describe what steps you will take to make sure the offense is not repeated. Keep the report on file.

Manufacturers and service centers offer leak test kits that include the analyses of the wipes. The kit includes a swab that you wipe across two areas of the gauge: the hole underneath the gauge where the source rod exits and on top of the moisture source radioactive sticker inside the gauge.

Use the same swab to wipe both sources. Fill out the paperwork and send it in with the swab. The analyses documentation should be returned to you within two weeks.

Many licensees post a leak test reminder on a clipboard at the gauge storage area. For example, if your license calls for a leak test every 6 months you may want to set a schedule for January 1st and July 1st. Try to complete your leak tests 2-3 weeks before those dates, allowing time for the tests to be mailed in, analyzed and returned before the due date.

Keep all results on file for three years.

If a test was found to be positive the leak test provider will notify you to pull the gauge for further analysis.

Note: Information on leak/wipe test providers and pricing can be found on the APNGA homepage under the “Industry” listings.

Daily Use Logs

Also known as daily utilization logs, this sign-in, sign-out log ensures that the licensee knows where all gauges are located at all times. This log can also be mounted on a clipboard at the storage area. The information on the log should include the date, time, gauge model and serial number, gauge user, location of gauge use, and time returned.

A copy of the log should be kept on file for three years. An additional copy of the log, attached to a private carrier bill of lading, will meet the HAZMAT requirement for keeping a copy of a dated bill of lading for each transport. Remember to attach a log for each type of gauge bill of lading.

It is a good idea to post the conditions of signing out a gauge:

a) Is the gauge, and specifically the source rod sliding block, operational?
b) Is the case and all hasps intact – no holes or cracks?
c) Is the gauge info pack, which should include copy of license, copy of original gauge certificate/receipt, manual, Type "A" Package test results, calibration data, emergency procedures with telephone numbers, copy bill of lading and emergency response sheet, complete?
d) Does the driver have a readily available bill of lading and emergency response sheet?
e) Does the gauge have handle and case locks in place?
f) Does the vehicle have blocking, bracing and concealment materials in place?
g) Does the vehicle have double lock/security materials ready?

View an example of a daily utilization log in the appendices/attachments.

Special Form Certificate required by IAEA – Certificate of Competent Authority

A Certificate of Competent Authority for each type/model of gauge you have must be kept on file. "Special Form" relates to the manufacturing and testing process of the double encapsulated sources in your gauge. The manufacturer of the gauge buys these completed sources and places them in the source rod and base of the gauge.

The manufacturer of the sources must have a 3rd party "Competent Authority" oversee and ensure the integrity of the manufacturing process the double encapsulation source is tested under conditions such as pressure, penetration, free drop and temperature. The 3rd party makes sure the process meets the criteria of the International Atomic Energy Agency.

The Special Form Certificate must be kept on file. It does expire so take steps to remember the expiration date. A new certificate can be downloaded at the manufacturer's website. Only one certificate is needed per each type/model gauge in use.

View an example of the certificate in the appendices/attachments.

Sealed Source and Device (SSD) Sheets

The SSD sheet is an approval certificate issued by a regulatory agency for a device, such as a gauge, that uses radioactive materials. It is very similar to the Special Form certificate for the encapsulated sources that are placed inside the gauge, except this one is for the gauge. When you first applied for your license you were required to attach a copy of the certificate along with the SSD number. This allows the licensing agent to cross-reference a database that contains the listings of all SSD devices, including gauges, thereby telling them everything they need to know about the gauge you are applying for.

The best place to obtain a copy of the SSD sheet is the manufacturer – check their website or give them a call. Each type/model of gauge requires a SSD sheet.

View an example in the appendices/attachments.

Original License Application Package

Keep a copy of the original license application along with any other supporting documents. Many regulatory agencies require you to re-apply for a license once your current license expires. Keeping a copy of this application packet will help you re-apply for the license.

Extra labels

It is always a good idea to keep an extra stash of gauge labels, including the Type “A” Package, Radioactive Yellow II and Air Cargo Only labels. It is

imperative that labels are legible before transporting a gauge. If labels are scratched or damaged to where the information is not readable you need to replace it. Make sure the Yellow II Transport Index number pertains to the gauge in the case.

Type “A” Package Test Results

The case that houses your gauge is classified as a **Type “A” Package**. This specially designed and tested case must be used whenever you transport the gauge. The manufacturer must have a 3rd party test and ensure that the case meets Type “A” specifications. These include penetration, compression, vibration, water spray and free drop tests. The Type “A” Package document should have descriptions of the cases and test verification.

The Type “A” Package document must be kept on file as long as you are transporting gauges and for 3 years after the last shipment.

Type “A” Package test results documentation can be obtained through the gauge manufacturer.

Radiation Safety Program

Every licensee must develop and maintain a radiation safety program. Your radiation safety program, which was a requirement of your license, acts as a “playbook”, reference and resource that will guide you through all aspects of owning a portable nuclear gauge. The program is run by the RSO, checked annually by an internal audit, and evaluated during a regulatory inspection.

An effective program begins with the RSO. The RSO ensures that the gauges are used only by authorized workers and in a safe manner.

Key components of the program include:

a) An effective ALARA program, including use of dosimetry
b) Required and effective training for all gauge workers
c) Storage and transport security
d) A radiation survey meter
e) Leak testing and proper maintenance
f) HAZMAT transport compliance
g) Emergency response procedures
h) Recordkeeping
i) Gauge operating procedures
j) Inventory reports
k) Disposal options
l) Annual audits

A further discussion of the radiation safety program as well as an example of a radiation safety program can be found later in this manual. For consistency and continuity, the example of a radiation safety program offered by APNGA follows the template of the annual audit listed in the NRC's NUREG 1556, Volume 1 guide:

http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1556/v1/r1/sr1556v1r1.pdf

We found it much easier to prepare, understand and follow a radiation safety program that matches the annual audit that the RSO conducts each year. APNGA examples follow this format.

Make sure to keep an up-to-date copy of your radiation safety program on file.

The APNGA example can be found under the Regulatory heading on the homepage.

Annual Audits

An annual audit is a review of the radiation safety program as well as a review of the past year. A further discussion of the annual audit and an example of an annual audit follows in a later section. Copies of these audits must be kept on file.

An example of an Annual Audit can be viewed in the appendices/attachments.

Transport Documents

You must file copies of all transport/shipping documents used whenever a gauge is removed from storage and transported by vehicle, air, rail or water. In the eyes of the U.S. DOT you are “shipping” a gauge whenever you move it by any of the above means. That includes transporting your gauge by company or personal vehicle to the worksite.

These documents will be reviewed during an inspection. In the case of air transport, such as a shipment by FEDEX to a gauge service facility, FEDEX will send a copy of the transport documents to the Federal Aviation Administration (FAA). The FAA can contact you about this shipment 1-2 years later. They will inquire about your copy of the documents as well as training certificates for any individuals involved in that shipment.

Emergency contact telephone numbers must be included on these documents. The mandatory transport documents are:

a) Bill of Lading
    1) Private carrier (you transporting the gauge to the worksite, etc.)
    2) Common carrier ground transport, such as R&L or Roadway Trucking
    3) Air Transport, such as FEDEX (must include Dangerous Goods Statement)
b) Emergency Response Sheet

Examples of these documents can be viewed in the appendices/attachments.

A set of documents must be on hand for each gauge in transport.

These documents must be readily available to the driver during transport. APNGA also recommends having a copy of the company emergency response program attached to these documents. Keep an example of the complete document bundle on file.

A further discussion of these documents, as well as examples, can be found later in the “Transport Requirements” section.

Gauge Operating Procedures

Gauge operating instructions guide the worker through the safety aspects of operating a gauge. From wearing a dosimeter and safely operating a gauge, to maintaining control and constant surveillance, to storing and transporting a gauge, each worker should have a copy of the operating procedures.

This guide should be part of the radiation safety plan but a separate file should likewise be maintained. This will make it easy to provide copies to an employee.

A further discussion and example will follow in the “Gauge Operating Procedures” section.

Emergency Procedure Documents/Procedures/Plans

An Emergency Procedures Plan is an important part of the radiation safety program. These procedures tell the gauge worker what steps to take in the event of damage or theft of the gauge. Each employee should have a copy of these procedures and a copy should be placed in every gauge case and transport document package. The plan includes emergency response contacts and telephone numbers.

Although the emergency procedures plan is part of the radiation safety plan that is already on file, you should also keep a separate plan under its own heading.

A further discussion can be found under the “Emergency Procedures” section.

Gauge Documents Package for File and Gauge Case

APNGA recommends creating a package of information to be placed in every gauge case. Keep an example stored in the main file drawer:

a) Copy of original gauge receipt with gauge and source serial numbers
b) Copy of license
c) Gauge manual
d) Emergency procedures with contact names and telephone numbers
    1) RSO office, mobile & home number
    2) Regulatory agency emergency number
    3) Gauge manufacturer’s emergency number
    4) Local police number
    5) Local fire & rescue number
    6) NRC 24 hr emergency 301-816-5100
    7) U.S. DOT 24 hr emergency number 800-424-8802
e) Copy of Bill of Lading (Keep another copy within reach during transport)
f) Copy of Emergency Response Sheet (Keep another copy within reach during transport)
g) Gauge Calibration data with telephone number for gauge manufacturer or service center
h) Field operating procedures

i) Emergency responder hand-out (police, fire, rescue, hazmat)
j) Current Leak Test Report
k) Media hand-out

See the appendices for a paperwork checklist.

License Application Guide

Every NRC and Agreement State regulatory agency offers a licensing application and guide that applicants must use. The NRC Form 313 License Application and the NRC NUREG 1556, Volume 1 Application Guide are used for applicants in a NRC State, but also act as templates for the license applications and guides used by the Agreement States. In fact, many Agreement States allow you to use the NRC license application for their state.

Most Agreement States require you to use their application and guide. And you will find that most Agreement States require additional information not found on the NRC application.

Moisture density gauge owners are required to have a "**Specific License**". A specific license allows for the use of a device with sealed sources and places the responsibility of protecting the general public and environment in the hands of the licensee. The sealed sources must only be used in the device and for the purposes intended as described in the license and the gauge SSD (Sealed Source &Device) sheet.

Newcomers seeking a license may find the process a bit bewildering. There is a lot of information to be covered and understood. But in all fairness, you should not qualify for a license unless you thoroughly understand the requirements of a license.

Fortunately, there is a wealth of information regarding the application and regulatory requirements. Do not try and complete this process by relying solely on the CFR's (Code of Federal Regulations). You'll only end up frustrated and confused. Think of the CFR's as the in-depth legalese version of the regulations, whereas licensing guides put the CFR's into an understandable "English". Look in the appendices for links to the CFR's.

The NRC NUREG 1556, Volume 1 Guide walks the NRC State applicant through the process. But it is also worthwhile to view some of the Agreement State guides, even if you are not applying in that particular state. Their guides offer varied approaches to the process which can sometimes be better understood than the guide from your state. Remember, some states require more information than the state you are applying in. You may not have to supply that information but covering the material will often give you a better understanding of the overall requirements.

You can access Agreement State websites or contact information and their license applications and licensing guides by using the "View My State" section on the APNGA homepage.

Another excellent resource for the license application process is the gauge manufacturer. Most have put useful guides on their websites. Information such as the

SSD sheet, Type “A” Package Test Results, Certificates of Competent Authority, and gauge manuals and applications should be readily available. Look under the “Industry Section, Gauge Manufacturers” on the APNGA home page for contact information.

The licensing application, once submitted to the regulatory agency, can take 6-8 weeks. And that’s if everything is in order. You must submit a non-refundable application fee with the application. If you are not granted a license the fee will not be returned. Regulatory agencies receive most of their funding from license fees. The time and effort they put into your application is payment for evaluating your application.

When considering ownership of gauges you will want to factor in the fees charged by the agencies. License application, renewal, inspection, amendment and reciprocity fees should be factored into the equation.

You can also expect a pre-license inspection before you receive a license. The agency will conduct background and in-person inspections of your company, premises, storage area, security and your understanding of the license requirements.

The information below will give a quick introduction to the requirements of the NRC Form 313 requirements. A copy of Form 313 can be found at http://www.nrc.gov/reading-rm/doc-collections/forms/nrc313.pdf. Print one out and follow along. Another excellent resource is the NRC Gauging Devices Licensee Toolkit at http://www.nrc.gov/materials/miau/industrial-uses/gauge-toolkit.html. The APNGA homepage and appendices also provide examples of applications and guides.

The application requires 13 responses. You should view these as a minimum set of requirements for a license. Most Agreement States will require additional information:

1) Check which you are applying for:

    a) New License
    b) Amendment to License Amendment #_____
    c) Renewal of License #_____

2) Applicants Name and Mailing Address

    This must be the person/entity with direct control over the gauge. It cannot be a division or department of a company – it must be the company. An individual can only apply in a private capacity – they cannot personally license the gauge and use it under direct use and employment of a company.

3) Address Where Licensed Material Will Be Used or Possessed

This is the location where you will be storing the gauge. A description and sketch of the area should be kept on file. If you plan on storing the gauge at a temporary storage area you should add the line “temporary jobsites anywhere in the United States where NRC maintains jurisdiction”.

4) Name of Person to be Contacted About This Application

Typically the designated Radiation Safety Officer (RSO), this is the person that the NRC will contact regarding any questions about the application, and if granted, any questions about the license and radiation safety program.

Always let the NRC know if a different person is designated. If allowable, assign an assistant RSO as well – just make sure that person is equally qualified and informed.

Remember, senior management must sign a commitment to be responsible for the radiation safety, security and control of gauges and compliance with the regulations. They are responsible for the completeness and accuracy of safety records and information provided to the NRC. They must be knowledgeable about the contents of the license and application. They must commit adequate resources, including space, equipment, personnel and time to the radiation protection program to where it ensures that public and worker safety is assured. They must assign and work with a qualified RSO to manage an effective program.

Submit items 5-11 on attached 8 ½ x 11 sheets of paper.

5) Radioactive Material

The information you need to provide in this section pertains to the radioactive materials, their physical form and the quantities of each material in the gauge. All of this information can be found on what is known as a SSD (Sealed Source and Device) Registration Certificate.

The SSD is in essence an approval certificate/license granted to a gauge manufacturer to manufacture and sell a gauge model. In the same way a sealed source must be approved by an IAEA approved competent authority, a gauge model must be approved by a regulatory agency. Once one agency approves a gauge all other agencies will likewise approve the gauge. Documentation will be filed for all agencies to access. The information you provide will include a

registration number that the agency will cross-reference that shows that shows the details of the gauge.

You can obtain a copy of the SSD Registration Certificate and/or registration number from the manufacturer. Check their website or contact them. This is the information you will provide for Item #5.

The information will include the radioactive materials, typically Cesium 137 and Americium 241. The physical or chemical form is “sealed source” and usually includes a drawing number. The quantities are usually 9-10 millicuries for Cesium 137 and 40-50 millicuries for Americium 241. The quantities should be spelled out on the certificate.

It is important to note that whatever you list on your application will become a condition of your license, and any changes/amendments to your license will cost money. Don’t “pigeonhole” yourself. If you initially apply for one specific model/manufacturer of gauge and want to try a different type of gauge in the future you will likely be charged an amendment fee to add that model of gauge. List all applicable models/manufacturers of gauges on your initial application.

The regulatory agency will issue a license that caps the cumulative amount of radioactive material or overall number of gauges, regardless of manufacturer, you can own at any one time. Although you may have no say in the number of gauges they initially allow, if you do have an initial number in mind, including future needs, you will want to request that number in the application.

So, to reiterate, your example entries for Item #5 should be:

Element and Mass Number	Physical Form*	Quantity per Gauge*
Cesium 137	Sealed Source	<10mCi
Americium 241	Sealed Source	<50mCi

*Obtain the information from the manufacturer’s SSD sheets. Include the number of gauges you anticipate owning. Type your answers on an 8 ½ x 11 sheet of paper and attach a copy of the SSD sheets if available.

6) Purposes for Which Licensed Materials Will be Used

The SSD sheets should also contain information about how the gauge should be used, typically for “the measurement of physical properties of materials”. Enter this description on a separate sheet of paper for Item #6.

7) Name the RSO and their Training Experience

Name your RSO and what training classes and experience they have. Their training should include an approved Gauge Safety Certification Class (An APNGA membership includes Gauge Safety Certification, HAZMAT, RSO and Annual Refresher training). The RSO should also have practical gauge field training. All APNGA training is accepted nationwide except for some Agreement States which are currently evaluating the APNGA Gauge Safety Certification Class. It will be noted which states have not yet approved the APNGA Gauge Safety Class. Keep training records on file.

Remember, the RSO should have full senior management backing and is responsible for stopping unsafe licensed activities, assuring proper gauge use and maintenance, providing training, incident response and investigation, ensuring gauge security and controlled storage, a disposal plan, adhering to HAZMAT gauge transport requirements, complete and accurate recordkeeping, conducting annual audits and communicating and interacting with regulatory agencies.

Training must be completed before the license is issued.

Your response to Item #7 should be:

The name of the RSO is:_____

“Before obtaining licensed materials, the proposed RSO will have successfully completed adequate training as described in the NUREG 1556, Volume 1 Guide. Future RSO’s will likewise complete this training”.

8) Training for Individuals Working In or Frequenting Restricted Areas

Individuals working with gauges should also have training similar to the RSO.

Individuals working with gauges, also known as “authorized” users are responsible for ensuring surveillance, proper use, security and routine maintenance of gauges.

Your response to Item #8 should read:

> "Before using licensed materials (gauges), authorized users will have successfully completed training as described in NUREG 1556, Volume 1".

Keep all training records on file.

9) Facilities and Equipment

Item #9 requires you to have pre-determined that your storage area will comply with public dose limits and that you are providing sufficient security and control over the gauges. These issues should have been calculated and covered in your Radiation Safety Program under "Public Dose" and "Operating and Emergency Procedures".

No formal response is required for Item #9. When you submit your application you are acknowledging that you determined and complied with Public Dose and Operating and Emergency Procedures requirements.

10) Radiation Safety Program

Although there is no response required on your application to Item #10 this is the most involved application requirement. You must establish and maintain an effective Radiation Safety Program.

View the "Radiation Safety Program" section and use examples in preparing your radiation safety plan. Your regulatory agency has examples and guides for your plan – view their website.

When you submit your application you are acknowledging that you have established and completed your radiation safety program.

Your radiation safety program, and annual audits of your plan, will be reviewed during an inspection.

11) Waste Management – Gauge Disposal and Transfer

There is no response required regarding gauge disposal or transfer but you must be familiar with the methods of doing so.

When you submit your application you are acknowledging that you are familiar with disposal and transfer methods and options. Make sure you always check beforehand that the gauge recipient is authorized to take possession of your gauge type. Keep all disposal and transfer records on file.

The “gauge manufacturer” is a typical response for where you plan on disposing of your gauge.

12) License Fees

Enclose the appropriate license application fee. See 10 CFR 170, section 170.31 for a list of NRC fees.

13) Certification

The individual signing the application must be authorized to make binding commitments and to sign official documents on behalf of the applicant.

Radiation Safety Program

Every gauge licensee must have an effective radiation safety program in place. It was a requirement of your license application and serves as your everyday guide for owning gauges. The radiation safety program should cover all aspects of gauge ownership, so virtually everything covered in this manual and training should be covered in the radiation safety program.

The RSO maintains, manages and is responsible for an effective radiation safety program. Because a license has only one RSO, most gauge workers taking this course will feel that it is not their responsibility to know this program material. But the gauge safety training class **does** qualify an individual to be a RSO and it likewise takes a collective company effort to achieve a successful program. The more you understand the radiation safety program, the more you will understand your role and responsibility as a gauge operator.

The APNGA example of a radiation safety program is based on the annual audit program presented in the NRC NUREG 1556 Licensing Guide. The annual audit, a required condition of your license, is performed annually by the company RSO to check the effectiveness of the radiation safety program. By using the audit checklist approach, which is used to look back at the past year's performance, you will be better able to institute, understand and manage an effective program.

Regulatory inspections likewise use the annual audit as a checklist for evaluating the effectiveness and performance of your radiation safety program. But inspectors also use live observations of gauge workers to assess how knowledgeable the workers are of safe gauge usage and license conditions. The RSO should make periodic observations of workers "in action". In essence, the RSO should be conducting periodic internal inspections. This is a very important part of evaluating the effectiveness of your radiation safety program.

Regulatory inspections, and violations, will be covered in a later section.

Although most Agreement States use the NRC material as a template it is important to familiarize yourself with the requirements of your regulatory agency. Go to their website or contact them about their specific requirements.

An Example of a Radiation Safety Program

Introduction

Some of the overall goals of the radiation safety program are:

a) Protecting the general public and environment from unnecessary exposure to radiation
b) Proper training and instruction to workers includes:
    1) The ALARA program and personnel radiation monitoring
    2) Safely and securely operating the gauge at the worksite
    3) Workers knowledge of emergency procedures and radiation detection equipment
    4) Safely and securely transporting gauges
    5) Maintenance and leak tests
c) Inventory and disposal recordkeeping
d) Self-reporting, corrections and enforcement of the program
e) Annual Audits and inspections

The RSO – Manager of the gauge safety program.

I (Name of RSO), have been designated as the Radiation Safety Officer for (Name of licensee), and will carry out the duties and enforce the conditions of the license including:

The Annual Audit

I, along with senior management, will annually conduct an audit of the gauge safety program, as well as checking, reviewing and correcting any deficiencies. All copies of audits will be retained. I will conduct periodic internal inspections, including in person observations of worker actions with gauges during transport and transportation.

Organization & Scope of Program

I will ensure that the original conditions and information on the license stays current, or when needed, file for timely amendments including address changes, new ownership (in advance), bankruptcies, and notice of a new and properly trained RSO.

I will review the license to ensure that gauge models match and source quantities have not been exceeded and will ensure that the Sealed Source and Device (SSD) Certificate or Sheet for each type of gauge are on file.

I will check to make sure that manufacturer operation & maintenance manuals are on hand for each type of gauge.

I will make sure the gauges are used for the way they are intended.

RSO Responsibilities

I will stop activities that are considered unsafe.

I will review the license and Sealed Source and Device Registration and manufacturer's recommendations and instructions. I will make sure the conditions match up regarding the model/type of gauge, number of gauges allowed, the type of operations licensed for, storage requirements, and maintenance restrictions and schedule.

I will make sure all employees are thoroughly trained and training certificates are on file.

I will make sure all necessary personnel are using personnel monitoring devices (film badges, TLD's) and records is on file.

I will make sure all gauges are locked and secured during storage and transportation.

I, and all gauge workers, will have contact information on hand (including on file, in the storage area, and in gauge cases) for proper authorities (RSO, licensing agency, police) in case of accident, damage, fire or theft.

I will investigate all unusual occurrences involving the gauge (accident, damage, theft, oversights), determine the cause, identify corrective actions and implement such actions.

I will make sure gauges that are transported meet all USDOT Hazardous Materials requirements.

I will make sure that gauge transfers and disposals are properly documented.

I will make sure all records are accounted for and maintained.

I will keep the license up-to-date, check the expiration date, request renewals and amendments in a timely manner.

I will give advance notice of reciprocity.

I will give advance notice of desire to terminate the license.

Training & Instructions to Workers

I will make sure that all employees working with gauges and preparing gauges for transport or transporting gauges are properly trained.

I will ensure, per Code of Federal Regulation (CFR) 19.12, that all employees expected to receive an excess of 100 mrem/yr occupational dose be given special instructions. Although gauge users typically receive less than this amount it is assumed that they may exceed this limit and are therefore subject to these instructions:

- Storage, transfer & uses of gauges
- Exposure issues and ALARA
- Required safety training
- How to report overexposure concerns
- workers know how to receive exposure reports
- workers receive emergency procedures training
- workers receive annual refresher training on these topics (The APNGA Annual Refresher Training Module can be used to guide you with this training – it is included with your annual dues)
- Each gauge operator must complete an approved gauge safety course before using the gauge. (The APNGA Gauge Safety Training Course is approved in most states & is included in annual dues – check the list for your state's status)
- I will have training certificates on file for each worker, including Initial Gauge Safety Training, HAZMAT Training and Annual Refresher.
- I will conduct interviews with each worker to determine if they are knowledgeable of emergency procedures (see the "Emergency Procedures" section under the "Regulatory" heading on the "APNGA homepage" and your regulatory agency for guidance).
- I will observe each worker operating the gauge in the field.
- I will observe each worker performing routine cleaning & lubrication.
- I will observe each worker transporting the gauge.
- I will observe each worker checking a gauge in and out of storage.
- I will make sure each worker demonstrates safe handling and security during operation, transportation and storage of the gauge.
- I will make sure USDOT HAZMAT (49 CFR 172.700-704) training is provided for each worker involved in preparing and/or transporting a gauge. (APNGA annual dues include a USDOT HAZMAT course that is accepted in every state).
- I will make sure HAZMAT training records are kept on file.

Radiation Survey Instruments

I will make sure the company owns a radiation survey meter. In the event of an accident it will be used to detect the location of a dislodged source, determine the Transport Index of a damaged gauge or determine the radiation levels around a storage area. It will also be used to determine if the gauge sliding block is malfunctioning.

I will make sure the survey meter meets the criteria of the regulatory agency. Typically this requires a survey meter that is able to detect gamma radiation and be recalibrated annually.

If we do not own your own a survey meter I will arrange for immediate access to one. I will have a plan for accessing a survey meter.

If we are licensed for and performing non-routine maintenance I will own a survey meter that is calibrated annually. I recognize that non-routine maintenance would include removal of the source rod. I will ensure that the source rod will not be removed if we do not have a special license to do so.

I will keep survey meter calibration records on file.

Gauge Inventory

I will complete an inventory of gauges every 6 months. I will keep an inventory sheet attached to a clipboard and place it at the storage area with the date of the next inventory. I will complete a hands-on inventory of each gauge and keep the completed document on file.

I will have a receipt for each gauge in inventory that shows the date each gauge was obtained and entered into your inventory?

Personnel Radiation Protection

I will provide, if required, personnel dosimetry to all gauge employees.

I understand that the dosimetry, typically in the form of a film badge, TLD (Thermoluminescent Dosimeter), or OSL (Optically Stimulated Luminescence) ensures that ALARA practices are being met and also creates a record that documents employees are receiving minimal exposure levels.

I understand that the key component of a sound Radiation Protection Program is a solid adherence to ALARA considerations. I will make sure that ALARA considerations (time, distance & shielding) are being taught and practiced and incorporated into the Radiation Protection Program.

I will make sure, that if any gauge workers are not provided dosimetry, documentation is provided confirming that they are receiving less than 500 mrem per year.

I will continually check to see if conditions of the activities of gauge workers not wearing dosimetry changed to where the possibility of receiving greater than 500 mrem per year exists.

If they did change I will perform a new evaluation.

If in use I will ensure that dosimetry is provided for gauge workers.
I will check if any workers are receiving more than 500 mrem.
I will make sure that the dosimetry supplier is NVLAP approved.
I will make sure that dosimetry is changed on time.
I will review the dosimetry reports as they are received.
I will make sure that NRC or equivalent Agreement State forms are being used:
NRC-4 “Cumulative Occupational Exposure History
NRC-5 “Occupational Exposure Record for a Monitoring Period”

Examples of these forms can be found in the appendices/attachments.

I will make sure that if a worker declared her pregnancy she was limited to a maximum of 500 mrem for the term of the pregnancy. I will make sure embryo/fetus dose records were kept on file.

I will make sure all exposure, survey, monitoring and evaluation records kept on file.

Public Dose

I will take steps to protect the general public (non-gauge workers) from exposure to radiation.

I will ensure that exposure levels to the general public are below 100mrem in a year or 2mrem in any 1 hour.

I will make sure that gauges are stored in a manner to keep doses to the public below 100mrem in a year.

I will conduct a survey or evaluation of public access areas around the storage area to ensure that exposure levels are below 100mrem per year.

I will monitor any gauge additions or changes to the storage area, security or use of the surrounding areas that would necessitate a new survey or evaluation.

I will monitor public access area radiation levels to determine if any areas have exceeded 2mrem in any one hour.

I will make sure that gauges are stored in a manner that prevents unauthorized use or removal.

I will keep storage survey and evaluation records on file.

Operating & Emergency Procedures

I will develop, implement and maintain Company Operating & Emergency Procedures.

All workers will have a copy of these procedures and know what steps to take in the event of an emergency. (Please refer to Appendix H of the NRC's NUREG Guide 1556 Vol 1, "Operating & Emergency Procedures" for an outline or use your Agreement State procedures). The APNGA website also contains information to complement your regulatory agency requirements. Procedures should include these instructions:

Using & maintaining the gauge
Security during transport and storage
Control & surveillance during use
Keep exposures ALARA
Constant accountability during use
How to deny access to a damaged gauge
Steps to take and who to contact when a gauge is damaged

I will make sure the above required elements, as specified by the regulatory agency, are part of the procedures.

I will make sure each gauge worker and gauge case have a current copy of the operating & emergency procedures, including RSO office, cell & home telephone numbers as well as the manufacturer's and regulatory agency emergency contact numbers.

Leak Tests

I will make sure each sealed source on each gauge leak will be tested on time (per the time interval stated on the license) and make sure the leak test was performed per the descriptions and requirements of the regulatory agency and the license.

I will make sure all gauges have a current leak test before being removed from storage.

I will make sure leak test results are kept on file.

I will make sure that, if any sources are found to be leaking, the gauge will be pulled from service and the regulatory agency notified.

Maintenance of Gauges

I will make sure the gauges are routinely cleaned and lubricated per the manufacturer's procedures, thereby allowing optimum safety and performance. I will make sure that the source rod is not removed during cleaning, unless specifically licensed to do so.

If so, I will make sure to adhere to the special requirements pertaining to procedures, dosimetry, survey instruments, individuals and compliance.

I will make sure that 3rd party service providers are licensed to handle our gauge models and are escorted at all times. If we are possession of gauges that meet quantities of concern I will make sure that the service provider has an authorized background check.

Transportation

To assure proper compliance of transportation regulations I will on occasion accompany each worker while they transport a gauge and assure that HAZMAT requirements are understood and met.

The evaluation will commence at the storage area and conclude upon return to the storage area.

I will make sure that only undamaged, manufacturer-provided and approved, Type "A" Package gauge cases are used during every transport of a gauge.

I will make sure that Type "A" Package test results for every different type of gauge case in use is kept on file.

I will make sure that a "Certificate of Competent Authority" is kept on file for each different type of source used in the gauge. (This will satisfy the requirement for documenting special form certificates. These special form certificates can be obtained through the manufacturer and can usually be downloaded off their website).

I will make sure that every gauge case displays (2) Radioactive ll labels that **legibly** show the Transport Index (TI), source types & activities, and hazard class (7).

I will make sure that each gauge case displays a Type A package label denoting UN3332, “Radioactive Material”, “Special Form” and “RQ” requirements.

I will instruct workers that every gauge case will be closed and locked for every transport.

I will instruct that applicable bill of lading and emergency response sheets are to be used during every shipment.

I will assure that the shipping papers contain the proper entries: (Shipping name (Radioactive Materials), Hazard Class (7), UN ID Number (3332), Total Quantity (number of gauges), Package Type (Type A), Nuclides (Cesium137 and/or Am241), RQ (if necessary), Description (Radioactive Material), Special Form, Activity (in Becquerels and Millicuries), Yellow ll labels, Transport Index (TI), Shipper’s name, Certification and signature, Emergency Response Telephone number, Cargo Aircraft Only label.

I will instruct the workers to have the gauge case secured against movement during transport.

I will ensure that double, independent, locked cables, chains or other security devices are used during transport.

I will instruct the workers to have the gauge concealed while transported in a vehicle.

I will make sure that any qualified transport incidents are reported to the USDOT.

Auditor’s Independent Survey Measurements (if made)

If any independent auditor is used I will make sure that the survey measurements describe the type, location and result of measurements. I will note if any radiation levels exceed regulatory levels.

Notification & Reports

I will assure that required notifications of incidents are made to the regulatory agencies. This does **not** include non-emergency oversights that must be noted and corrected in your Radiation Safety Program.

I will make notifications of any lost or stolen gauges and make appropriate reports.

I will report any overexposures or high radiation levels and note the causes and take corrective actions.

In the event of any of the above occurrences I will contact the NRC Emergency Operations Center at 301-816-5100 as well as the Agreement State, if appropriate.

Posting & Labeling

I will post or make available certain documents and/or posters for public viewing. I will make sure I am familiar with the regulatory agency's requirements, be it NRC or Agreement State.

I will keep all originals under lock and key and only post **copies** of the documents and posters.

I will post the "Notice to Employees" poster in an area accessible to all employees.

I will post all regulations and license documents or post a notice as to where these documents can be viewed (post **copies** in a publicly viewable area).

I will be aware and post any documents required by the regulatory agency or other state or local authorities.

Recordkeeping for Decommissioning

I will be aware that regulatory agencies require a minimum of 60 days notice before terminating the license and transferring or disposing of all gauges. I will be aware of requirements and maintain all decommissioning, transfer and disposal documents.

I will maintain records important for decommissioning.

Bulletins & Information Notices

I will make sure that I am on the mailing list or email list for documents issued by the NRC and/or Agreement State. (Go to www.nrc.gov to sign up for NRC Bulletins, Information Notices and NMSS Newsletters. Do the same for your Agreement State).

I will make sure that appropriate training and actions are taken in response to these notices.

Special License Conditions or Issues

I will make sure to review any special license conditions or issues pertaining to your license (e.g., non-routine maintenance).

Deficiencies Identified in Audit and Corrective Actions Planned

If I discover any deficiencies or oversights during the year I will investigate, report, summarize and take corrective actions to rectify the issue. I will document the corrective

actions. I will make sure that corrective actions will be taken at all licensed facilities. I will likewise provide any recommendations for improvements.

Evaluation of Other Factors

I will ensure that senior management is constructively involved and informed about the radiation safety program.

Senior management will assure that the RSO has sufficient time to perform Radiation Safety Duties.

Senior management will assure that the RSO has sufficient staff to support the Radiation Safety Program.

Senior Management and RSO Commitment to the Radiation Safety Program

I duly commit to upholding the Radiation Safety Program:

Title_____ Name _____ Date_____

RSO_____ Sr Manager_____

Note: A stand alone example of a radiation safety program is available on the APNGA homepage and appendices/attachments.

Gauge Safety Operating and Emergency Procedures

Every license holder must develop **Gauge Safety Operating Procedures** and **Gauge Emergency Procedures.** A copy of both procedures must be given to every gauge worker. Likewise, a copy of both procedures should accompany every gauge (in the gauge case information packet). Copies should also be kept on file by the RSO. Copies of the manufacturer's operation and maintenance manual should also be on file.

Examples of these procedures can be found on the APNGA home page. Always adhere to the rules of your regulatory agency.

Gauge Operating Safety Procedures

All new gauge handlers, transporters or users must first complete a gauge safety certification class.

The RSO or senior gauge user should spend time familiarizing each worker with each type of gauge in use.

The RSO should also familiarize the worker with all aspects of **Gauge Operating Safety and Emergency Procedures.**

In addition, only users authorized by the company RSO can operate a gauge.

Of upmost importance is a solid understanding of and commitment to the ALARA (As Low as Reasonably Achievable) Principle. The objective is to reduce occupational and public exposures as far below regulatory limits as possible by means of good work practices. The three components of ALARA are:

a) Time – Minimize the time spent around a gauge by working quickly and returning the gauge to storage when not in use. The shorter the time spent around a gauge will result in lower exposure dosages.
b) Distance – Always maintain a safe distance when performing a test (10 feet should be sufficient). When in transport, always store the gauge in the rear most part of the vehicle.
c) Shielding – Let the gauge shielding do its job. Never extend the source rod into open air. Always retract the source rod before recording the results. Always check to make sure the sliding block is fully closed when in the safe position.

Where provided, always wear a personnel monitoring film badge or TLD when handling, transporting or operating a gauge.

a) Never borrow another person's badge or TLD.
b) Do not wear the badge or TLD to the doctor or dentist office or any other location where non-occupational radiation exposures are present.
c) Do not store the badge or TLD near a gauge.
d) Immediately notify the RSO is you lose or damage your badge or TLD. The RSO should always have an extra badge or TLD in storage for such an occurrence.
e) Badges or TLD's should be worn between the waist or chest area (belt loop or shirt pocket).

Storage and Security

All gauges must be stored in an approved and secure storage area. Proper security would include an area with double locked and limited access. An example of double locked would be a lock on the vicinity that houses gauge storage and an additional lock on the immediate gauge storage locker or closet.

Cased gauges should also incorporate two locks – one on the gauge case and one on the handle of the gauge.

When removing a gauge from security make sure that the gauge and gauge case are intact and undamaged. Make sure the sliding block shielding the bottom of the source rod (above the hole in the base of the gauge is located) is functional and fully closed. A measurement with a radiation survey meter will verify if the sliding block is ajar.

Always sign the gauge out. Gauge owners and the RSO must always know the location of each gauge at all times. Remember, the person signing out the gauge is personally responsible for its well-being.

Remember to post a "Notice to Employees" poster in a public area and a "Radioactive Materials" sign on the storage door.

If changes or quantities occur in the storage location you will need to reevaluate compliance pertaining to public dose limits and security. Please refer to the "Storage, Security and the General Public" section for more information.

Do not allow unrestricted access of gauges to 3rd party service/repair personnel. They are likewise not allowed to remove gauges to a service vehicle or facility without escort or transfer documentation. If you are in possession of gauges that exceed quantities of concern the 3rd party service/repair personnel must have regulatory approved background checks.

Any 3rd party service/repair person handling your gauges must have a license that lists the type of gauge you own. If it is not listed on their license they cannot handle the gauge.

View the NRC notice about 3rd party service/repair personnel security clearance and access to gauges in the appendices/attachments.

Constant Surveillance

Whether you transport the gauge or use the gauge at the worksite always maintain constant surveillance and immediate control of the gauge. Keep unauthorized individuals away from the gauge.

Transporting the Gauge

Be nice to the gauge. Gauge cases cost upwards of $400.00. Dragging a gauge case along the ground by its handle is a sure way to wear a hole in the base of the case. Once there's a hole the case is no longer considered to be a "Type A" Package and you will be in violation of the transport regulations.

Gauges can cost as much as a car. Gauges do break or easily lose their precision and calibration.

Before removing the gauge from the storage area make sure the gauge is affixed with all the proper, and legible, labels and markings, and that you have the proper transport documents and procedures in place. Likewise, make sure the transport blocking, bracing and security features are in place.

Store the gauge away from all passengers and driver, and braced, concealed and under double lock and key.

Always have the bill of lading and emergency response sheet in immediate access to the driver (seat beside you or info packet on the driver side door). At the worksite leave the documents on the driver's seat.

Always return the gauge to proper transport security when not in use at the jobsite.

At the end of the day always sign the gauge in, making sure it is fully operational and secured.

Operational Procedures at the Worksite

Always use the gauge for the purpose intended and according to the manufacturer's instructions and recommendations.

Again, be nice to the gauge. Do not use the source rod as a drill rod. A hammer should never touch any part of a gauge.

Gauges are most vulnerable to damage while in use at a worksite. Although you are required to maintain constant surveillance over the gauge, you don't want to find yourself between the gauge and a heavy construction vehicle. Many gauge operators use a flag staked at the top of a fiberglass whip to make the presence of a gauge readily evident. Fiberglass whips with flags can be purchased at most bike shops.

You should first prepare the testing area before bringing the gauge to the test-site. If performing a soils test use the scraper plate to smooth the area and then insert the drill rod into the scraper plate drill rod guide column (first place the drill rod removal device over the column). Hammer the drill rod to create the hole and lift the drill rod out by grabbing the handles of the removal device.

The Scraper Plate Template Method:

Most important, before you lift the scraper plate, use the tip of the drill rod to etch around the sides of the scraper plate. The dimensions of the scraper plate serve as a template for the base of the gauge. Once etched, place the gauge into this rectangle. The source rod opening at the base of the gauge will be situated right over top the drilled hole. Extend the rod into the hole, push the gauge towards the side of the hole – you're ready to take a test.

By using this scraper plate template method you will be able to operate the gauge without ever seeing the source rod – no need to extend the source rod to guide it into the hole.

Remember to limit your time and keep a safe distance around the gauge while the gauge completes its test. As you re-approach a gauge you will want to first retract the source back into the safe position, then record the results. This allows the shielding in the gauge to limit your exposure.

Note: If you are taking measurements that require an unshielded source rod to be extended deeper than 3 feet beneath the surface you will need to use piping, tubing or casing material to secure the sides of the hole. This material must extend to 12 inches above the surface. Make sure the hole is free of debris. This will protect the gauge from a cave-in.

Any damage to the gauge should be immediately reported to the RSO and emergency steps should be taken. Refer to your company Emergency Procedures for further instruction.

Gauge Maintenance

The last place you want to find out that the gauge needs maintenance is the worksite. Regular and routine gauge maintenance, according to manufacturer recommendations, will keep your gauge in good operating condition.

First off, most licensees are forbidden to remove the source rod – that takes a special license.

Only authorized users are allowed to clean a gauge. Make sure you are wearing your badge or TLD. Make sure you have a manufacturer's gauge manual present. Do not directly touch the source rod with any part of your body.

Cleaning tools and an inspection mirror are a must. Position the inspection mirror on a table or counter. Place the gauge upright on the table between you and the mirror and pull the gauge handle towards you. This will tip the base of the gauge away from you and towards the mirror. Lean your arms and hands over the gauge to remove the base plate, using the mirror image as a guide. This will keep the gauge shielding between you and the bottom of the source rod.

Perform sliding block removal and cleaning per the manufacturer's recommendations, including debris removal and lubrication. That is also an effective way to check the position of the sliding block mechanism. Asphalt build-up on the bottom of the gauge can usually be removed with a cleaner like WD-40.

Anything beyond routine maintenance must be performed by the manufacturer or an approved and licensed service provider.

A "stand alone" copy of this procedure can be found on the APNGA home page or in the appendices.

Emergency Procedures

All licensees must develop an emergency procedures document. This document covers response procedures for incidents of a missing, stolen or damaged gauge and provides contact and telephone information. Copies of the plan should be kept in permanent file, the storage area, the gauge case transportation document packet and given to every gauge worker.

An emergency procedures plan should begin at the gauge storage facility area. Many regulatory agencies require the licensee to provide a sketch/schematic of the building

and storage area, including number of gauges in storage, to the local fire department. This document would obviously be of vital importance in the event of a fire at the facility. An example of a sketch can be found in the appendices. Keep a copy in the permanent file drawer.

A non-reportable storage area emergency response would occur with the discovery of a gauge with a dislodged or damaged sliding block. The gauge may only need a minor adjustment but it should only be handled and serviced by an authorized gauge handler.

Set the gauge on a table with a positioned mirror. Tilt the gauge away from you, and while viewing the base of the gauge through the mirror image, open the source rod access panel to make an adjustment to the spring loaded sliding block.

Note: Whenever gauges are removed from storage they should be checked with a radiation survey meter.

Tip the gauge on its side and take a survey meter measurement. A reading of <20mrem per hour at the surface of the base of the gauge or <0.8mrem at one meter away would be indicative of a gauge with the sliding block fully closed. A reading significantly higher is an indication that the shielding may be ajar. Contact the RSO and use the above mirror procedure to determine the cause and if it can be locally corrected.

The emergency response document should have adequate company, regulatory and law enforcement contact telephone number information. At a minimum it should include:

Company RSO_____

RSO work #_____

RSO mobile #_____

RSO home #_____

Regulatory Agency Emergency # (Day)_____

(Night)_____

Police/Fire #_____

Gauge Manufacturer Emergency Response #_____

NRC 24hr Emergency Response # 301-816-5100

USDOT 24hr Emergency Response # 800-424-8802

The USDOT # should only be used in the event of a transport accident where the gauge is involved in a fire, breakage or suspected contamination. Don't call if the accident only resulted in damage to the gauge case.

In the event of a missing gauge immediately contact the RSO, who will in turn immediately contact the regulatory agency.

In the event of a stolen gauge, and if the theft just occurred, call the police immediately with the details. Then call the RSO, who will in turn call the regulatory agency. If you can't immediately reach the RSO, call the regulatory agency.

In the event of physical damage to the gauge at the worksite:

a) First, if there are any serious injuries, immediately contact fire and rescue. Then attend to those injured in the accident.
b) If the gauge is involved in a fire immediately contact the fire department and keep all individuals away from the gauge and up-wind of the smoke stream.
c) Secure and control the area by keeping individuals at least 15 feet away from the gauge. Stop all unauthorized entries to the area.
d) Although contamination from a damaged gauge is not likely, do not allow any individuals suspected of contamination or radiation exposure to leave the area. Direct emergency response individuals to these individuals.
e) If any vehicle or construction equipment was involved keep it at the site until it can be determined if it was contaminated.
f) Gather facts. If a camera is available, take photos.
g) Document your actions.

h) Do not touch or move the gauge. Is the source rod extended? Visually inspect the gauge to determine if the end of the source rod is still attached. If it is still retracted inside the gauge inspect the housing of the gauge. Is the base of the gauge cracked or damaged?
i) Call the RSO, and if necessary, the regulatory agency. Have the following information ready:
    1) Give your name, company and mobile telephone number.
    2) Location and description of the incident.
    3) What type of gauge was involved and what type and quantities of sources were involved. Quantities are typically:
        a) Cesium 137, 8-10 millicuries, sealed source
        b) Americium 241, 40-50 millicuries, sealed source
    4) How the gauge was damaged, e.g. vehicle.
j) If a radiation survey meter is on hand and you are authorized and competent to do so, take a reading of the gauge at one meter (one yard) away. The reading should be < 0.8millirem. A reading at the base of the gauge where the source rod is extended should be <20millirem. A significantly higher reading is an indication that the sliding block is ajar. A reading of <.01 might be an indication that the source rod has broken off. Give the details to the RSO and await instructions.
k) If cleared to do so and one is available, place the gauge in an approved storage container.
l) Workers using the gauge below 3 feet of the surface must have specific emergency procedures training.
m) Many licensees prepare an emergency response kit. This kit would typically include:
    a. A leak test kit
    b. Latex gloves
    c. 100 feet of rope to cordon off a 15 feet radius area
    d. A radiation survey meter (keep it calibrated on an annual basis)
    e. Packaging tape
n) Licensee RSO or Management must make necessary notifications to the regulatory agency.
o) Notify an approved disposal provider (typically the gauge manufacturer). They will usually want photos and a leak test. When cleared, arrange for transfer.
p) Review the incident. If warranted, take corrective actions and/or revise procedures.

Damage during transport that involves fire, breakage or suspected contamination should take the above steps but also contact the U.S. D.O.T. at 800-424-8802.

A stand alone Emergency Procedures Document example, along with a page of Emergency Response Wallet cards, can be found on the APNGA home page and in the appendices.

Annual Audits

Introduction

As a licensee you are required to conduct an annual audit of your Radiation Safety Program. The audit will re-familiarize you with the requirements of your license.

You should note that the “flow” of this audit matches the “flow” of the APNGA example of a radiation safety program example. This will allow you an apples-to-apples approach to the safety program and the audit.

The annual audit will likewise keep you prepared for the eventual regulatory inspection The RSO should conduct the audit along with senior management.

Audit Checklist

To assist you in conducting the annual audit you should print out a copy of the NRC Audit Checklist (nrc.gov)or you can find the checklist on the APNGA Homepage under “Industry listings – Helpful Checklists” or appendices. Or, use your Agreement State checklist if available & applicable.

1. Audit History

The first section of the audit reviews past audits. You should be keeping a documented record of your audits.

For this new audit, keep records of the checklist and your notes. If desired, you can complete the Annual Audit “How To” and print out a copy of the certificate that the tutorial generates at its completion.

Audit History 1.a

To begin, retrieve a copy of your last audit and note that audit’s date on your new audit checklist. Return the previous audit to the file.

Audit History 1.b

Check to make sure that you or previous RSO’s have conducted an audit since the original inception date of your license.

Audit History 1.c

Make sure copies of all previous audits have been kept on file.

Audit History 1.d

Next, check to see if there are any recurring deficiencies in your Radiation Safety Program that have been likewise noted in the previous two audits. RSO's are required to note any deficiencies in their programs that may occur during the year, investigate and record them, and state what corrective actions have been taken.

An example of a deficiency would be forgetting to take your inventory on time (every 6 months) or leak tests on time.

If you have had deficiencies in your program during the last two years or audits you should make a list and attach it to this audit.

Note: - You are far better off to acknowledge & correct your deficiencies and oversights by yourself than to have a licensing agent discover them during an inspection.

Audit History 1.e

Did you take corrective actions when deficiencies were discovered?

If deficiencies do occur you should take steps, and document the steps, to make sure such deficiencies do not happen again. Pay special attention to recurring deficiencies.

Attach the corrective actions you have taken.

2. Organization & Scope of Program

This 2nd section focuses on the information on file with your licensing agency.
Grab a copy of your current license and, if available, your original license application.

Organization & Scope of Program 2.a

Has your address changed or have you changed the other locations where your gauge is stored and/or used?

If so, did you file an amendment with the licensing agency?

If you didn't – do so, note the deficiency and what steps you will take to make sure it won't happen again.

Organization & Scope of Program 2.b

Are there new owners of the company?

If so, did you notify your regulatory agency and obtain prior approval?

Did the owners/company file for bankruptcy?

If so, was the regulatory agency notified?

Organization & Scope of Program 2.c

Is there a new RSO since the last audit?

If so, was the license amended?

Does the new RSO have prerequisite training requirements – Gauge Safety Certification, HAZMAT Training and any additional Agreement State Requirements?

Organization & Scope of Program 2.d

Every company must designate an individual that will be the spokesman when communicating with your regulatory agency. Ideally, that person should be the RSO.

If the designated contact person (If different than the RSO) changed, did you notify the regulatory agency?

If notification is necessary, do it now.

Organization & Scope of Program 2.e

Read your license as to which gauge models, radioactive sources and millicurie activity levels are allowed. Make sure you have not added any models & sources that are not listed and likewise make sure millicurie quantities of the sources are not exceeded.

Organization & Scope of Program 2.f

Do you have a copy on file of the Sealed Source and Device (SSD) Certificate or Sheet for each type of gauge you own? Copies can be obtained from the manufacturer – see their website.

Do you own manufacturer operation & maintenance manuals for each type of gauge? If not, download from the manufacturer website.

Organization & Scope of Program 2.g

Are you using the gauges the way they are intended? – see the authorized uses as stated on your license and SSD sheets.

Organization & Scope of Program 2.h

Are you, the RSO, fulfilling your duties? See the “RSO Responsibilities” section under “Regulatory” headings on the “APNGA Homepage”.

Make sure to check with your regulatory agency for any other requirements.

3. Training & Instructions to Workers

This section will review the training and instruction required of all workers using portable nuclear gauges as well as employees involved in preparing gauges for transport.

Training & Instruction to Workers 3.a

Code of Federal Regulation (CFR) 19.12 requires that all employees expected to receive an excess of 100 mrem/yr occupational dose be given special instructions. Although gauge users typically receive less than this amount it is assumed that they may exceed this limit and are therefore subject to these instructions

10 CFR 19.12 states workers must be instructed in:

- storage, transfer & uses of gauges
- exposure issues and ALARA
- required safety training
- how to report overexposure concerns
- emergency response procedures
- how to obtain their exposure reports

Workers are to receive annual refresher training on these topics

Have workers received initial instructions on these issues and have they received an annual refresher? (The APNGA Annual Refresher Training Module can be used to guide you with this training – it is included with your annual dues)

Training & Instruction to Workers 3.b

Did each gauge operator complete an approved gauge safety course before using the gauge? (The APNGA Gauge Safety Training Course is approved in most states & is included in annual dues – check the list for your state's status)

Training & Instruction to Workers 3.c

Do you have training certificates on file for each worker? Each worker should have a record for Initial Gauge Safety Training, HAZMAT Training and Annual Refresher.

Training & Instruction for Workers 3.d

Did you conduct interviews with each worker to determine if they are knowledgeable with emergency procedures (see the "Emergency Procedures" section under the "Regulatory" heading on the "APNGA homepage" and your regulatory agency for guidance.

Training & Instruction to Workers 3.e

Did you observe each worker operating the gauge in the field?

Did you observe each worker performing routine cleaning & lubrication?

Did you observe each worker transporting the gauge?

Did you observe each worker checking a gauge in and out of storage?

Training & Instruction to Workers 3.f

Did each worker demonstrate safe handling and security during operation, transportation and storage of the gauge?

Training & Instruction for Workers 3.g

Was USDOT HAZMAT (CFR 172.700-704) training provided for each worker involved in preparing and/or transporting a gauge? (APNGA annual dues include a USDOT HAZMAT course that is accepted in every state).

Make sure HAZMAT training records are kept on file.

4. Radiation Survey Instruments

Radiation Survey Meters, also known as hand–held Geiger Counters, allow you to detect the presence of radiation. All license holders should be in possession of a survey meter. In the event of an accident they can be used to detect the location of a dislodged source, determine the Transport Index of a damaged gauge or determine the radiation levels around a storage area. Check the “Survey Meters” section under the “Industry” heading on the “APNGA Homepage” for guidance in buying a survey meter.

Radiation Survey Instruments 4.a

Does your survey meter meet the criteria of your regulatory agency? Typically this requires a survey meter that is able to detect gamma radiation and be recalibrated annually.

Radiation Survey Instruments 4.b

If you do not own your own survey meter you will need to show you have immediate access to one. Do you have a plan for accessing a survey meter?

Radiation Survey Instruments 4.c

If you are licensed for and performing non-routine maintenance you must own a survey meter that is calibrated annually. Non-routine maintenance would include removal of the source rod. Do not remove the source rod if you do not have a special license to do so.

Radiation Survey Instruments 4.d

Do you have survey meter calibration records on file?

5. Gauge Inventory

An inventory of your gauges should be completed every 6 months. Keep a inventory sheet attached to a clipboard and place it at the storage area with the date of the next inventory. Complete a hands-on inventory of each gauge and keep the completed document on file.

Gauge Inventory 5.a

Do you have a receipt for each gauge in inventory that shows the date each gauge was obtained and entered into your inventory?

Gauge Inventory 5.b

Are each of your gauges physically inventoried every 6 months?

Gauge Inventory 5.c

Do you have all physical inventory documents on file?

6. Personnel Radiation Protection

It is recommended that all license holders provide personnel dosimetry to their employees. Dosimetry measures any exposure that workers receive and provides a record of this exposure.

The Dosimetry, typically in the form of a film badge, TLD (Thermoluminescent Dosimeter, or OSL (Optically Stimulated Luminescence) ensures that ALARA practices are being met and also creates a record that documents that employees are receiving minimal exposure levels.

Personnel Radiation Protection 6.a

The key component of a sound Radiation Protection Program is a solid adherence to ALARA considerations. Are ALARA considerations (time, distance & shielding) being taught and practiced and incorporated into the Company Radiation Protection Program?

Personnel Radiation Protection 6.b

If any gauge workers are not provided dosimetry is documentation provided confirming that they are receiving less than 500 mrem per year?

Personnel Radiation Protection 6.c

Did the activities of gauge workers not wearing dosimetry change to where the possibility of receiving greater than 500 mrem per year exist?

If so, was a new evaluation performed?

Personnel Radiation Protection 6.d

Is dosimetry currently provided for your workers?

Are any workers currently receiving more than 500 mrem?

Is the dosimetry supplier NVLAP approved?

Are film badges changed monthly? TLD's quarterly?

Are the dosimetry reports reviewed by the RSO as they are received?

Are NRC or equivalent Agreement State forms being used?

NRC-4 "Cumulative Occupational Exposure History

NRC-5 "Occupational Exposure Record for a Monitoring Period"

If a worker declared her pregnancy was she limited to a maximum of 500 mrem for the term of the pregnancy? Were embryo/fetus dose records kept on file?

Are all exposure, survey, monitoring and evaluation records kept on file?

7. Public Dose

One of the primary responsibilities of a license holder is to protect the general public (non-gauge workers) from exposure to radiation.

Assurances must be made to keep exposure levels to the general public below 100mrem in a year or 2mrem in any 1 hour.

Public Dose 7.a

Are gauges stored in a manner that keeps dose limits to the public below 100mrem in a year?

Public Dose 7.b

Has a survey or evaluation of public access areas been performed around the storage area to ensure that exposure levels are below 100mrem per year?

Has there been any gauge additions or changes to the storage area, security or use of the surrounding areas that would necessitate a new survey or evaluation?

Public Dose 7.c

Do public access area radiation levels exceed 2mrem in any one hour?

Public Dose 7.d

Are gauges being stored in a manner that would prevent unauthorized use or removal?

Public Dose 7.e

Are storage survey and evaluation records being kept on file?

8. Operating & Emergency Procedures

Each licensee RSO must develop, implement and maintain Company Operating & Emergency Procedures.

All workers must have a copy of these procedures and know what steps to take in the event of an emergency.

Please refer to Appendix H of the NRC's NUREG Guide 1556 Vol 1, "Operating & Emergency Procedures" for an outline or use your Agreement State procedures.

This APNGA website also contains information to complement your regulatory agency requirements.

Procedures should include these instructions:

Using & maintaining the gauge

Security during transport and storage

Control & surveillance during use

Keep exposures ALARA

Constant accountability during use

How to deny access to a damaged gauge

Steps to take and who to contact when a gauge is damaged

Operating & Emergency Procedures 8.a

Have Operating & Emergency Procedures been developed?

Emergency & Operating Procedures 8.b

Do they contain the required elements as specified by the regulatory agency?

Emergency & Operating Procedures 8.c

Does each gauge worker and gauge case have a current copy of the operating & emergency procedures, including RSO office, cell & home telephone numbers as well as the manufacturer's and regulatory agency emergency contact numbers?

9. Leak Tests

Performing leak tests on your gauges is an important safety requirement of your license. These tests will ensure that contamination and/or increased levels of radiation do not harm workers or the public.

Forgetting to perform a leak test is one of the most frequent violations of gauge licensees.

Leak Tests 9.a

Was each sealed source on each gauge leak tested on time (per the time interval stated on your license)?

Leak tests 9.b

Was the leak test performed per the descriptions and requirements of the regulatory agency and your license?

Leak Tests 9.c

Are leak tests results kept on file?

Leak tests 9.d

Were any sources found to be leaking and, if so, was the gauge pulled from service and the regulatory agency notified?

10. Maintenance of Gauges

Keeping your gauges clean and lubricated will result in optimum safety and performance of the gauge.

Remember, you are not allowed to remove the source rod unless specifically licensed to do so.

Maintenance of Gauges 10.a

Are the gauges routinely cleaned and lubricated per the manufacturer's procedures?

Maintenance of Gauges 10.b

Does the source rod remain attached to the gauge during cleaning?

Maintenance of Gauges 10.c

Are you licensed to remove the source rod for non-routine cleaning?
If so, did you adhere to the special requirements pertaining to procedures, dosimetry, survey instruments, individuals and compliance?

11. Transportation

The best way to complete the transportation portion of the audit is to accompany the worker while a gauge is in transport. Every worker should be viewed transporting a gauge to assure that HAZMAT requirements are understood and met.

The evaluation should commence at the storage area and conclude upon return to the storage area.

Transportation 11.a

Was an undamaged, manufacturer-provided and approved, Type "A" package gauge case used during every transport of a gauge?

Transportation 11.b

Are the Type "A" Package test results for every different type of gauge case in use kept on file?

Transportation 11.c

Is a “Certificate of Competent Authority” kept on file for each different type of source used in the gauge? (This will satisfy the requirement for documenting special form certificates).

These special form certificates can be obtained through the manufacturer and can usually be downloaded on their website.

Transportation 11.d

Did the gauge case display 2 Yellow Radioactive ll labels that **legibly** show the Transport Index (TI), gauge sources & activities, and hazard class (7)?

Transportation 11.e

Does each gauge case display a Type “A” package label denoting UN3332, “Radioactive Material”, “Special Form” and “RQ” requirements?

Transportation 11.f

Was the gauge case closed and locked for every transport of every gauge?

Transportation 11.g

Were applicable bill of lading and emergency response sheets used during every shipment?

Were shipping documents filed for every shipment?

Transportation 11.h

Did the shipping papers contain the proper entries? (Shipping name (Radioactive Materials), Hazard Class (7), UN ID Number (3332), Total Quantity (number of gauges), Package Type (Type A), Nuclides (Cesium137 and/or Am241), RQ (if necessary), Description (Radioactive Material), Special Form, Activity (in Becquerels and Millicuries), Yellow ll labels, Transport Index (TI), Shipper’s name, Certification and signature, Emergency Response Telephone number, Cargo Aircraft Only label.

Transportation 11.i

Were the shipping papers (Bill of Lading & Emergency Response Sheet) within eyesight, driver's reach and readily accessible during every gauge transport?

Transportation 11.j

Was the gauge case secured against movement?

Transportation 11.k

Were double, independent, locked cables, chains or other security devices used during transport?

Transportation 11.l

Was the gauge concealed while temporarily stored in a vehicle?

Transportation 11.m

Were any incidents reported to the USDOT?

12. Auditor's Independent Survey Measurements (if made)

If any independent survey measurements were made describe the type, location and results of measurements. Do any radiation levels exceed regulatory levels?

13. Notification & Reports

This section relates to incidents that require notifications to the regulatory agency. This does **not** include non-emergency oversights that must be noted and corrected in your Gauge Safety Program.

Notification & Reports 13.a

Were any gauges lost or stolen since the last audit?

Was your regulatory agency and/or NRC notified and reports made?

Notification & Reports 13.b

Did any reportable incidents occur? Were reports made?

Notification & Reports 13.c

Did any overexposures or high radiation levels occur? Were they reported?

Notification & Reports 13.d

If any reportable events (a-c) did occur what were the causes?

Were the corrective actions appropriate and/or effective?

Notification & Reports 13.e

Are you aware of the NRC Emergency Operations Center 301-816-5100 telephone number? You should call this number for any of the above incidents – they will in turn contact your Agreement State, if appropriate.

Do you have the Agreement State emergency telephone number?

14. Posting & Labeling

You are required to post or make available certain documents and/or posters for public viewing. Make sure you are familiar with your regulatory agency's requirements, be it NRC or Agreement State.

Keep all originals under lock and key. Only post **copies** of the documents and posters (keep originals on file).

Posting & Labeling 14.a

Is the "Notice to Employees" poster posted?

The poster should be viewable in an area accessible to all employees.

Posting & Labeling 14.b

Are regulations and license documents posted or is a notice posted indicating where these documents can be viewed (post **copies** in a publicly viewable area).

Be aware and post any documents required by your regulatory agency or other state or local authorities.

15. Recordkeeping for Decommissioning

Regulatory agencies require a minimum of 60 days notice before terminating your license and transferring or disposing of all of your gauges. Be aware of their requirements and maintain all decommissioning, transfer and disposal documents.

Recordkeeping for Decommissioning 15.a

Have you maintained records important for decommissioning?

Recordkeeping for Decommissioning 15.b

Do records contain all information outlined and required?

16. Bulletins & Information Notices

You should be on the mailing list or email list for documents issued by the NRC and/or your Agreement State. Go to www.nrc.gov to sign up for NRC Bulletins, Information Notices and NMSS Newsletters. Do the same for your Agreement State.

Bulletins & Information Notices 16.a

Are you receiving pertinent NRC and Agreement State notices?

Bulletins & Information Notices 16.b

Has appropriate training and actions been taken in response to these notices?

17. Special License Conditions or Issues

Have you reviewed any special license conditions or issues pertaining to your license (e.g., non-

routine maintenance)?

18. Deficiencies Identified in Audit and Corrective Actions Planned

This section discusses any deficiencies or oversights that you have discovered during the audit and what corrective actions that you will plan and take to rectify the issue.

Deficiencies Identified in Audit and Corrective Actions Planned 18.a

Summarize the problems and/or deficiencies discovered during the annual audit.

Deficiencies Identified in Audit and Corrective Actions Planned 18.b

Describe the corrective actions planned or taken to rectify the deficiencies.

Are corrective plans or actions being carried out at all of your licensed facilities?

Deficiencies Identified in Audit and Corrective Actions Taken 18.c

Provide any other recommendations for improvements.

19. Evaluation of Other Factors

Is senior management constructively involved with the RSO in conducting the Annual Audit?

Does the RSO have sufficient time to perform Radiation Safety Duties?

Does licensee have sufficient staff to support the Radiation Safety Program?

Completion of Audit

Make notes or comments of any other issue pertaining to the Annual Audit.

Keep all notes and checklists used to complete the audit. These documents should be filed for future reference and proof of audit.

Storage, Security and Protecting the General Public

An important requirement of your license is to provide a safe and secure storage area for your gauges that protects members of the public (MOP) from excessive levels of radiation. Excessive levels for a MOP individual are defined as >100mrem/year or >2mrem/hr. This section discusses storage and how to calculate the radiation levels around your storage.

You must designate a permanent storage location for your gauge. Many license applications require a drawing of your storage facility to be included and kept on file. The diagram should indicate the distances from the stored gauges to public access areas. An example of a storage drawing follows later in this section and in the appendices.

The boundary of the control area around the gauge is determined by a dose detection level that is <2mrem per hour or <100mRem annually. The general rule of thumb for the minimum distance from the gauges to a full-time work station is 15 feet. The dose rate for a single gauge at 15 feet is <0.05mrem/hr. A person working a 40 hour week for a year at 15 feet away would receive a dose <100mrem/yr. The distance must be increased for multiple gauges. Use the calculations listed later in this section to determine multiple gauge levels (or check with the manufacturer). A full time workstation is typically a working area that is occupied by employees on a full-time basis. The 15 feet rule does not mean that people cannot pass through the area, it just means they can't occupy that area on a full-time basis or exceed the above limits. Remember, your storage area is considered to be a secure area and therefore unauthorized individuals should be restricted from the area.

Shielding can be used to reduce the intensity of radiation. Ideally, if room permits, use concrete blocks to dampen the intensity. Concrete blocks are an effective shield for both gamma and neutron radiation. Shielding effectiveness is expressed in half-value layers (HVL), which is a thickness measurement that reduces the radiation intensity by one-

Half-Value Shielding Layers

Shielding Material	Cs137/Gamma	Am241/Neutron
Lead	0.25"	ineffective
Polyethylene	3.8"	2.4"
Concrete	1.9"	4.3"

half for each thickness of a given shielding. Lead is an effective shielding for gamma but not for neutron. Polyethylene (plastic) is an effective shield for neutron. Concrete blocks are effective for both. Stacking concrete blocks six feet high and two feet thick will dampen lateral intensity but not floor and ceiling intensity.

Any changes in the design of your storage or increase in gauges will necessitate a new calculation.

Remember to select a storage area that can house the maximum number of gauges that your license allows. The area must be completely under the license holder's control. Choose an area that restricts unauthorized removal and deters theft.

The storage area you choose can be in a multi-use area, a trailer, a storage shed, warehouse, etc. It is a good idea to get clearance from the landlord and/or other tenants before setting up the storage area. If you choose a closet area in a building that has many tenants make sure the 15 foot rule extends to areas other than your area. In other words, the 15 feet area extends to other offices and other floors. If your company fully occupies your own building try and set up your storage area in a sparsely occupied area of the building.

You must provide adequate security for your storage area. Typically, access to the storage area should be secured by a minimum of two locking deterrents (Check with your licensing agency for their requirements) that will restrict access to unauthorized individuals. This usually takes the form of a lock on all access points to the building as well as a lock on the storage closet. You will not want to use a storage closet that includes a window. That would provide easy access to the gauge. It's also a good idea to secure your gauge inside the closet with an additional locked chain or cable. Consider using an area with available AC power for charging gauges.

You must post a yellow and magenta "Caution – Radioactive Materials" sign on your door or cabinet that is readily visible to all passersby. An additional "Radiation Area" sign must be used on storage areas that exceed 5mrem per hour. These signs can usually be obtained through the gauge manufacturer or service provider.

You must also post a "Notice to Employees" poster. This poster can be obtained through your licensing agency – check out their website. A "Notice to Employees" poster advises employees of their rights regarding working around radioactive materials.

APNGA recommends the use of 3 clipboards or equivalent at the storage location. Nail these 3 clipboards next to your storage area. The first clipboard will hold the daily utilization log. This sign-in/sign-out log will show the whereabouts at all times of each and every gauge you own. License holders must be aware of the location and user of every gauge they own. The log should show who checked out the gauge, the date, the

serial number, the location of use and return. All gauges and cases should be inspected to make sure they are properly operating before the gauge is signed out. For example, if the sliding block that covers the source rod is not fully closed the gauge should not be used. If the gauge case is damaged or cracked in any way the case cannot be used. Cases are expensive – treat them nicely. The daily utilization logs will need to be kept on file for 3 years. An example of a daily utilization log can be found in the appendices.

The second clipboard should hold the leak/wipe test intervals. Check with your agency and/or manufacturer as to how often you must perform a leak test. Typically the frequency is 6 or 12 months. Try to schedule all of your leak tests at the same time. For example, if your frequency is every 6 months set your schedule January 1st and July 1st. You will want to perform your leak test about 3 weeks before that date. This will give you time to send in your wipes for analyses and receive the results. Again, keep these records on file for 3 years. It would be a rare event for you to have a gauge that is releasing radioactive contaminants outside of the double encapsulation and source rod. The double encapsulation is virtually impenetrable. But, because radioactive materials are highly regulated regardless of quantity, you must perform these tests. Don't forget them! Forgetting to perform a leak test is among the top infractions of owning gauges. Your agency inspector will look for timely documentation. If you do forget to perform a test on time go ahead and perform the test. Write an incident report and describe what actions you have taken to prevent such an infraction in the future. This is a requirement of your license and it will show the inspector that you are up-front regarding any oversights and that you have taken the necessary corrective actions. Don't try and hide your oversight! Let the clipboard serve a reminder.

The third clipboard holds your inventory report. The frequency is every 6 months. Set this frequency to match your leak/wipe test frequency. An inventory check is performed to make sure you are in possession of all of you gauges. Match the gauge serial number to your records to make sure they are the same. Again, keep these records in your permanent file for 3 years.

Whenever you remove a gauge from storage always check to make sure the gauge is operational, especially the sliding block source shutter. The source shutter is a spring loaded trap door that closes shut over the bottom of the source rod when it is retracted back into the gauge. Make sure that it fully closes. At times it will be necessary to remove the bottom plate and remove fine debris that has accumulated inside the chamber. A brush or blast of air will remove most of the debris. If you have to remove the sliding block shutter do by placing the gauge on a flat surface and tilting the handle towards you. This will tilt the base of the gauge away from you allowing the gauge shielding to be between you and the exposed bottom of the source rod. Use a mirror to view and clean the shutter assembly, add lubricant and reassemble the assembly and bottom plate.

Temporary Storage

Whenever possible you should return your gauge to the permanent storage area. When not possible or convenient you may need to store your gauge at a temporary job site. A temporary job site usually takes the form of a secured trailer. Make sure you follow all of the rules for security, posting and limited access as you would at your permanent storage area. If you will be storing your gauge at the site for longer than 30 days you will want to notify your agency. Check with their regulations for specific requirements. Storage lasting longer than 180 days may require an amendment.

Although your vehicle, when properly secured, is considered a temporary storage site, you will not want to make a habit of leaving the gauge in the vehicle. Check with your regulations about limitations of leaving your gauge in the vehicle. Some states forbid storing a gauge in a vehicle overnight.

Places that are **not** considered to be temporary storage locations are a hotel room or your house. If permitted, leave the gauge secured inside your vehicle.

3rd Party Gauge Service Providers

3rd party service providers that visit your facility to perform service and calibration must produce a valid license that allows them to work on your exact brand and model of gauge(s). If they cannot produce one **do not** allow them near your gauges. If they are removing the gauge source rod they must also have a special license that allows them to do so. You should also verify their identification and proof that they work for the company.

Take note that many one-man service providers will entice you with low cost service and calibration offers. These service providers typically use a marginal calibration device that does not adequately calibrate your gauge. They likewise will bypass many important service functions, such as source rod inspection. They bypass these functions because they are not licensed to do so. This leaves you with a gauge that has not been adequately serviced.

Gauges cannot be left unsupervised with 3rd party gauge service personnel. If you have an individual from a gauge service company visit your facility to calibrate, service or repair your gauges you must have one of your authorized gauge operators accompany the individual at all times. They cannot be left alone with your gauges nor can they be left alone in the secured storage areas of the gauges. The service individual is not employed by your company and you have not transferred the gauge to their ownership.

You cannot let the individual remove a gauge to take to their vehicle without supervision. If a gauge is removed from storage you must adhere to all requirements of the radiation safety program.

If you are in possession of radionuclide quantities of concern you are not allowed to let 3rd party individuals access the gauges unless they have and can produce regulatory background clearance documentation. You can view the NRC background clearance notice in the appendices/attachments.

Guide for Demonstrating that Members of the Public will not Receive Doses Exceeding Allowable Limits

This generic guide provides a basic understanding of the requirements for determining doses to the general public. Consult with your regulatory agency for specific requirements of your license.

I. Introduction

Your license requires that:

- Radiation doses in unrestricted areas not exceed **2mrem (0.02mSv) in any one hour**
- Doses to members of the public not exceed **100mrem (1mSv) in a year**

Your license requires surveys, calculations and/or environmental monitoring to be used to demonstrate compliance with the dose limits. A member of the public (MOP) dose compliance study provides documentation of compliance with both regulatory limits. This procedure describes methodologies for use by portable gauging device license applicants and license holders conducting MOP studies.

II. Dose Limit for Unrestricted Areas

For portable gauging device operations, there are three situations that must be addressed in order to demonstrate compliance with the 2mrem in any one hour dose limit for unrestricted areas:

- Storage of portable gauging devices in transport vehicles;
- Use and storage of portable gauging devices at temporary job sites; and
- Storage of portable gauging devices at the permanent facility.

Section A demonstrates compliance with the unrestricted area dose limit for shipment of portable gauging devices to and from temporary job sites and their use and storage at job sites.

Section B's Method 1 describes the procedure followed when a survey meter is available to conduct radiation measurements. Compliance with the unrestricted area dose limit can also be demonstrated without direct measurements. Section B's Method 2 describes the procedure followed when a survey meter is unavailable. The selected box indicates the method used.

A. <u>Transport Vehicles and Temporary Job Sites</u>

Security procedures, approved by the regulatory agency and incorporated into the license, describe the measures taken by operators to restrict public access to portable gauging devices while in transport vehicles or at temporary job sites. During transport and storage at temporary job sites the procedures require a minimum of two independent physical controls, which comprise of tangible barriers, that must be used to prevent public access to the device. While in use, the portable gauging device must always be under the direct supervision of the operator to prevent unauthorized access.

Adherence to these procedures ensures compliance with the 2mrem in any one hour public dose limit.

B. Permanent Facility

Method 1. Physical Surveys

Your license requires prevention of unauthorized public access to gauges at the permanent facility. Portable gauging devices are stored in an approved storage area and are kept locked in their transport cases and secured using a minimum of two independent physical controls, comprising of tangible barriers. All portable gauging devices will be appropriately secured from public access, unless they are kept under the physical control and personal supervision of an operator.
A radiation detection instrument is used to measure ambient radiation levels in the unrestricted areas around the permanent storage area while all inventoried portable gauging devices were in storage. This survey evaluates the "worst case scenario" – where radiation emitted by the portable gauging devices are at their highest levels. Survey results revealing dose rates below 2mrem per hour demonstrate compliance.

The following information should be attached:

- Date of the survey and the name of the individual(s) performing the measurements
- Information about the instrument used to perform the survey (manufacturer and model number, the types of radiation detected by the instrument, its minimum and maximum range, and the date it was last calibrated)
- Diagram of the permanent facility identifying the restricted area, adjacent unrestricted areas, nearby MOP workstations, and the locations where all recorded measurements are taken
- Information about the type and number of portable gauging devices present during the survey and a description of their placement within the storage area (e.g., contained in transport cases, stacked against back wall, etc.)
- Results of survey(s) of unrestricted area radiation levels, with results keyed to facility diagram

Note: If surveys note radiation levels > 2mrem/hr, attach a description of controls in place to further restrict access to the storage area (e.g., establishment of expanded restricted area around the storage area, using barricades and/or posted notices).

Method 2. Calculations

Radiation levels in unrestricted areas can be calculated using information provided by portable gauging device manufacturers. Prior to shipment, the manufacturer lists the Transport Index (TI) number on the RADIOACTIVE YELLOW II label on the transport case's exterior surface. The TI indicates the radiation levels at 1 meter (3.3 feet) from the case per hour when it contains a portable gauging device. The TI value was used as the basis for the calculations. If the TI is less than 2, then radiation levels in all directions around the portable gauging device when it is stored in its transport case are 2mrem per

hour (or less) at 1 meter, so that is the boundary of the restricted area. Additional distance and shielding provided by the storage area lowers the dose rate even further. Storing the portable gauging device in its case and then in a cabinet, locker, room, etc. prevents unauthorized access to within a meter or more, so no MOP can receive 2mrem in any one hour.

B. Permanent Facility Method 2: Calculations

When calculating for two or more stored portable gauging devices, each case's TI is added together. Although this method is overly conservative it should not cause the 2mrem limit to be exceeded.
The following information is attached:

- Diagram of the permanent facility identifying the restricted area, adjacent unrestricted areas, and distance to MOP workstations
- Information about the type and number of portable gauging devices present and a description of their placement within the storage area (e.g., contained in transport cases, stacked by wall)
- Copies of manufacturer-provided documentation providing information on portable gauging device dose rates and/or TI numbers for the portable gauging devices being evaluated
- Results of calculations demonstrating estimated radiation levels in unrestricted areas, with results keyed to the facility diagram

Note: If calculations note radiation levels > 2mrem/hr, attach a description of controls in place to further restrict access to the storage area (e.g., establishment of expanded restricted area around the storage area, using barricades and/or posted notices).

III. Annual Public Dose Limit

"Total effective dose equivalent" (TEDE) describes the dose from summation of internal and external radiation doses. However, there is little possibility of internal exposures during routine operations so internal doses can be ignored for portable gauging device MOP studies. Thus, for portable gauging device licensees demonstrating compliance with the 100mrem annual MOP dose limit, the individual's external dose ("deep dose equivalent" or DDE) is equal to the total dose (TEDE).

Licensees must demonstrate compliance with the annual dose limit with measurements or calculations showing that the MOP likely to receive the highest dose from the licensed operations does not exceed the 100mrem limit. Different methods of using this regulatory approach are described below. The selected box indicates the method used in this study.

Method 1. Radiation Level Data

Survey measurements and calculations can be used to demonstrate that the radiation levels resulting from licensed operations are not likely to cause any MOP to exceed the annual public dose limit.

Radiation levels generated by gauges present in the workplace can be determined by direct measurement with survey instruments, or from indirect information, such as radioactive

material package transport index values (describing radiation levels at 1 meter from a package's exterior surface). The radiation level data can then be used with the inverse square law to calculate the DDE.

Method 1: Radiation Level Data (Continued)

Use either radiation survey instrument measurements or Transport Index (TI) values with the inverse square law to calculate the DDE.

Occupancy factors are addressed by selecting one of two options.

The first and most conservative scenario assumes a MOP is continuously present in the unrestricted area (24 hours/day, 365.25 days/year = 8766 hours).

The second is more realistic (but still very conservative) assumes the individual located in the unrestricted area is present during all business hours (8 hours/day x 40 hours/week x 50 weeks/year = 2,000 hours).

Inverse Square Law: $I_2 = \frac{I_1 R_1^2}{R_2^2}$

Where: I_1 = intensity (radiation dose rate) at distance R_1

I_2 = intensity (radiation dose rate) at distance R_2.

R_1 = distance from RAM with dose rate I_1

R_2 = distance from RAM where dose rate I_2 is calculated

Notes: A. This formula has two limitations:

(a) it only applies to gamma-emitters

(b) the closest distance should be at least five source diameters.

B. If using transport package exterior radiation levels, set R_1 = 1 inch.

Example of an Inverse Square Law Calculation Using Survey Meter Measurements

Assume a lab contains a variety of sealed sources. The sources may be treated as a single point source by positioning them together for the measurement. Assuming a collective source diameter of 12 inches, a radiation measurement (I_1) is taken at a distance equal to at least five source diameters from the grouped sources, which serves as R_1 in the inverse square formula. The intensity at 10 feet is the unknown value being sought (the distance to the nearest unrestricted area).

I_1 = 0.1mrem/hr

I_2 = ?mrem/hr

R_1 = 60 in. (5 x 12 in.)

R_2 = 120 in. (10 ft.)

$I_2 = \frac{0.1 \times (60)^2}{(120)^2}$

I_2 = .025mrem/hr

A 2,000 hour occupancy factor yields:

.025 mrem/hr x 2,000 hours

= 50mrem = DDE

Example of an Inverse Square Law Calculation Using a Package Transport Index

A shipping case used to store a portable nuclear density gauge bears a Radioactive Yellow II label that shows its TI = 0.6. The nearest MOP workstation is located 24 feet away.

I_1 = 0.6 mR/hr

I_2 = ? mrem/hr

R_1 = 3.3 ft. (1 meter)

R_2 = 24 ft.

$$I_2 = \frac{0.6 \times (3.3)^2}{(24)^2}$$

I_2 = .011 mrem/hr

A 2,000 hour occupancy factor yields:

.011 mrem/hr x 2,000 hours

= 22mrem = DDE

Method 2. Using Dosimetry Data to Determine Maximally Exposed Individual MOP

If annual occupational doses for workers exceed 100millirem, the MOP that is likely to receive the highest dose from the licensed operations may be used to demonstrate compliance with the annual public dose limit. The "maximally exposed individual MOP" may be a person that does not operate portable gauging devices but works at the same site where they are used or stored. It could also be an employee working in a management, clerical, or maintenance position at the permanent facility, or an employee or a regular customer that has routine contact with the operators when they are working.

Justification for how the maximally exposed individual was identified must be documented; i.e., why the person is likely to receive the highest radiation dose compared to other members of the public. Next, assign the individual a personnel monitoring device (film badge, TLD or OSLD). Provide instructions on when (during working hours) and where (on the torso, waist or chest level) the badge must be worn, and on proper use (protect badge from excessive heat, light, moisture or chemicals, store with control badge in low background area when not being worn). In general, at least one year of monitoring should be conducted to provide adequate measurement data and to account for seasonal fluctuations in workloads. If the dosimetry reports show that the monitored person received < 100millirem for the year, compliance with the annual public dose limit has been demonstrated, because if the MOP likely to receive the highest dose from the licensed operations is receiving < 100millirem, then so are all other members of the public. It is not necessary to wait for a full year of dosimetry records to begin drawing conclusions from the collected data. As dosimetry reports arrive, the recorded dose can be extrapolated to gain an estimate of the annual exposure, which can serve as a MOP study "in-progress" until the year of monitoring is completed. The study can then be updated to reflect the results of a full year of monitoring.

If this method is employed attach the following:

- Description of the maximally exposed individual MOP (name, title) and justification for why the individual was selected
- Facility diagram identifying all restricted areas, adjacent unrestricted areas, and where the monitored MOP's workstation is located
- Copies of the dosimetry reports used in the study. Prior to submitting the reports, be sure to delete all personal information (e.g., social security numbers, last names, birth dates).

Method 3. Environmental Monitoring Data

If the maximally exposed individual MOP is a worker at the permanent facility, a third approach is available. A film badge/TLD/OSLD can be mounted at the person's work station to record radiation levels, which can then be related to the dose received by the person working in the area. If environmental monitoring demonstrates that the annual workplace continuous exposure to the ambient radiation levels results in a total dose less than 100mrem, then it can be concluded that no MOP would be likely to exceed the annual public dose limit from the licensed operations. If environmental monitoring indicates that continuous occupancy would result in exposures that would exceed the public dose limit, then the use of realistic occupancy factors might be used to demonstrate compliance. The maximally exposed individual MOP's annual occupancy time can be determined by review of the person's time cards, interviews of the person and his/her co-workers, etc. Note: An environmental badge is not the same type of badge used for personnel monitoring, so it is important to specify to the dosimetry supplier what type of monitoring is planned when ordering badges. In addition, posted badges must be protected from adverse environmental conditions such as excessive heat, light and moisture.

One or more badges should be posted in the unrestricted areas adjacent to restricted areas (or in the restricted area on a wall adjacent to unrestricted areas) for at least 12 months. Badges should be posted where the highest radiation exposure is expected and where exposure to non-regulated sources of radiation (e.g., medical patients injected with radionuclides) will not contribute to the measurements. If the results for the monitoring period total < 100mrem, use continuous occupancy for the dose determination. If the results for the monitoring period exceed 100mrem, it may be possible to demonstrate compliance with the annual dose limit by applying a more realistic (but still very conservative) occupancy factor, such as 2,000 hours for a work year.

Example: The total dose measured by the environmental badge = 280mrem; the dose received by a MOP working 2,000 hours in the area that the badge was posted is:

280mrem/8,766 hrs = .032mrem/hr x 2,000 hrs = 64mrem

Using a 2,000 hour occupancy factor means that any annual dose from environmental monitoring that totals < 438mrem will demonstrate compliance

Example: 438mrem/8,766 hrs = .049mrem/hr x 2,000 hrs = 99.9mrem

If the results for the 12 month monitoring period total > 438mrem, compliance may still be demonstrated by using an even more realistic occupancy factor, provided the number can be legitimized by supporting documentation (e.g., employment records).

Example: Environmental badges total 680mrem for the 12 month monitoring period; time sheets indicate that a conservative estimate of the most time spent by any MOP in the monitored area is 25 hours a week, 50 weeks a year = 1,250 hours.

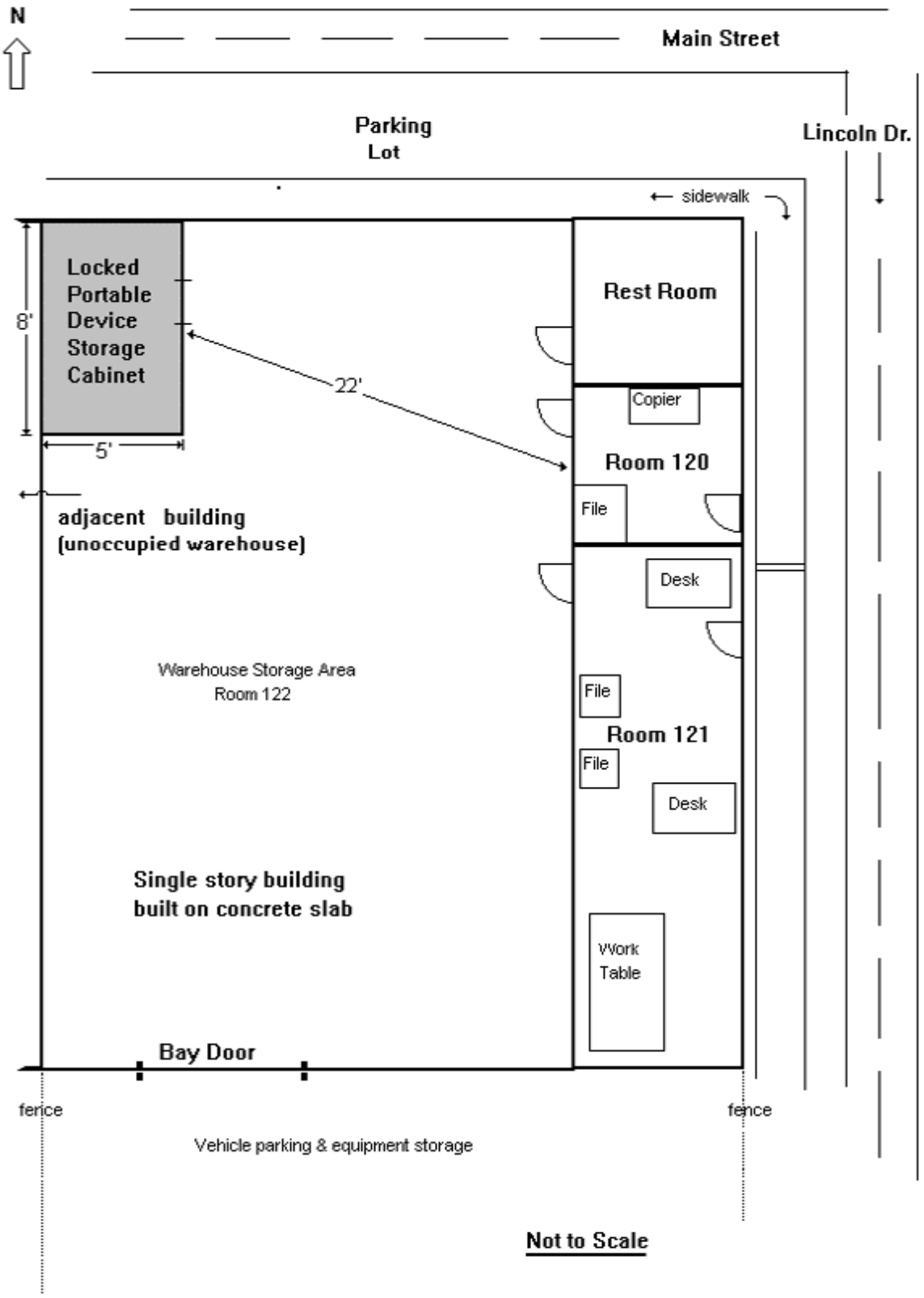
680mrem/8,766 hrs = .078mrem/hr x 1,250 hrs = 97mrem

Attach an annotated diagram of the facility identifying restricted areas, adjacent unrestricted areas, and the location of posted badges.

Method 4. Occupational Worker Dosimetry Data

If measurements show that all of a licensee's portable gauging device operators receive less than 100mrem annually, then by extrapolation, no MOP receives 100mrem annually, because operators receive higher exposures from portable gauging devices than any MOPs.

The NRC NUREG 1556, Volume 1 guide also has examples of MOP calculations as well as an example of a storage facility drawing.


N
Main Street
Parking
Lot
Lincoln Dr.
sidewalk
Locked
Portable
Device
Storage
Cabinet
8'
5'
22'
Rest Room
Copier
Room 120
File
adjacent building
(unoccupied warehouse)
Desk
Warehouse Storage Area
Room 122
File
Room 121
File
Desk
Single story building
built on concrete slab
Work
Table
Bay Door
fence
fence
Vehicle parking & equipment storage
Not to Scale

U.S. DOT HAZMAT Requirements

There are approximately 22,000 radioactive materials licenses in the United States, of which approximately 7,000 are for portable gauges, most being moisture density gauges. Those licenses collectively represent about 25,000 gauges. The portability of the gauges, combined with their high number, leads to what seems like a high number of incidents, specifically thefts and damaged gauges. Many of these incidents could have been avoided if the involved licensees would have adhered to proper security compliance.

These incidents draw the attention of the media, which can't pass up the opportunity to post headlines such as "RADIOACTIVE MATERIALS STOLEN" or "RADIOACTIVE MATERIALS DAMAGED". The general public, unaware that the actual radioactive materials are relatively miniscule in size and double shielded, are subject to panic and paranoia. Local, state and eventually federal government officials take notice and soon attention is focused on the licensing and enforcement agencies (the Nuclear Regulatory Commission, the Agreement States and the USDOT).

If enough of the incidents are determined to be the result of inadequate security compliance on the part of the license holders, the agencies may take steps to improve compliance through stricter regulations and less tolerance, which could lead to increased or more frequent fines.

A NRC report dated December 12, 2007 focused on the number of incidents involving gauges. The report concluded that the number of thefts have not been reduced since earlier NRC security advisories cautioned license holders about improving security and control of gauges.

The NRC instituted the double lock system for transported gauges in 2005. The Agreement States were required to have the same program in place by July, 2008. But it doesn't matter how many locks are used to secure a gauge to a vehicle when the target of the thief is the vehicle. Licensees must reduce the number of times they unnecessarily use the vehicle as a storage area or they must take further steps to prevent the theft of the vehicle.

The transportation of hazardous materials can be enforced by the U.S. Department of Transportation (U.S. D.O.T.), NRC, Agreements States and law enforcement. Specifically, the regulations for transporting hazardous materials are covered under Title 49 of the Code of Federal Regulations (CFR's) Parts 100-177. There are also regulations under Title 10 CFR Part 71 for the NRC. Agreement States and other state and local regulations must also be followed.

The minimum fine for a NRC violation is $3,250.00.

The industry as a whole must improve compliance in transporting gauges. As mentioned, failure to do so will be met with increased fines and stricter regulations and enforcement.

There are currently initiatives taking place to improve increased controls for radioactive materials in quantities greater than those found in portable nuclear gauges. Some of these measures include finger printing, strict source tracking accountability and GPS in every vehicle that transports a gauge. If conditions do not improve among users of portable gauges, these same measures may be considered for this industry.

Law enforcement and detection is another area that gauge owners need to take notice. Police cruisers are being outfitted with radiation detection monitors sensitive enough to detect a moisture density gauge. Officers are trained in HAZMAT compliance, and if you are pulled over, they will inspect your vehicle for proper gauge security and documentation.

When the gauge is moved from storage and transported by highway, air, rail or water you are considered to be shipping the gauge and must adhere to HAZMAT regulations, security and documentation. It is during transport that gauges are most vulnerable.

Training

License holders and users of moisture density gauges must receive Hazardous Materials Training (49 CFR 172 Subpart H) as a condition of their license. The USDOT considers anyone involved in the transportation to be a HAZMAT worker and must therefore have the appropriate training.

Training records must be on file for all HAZMAT workers. HAZMAT training is included in the initial gauge safety training required of all users, but it must be renewed every 2-3 years. Your annual APNGA dues include a HAZMAT refresher class. Annual HAZMAT classes will result in a better understanding and adherence to HAZMAT rules and regulations.

Any individual involved in the transportation process in any way, including document preparation, loading and unloading of gauges, maintenance or courier service must receive HAZMAT training.

New employees can perform HAZMAT job functions for 90 days but must be under the direct supervision of trained personnel. After 90 days they must be trained.

Training must familiarize the employee with the rules and regulations, including safety and security awareness, all job related hazardous materials functions, recognition of

hazardous materials classifications, labels and markings, accident prevention and emergency response.

General Understanding and Awareness

A hazardous material is defined as any substance or material that is capable of posing a risk to the health and safety of the public, company employees, shipping carriers or property during transportation. These materials can be found listed on the Hazardous Materials Table under 49 CFR 172.101. The hazard class number and description are as follows:

Class 1	Explosives
Class 2	Compressed gases – flammable, non-flammable or poisonous
Class 3	Flammable liquids – flammable or combustible
Class 4	Flammable Solids
Class 5	Oxidizers and Organic Peroxides
Class 6	Toxic Materials – Poisons and infectious agents
Class 7	**Radioactive Materials – I, II, and III**
Class 8	Corrosive Materials
Class 9	Miscellaneous – other hazards not listed above

Gauge Sources

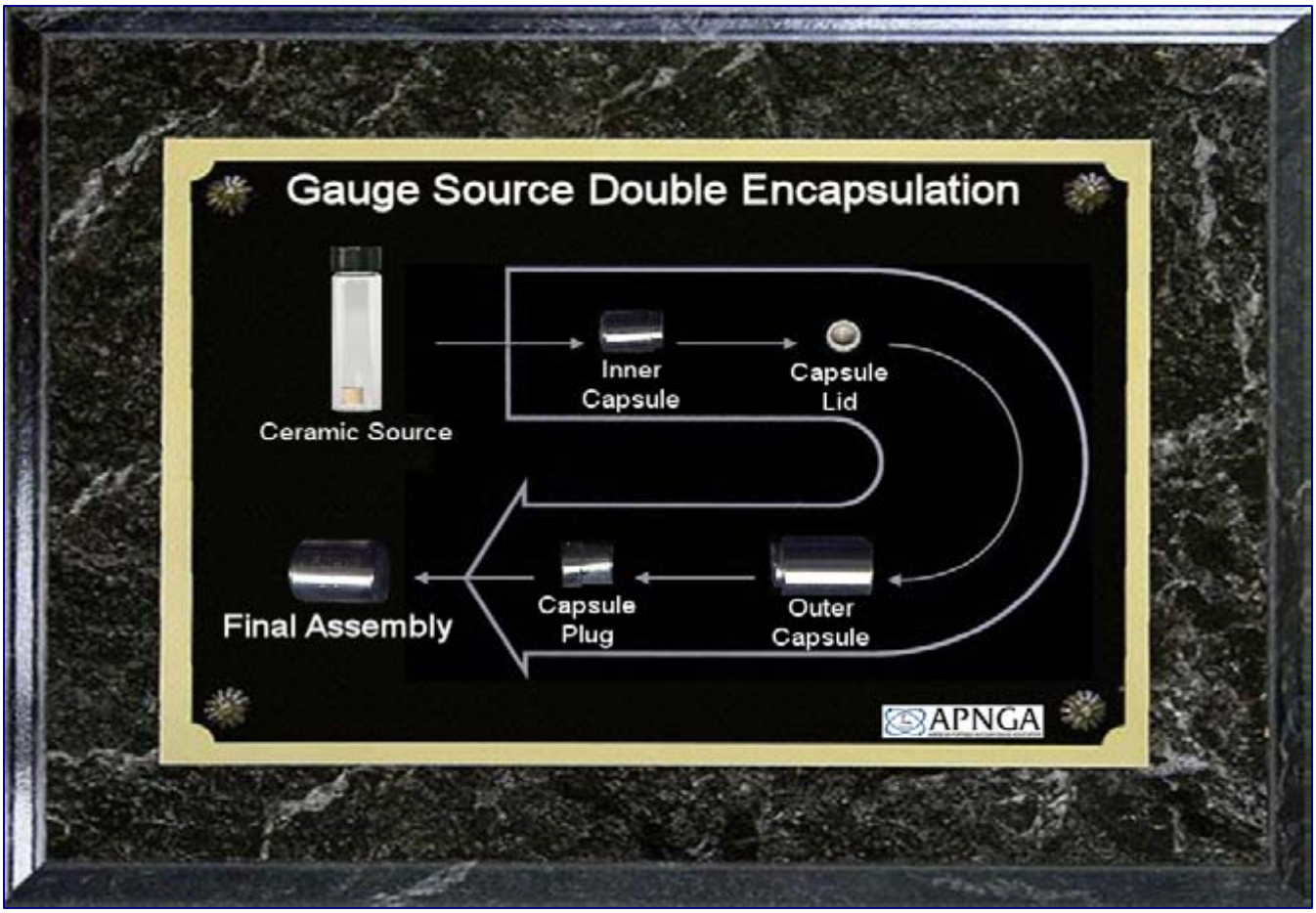
The moisture density gauge is a **Hazard Class 7** device, described as **Radioactive Material**, containing very small amounts of Cs137 and Am241. The sources in the gauge are classified as **Special Form Radioactive Material**. Special form relates to the double encapsulation shielding that contains the sources. It is described as follows:

Sealed source radioactive material that is contained in a capsule, sealed between layers of non-radioactive material. The confining barrier prevents dispersion of the radioactive material under normal and most accidental conditions. Special Form Class 7 Radioactive material is defined as a single solid piece contained in a sealed capsule that can be opened only by destroying the capsule.

Your gauge manufacturer is not involved in this manufacturing process. They purchase the encapsulated sources from a company authorized to encapsulate the material. There are very strict guidelines regarding the manufacture of this material. The encapsulation process is overseen by an independent “competent authority” authorized by the International Atomic Energy Agency, a division of the United Nations.

The sealed source is virtually impenetrable. It is tested for impact, percussion, bending and extreme heat. The gauge manufacturer secures this double encapsulated source into a threaded and fused cap at the base of the source rod (gamma source) or imbedded into the shielding at the base of the gauge (neutron source).

Each source receives a serial number with a life expectancy. Your source serial numbers, which are different than the gauge serial number, is stated on the gauge as well as the gauge documentation. Source serial number information can also be obtained through the manufacturer. The **Special Form Certificate**, also known as a **Certificate of Competent Authority**, must be kept on file for viewing. Each different type of gauge and manufacturer has their own unique certificate – keep one on file for each different gauge. The form has an expiration date. New forms can be downloaded or printed off the manufacturer’s website.



Step by step HAZMAT Guide

To help you understand the requirements of HAZMAT training we have developed a step-by-step approach that starts at the storage area, moves to the transport of the gauge, covers emergency procedures and concludes with the return to storage.

Step One Before You Go - Checking the Condition of the Gauge:

Decide which gauge in the storage area you will be using/shipping.

Make sure the gauge is operational. Is it charged? Turn it on and make sure the display appears.

Note: Always wear gloves when cleaning or leak testing a gauge.

The gauge uses a tungsten sliding block to completely shield the source rod while inside the gauge. A quick test will determine if the sliding block mechanism is fully functional. While the gauge is sitting flat on the floor quickly put the source rod in the backscatter position and then return it to the safe position. Use a survey meter to make sure the sliding block is fully closed. Turn it on and point it at the base of the gauge where the source rod resides. At one meter away the reading should pretty much match the number on the Yellow Radioactive II sticker, known as the transport index number – it should read less than one millirem. At the surface of the gauge the reading should be <20mrem per hour.

How does the gauge case look, inside and outside? Are there any holes, cracks or areas where the plastic has worn away? Are the clasps in undamaged condition? If there is any damage you can't use that case.

Does the gauge have a lock on the handle? Is there a lock on the outside hasp?

How do the labels look? Can you read all the information contained on all labels? If not, you need to replace the label.

Is there a current leak test on the gauge?

If everything checks out write down the serial number of the gauge.

Step Two Understanding the Labels and Documents - Preparing the Paperwork:

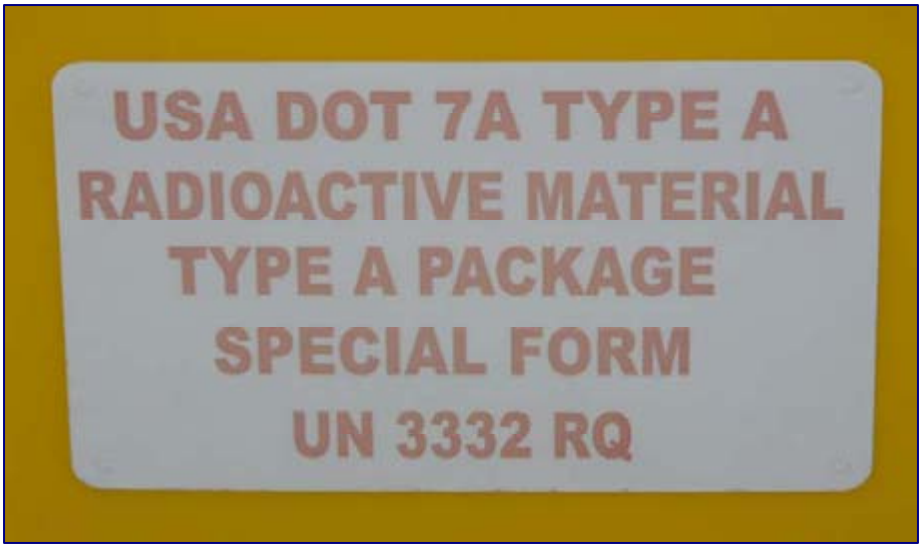
Before you remove the gauge for transport you must first prepare bill of lading and emergency response documents. This section will discuss these documents and how to prepare them.

Communicating the Hazards

Labels and documents are used to communicate the hazards associated with portable nuclear gauges. Shippers and emergency response individuals are trained to recognize this information and take the necessary precautions. Examples of these labels and documents with explanations of the information are described below.

A properly labeled gauge case will display one Type “A” Package Label on one of the broadsides of the case and situated next to a Yellow Radioactive II label. There must be two Yellow Radioactive II Labels on opposite broadsides. There must also be two Air Cargo Only Labels on opposite broadsides. These labels must always be in legible condition.

The Type “A” Package identifies the type of case you are using to store the gauge as well as identifying information in the event of emergency response. It should be placed on one broadside of the gauge case next to one of the Yellow Radioactive II Labels and be in legible condition.



Information on the Type “A: Package Label includes:

1) **UN3332 - UN Identification Number** – This universal reference number lets emergency response personnel know exactly the type of material that you are transporting. A future requirement states that this number must **precede** the other identifying information on your labels and papers. Moisture density gauges have been assigned UN3332 – individuals will cross-reference this number to determine the hazardous material.

2) **USA DOT 7A Type “A” Package** – Refers to the case the gauge is shipped in. The case must meet integrity tests before qualifying for this designation. Type “A” Package documentation must be kept on file. This document will be discussed later in this section.

3) **Radioactive Material - Proper Shipping Name** – The proper shipping name for the gauge.

4) **Special Form –** This identifies the physical form of the radioactive sources inside the gauge**.**

5) **RQ - Reportable Quantity –** Abbreviated as **RQ**, the EPA has set threshold limit levels that, if exceeded, must be indicated at the end of the **Proper Shipping Name.** The limit for Americium 241 is 10mCi. Because moisture density gauges use more than 10mCi (usually 40-50mCi) of Am241 the designation **RQ** must be shown (If you are using a gauge that only has a density/gamma source it will not have to show the RQ).

The above label and information tells the handler you are shipping **Radioactive Material** in a **Type “A” Package, Special Form, RQ.**

The Radioactive II Label identifies the gauge as a Hazard Class 7 Radioactive Device. The label must list the type of radioactive materials contained in the gauge as well as the quantity of each radioactive material. A Transport Index number must also be displayed. The case requires two of these labels on opposite broadsides of the gauge case.

An explanation of the required information is as follows:

Contents – the abbreviated names of the radioactive materials

Activity - The activity of the radioactive materials must be in SI units (becquerels) but can also list the equivalent millicuries.

Example:

Contents	Cs137/Am241
Activity	0.30 GBq (8.0mCi) /1.48 GBq (40.0 mCi)

Transport Index – usually handwritten in the box – typically in the 0.2 – 0.7 range. Use the number that originally came with the gauge or contact the manufacturer for the correct number. This number informs the handler what their exposure rate is for every hour that they sit one meter away from the gauge. It's a piece of information that lets them know how much radiation is present (and indirectly how radioactive the package is). In practice the handler will put more distance between themselves and the gauge, typically in the rearmost part of the vehicle, thereby further reducing the exposure rate.

The "Air Cargo Only" labels inform the handler that gauges cannot be transported on passenger aircraft. There must be two labels, one on each broadside.

Shipping Documents

Shipping documents must also communicate the hazards associated with portable nuclear gauges. Every time you "ship" a gauge to the work site, or turn your gauge over to a shipper for delivery, you must prepare a bill of lading.

There are three versions of the bill of lading. There is a private carrier bill of lading, used when you take the gauge to the worksite, a ground transport bill of lading when shipping by ground transport and an air transport type of bill of lading, also known as a dangerous goods statement.

The bill of lading must be accompanied by an Emergency Response Sheet.

Private Carrier Bill of Lading – This is the type of bill of lading you will use whenever you transport the gauge on a public roadway. It doesn't matter if you are going to the worksite, the FEDEX office or a gauge service center. You can create your own document. There is no official private carrier document already prepared for you. It's a

do-it-yourself-document. The bill of lading document must contain specific information about you and your gauge. Include the following:

a) Type the information on company letterhead.

b) Type the words “Bill of Lading” under your letterhead.

c) Date: 2/1/20**

d) Type your company name and address:

Example:

Shipper: APNGA Paving
1234 Gauge Road
Rockroad, MD 12345

e) In the body of the document type the following line of information about your gauge:

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

Gauge Manufacturer, Model & Serial Number

Cs-137, 0.30 GBq (8 mCi)

Am-241, 1.48 GBq (40 mCi)

Radioactive Yellow II Label, TI = 0.5

Emergency Gauge Manufacturer Contact Telephone Number: 301-123-4567

Company RSO Telephone Numbers: 123-456-7890, 234-567-8901

US DOT Emergency Number: 800-424-8802

US NRC Emergency Number: 301-816-5100

Agreement State Emergency Number: 123-456-7890

f) The authorized person preparing the document must print and sign their name.

The following information describes the information listed on the above bill of lading:

UN 3332 Identification Number – This universal reference number lets emergency response personnel know exactly the type of material that you are transporting. A future requirement states that this must **precede** the other identifying information on your papers – you may as well start doing it now.

Proper Shipping Name – The proper shipping name for moisture density gauges is “Radioactive material”:

Type A package – This describes the case the gauge is stored/shipped in.

Special Form – This identifies the physical form of the encapsulated sources.

7 –This is the hazard class for radioactive material.

RQ - Reportable Quantity – Abbreviated as **RQ**, the EPA has set threshold limit levels that, if exceeded, must be indicated at the end of the **Proper Shipping Name.** The limit for Americium 241 is 10mCi. Because moisture density gauges use more than 10mCi (usually 40-50mCi) of Am241 the designation **RQ** must be shown (If you are using a gauge that only has a density/gamma source it will not have to show the RQ).

So, the above bill of lading and information tells the viewer you are shipping **Radioactive Material** in a **Type “A” Package, Special Form, 7, RQ.**

The next section of the bill of lading lists the **gauge manufacturer, gauge model and serial number**. Although not technically required this information could be invaluable when describing the gauge to emergency response individuals.

The next section of the bill of lading describes the:

Radionuclide name and activity – Your shipping papers must list the name of each radioactive material and its activity. The activity must be expressed in becquerels with the equivalent millicurie in parenthesis. Examples:

Cs-137, 0.30 GBq (8 mCi)

Am-241, 1.48 GBq (40 mCi)

The next requirement describes the:

Radioactive Label Category – Radioactive materials are categorized by their level of activity, Radioactive I-White, Radioactive II-Yellow or Radioactive III-Yellow. The higher the activity, the higher the Radioactive number. The radioactive label for moisture density gauges is:

Yellow Radioactive II

Transport Index – Also known as "TI". The transport index box is located on the Radioactive Yellow II label. This box will have a number written in that tells the viewer what their radiation dose rate will be, in millirems, if they were to sit for one hour at one meter away. It is an easy way for the handler/shipper to know how much radiation they are exposed to by the package. The "TI" will already be designated and written on the label when you first receive the gauge. If the label needs to be replaced you will want to enter this same number on the new label. The TI number for moisture density gauges will usually be in the range of 0.2 – 0.7. Example:

TI = 0.5

Next bill of lading requirement:

Emergency Contact Number – Every license holder should have a 24 hour emergency contact telephone number for a competent emergency response source. The source should have first-hand knowledge about the gauge and be able to give comprehensive emergency response information, specifically the steps to be taken for remediation and control measures involving gauges whose integrity have been compromised in an accident or fire. Gauge manufacturers supply a contact number for this purpose. Make sure that the contact complies with your agency's regulations. This emergency contact number should be listed on the bill of lading and emergency response sheet.

APNGA also recommends listing emergency contact numbers for the RSO, USDOT, NRC and Agreement State.

An example of a private carrier bill of lading can be found in the appendices/attachments.

The above information is the same information you will use when preparing transport document for a ground transport shipping company or cargo air transport company. If available, always use shipping documents offered by the shipping company. They can

usually be accessed and filled out on their websites. Additional information will be required as follows:

Shipping paper certification statements – This statement, which is stated at the bottom of a common carrier or air transport shipping company bill of lading, commits you to providing a package whereby you state “I hereby declare that the contents of this consignment are fully and accurately described above by proper shipping name, and are classified, packaged, marked and labeled, and are in all respects in proper condition for transport according to applicable International and National Governmental Regulations”. If your gauge is shipped by air you must also add the line “I declare that all of the applicable air transport requirements have been met”. Most trucking and air transport forms have already listed these statements on their documents.

An example of a ground transport common carrier document can be viewed in the appendices/attachments.

Notice the shipper certification at the bottom of the page.

Make sure you verify the identity of the common carrier.

An example of the FEDEX air transport document can be viewed in the appendices/attachments.

Air transport – You cannot ship your gauge on a passenger aircraft. Your best option is FEDEX. FEDEX only ships by cargo aircraft and can ship your gauge anywhere overnight (if necessary). Their form will require the same information as seen on the private carrier and common carrier documents. It must also include gauge case dimensions (include metric dimensions). It must also state that “All packed in one Type “A” package”. Their dangerous goods statement, known as a “Declaration of Dangerous Goods Document” meets the requirements of the IATA (International Air Transport Association). It is accessible on their website, making it easy to type in the fields and print out the document. It also includes the required statement “Cargo Aircraft Only”.

Make sure to pay close attention to filling out the forms. FEDEX is not allowed and will not make corrections for you.

You should print out 4 copies of the document. Make sure you print the documents on a color printer since the candy striped slashed borders must show up red. You will also need to fill out a normal air waybill. The gauge case must your company name, address and phone marked on it. Make sure to keep a copy of these documents on file. The FAA, a division of the USDOT, may very well contact you in the future for a copy of

these documents. They will also want to see a copy of your license and your training certificates.

International Shipments

If you are shipping your gauge outside of the US you will need to use the shipping documents provided by the air cargo shipper. The required information will be the same as domestic shipments but, because the shipment will likely be turned over to a forwarder, you will need to supply the forwarder a “Letter of Instruction”, who will act to complete further Air Waybills for you. International shipments must also include a copy of the gauge Certificate of Competent Authority.

Emergency Response Information Sheet

This is the other document, along with the bill of lading, that you must have direct access to whenever transporting a gauge. Slide them back-to-back in a plastic sleeve and place them in the seat beside you or in the driver side door slot. The emergency response sheet is very similar to a MSDS sheet. It lists the potential hazards of radiation as well as the emergency actions you would take in the event of an accident or fire. It lists first aid measures you would take and includes the 24 hour emergency contact number. These information sheets are readily available through the manufacturer and should contain the following:

- Hazards to health
- Fire or explosion risks
- Accident precautions
- Emergency actions for fires
- First aid
- Emergency contact numbers – response personnel should be able to provide information regarding hazards and risks, emergency response and accident mitigation

Direct access also means readily viewable, meaning that the documents cannot be placed in the gauge case, glove compartment or trunk. Emergency response personnel know to look for HAZMAT information on the passenger seat or document holder on the driver side door. If you leave the vehicle place the documents on the driver’s seat. Check with your licensing agency for any other requirements.

Keep copies of the bill of lading and emergency response sheets on file for three years after the shipment. You can use the same documents for multiple shipments provided you keep a log of the different shipping dates. Each gauge must have its own set of documents.

An example of an Emergency Response Sheet can be viewed in the appendices/attachments.

Step Three – The Type "A" Package Gauge Case

The gauge case is known as a Type "A" Package. The gauge must be transported in this case. You cannot transport a gauge in a self-made box or crate. All Type "A" Packages/Cases must pass a series of tests that ensure their integrity. These tests include water spray testing, free drop testing, a stacking test and a penetration test.

Each manufacturer uses their own unique Type "A" Package. You can download a copy of the Type "A" Package document from the manufacturer website or contact them for a copy. The documentation must be kept on file up to three years after the last shipment.

Overpack

If you use an overpack (a cardboard carton to ship the gauge and case in) you must also place two Yellow II Radioactive and two Air Cargo Only labels on the broadsides. You must also mark the carton as an "Overpack".

Package Inspection

The gauge and the case must be inspected before it is signed out of storage. Make sure the case is not cracked or damaged in any way, including hinges and hasps, make sure

that all labels and markings are affixed and legible, and make sure the release mechanism on the gauge handle and the case is locked.

Step Four – Your Commitment

Before you leave with the gauge you must remember your role in protecting yourself and the general public from any unnecessary exposure to radiation.

ALARA Philosophy

The concepts of ALARA; protecting yourself from radiation exposure through time, distance and shielding, are of upmost importance during the transport of the gauge. All employees should be thoroughly trained in HAZMAT safety regulations. A copy of the company Radiation Safety Program should be enclosed with every gauge and in the driver's area that includes a list of emergency contact telephone numbers (RSO work, cell & home, National and/or State Emergency numbers, and Law Enforcement and Medical numbers). The RSO should perform training drills with all gauge users to ensure that they are familiar with emergency actions.

Constant Surveillance

You are primarily in charge of keeping the gauge out of harm's way and for keeping unauthorized individuals away from the gauge. The gauge is most vulnerable when it is away from the storage area.

Step Five – Preparing the vehicle

Before you secure the gauge in a vehicle you should have all necessary restraints in place. The gauge must be secured inside the vehicle with two independent controls. A gauge must be secured, blocked and braced in a storage area of a vehicle. The gauge

cannot be transported in an area of the vehicle that has passengers. A cable tie or other form of tamper evident seal can be used to confirm that no one has tampered with the gauge during transport. Examples of proper storage for different types of vehicles include:

a) Typical passenger automobile – The gauge must be secured in the trunk. The first independent control would be the trunk lock. The second independent control would be a locked chain or cable securing the gauge case to the body of the vehicle inside the trunk. You cannot transport a gauge in the seat beside or behind you.
b) Van, SUV or station wagon – The gauge must be secured in the rear most part of the vehicle, behind the rear most passenger seating. The vehicle's door locks would act as the first level of control. An additional locked chain or cable attached to the gauge and inside body of the vehicle would act as the second. Make sure to block and brace the gauge to ensure no movement inside the vehicle. Conceal the case with a blanket or cover.
c) Pick-up truck – The gauge can be secured inside a large tool chest with two locks on the exterior of the chest. The chest itself must be double-secured (locked) to the body of the vehicle. If you do not use a tool chest (or similar) you must use two locked deterrents to attached the gauge case to the body of the vehicle as well as two locked deterrents that prevent anyone from opening the gauge case, such as two locked latches on the outside of the case or one locked latch along with one locked cable wrapped around and overtop the case that likewise prevents opening the case. The gauge should be blocked and braced to prevent shifting or bouncing and be concealed with a blanket or tarp.

Step Six – Be Nice to the Gauge

Gauges are heavy and seem very solid. Gauge cases also seem to be solidly constructed. But both will break and both are expensive.

Gauges can cost as much as a small car. There is a lot of precision and balance built into a gauge. Banging a gauge around, be it inside or outside the case, will destroy that precision and balance, resulting in repair costs that can run into the thousands of dollars. All gauges come with a drill rod that is used to create a hole for the source rod. **The source rod is not a substitute for a drill rod**. Hitting it with a hammer will bend or break it, which not only leads to a costly repair bill but also results in an incident that must be reported to the regulatory agency.

A gauge inside a case makes for a very heavy and awkward package. Grabbing the handle on the side of the case and dragging the package it to its destination is an easy way to save your back but also an easy way to wear a hole into the base of the case. A hole or crack in a case violates the Type "A" Package designation and cannot be used

to transport a gauge. New cases can cost $400.00+. Use a cart to move the gauge to and from the vehicle.

Gauges are not waterproof. Do not leave them out in the rain or set them in puddles of water. Likewise, internal condensation can have the same effects as rain. The electronics in the gauge will fry if exposed to moisture. The temperature changes a gauge is exposed to can cause condensation. Take steps to “air out” the inside of the gauge. Many gauges have vent ports that can help reduce condensation. You can also unscrew the keyboard and leave it ajar while the gauge is in storage. This will help to air out the gauge.

Make sure storage areas are not subject to flooding. Place gauges on pallets or shelves.

Do not let gauges “cook” on a hot asphalt mat. When testing on asphalt never allow the gauge to sit on the mat beyond the test period. The hot temperature can overheat the electronics in the gauge and distort the readings. Some users have resorted to using ice to cool down the gauge but this can also subject the gauge to condensation.

Step Seven – Are you wearing your Personnel Dosimetry Device?

Don’t leave the office without it. You can’t transport or operate a gauge if you’re not wearing your film badge or TLD. And you can’t borrow one from someone else.

Dosimeters should be stored along with the control badge, which should be located in a radiation free area at the office.

Step Eight - Security while in Transport, at the Jobsite, Temporary Storage, and the Vehicle

Security concerns regarding gauges are at an all time high and therefore awareness of security risks are a training priority. Because gauges are portable they are more vulnerable to theft and damage. RSO's must teach their employees to recognize and respond to security threats.

It is very rare that a thief is targeting the gauge itself. More often the vehicle is the target. That is why regulatory agencies frown on the idea of using the vehicle as a temporary storage area. However, if you must leave the gauge in the vehicle you need to take extra measures in securing your vehicle. Use vehicle alarm systems, steering wheel locks, GPS tracking (Lo-Jack), and other anti-theft methods.

Always park the vehicle in well lit areas and, if possible, behind gated access. If you stop at rest areas and have other workers with you, take turns using the facility. If you stop at a restaurant always keep the vehicle in sight (sit at a window).

Thieves target anything they believe has value. To a thief a gauge case looks like any other tool chest or power-tool box. They're usually in a hurry and they don't stop to read the labels and stickers on the case. It is only later that the thief discovers he has a device with radioactive materials. At that point they are only interested in getting rid of the gauge as fast as they can. That's why they're often found in ditches, fields and rivers.

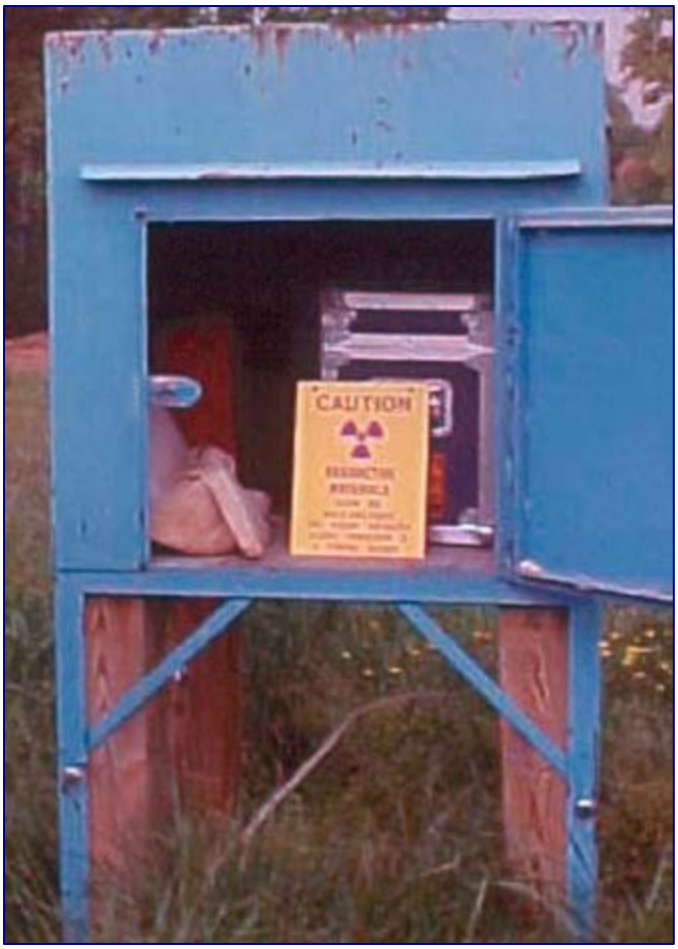
But that still leaves an unsecured radioactive device. APNGA recommends leaving information on and in the case that can be viewed by the thief asking them to leave the gauge in the vehicle or anonymously notify the gauge owner or authorities as to its location. It may not work but it gives them an out. Some companies have offered a reward for the return of the gauge.

Step Nine – Gauges at the Worksite/Constant Surveillance

Always keep constant surveillance on the gauge while taking tests. Only remove the gauge from the vehicle when you are in the act of taking a test. When the test is finished immediately return it and secure it in the vehicle. Do not chain it to a telephone pole or some other location that can be accessed by unauthorized individuals.

While a test is in progress many gauge users mark the location of the gauge with a flag attached at the end of a flexible whip pole. These flags are easily viewable by operators of heavy construction equipment. Poles and flags can be purchased at most bicycle shops.

Step Ten – Temporary Storage and the Vehicle



Once the day is done and you're on your way back make sure to keep all transport security and control requirements in place. If you are staying in the area and putting the gauge in an authorized temporary storage area make sure that area meets the same requirements of the permanent storage area.

Where permitted, and absolutely necessary, you can use the vehicle as a temporary storage area. The gauge cannot be brought into a hotel or motel, nor can it be stored in a home, garage or local shed or storage area that is not pre-authorized. Take every means reasonably available to provide the ultimate security for a vehicle that is storing a gauge.

Step Eleven - Returning the Gauge to the Company Storage Area

Upon return to the permanent storage area make sure to sign the gauge back in. Check to make sure the gauge and case are not damaged and that the sliding block is fully closed. If you suspect that the gauge needs service notify the individual authorized to perform gauge maintenance. Remember to charge the gauge batteries while the gauge is in storage.

Reciprocity

Taking Your Gauge into Another State

Reciprocity is another name for requesting and receiving permission from another state's regulatory agency to enter and use your gauge in that state. Your license allows you to use your gauge in your state, and, as long as you receive permission, in any other state.

You spent a lot of time and effort – and money – to let your state know all there is to know about you and your company. Other states do not have that information. But they are willing to honor a valid license from your state without putting you through the complete license application process again. Reciprocity is in essence a short term license from another state. And the fee for reciprocity usually matches the fee to obtain a license in that state. Reciprocity usually limits the amount of time you are permitted to use the gauge in another state, usually 30-365 days. If you will be conducting business on a longer term basis in another state you will be required to obtain a full-time license in that state as well.

If you do anticipate a long term job in another state you may be better off to go ahead and obtain a license in that state. You don't want to put yourself in a position where you pay a reciprocity fee only to end up paying a license fee six months into the job.

If you have a license in an Agreement State and you are looking to do business on a U.S. Government installation you will need to check whether you need reciprocity from the NRC. The NRC maintains regulatory authority over most military installations as well as many other U.S. Government sites.

NRC licensees are not required to obtain reciprocity from another NRC state.

You do not need reciprocity to pass through a state on your way to the state for which you have acquired reciprocity. Make sure you do not use the gauge or overnight in a state for which you do not have reciprocity.

The typical requirements of reciprocity are as follows – you will want to check with the given state for their exact requirements – see the "View My State" listings for contact and requirement information. For your initial visit to another state you will need to provide information to that state. Be prepared with the following:

A copy of your Radioactive Materials License

A copy of the your operating & emergency procedures

Gauge manufacturer and model, radionuclides, source models, and activity.

Current leak test reports

Reciprocity Fee

Name of company for who service will be performed

Name and contact information of individual representing that company

Exact temporary address and storage where you will be using the gauge

Starting date

Duration of service

Type of service to be performed

Name of individuals using the gauge, ID’s and training certificates

Local address (Hotel name, address, phone) of individuals responsible for the gauge

A 3+ day written notification of your intent to bring the gauge into the state

Every time you bring the gauge in and out of the state you will need to notify the agency. You’d be better off establishing a temporary storage site if the job is of any duration. You will also want to have contingency plans in place in the event you need to quickly supply a gauge to the site. For example, the gauge you have on site dies and you need another gauge ASAP. Call the agency, explain the situation and expedite a new reciprocity request. Have agency contact information on hand.

You will want to keep your reciprocity records on file. APNGA recommends keeping them for 3 years.

Disposal/Transfer

A requirement of obtaining a license is for you to know how you are going to dispose of your gauge when you are done using it. It could be the gauge is too old and no longer worth upgrading or maintaining it, or the job for which you obtained the gauge has ended. The important factor is that you know you can't just throw the gauge in a dumpster or scrap yard.

It must be properly disposed or transferred and you must be aware of options available to you before are granted a license. Your agency is going to have very specific requirements as to your knowledge of disposal options. Many independent disposal options can be very expensive. Try and stick with options within the moisture density gauge market – manufacturers, service providers and other properly licensed gauge users.

You cannot loan, lease, rent or release your gauge to any party, including service/repair personnel, without proper transfer documents. If their license does have your license type listed you cannot let them touch your gauge. If they do not have a copy of their license they cannot touch your gauge. Likewise, they cannot work under your license. You must escort and oversee their presence at all times.

You cannot transfer for any reason, be it disposal, sale or service, unless you have first determined that the receiving party is authorized to accept this specific radioactive material. You should view a copy of their license, specifically parts designating the type of gauge/model and quantities they are licensed for. Also make sure their license has not expired.

Never lend your gauge to another party without proper transfer documentation and license verification.

One option is to have the manufacturer dispose of the gauge for you. Sometimes there is a fee but you may find that the manufacturer is willing to accept the gauge at no charge and, if you're in the market to buy a new gauge, might even give a discount on

the new gauge. In some cases the manufacturer or service provider may even buy the gauge from you. If the gauge is still functional, in relatively good shape and not too old you might be able to recoup some money. Shop around.

You can also sell your gauge to another user. It is perfectly legal to sell your gauge to another properly licensed user. You will want to check with your agency as to what restrictions there may be. Some agencies charge extra fees to companies that are in the business of selling gauges. If they do allow you to sell your gauge you will want to check with the buyer's agency to make sure the buyer is qualified to make the purchase.

Regardless of where the gauge goes you will want to have clear transfer records. Obtain a bill of sale, a copy of the transferee's license, make sure you have a current leak test on the gauge and make sure you amend your inventory. If you are getting out of the gauge business and are looking to decommission your license make sure you follow your agency's requirements for decommissioning. This usually requires advance notice – you don't want to wait until you are too close to your license renewal anniversary date – you may end up paying for an additional year. Keep good, solid records of any transfers. Notify your agency of any transfers and/or disposals.

View an example of a transfer sheet in the appendices/attachments.

Decommissioning – Terminating Your License

When you have made the decision to transfer or dispose of all of your gauges and terminate your license you must give advance notice, usually 60 days or more, to your regulatory agency. Failure to give adequate notice may cost you an additional annual license fee.

Depending on the number of gauges you owned and any incidents of leakage, you may have to conduct a decommissioning radiation survey of the areas where gauges were stored. Obtain from your regulatory agency the required regulations and decommissioning form, also known as a "Certificate of Disposition of Materials".

Maintain a copy of all decommissioning documents, including final surveys and transfer/disposal records for all gauges. If moving, leave forwarding contact information.

An copy of the NRC's decommissioning form (Form 314) can be found in the appendices/attachments or at:

http://www.nrc.gov/reading-rm/doc-collections/forms/nrc314.pdf

Call your Agreement State or go to the "View My State" listings on the homepage to access their decommissioning documents.

Inspections and Violations

Inspections are an important process in the regulatory agency's oversight of your license. The agency conducts inspections to ensure that licensees are meeting regulatory requirements. When you meet the requirements of your license the agency knows that you are doing your part in protecting your workers, the public and the environment from undue radiation risks.

If the inspection indicates that a licensee is not safely conducting an activity or safely overseeing a facility, the inspector will inform the licensee of any problems that they find and ensure that they are addressed. The agency will continue to inspect that activity or facility until the problems are corrected. Continued violations can lead to fines, typically beginning at $3,250.00.

Your agency has a schedule for inspecting licensees. A clean slate can sometimes lead to longer intervals between inspections whereas continued infractions can lead to more frequent inspections.

Inspections may be prearranged or surprise drop-ins. You must be agreeable to a reasonable time to allow the inspection.

Your agency has a comprehensive program that guides them through the inspection process. Generally, inspectors verify that the organizational structure, operator qualifications, storage design, gauge maintenance, gauge handling, and environmental and radiation protection programs are adequate and that they comply with agency safety requirements. These inspections also cover areas such as personnel training, company radiation protection programs, dosimetry records, and security of gauges.

You can think of a regulatory inspection as an official annual audit. If you are conducting solid and successful internal annual audits you should do well during an inspection.

A good first step is to have complete and accurate recordkeeping. But make no mistake, the inspection is an interactive event. The inspector will review training records and utilization logs to determine which employees have been using gauges. They may then question employees to determine their knowledge of operating and emergency procedures. They may ride along with an employee to visually determine their understanding of the Radiation Safety Program.

The following represents a sample manual, similar to a playbook, used to inspect your premises:

Inspection Objectives:

To determine if licensed activities are being conducted in a manner that will protect the health and safety of workers and the general public.

To determine if licensed activities are being conducted in accordance with the regulatory agency requirements.

Inspection Requirements:

The review of the licensed activities will be commensurate with the scope of the licensee's program. The inspector's evaluation of a licensee's program will be based on direct observation of work activities, interviews with workers, demonstrations by workers performing tasks regulated by the agency, and independent measurements of radiation conditions at the facility, rather than exclusive reliance on a review of records.

The inspector should determine if the licensee possesses gauges as authorized by a specific license. If so, the inspector should assess the adequacy of the licensee's program for management and oversight of the specific licensed gauges.

The structure and the emphasis of the inspection will be on the following Focus Elements that describe the outcomes of an effective portable nuclear gauge radiation safety program:

Focus Elements

a. The licensee should control access to and prevent loss of licensed gauges so as to limit radiation exposure to workers and members of the public.
b. The licensee should maintain shielding of gauges in a manner consistent with operating procedures and design and performance criteria for devices and equipment.
c. The licensee should implement comprehensive safety measures to limit other hazards from compromising the safe use and storage of gauges.
d. The licensee should implement a radiation dosimetry program to accurately measure and record radiation doses received by workers or members of the general public as a result of licensed operations.

e. The licensee should provide radiation instrumentation in sufficient number, condition, and location to accurately monitor radiation levels in areas where gauges are used and stored.
f. The licensee should ensure that workers are:
    1. Knowledgeable of radiation uses and safety practices
    2. Skilled in radiation safety practices under normal and accident conditions
    3. Empowered to implement the radiation safety program
g. The licensee's management system should be appropriate for the scope of use and should ensure:
    1. Awareness of the radiation protection program
    2. That audits for ALARA practices are performed
    3. That assessments of past performance, present conditions and future needs are performed and that appropriate action is taken when needed

In reviewing the licensee's performance the inspector should cover the period from the last to current inspection. However, older issues preceding the last inspection should be reviewed, if warranted by circumstances, such as incidents, noncompliance, or high radiation exposures.

The NRC's inspection guides can be viewed at the nrc.gov website (Most Agreement States also have guides – Go to the "View My State" listings to access their websites for their versions).

The inspection guide used by the NRC can be viewed in the appendices/attachments.

Fines for violations typically begin at $3,250.00. The following are examples of actual violations:

- A current copy of the regulations is not available to radioactive material users
- A current copy of the Materials License is not available to radioactive material users
- Operating & Emergency procedures are not available to radioactive material users
- The "Notice to Employees" form is not posted or not readily visible to all gauge users
- Gauges were not adequately secured from unauthorized removal or access by unauthorized individuals
- A daily utilization log to track where, when, and by who gauges are being used is not in use.
- Radioactive Material Storage areas are not posted with "Caution: Radioactive Material" signs
- Sources or cases of gauges are not labeled with radioactive material labels

- Radioactive Material source or container labels do not contain the required information (radiation symbol, nuclide, activity, assay date, etc.)
- Radiation Areas were not posted with "Caution: Radiation Area" signs
- A documented Radiation Protection Program was not available for inspection
- The Radiation Protection Program does not appear to be complete or is not adequate to ensure compliance with the rules
- Annual program audits are either not performed or not documented
- The Radiation Protection Program does not adequately address the ALARA philosophy of keeping doses as low as reasonably achievable
- Inventories were not performed at the required frequency
- Inventory records do not contain the required information
- Leak tests were not performed at the required frequency
- Leak tests are not being performed in accordance with license application or rules
- Leak test records do not contain the required information
- Written procedures for receipt and opening of packages containing gauges were not readily available, or not being used
- Damaged packages were not surveyed for contamination or radiation level, or provisions to perform surveys are not in place
- Packages containing Type A quantities of radioactive material were not surveyed for radiation levels
- Package receipt surveys are not properly documented or records were unavailable
- Gauges were improperly transferred to another licensee
- Gauges were improperly transferred between branch offices of the licensee
- Radiation workers were not monitored for radiation dose
- Individuals who were monitored for radiation dose were not provided with an annual written record of their radiation dose
- Records of individual dose monitoring were not available or not complete
- Dose monitoring reports were either not reviewed or reviewer failed to take action on abnormal readings (ALARA concern)
- Individuals were allowed to use gauges without receiving adequate training

- Individuals working with gauges were not receiving annual refresher training
- Individuals were working with gauges without prior approval of the RSO
- Support staff were not trained in applicable radiation safety issues
- Training records were either not complete or not available
- Shipping papers were not complete or not in use
- Emergency response information did not accompany the shipping papers
- An emergency response phone number (monitored at all times during transit) was not available in the shipping papers
- Shipping papers are not readily available to, and recognizable by, authorities in the event of an accident or inspection
- Labels and/or markings on shipping containers were either missing or incomplete
- Packages containing radioactive material were not blocked and braced during transportation
- Individuals have not received hazmat or Department of Transportation training within the last 3 years
- Special form certificates and Type A package test documents were not on file
- Transportation requirements for Type A packages were not met
- Transportation requirements for use of an overpack were not met
- Radiation worker did not have an adequate understanding of the operating procedures
- Radiation worker did not have an adequate understanding of the emergency procedures
- Radiation worker did not have an adequate understanding of the licensee's ALARA program
- Radiation worker did not have an adequate understanding of the annual dose limits
- Radiation worker did not have an adequate understanding of survey meter use and operation
- Radiation worker did not have an adequate understanding of package receipt procedures
- Radiation worker did not have an adequate understanding of transportation procedures

Portable Nuclear Gauges in the Age of Terrorism

The following excerpts from an article by the NRC discusses and describes a dirty bomb. It is important to note that there has never been a dirty bomb devised or exploded using sources from portable nuclear gauges, nor has there been a radioactive dirty bomb of any kind ever exploded in the history of the planet.

Unfortunately, gauges are inadvertently the #1 stolen radioactive device in the country. The target of the thief is usually the vehicle the gauge is stored in or what they believe is a power tool. But the incidents are reported and overzealously covered by the media. The politicians hear about it and put pressure on the regulatory agencies. Guess who the regulatory agencies are going to crack down on?

Collectively, gauge licensees must do everything possible to reduce the number of thefts and damaged gauges. Strict adherence to safety and security regulations are the best ways to meet this goal. Remember these key requirements:

1) Use double locks on storage areas and vehicles.
2) Use vehicle alarms and steering wheel locks.
3) Use Lo-Jack type devices.
4) Keep gauges blocked, braced and concealed.
5) Maintain constant surveillance on gauges while out of storage.
6) **Do everything possible to keep from storing gauges in vehicles overnight**.

Dirty Bombs

In order to better inform the public on what a dirty bomb is and what terrorists might intend to try to accomplish in setting off such a weapon, the following information is provided. Given the scores of exercises–federal, state and local–being staged to assure that all emergency response organizations are properly equipped, trained and exercised to respond to terrorist chemical, biological or radiological attack, we believe members of the public, as well as news organizations, will value some concise, straightforward information.

Basically, the principal type of dirty bomb, or Radiological Dispersal Device (RDD), combines a conventional explosive, such as dynamite, with radioactive material. In most instances, the conventional explosive itself would have more immediate lethality than the radioactive material. At the levels created by most probable sources, not enough radiation would be present in a dirty bomb to kill people or cause severe illness. For example, most radioactive material employed in hospitals for diagnosis or treatment of cancer is sufficiently benign that about 100,000 patients a day are released with this material in their bodies.

However, certain other radioactive materials, dispersed in the air, could contaminate up to several city blocks, creating fear and possibly panic and requiring potentially costly cleanup. Prompt, accurate, non-emotional public information might prevent the panic sought by terrorists.

A second type of RDD might involve a powerful radioactive source hidden in a public place, such as a trash receptacle in a busy train or subway station, where people passing close to the source might get a significant dose of radiation.

A dirty bomb is in no way similar to a nuclear weapon. The presumed purpose of its use would be therefore not as a Weapon of Mass Destruction but rather as a Weapon of Mass Disruption.

Impact of a Dirty Bomb

The extent of local contamination would depend on a number of factors, including the size of the explosive, the amount and type of radioactive material used, and weather conditions. Prompt determination of the kind of radioactive material employed would greatly assist local authorities in advising the community on protective measures, such as quickly leaving the immediate area, or going inside until being further advised. Subsequent decontamination of the affected area could involve considerable time and expense.

Sources of Radioactive Material

Radioactive materials are widely used at hospitals, research facilities, industrial and construction sites. These radioactive materials are used for such purposes as in diagnosing and treating illnesses, sterilizing equipment, and inspecting welding seams. For example, the Nuclear Regulatory Commission, together with 35 states which regulate radioactive material, have over 22,000 organizations licensed to use such materials. The vast majority of these sources are not useful for constructing an RDD.

Control of Radioactive Material

NRC and state regulations require licensees to secure radioactive material from theft and unauthorized access. These measures have been stiffened since the attacks of September 11, 2001. Licensees must promptly report lost or stolen material. Local authorities make a determined effort to find and retrieve such sources. Most reports of lost or stolen material involve small or short-lived radioactive sources not useful for an RDD.

Past experience suggests there has not been a pattern of collecting such sources for the purpose of assembling a dirty bomb. Only one high-risk radioactive source has not been recovered in the last five years in the United States. However, this source (Iridium-192) would no longer be considered a high-risk source because much of the radioactivity has decayed away since it was reported stolen in 1999. In fact, the

combined total of all unrecovered sources over a 5-year time span would barely reach the threshold for one high-risk radioactive source. Unfortunately, the same cannot be said world-wide. The U.S. Government is working to strengthen controls on high-risk radioactive sources both at home and abroad.

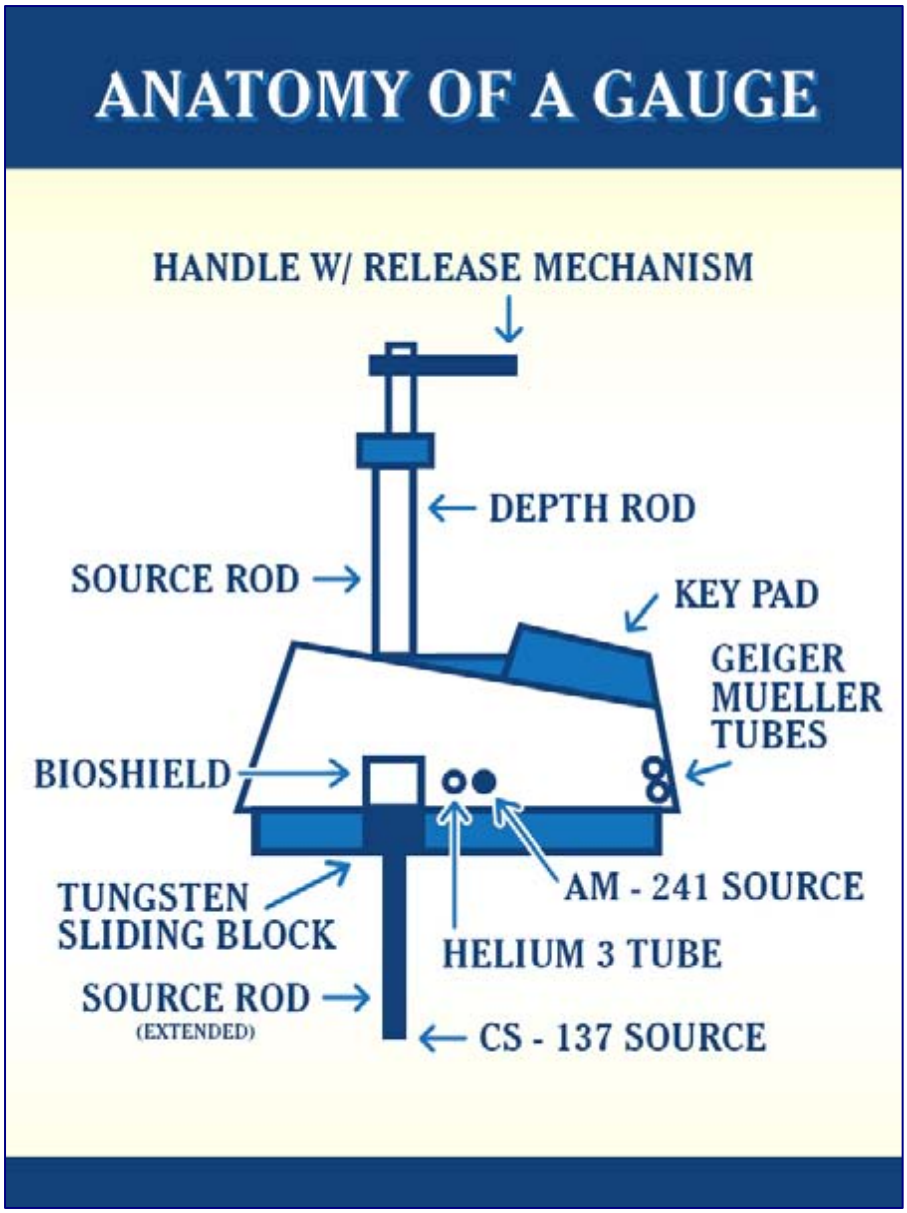
Gauge Operation

There are currently 5 gauge manufacturers; CPN (recently purchased by InstroTek), Humboldt, InstroTek, Seaman and Troxler, which collectively have more than 20 different gauge models that measure soil, asphalt and concrete density and soil and rooftop moisture. Mechanically, all soils and asphalt moisture density gauges work the same. The gauges have a source rod that lowers into the ground to measure wet density and another stationary source contained in the base of the gauge that measures moisture.

Hands-on training provided by the RSO or senior gauge operator is a very important requirement for new gauge workers. There is no practical way to cover the different software functions of all the different models in a training class or internet setting. If a gauge is in use in a live class, and even if you had time to do so, it represents only one of the 20+ gauges on the market. It would take most of the day to give each attendee the opportunity to get hands-on with the gauge. Even then, most attendees would be viewing a gauge that is not in use at their company. For that reason, along with time constraints and expensive reciprocity fees, most live class instructors have abandoned the use of gauges in the class setting.

Powerpoint presentations showing cutaway views of a generic gauge are a far more safe and effective way of showing the safety features and “anatomy” of a gauge. Back at the company, the RSO should ensure that the worker is given hands-on field familiarity of the gauges in use by the company. Other effective teaching tools are the gauge application materials available at most manufacturer websites.

The Gauge



The radioactive source that measures density is located at the base of the source rod. The actual radioactive material is fused into a dry pellet about the size of a pebble. The pellet is encapsulated in two laser fused metal cells that in essence create a solid piece

of material that is virtually impenetrable. This double encapsulated cell is secured in another metal capsule that forms the bottom of the source rod. Geiger Mueller tubes embedded in the base at the other end of the gauge detect the gamma radiation that is emitted from the radioactive pellet and passes through the material under the gauge (A Seaman gauge reverses the positions of the emitter and detector).

In its normal retracted position inside the gauge base, the source rod is shielded by a spring loaded tungsten sliding block. Tungsten is a denser and heavier metal that provides far more shielding and fire protection than lead.

It is only when the trigger at the top of the source rod is recessed that the source rod is released from the gauge housing. When released, the source rod gives off just enough radiation to measure density. In practice, the gauge user should never see the exposed source rod. Proper methods of gauge measurements will be discussed in this chapter.

Remember that radiation is **always** being emitted from the gauge.

Standard Counts

Standard counts provide a quick reference check to ensure that your gauge is operating correctly. One of the accessories you receive with a gauge is a standard block, typically a rectangular block of plastic material. Set your gauge on the block and take a standard

count. It will measure the number of counts received from the density and moisture sources. The results should be very close to previous standard counts, typically 1% for density and 2% for moisture. Standard counts should be taken every day you use the gauge. Additional tests should be taken whenever you are test a different material. Check the gauge manual for manufacturer recommendations.

Always record the results for use and comparison to future counts.

A few preparatory steps should be taken before the standard count:

a) Make sure the base of the gauge and the top of the standard block are clean.

b) Most standard blocks have a small metal butt plate that rises above the surface of the block. The gauge should be placed on the block with the source rod at the opposite end of the butt plate. Make sure to slide the gauge towards and up against the butt plate.

c) The source rod stays in the safe position when taking the test.

d) Make sure there are no other gauges within 30 feet.

e) Make sure to take the test in an area away from any large vertical objects including walls, vehicles and people.

f) Take the test on the material where you will be performing the density tests.

g) The material under the standard block should be at least 100pcf (no tailgates).

h) Turn the gauge on and let it warm up for 10 minutes.

Put the gauge in the standard count mode and take the test. If the test passes, record the results. One reason for a failure is the time increment between standard counts. If the last count has been longer than 60 days you may need to re-establish the previous standard count average that is used to compare to today's count. This can be done by taking three more tests and averaging these most recent results to establish a new count average.

Gauge Data Entry

When taking a test the gauge measures the amount of radiation detected over a predetermined timeframe, such as one minute. The detector tubes count the radiation that is able to pass through the material between the bottom of the source rod and the detector tubes. The denser the material, the lower the amount of radiation that is able to reach the detector tubes to be counted. The gauge converts these counts into a wet density reading. It is referred to as wet density because the material under the gauge has natural moisture contained in its physical form.

The wet density is compared to a lab standard, typically the proctor test. But the gauge's field wet density reading is not an apples-to-apples comparison to the lab's proctor test. You need to compensate for the moisture in the gauge's field reading. That's where the moisture count comes in.

The other radioactive source, Americium 241, embedded in the base of the gauge, measures moisture at the same time the gauge is measuring wet density. The gauge software then automatically adjusts the readings to match the proctor test.

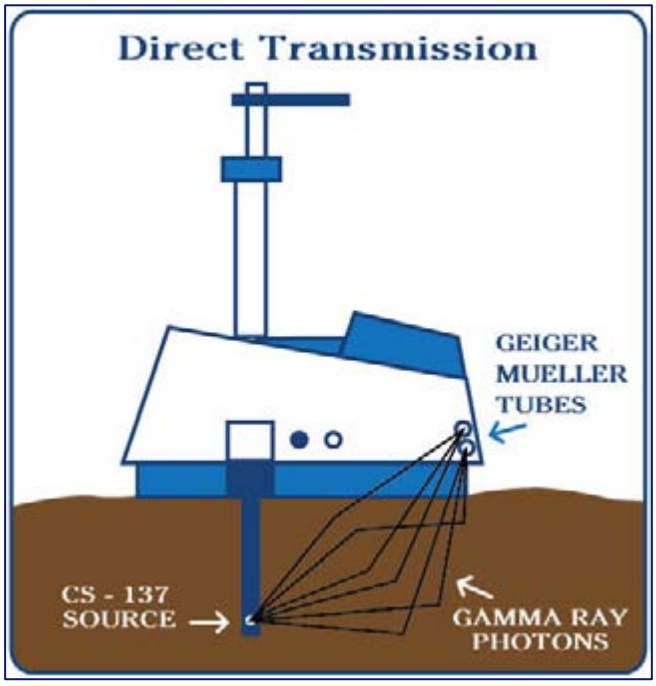
When taking asphalt density readings the moisture content readings are of no consequence. Asphalt readings are compared to lab tests such as Marshall Hammer or Rice.

The results from the proctor (the test used to determine ultimate density for soils) and the test used to determine ultimate density in asphalt (usually the Marshall Hammer or Rice test) are used as **target numbers** for the gauge. These numbers should be entered into the gauge and used to compare subsequent tests in the field. The field result should be divided by the lab target value to determine percent of ultimate density achieved. The remaining percentage is moisture for soils and air for asphalt.

The proctor test involves compacting the soil into a mold using a force at different levels of moisture content. The maximum dry density and optimum moisture content are determined from the results. Field soils are tested for in-place dry density and the result is divided by the maximum dry density (from the proctor test) to obtain a relative compaction for the soil in place.

Compaction

Buildings and roads are only as good as the foundations you build them upon. Hills have to be flattened and valleys have to be filled. Ideally, you can use the material removed from the hill to fill in the valley. But you must use heavy rolling equipment to compact the soil to create a safe and sturdy foundation for the building or road. And to effectively compact the soil you typically put it down in 4 – 12 inch lifts. Compaction efforts differ depending on the types of soils you are compacting. For example, sandy soils can be easier to compact than clay soils.



The one big advantage you have in determining how well you are compacting the soil is the use of the moisture density gauge. Density measurements have proven to be an excellent indicator of the soils ability to support loads. Density is the mass per unit volume. Wet density, also known as bulk density, typically consists of the soils and moisture evident in the ground that you are compacting. Dry density consists of only the soil solids and is typical of a lab analysis. You will need to correlate the field measurement to the lab measurement and this is best done by subtracting the gauge's moisture measurement reading from the gauge's wet density reading:

Dry density = (Wet density – moisture)

Most gauges will automatically make this calculation for you.

The key to maximum density is the percentage of moisture in a given soil. The moisture acts as a bond for the soil. If it is too wet, the water will displace the denser soil particles, no bonding will occur, and you end up with mud. If it's too dry there will be increased friction and you will not achieve the desired bonding. The gauge will help you determine the desired optimum moisture content. The other key factor, pressure applied by the compaction rollers, will allow you to match up to the design criteria.

Procedures, known as standards, have been established by the American Society of Testing Materials (ASTM) for determining maximum density and optimum moisture content. AASHTO and certain states also have varying procedures.

When working with a gauge on soil it is wise to follow a few guidelines:

a. Always have as much predetermined information already entered into the gauge. If applicable, have the following information pre-loaded:
    1. Date & time
    2. Target value (Proctor)
    3. Test length (Typically one minute)
    4. Project number
    5. Offsets

b. When testing on soils always prepare the ground by using the scraper plate to smooth out any obstacles or fill in any voids. This will reduce the chance that open pockets or protruding objects impact your reading.

c. When using the drill rod always make sure to first place your drill rod removal device – this is a mistake you will probably only make once. If you encounter soils that make it very difficult to remove your drill rod you may want to purchase a fence post puller at your local hardware store. These are much cheaper than the drill rod removal devices that some manufacturers sell.

d. The dimensions of most scraper plates match the base of the gauge that they are paired with. This is a safety feature that, once the hole has been drilled, allows you to create a template for the base of the gauge. Simply etch around the base of the scraper plate before picking it up. You then place the gauge down inside of this etched area. You will find that the opening for the source rod is now positioned over the hole that you drilled. Pull or depress the gauge trigger and drop the rod into the hole. By using this method you will be able to use the gauge without ever visually seeing the source rod. This will ensure that you keep your exposure to gauge radiation to a minimum.

<u>IMPORTANT</u>: Do not extend the source rod to guide it into the hole! This exposes you and others to an unnecessary exposure of radiation.

e. Before taking a test push the gauge towards the side of the hole with the detector tubes. This ensures that there is no air gap between the source rod and the side of the hole.

f. Make sure that the source rod is well seated in the depth position notch. Any misalignment will impact the results.

g. Always practice good ALARA by returning the source to its safe position before recording your results.

h. Always practice good ALARA by maintaining your distance during the test.

i. Always practice good security by never taking your eyes off the gauge while in operation. This will prevent possible damage from heavy equipment.

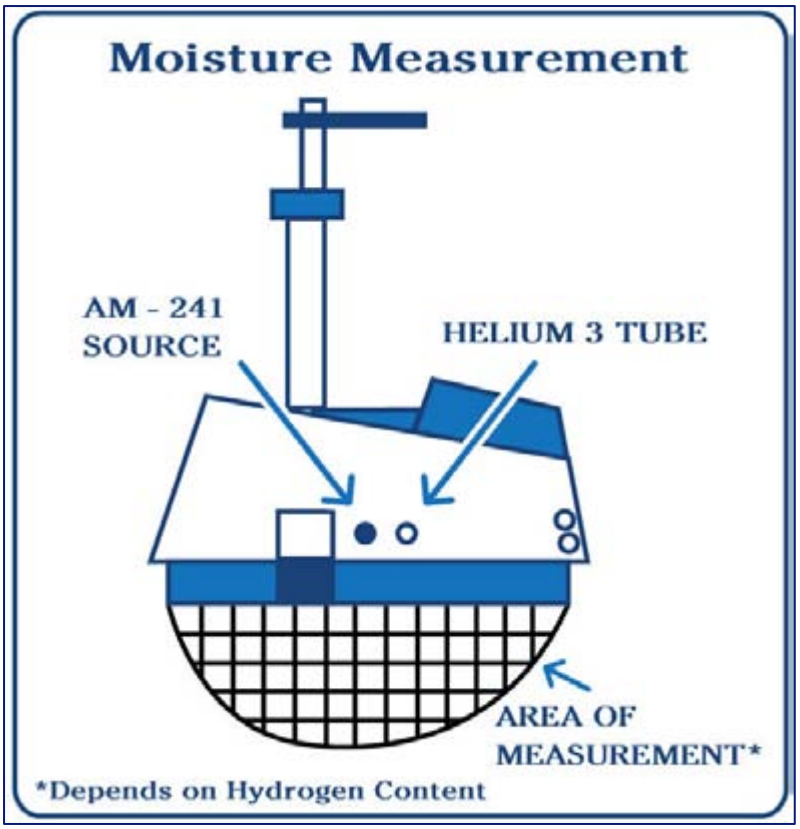
j. Never take a test while within 30 feet of another gauge.

k. Never take a test adjacent to large vertical objects, including vehicles and people.

l. After use, always return the gauge to its case and secure the case to the vehicle.

m. You can do a quality control test for your gauge by comparing your gauge readings to a sand cone test. If needed, you can do a simple offset of the gauge's result to match those of the sand cone test.

Moisture Detection



The nuclear gauge determines moisture by releasing “fast” neutrons that are slowed down, or thermalized, when they interact with the nucleus of hydrogen, a key ingredient of moisture. The Helium 3 tubes in the gauge can only detect “slow” neutrons. It is a very direct relationship, more counts = more moisture. That is why anything loaded with hydrogen acts as an excellent shield for neutron radiation. The plastic casing around the gauge acts somewhat like a radiation shield.

The gauge can generally determine the level of moisture under the gauge to a depth of 4-8 inches. This depth is controlled by the level of moisture. The higher the moisture content becomes, the shallower the depth of measurement will be.

Density Methods

There are two basic modes of using a gauge to determine density of soils or asphalt. The Direct Transmission Method is used for soils and aggregates while the Backscatter Density Method is generally used only on asphalt. The Backscatter Method will be described at the beginning of the asphalt section.

The Direct Transmission Method consists of drilling a hole in the material, lowering the source rod to a specified depth, and counting the amount of radiation that is able to pass through the material to the detector tubes.

The gamma rays pass through the material and are counted by the detector tubes, or, they are absorbed, never making it far enough to be counted.

a. The denser the material becomes under the gauge the lesser amount of gamma ray radiation there is to be counted.
b. The material becomes more compacted, and therefore more dense, with each pass of the roller.
c. You can track this densification by measuring after each pass of the roller.

Remember that radiation is present at all times and travels in all directions. The gauge is designed to detect and interpret that portion of the radiation that travels to the detector tubes. Individuals must be aware that radiation is also traveling undetected in other directions, including areas that they may be occupying. That is why you will want to maintain a distance that is safely outside of this radiation zone (10 feet is sufficient).

The gauge works by counting the radiation that is received over a given period of time, usually one minute. When you push the button to take a test the gauge counts the radiation for one minute and calculates the density based on the depth of measurement. Remember, even though the test has finished, the radiation is still present.

If you are performing work for the state you will probably be required to take and pass that state’s certification program. Some regions of the country have certification programs that cover working in all states of that region.

Asphalt Compaction

The Backscatter Density Method is very similar to the Direct Density Transmission Method except that the rod is only lowered to the first notch position, also known as the backscatter notch.

a. The backscatter notch positions the bottom of the source rod just above the surface.
b. It is not necessary to drill a hole for backscatter tests.
c. Backscatter tests are usually made just for asphalt.
d. The radiation emitted from the bottom of the source rod can generally only penetrate the depth of the asphalt to a few inches before being reflected back to the detector tubes.
e. Regular backscatter measurements can be used to measure thicker lifts of asphalt.
f. Some manufacturers incorporate a thin lift mode that allows you to focus your measurement on a distinct depth of asphalt, say 1 ½ or 2 inches. The thin lift mode will aid in filtering out the density levels below the chosen depth.

The gamma rays pass through the material and are counted by the detector tubes or they are absorbed, never making it far enough to be counted.

a. The denser the material becomes under the gauge the lesser the amount of gamma ray radiation there is to be counted.
b. The material becomes more compacted, and therefore more dense, with each pass of the roller.
c. You can track this densification by measuring after each pass of the roller.

Remember that radiation is present at all times and travels in all directions. The gauge is designed to detect and interpret that portion of the radiation that travels to the detector tubes. Individuals must be aware that radiation is also traveling undetected in other directions, including areas that they may be occupying. That is why you will want to maintain a distance that is safely outside of this radiation zone.

The gauge works by counting the radiation that is received over a given period of time, generally one minute. So when you push the button to take a test the gauge counts the radiation for one minute and calculates the density based on the depth of measurement. Remember, even though the test has finished, the radiation is still present.

In a general sense, compacting asphalt is not all that different than compacting soil. You are moving new material to a given surface and then compacting that new material. With asphalt, you just need to think of the aggregate as soil and the asphalt binder as the moisture.

Asphalt moves through the screed and is placed in a uniform nature on a surface that is being prepared as a roadway. The type of road has already been determined and the design criteria have already identified the aggregate blends and liquid bitumen. Lab tests (Marshall for percent asphalt and Rice for specific gravity) will give you the target values that should be used in the gauge. You need to compact the asphalt to a predetermined and/or specified compaction level.

For example, specifications may call for you to compact the asphalt mat to 95% of the target value (Rice Test). As you begin to roll the asphalt you will want to place the gauge on the mat and test for compaction. Every time you test you will be looking at a result based on a percentage of your lab standard (Rice Test). Keep rolling the asphalt until you achieve your desired level (95%). If it takes 5 passes you will now know that your rolling pattern is 5.

When working with a gauge on asphalt it is wise to follow a few guidelines:

1) Always have as much predetermined information already entered into the gauge. If applicable, have the following information pre-loaded:
   a) Date & time
   b) Target value (Marshall or Rice)
   c) Test length (Typically one minute)
   d) Project number
   e) Special calibrations
   f) Offsets
2) When testing on asphalt always place the gauge long-ways in the direction of the pavers. This will reduce the chance that unseen creases will impact your reading.
3) Always take 3-4 tests and average the results at each testing site. This will give a more representative indication of density.
4) If the mat has a lot of surface voids you may want to fill in the surface with fine sand or sediment. This will dampen the effects of the voids.
5) Always make sure that the source rod is well seated in the backscatter position notch. Any misalignment will impact the results.
6) Always practice good ALARA by returning the source to its safe position before recording your results.
7) Always practice good ALARA by maintain your distance during the test.
8) Always practice good security by never taking your eyes off the gauge while in operation. This will prevent possible damage from heavy equipment.
9) Never take a test while within 30 feet of another gauge.
10) Never take a test adjacent to large vertical objects, including vehicles and people.
11) After use, always return the gauge to its case and secure the case to the vehicle.
12) You can do a quality control test for your gauge by comparing your gauge readings to a core sample. If needed, you can do a simple offset of the gauge's result to match those of the core results.
13) After the test, never leave the gauge sitting on a hot asphalt mat. Doing so might "cook" the electronics.

If you are performing work for the state you will probably be required to take and pass that state's certification program. Some regions of the country have certification programs that cover working in all states of that region.

Reasons for Errors in Gauges

There may be nothing more frustrating than a gauge that isn't measuring correctly and there can be plenty of reasons for malfunctioning gauges:

a. **Environmental factors** – Environmental errors are typically out of the control of the operator.

    1. Natural hydrogen content – Some soils contain naturally bound hydrogen. The gauge views this natural bound hydrogen as moisture. The natural hydrogen may give a false low dry density reading, which in turn can lead to false low percent compaction. The Proctor procedure may likewise be fooled by the hydrogen. An additional oven dry or microwave test will be needed to recalculate the values. They can be time consuming but necessary.
    2. Bad luck of the draw – Some DOT's specify the spot, through random selection, the exact spot where a test must be performed. If a "soft" spot is selected it can give a bad representation of the overall job. But, then again, some believe that the job is only as good as its weakest spot.
    3. Trench & vertical object errors & corrections – Sometimes you're put in a spot where there is no escape from adjacent vertical walls or objects. These surfaces can reflect back the neutron radiation and give a higher moisture count than actual. You can correct for trench factors by performing a standard count on a normal surface setting and compare to a trench standard count. The difference should be subtracted from the actual trench moisture count.

b. **Operator errors** – All gauges have small degrees of errors evident in their systems. You can never achieve a perfect level of precision and accuracy because of the very slight mechanical imperfections and electronic drift. But the last thing you need is additional errors due to operator oversights. Don't compromise your readings due to these errors:

    1. Make sure the source rod is well seated in the depth notch.
    2. Make sure, once the source rod is extended into the hole, that you push the gauge and inserted rod against the side of the hole. This will eliminate any open air space between the rod and soil.
    3. Make sure the base of the gauge is sitting flush against the ground surface. Use the scraper plate to properly smooth the ground, removing any protruding objects and filling any air voids.
    4. Make sure to check for active offsets stored in your gauge.
    5. Make sure you do your standard counts every day you use the gauge.

c. **Other errors**:

    1. Don't skimp on the gauge calibration. If you want a truly calibrated gauge send it to a service center that uses a minimum of a 3 block calibration.

Lesser verification devices can only serve to increase error in your gauge. Too much is riding on the results of your gauge to allow cut-the-corner calibration devices or methods.

2. Gauges are subject to wear and tear. A good service center will check for and replace worn parts. Likewise, circuit boards, detector tubes and batteries can all impact the accuracy and precision of your gauge. These items should be checked during a gauge calibration.

Many government agencies and engineering firms will send inspectors to the job to verify specified compaction. Don't let errors in your methodology compromise your work to the point that the inspector's findings do not match specifications.

The following is an example of test methods:

Sample Test Methods for Determining Percent of Moisture and Density of Soils and Asphalt (Nuclear Method)

Scope

This method covers the procedure to be used in determining the percent of moisture and density of soil embankments, base, sub-base, and select materials, and the percent density for asphalt concrete.

Apparatus

The apparatus required shall consist of the following:

A. Portable Nuclear Moisture-Density Gauge
B. Transport case (Type "A" Package)
C. Charger
D. Reference Standard Block
E. Transport Documents (Bill of Lading)
F. Leveling Plate/Drill Rod Guide
G. Drill Rod w/extraction tool
H. Hammer (4 lbs.) used for Driving the Pin
I. Safety Glasses
J. Square-Point Shovel
K. No. 4 sieve
L. Set Balance Scales
M. Drying Apparatus
N. Miscellaneous Tools such as Mixing Pans and Spoons

Procedure

There are two different methods to determine percent density and percent moisture using the portable nuclear density gauge. The methods are direct transmission and backscatter.

The direct transmission method requires punching a hole into the surface of the material being tested and lowering the source rod to the desired depth of test. This method is used to test soil and aggregate materials. Please note that when testing soils, the backscatter position **shall not** be used as a means of acceptance for density.

In the backscatter method, the source rod is lowered to the first notch below the safe position placing the source and detectors in the same horizontal plane. No hole is required for the probe since it is flush with the bottom of the gauge. This method is used to test aggregate (sub-base and base course) and asphalt materials.

The Roller Pattern is performed first. The purpose is to determine the number of passes to be made by the roller in various combinations of static and/or vibratory rolls to achieve maximum density for that depth of material using that roller. The data collected from the gauge when properly plotted, will provide a graphical comparison of the number of roller passes necessary to produce a properly compacted product. Once completed this information is used to establish a Control Strip(s).

The Control Strip determines the target values for density that will define the acceptance criteria for the material placed and compacted using the previous determined roller pattern. The values determined by the control strip will not change until a new roller pattern is required. The Control Strip provides an accurate method of evaluating materials, which are relatively uniform and exhibit smooth surfaces.

Roller Pattern

The Roller Pattern is constructed on the same material being placed and once established, will be used for the remainder of the project. The Roller Pattern is 75 feet in length plus some additional area to accommodate the lateral positioning of the roller. The width and depth of the material depends on the projects design.

Listed below are the steps used to construct a Roller Pattern:

1. Establish an area at least 10 feet from any structure, and 33 feet from other radioactive sources (another gauge) to take standard counts. This area can be concrete, asphalt, or a well compacted soil with a minimum density of 100 lb/ft3. Do not set the gauge on truck beds, tailgates, tabletops, etc when taking a standard count. Turn the gauge on and allow it to warm up. At this time, standard counts can be taken and recorded.

Note: A standard count will be taken each day of use. If count fails, refer to the gauge

Manual of Operation and Instruction guide for further instructions.

2. To prepare a Roller Pattern, place the material on a section of roadway approx. 75 feet in length for the typical application width (an area of at least 100 yards), and at the proper loose depth before any rolling is started. (The Contractor should be allowed to place 100 feet of material prior to the 75 foot section for plant mix stabilization, adjustment, and compaction purposes, with testing to be conducted at the completion of the roller pattern.)

The compaction is to be completed uniformly and in the same manner for the remainder of the job. (It is also recommended that a 50 foot section be placed before and after the roller pattern section for positioning of the roller.)

The moisture content of aggregates should be kept as near optimum as possible throughout the rolling operation. Water must be added when needed to maintain optimum moisture. To speed up operations, select the 15-second mode on the read out panel and record the density and moisture readings. When testing the control strip and test section, select the 60 second mode for acceptance.

3. Make two (2) passes (1 pass is counted each time the roller crosses the test site) with the roller over the entire surface of the Roller Pattern. Make sure the previous passes have been completed over the entire surface before the next pass is started. When testing asphalt materials, take a nuclear test for density only, using the Backscatter Method. The above test on aggregates and asphalt materials should be made at three randomly selected points within the area to be tested.

Choose points with good surface conditions, and try to spread the 3 tests over most of the 75 foot section, making sure not to place the gauge closer than 18 inches to an unsupported edge. Be sure to mark the exact location where the gauge is placed. (If using spray paint to mark the locations, do not spray the gauge with paint.) The gauge, when in use, shall always be positioned parallel with the roadway, with the source end toward the direction of the paver.

Obtain the total and average for both moisture and density.

All further tests for the Roller Pattern must be made in the same 3 locations, with the gauge source rod pointing in the same direction as the first test. Plot the average dry density versus the number of roller passes on the graph.

4. Make additional passes with the roller over the entire surface of the Roller Pattern, and again obtain and record the 3 readings for density and moisture in the same location as the previous set of readings. Calculate the average from the readings.

Continue the rolling and testing of the section until the Roller Pattern reaches its maximum density before decreasing or the curve levels off. To be certain this is a

sufficient degree of compaction, make one additional roll over the entire surface and test again.

Note: The number of passes that are indicated do not necessarily have to be set at two (2) every time. It may be found that in some instances one pass would be sufficient between readings and, in other instances, 3 or 4 passes would be required. An accurate count of the required passes should be maintained and may vary, depending on sub-grade conditions, roller efficiency, type of materials and moisture content.

Note: When testing aggregates, upon completion of the control strip, perform a direct transmission test to validate that compaction has been obtained comparing the result to
AASHTO T-99.

Notes on determining Maximum Attainable Density with Roller Pattern/Control Strip Technique

The Control Strip shall be rolled until maximum dry density for granular materials or maximum density for asphalt materials is obtained. Materials compacted to maximum density provide a solid platform on which to construct pavement. Materials at maximum density increase pavement load carrying capacity and pavement life. Opportunities for future pavement distress will be greatly decreased.

In the interest of good construction procedure and practice, the inspector should use these guidelines to the best of his/her ability.

In brief, the change in density in a typical Roller Pattern, for example, on Aggregate Base
Material, Type I, Size 21B, may look as shown below:

Number of Passes	Change in Density, lb/ft3
4	+ 3.1
6	+ 2.1
8	+ 2.3
10	+ 0.9
11	+ 0.4

It can be seen from the above that continued rolling after 10 passes resulted in diminishing returns. This is typical for many Roller Patterns. Based on an analysis of this type, the following is recommended as a guideline for granular materials.
In the event that the increase in dry density for a Roller Pattern on granular material is less than 1 lb/ft3, one additional pass shall be required.

For asphalt base, the same guidelines as for granular materials should be used, with the exception that after the increase becomes less than 0.5 lb/ft3 per pass, one

additional pass shall be required. If the density does not increase by 1 lb/ft3 with the additional pass, rolling should be discontinued.

Occasionally, there will be instances where a decrease in density rather than a small increase will occur. This usually occurs for two reasons: a false break, where the density levels off well before maximum density is achieved, and over rolling. In this case, consideration should be given to the number of passes already made and the materials involved, making certain that the break occurring in the Roller Pattern curve is not greater than 1.5 lb/ft3.

When the break is greater than the above value, re-compact the material to the maximum dry density based on the peak of the roller pattern.

A new roller pattern should be established whenever there are multiple lifts of material or there is a change in the following:

- Source of material
- Compaction equipment
- Visual change in subsurface conditions
- Gradation or type of material
- Nuclear Density Gauge
- Test section readings are significantly above the target values by more than 8 lb/ft3
- Another Control Strip will be established.

Control Strip

To prepare a Control Strip, an additional 300 ft. of roadway is required extending from the Roller Pattern area (same spreaderbox width at the same designed depth). This area is to be rolled the same number of passes from the Roller Pattern.

In order to determine the maximum dry density of the Control Strip, 10 readings for density and moisture should be performed and recorded over the entire 300 ft. section. Calculate and enter the data. The Target Values of 98% and 95% of the average dry density can now be determined. The dry density determined from the average of the Control Strip should compare within 3 lb/ft3 of the roller pattern's maximum dry density. This applies to both aggregate and asphalt materials.

Note 1: When testing Asphalt Concrete, the gauge should be programmed to the asphalt mode.

Note 2: When testing aggregates a verification test will be performed at the completion of the control strip using the direct transmission method or other methods approved by the engineer.

Test Sections

To complete a test section, 5 readings are required. Each test section for asphalt concrete will be one quarter mile in length for the full width of the roadway or one half mile in length or half the width of the roadway. Each test section for aggregate base, sub-base, and select materials will be one half mile in length per application width. The length of test sections for shoulders will be the same as the mainline. If possible, test alternating sides.

Five (5) readings will be made on each test section for both density and moisture using the same method of test used on the Roller Pattern and Control Strip. Rolling is continued until none of the 5 readings is less than 95% of the Control Strip density, and the average of the 5 readings is equal to or greater than 98% of the Control Strip density.

This does not apply to aggregate shoulder material, which requires an average density of 95 ± 2 percentage points of the control density, with individual densities within 95 ± 5 percentage points of the control density. No other test will be required, unless specified by the engineer.

When test section readings are significantly above or below the target values by more than 8 lb/ft3, another Control Strip will be established.

When testing turn lanes, acceleration lanes, deceleration lanes, and crossovers, take 2 or 3 readings on each, whichever is needed, to complete the full test section.

Note: For sections of roadway less than 900 feet, the direct transmission method or other approved testing methods for density determinations may be used. If obvious signs of distress are observed while rolling, cease rolling and evaluate the area of distress. Such signs include cracking, shoving, etc. Structural failures will cause the gauge to give an erroneous reading indicating more compaction is needed, when actually over-compaction is causing the failure. If this situation occurs, it should be brought to the attention of the engineer.

Note: When taking tests for Asphalt Concrete only record the wet density from the gauge.

Direct Transmission Method

Establish an area at least 10 feet from any structure and 33 feet from other radioactive sources (another gauge) to take standard counts. This area can be concrete, asphalt, or a well compacted soil with a minimum density of 100 lb/ft3. Do not place the gauge on truck beds, tailgates, tabletops, etc when taking a standard count.

Turn the gauge on and let it warm up (10 minutes). At this time, standard counts can be taken and recorded.

When testing soil, level off an area with the scraper plate. The surface of this area should be as smooth as possible. Care should be taken not to additionally compact the surface during its preparation.

All density tests on embankments and sub-grade will be tested using the direct transmission
method.

Place the guide plate on the surface. Make a hole in the material with the drill rod, using the guide plate to be sure the hole is straight and vertical.

Extend the rod to the desired depth of test making sure the device is sitting flush on the surface and the rod is pulled back tight against the back side of the hole. Take a one-minute count in this position.

When the test is complete record the results.

If the material tested is represented by a predetermined proctor test the dry unit weight should be entered into the gauge as a target value. This allows the gauge to calculate the percentage of compaction.

When it is apparent that the material being placed is different from the material that is described, such as color, texture, rock size, etc., another proctor may need to be performed.

In the event the material contains appreciable amounts of material retained on the No. 4 sieve a correction shall be performed to determine the correct Proctor Density.

If the material being placed is determined to be “rock fill” make an entry showing location and elevation of rock.

Aggregate material shall be compared to the theoretical maximum density. The density shall conform to the following:

% Retained on No. 4 Sieve	Minimum % Density
0-50	95
51–60	90
61-70	85

Note: Percentages of material will be reported to the nearest whole number. The requirements for percent density referenced above apply only to the direct transmission method for aggregate.

Background Calculations for Trench and Sidewall Moisture Testing

When a gauge is operated within 24 inches of a vertical structure, the density and moisture counts will be influenced by the structure.

Due to the hydrogen-bearing materials in trench walls, on occasion, a higher moisture reading will be observed when testing backfill materials around pipe, culverts, abutments, etc. It is necessary, therefore, to determine the “background” effect and apply this correction to the observed moisture count readings. The background correction count should be determined each day of testing and when trench wall conditions (distance from wall, moisture content,
material composition, etc.) vary.

Moisture in certain soil properties containing high amounts of hydrogen rich compounds such as ash, mica, organics, cement, boron and cadmium, will give inaccurate readings and as a result a moisture offset should be performed. The moisture offset should be a minus for ash, mica, organics and cement and a plus for boron and cadmium. Other alternative methods to determine moisture content are the speedy moisture tester and hotplate method.

The procedure to determine the background effect and apply the necessary correction is as follows:

Take a standard count with the gauge on the standard block outside the trench and record these values.

Place the gauge on the standard block inside the trench in the testing area and select trench offset. The density and moisture trench offset constants will be calculated and stored. Always disable the offset when the gauge is not being used for trench measurements.

Gauge Maintenance

The typical portable nuclear gauge license **does not allow you** to perform extensive service and repair to your gauges. Just because you are proficient at electronics or mechanical assembly and you are able to obtain parts, you are expressly forbidden to disassemble a gauge, specifically the source rod. You have to obtain a special license to do so. The additional license carries many extra regulations and requirements.

Keeping Bottom Plates and Sliding Blocks Clean

Don't wait for the source rod in the gauge to become so clogged that it fails to automatically retract when lifted by the handle. An exposed source rod is a violation of your license and fails the ALARA principle.

As in the case with most high quality test equipment, moisture density gauges will provide many years of dependable service provided proper maintenance is performed on a periodic basis. An important component (of these gauges) that requires maintenance is the bottom plate and sliding block located in the bottom plate of the gauge. Typical problems reported as a result of insufficient maintenance include: difficulty in raising and lowering the source rod, improper sliding block operation, and erratic moisture or density counts. Following the procedure outlined below will ensure that your gauge is maintained in the best condition.

Never attempt to remove the source rod. When the Cs-137 source is in the safe position it is surrounded by tungsten steel, reducing the radiation to a safe level to perform maintenance.

1) Place the source rod in the "Safe" position. Lay the gauge on one side. Make sure you stand to the side to avoid unnecessary radiation exposure. One option is to position a mirror on the table that allows you to view the sliding block area.

2) Clean the four screw heads holding the bottom plate to the gauge base. Cleaning the screw heads helps prevent stripping.

Remove the four screws.

3) Remove the bottom plate and inspect for dirt build up in the cavity. If dirt is present replace the scraper ring in the bottom plate. To replace the scraper ring, remove the retaining ring with a screwdriver and remove the scraper ring. Replace with a new scraper ring. Reinstall the retaining ring.

4) Inspect the back of the bottom plate for excessive wear from the sliding block. If the plate shows excessive wear, replace with a new bottom plate.

5) Remove the sliding block. The source will be exposed at this time. Stand to one side to minimize exposure. Clean the block and the cavity with a rag attached to a probe and use a stiff brush to further clean the area.

6) Replace the sliding block after cleaning. Orient the block with the angled side up, toward the source. If the block is installed incorrectly the source rod will not operate.

7) Install the four screws in the bottom plate. Do Not Over-tighten the screws, as this could strip the threads.

Daily and Weekly Maintenance

The cavity formed by the scraper ring should be cleaned frequently. If the gauge is used in wet sand or concrete, the cavity should be cleaned every day. If you regularly use the gauge in soils clean the cavity when raising and lowering the source rod.

Calibration

ASTM recommends a verification of your gauge every 12 months and a calibration not to exceed 24 months. But be aware that many state DOT's supersede the ASTM requirement and require a calibration every 12 months. So, if you are contracting to perform state work and testing, you will need to have your gauge calibrated every 12 months.

You should also receive a new calibration after a repair that involves electronics or GM tube replacement. Likewise, it is the "drift" in electronics and the GM tubes that represent the top reasons for needing a recalibration.

Any dispute between a gauge that has been properly calibrated vs. a gauge that is outside of calibration will generally be settled on the side of the properly calibrated gauge.

A properly calibrated gauge should work fine provided you perform timely standard counts. You should take a standard count every day you use the gauge. Some manufacturers recommend taking a new standard count if the material you are testing changes throughout the day.

If your gauge has not been used for over 2 months you will want to re-establish your standard count averages. To do this you need to take 4 new standard counts and then compare subsequent counts to the average of those 4 counts.

Other reasons for calibration problems include poor factory calibration, operator errors, operation near large vertical objects such as walls or vehicles or close proximity to other gauges. Other factors include internal moisture, mechanical wear and detector tube misalignment.

All manufacturers perform gauge calibration, service and repair. There are also numerous independent service centers that work on all model gauges. Many of these independent service centers are run by former technicians of the manufacturers and their expertise is sometimes equivalent or superior to that of the manufacturers.

Many service centers offer “winter specials”. These specials are designed to entice you into sending your gauge in during the winter months when your gauge operations either slow down or halt due to the colder climate. It can be very beneficial to have your gauge worked on during this time of inactivity and it can save you money, sometimes as much as $200.00. Keep in mind that many companies wait until the “thaw” before sending their gauges in and this can result in a “log-jam” and longer lead times.

But you can still save a lot of money by shopping around for service. The aforementioned winter specials only last a couple of months and the same service during the summer will cost you a couple of hundred dollars more. Other service centers offer a standard price throughout the year and this price is much more attractive during the months when you are actually using the gauge.

When shopping for service keep in mind the shipping costs and gauge turn-around. If time is critical go with a highly qualified service provider with timely turn-around. The only thing worse than having a gauge go down in the middle of a job is getting a gauge back from service that has not been properly repaired.

You should expect the following as part of your gauge calibration:

- 3 Block Calibration per ASTM & AASHTO & NIST Traceable
- Source rod inspection
- Scraper ring, wiper seal, gasket and bumper replacement
- Mechanical inspection, lubrication & cleaning
- Electronic inspection & adjustment
- Battery/charging system check
- Shipping case inspection and gauge cleaning
- Replacement of radiation labels, if needed
- Leak test

Basic gauge calibration service does not include other types of gauge repair and damage. You should request a verbal quotation as to the expected costs of other gauge repairs. If the service provider cannot give you a specific quotation you will want to ask for a general parts list with pricing as well as labor charges. You may be surprised how much you can save comparing one service provider to another.

Make sure to fill out all necessary Return Goods forms as well as any regulatory forms for transfer of radioactive materials. The service center should be able to help you with shipping and forms.

A Word of Caution

There are many “one man” traveling service operations that offer low cost calibrations and service at your facility. An individual, typically driving in a van, will arrive at your location with the promise of saving you lots of money. Be very careful and consider the following:

1) Some of these individuals do not have a license. Regardless of what they tell you, your license prohibits you from letting such an individual touch your gauge, even if you are present. Others will present a license that does not list your exact model of gauge – Again, your license prohibits you from letting them touch your gauge.

2) Some of these individuals may have a license but not the type that allows them to disassemble a gauge, specifically the source rod. They must have a special license to do so. Some will perform service without removing the source rod. The problem with that is they are not adequately servicing your gauge, such as inspecting the source rod for damage, which requires viewing the rod with special instrumentation.

3) Any individual that visits your facility and enters the storage area must be escorted at all times. You cannot allow them to enter your storage area, remove a gauge and take it to their vehicle. You must escort them, sign the gauge out and stay with them at all times. Maintain records of all visits, logs, transfers, and service provided.

4) If they are taking a gauge to their vehicle for calibration it is a sure sign they are **not** using a 3 block calibration system. You should never settle for anything less than a 3 block calibration. Although it does require you to spend the money to send the gauge to a service provider that has and uses 3 block calibrations, the accuracy and precision the 3 block calibration offers will ensure that your gauge is measuring proper density and moisture under the best available means. Do not assume that a service facility has the necessary 3 block calibration system. They may take your gauge and calibrate it with the same 1 point calibration system that is carried in a van. Always ask!

5) NRC regulations require that any service individual visiting a licensee with radioactive quantities of concern have official background clearance documentation. If they do not have it or know what it is, do not let them in your building.

6) Always check and verify the identification of any individual accessing and servicing your gauges.

Glossary

Absorbed dose: The quantity of ionizing radiation deposited into a material, including an organ or tissue, expressed in the terms of the energy absorbed per unit mass of material. The basic unit of absorbed dose is the rad or its SI equivalent, the gray (Gy).

Activity (Radioactivity): The rate of decay of a radionuclide, more formally, the number of decays per time. Its SI unit is the Becquerel (Bq) corresponding to one radioactive decay (disintegration) per second; its old unit, the curie (Ci), was originally defined as the activity of 1 gram of radium-226 or 3.7 x 10/10 disintegrations per second.

Acute dose: An acute dose means a person received a radiation dose over a short period of time. Example: 5,000mrem per hour.

Acute effect: Effects in organisms manifest themselves soon after exposure to radiation and are characterized by inflammation, edema, denudation and depletion of tissue, and hemorrhage.

Acute radiation exposure: A radiation exposure that occurs over a relatively short period of time (less than 24 hours).

Acute Radiation Syndrome-"ARS" (Radiation Sickness): A person exposed to radiation will develop ARS only if the radiation dose was very high, penetrating (gamma rays), encompassing the whole body and received in a short period of time.

Agreement State: States that assumed authority under Section 274b of the Atomic Energy Act to license and regulate by-product materials (radioisotopes), source materials (uranium and thorium), and certain quantities of special nuclear materials.

Air Cargo Only label: Two labels on opposite sides of the gauge case and next to the Yellow ll labels that instruct that gauge scan only be shipped on cargo aircraft – no passenger aircraft.

ALARA: "As Low As Reasonably Achievable" – Taking every reasonable safeguard to protect person and public against ionizing radiation exposure.

Alpha particle: A heavy particle emitted form the nucleus of an atom. It consists of two protons and two neutrons, which is identical to the nucleus of a helium atom without electrons. These heavy charged particles lose their energy very quickly in matter. They are easily shielded by clothing, a sheet of paper or the top layer of skin. Alpha particles are only hazardous when ingested. Alpha particles emitted by the radioactive materials in the gauge are permanently shielded and therefore not used in the operation of the gauge.

Americium-241 (Am241): Portable nuclear gauges use a radioactive isotope of Americium, Am241, coupled with beryllium to produce neutron radiation for measuring hydrogen/moisture content.

Atom: The smallest particle of an element that can enter into a chemical reaction.

Atomic Mass: The weight of an atom measured in atomic mass units, typically protons and neutrons.

Atomic Number: The number of protons in the nucleus of an atom and the number of electrons in a neutral atom. This number determines the atom's chemical element.

Atomic Weight: The mass of an atom. Mass is roughly determined by counting the number of protons and neutrons in the nucleus.

Background Radiation: Ionizing radiation that occurs naturally in the environment, including cosmic, terrestrial and radon radiation. Also known as natural background radiation.

Becquerel (Bq): An SI unit of measure for activity. One becquerel equals 1 disintegration per second. Typically, becquerels associated with portable gauges, are expressed in billions (GBq) of a becquerel. There are 37,000,000,000 becquerels in 1 curie.

Beta particle: A high speed particle emitted from the nucleus which is identical to an electron. They can have a -1 (electron) or +1 (positron) charge and are effectively shielded by thin layers of metal or plastic. Beta particles are most hazardous when ingested. Beta particles emitted from the radioactive materials in the gauge are permanently shielded and therefore not used in the operation of the gauge.

Bill of Lading: A shipping document required whenever radioactive material is transported or shipped on public highways, waterways, cargo aircraft or rail. Must be readily visible and accessible to the driver.

Certificate of Competent Authority/IAEA Certificate/Special Form Certificate: A certificate that confirms the manufacture and encapsulation of radioactive material into an impervious container. See: Sealed Source.

Cesium 137 (Cs137): Radioactive isotope of Cesium which decays by beta emission into barium 137m, which in turn emits a photon for measuring density. Cs137 has a half-life of 30.17 years.

Chronic exposure: Exposure to a source of radiation over a longer period of time, typically greater than 24 hours.

Contamination (radioactive): Contamination means that radioactive materials are released in the form of solids, gases or liquids into the environment and contaminate people externally, internally or both.

Controlled area/zone: An area where entry, activities and exit are controlled to help ensure radiation protection and prevent the spread of contamination.

Cosmic Radiation: Radiation produced in outer space that enters the earth's atmosphere.

Count: Electronic pulse from a radiation detector tube that indicates an ionizing event. Portable nuclear gauges use Geiger-Muller tubes to detect ionizing events.

CFR: Code of Federal Regulations

Chronic dose: A chronic dose means a person received a radiation dose over a long period of time. Example: 300mrem per year.

Chronic Radiation Exposures: Radiation exposures that occur over extended periods of time (greater than 24 hours). Exposure to natural background is a chronic radiation exposure.

Contamination: Radioactive material distributed and in contact with some person, equipment or area. Requires decontamination efforts.

Critical Mass: The minimum amount of fissile material necessary to achieve a self-sustaining nuclear chain reaction. Nuclear gauges only contain non-fissile material and are therefore not capable of creating a chain reaction.

Curie (Ci): The basic measure of radioactivity equal to an average transformation of 37 billion disintegrations per second. One curie is the approximate activity of 1 gram of radium. Named for Marie and Pierre Curie, founders of radium in 1898.

Decay (Radioactive): The decrease of radioactive material, specifically the emission of alpha and beta particles and gamma electromagnetic energy, with the passage of time.

Decontamination (Radioactive): The reduction or removal of radioactive contamination from a structure, object or person.

Detector (Radiation): A device that is sensitive to radiation and can produce a response signal suitable for measurement or analysis. A radiation survey meter.

Dirty bomb: A radiological dispersal device (RDD). A device designed to spread radioactive material by conventional explosives for malevolent purposes. The objective of such a device would be to cause social disruption and panic.

Dose/Dose Rate: The quantity of ionizing radiation deposited into a material, including an organ or tissue, expressed in the terms of the energy absorbed per unit mass of material. The basic unit of absorbed dose is the rad or its SI equivalent, the gray (Gy). The radiation dose delivered per unit of time.

Dose equivalent: A quantity used in radiation protection to place all radiation on a common scale for calculating tissue damage. Dose equivalent is the absorbed dose in grays multiplied by the quality factor. The quality factor accounts for differences in radiation effects caused by different types of ionizing radiation. The sievert is the unit used to measure dose equivalent.

Dosimeter: A small portable instrument such as a film badge or TLD for measuring and recording the total accumulated dose of ionizing radiation person receives.

Effective dose: A dosimetric quantity useful for comparing the overall health affects or irradiation of the whole body. It takes into account the absorbed doses recived by various organs and tissues and weighs them according to present knowledge of the sensitivity of each organ to radiation. It also accounts for the type of radiation and the potential for each type to inflict biological damage. The unit of effective dose is the sievert.

Electromagnetic Radiation: A traveling wave motion that results from changing electric and magnetic fields. Types of electromagnetic waves include short-wave such as x-rays & gamma to ultraviolet, visible & infrared to longer wave such as radar and radio. The gamma ray photons used in a gauge to measure density is a type of electromagnetic radiation.

Electron: Sub-atomic negatively charged particle with very low mass that orbits the nucleus.

Element: All isotopes of an atom that contain the same number of protons.

Emergency Response Sheet: A document that discusses the precautions and emergency actions pertaining to radioactive gauge during transport. An Emergency Response Sheet must be readily visible and available to the driver during transport. Similar to a Material Data Safety Sheet (MSDS).

Encapsulation/Encapsulated: The shielding that encompasses a radioactive material used in a gauge.

Exposure (Radiation): A measure of ionization in air caused by x-rays or gamma rays only. The unit of measure most often used is the roentgen.

Exposure rate: A measure of the ionization produced in air by x-rays or gamma rays per unit of time, frequently expressed in roentgens per hour.

External exposure/irradiation: An exposure received from a source of ionizing radiation outside of the body. Similar to a chest x-ray in that following exposure the individual is not radioactive. Exposure to gamma radiation from the gauge is an external exposure.

Film badge: Dosimetry monitoring device that uses photographic film to measure a person's radiation dose.

Fissile material: Any material in which neutrons cause a fission reaction.

Fission: The splitting of a nucleus into at least two fragments, accompanied by the release of neutrons and energy. Fission of a nucleus may be initiated by absorption of a neutron or, in some materials, can happen spontaneously.

Fusion: The joining together of two or more less stable nuclei into one more stable nucleus.

Gamma ray photon radiation: High-energy electromagnetic radiation emitted from the nucleus of an atom. Gamma rays have no charge, are very penetrating and are best shielded by lead or steel. Gamma rays can cause internal and external damage. All gamma rays emitted from a given isotope have the same energy, a characteristic that enables scientists to identify which gamma emitters are present in a sample. Gamma rays penetrate tissue farther than do beta or alpha particles but leave a lower concentration of ions in their path to potentially cause cell damage. Very similar to x-rays except that x-rays originate from the outer shell of the atom. The gauge uses gamma ray photons to help measure density.

Geiger-Mueller Detector Tube (G-M tube): A gas filled tube that measures voltage pulses created by ionizing gamma radiation. Used in a gauge to determine density.

Geiger counter: A device that utilizes Geiger-Mueller tubes for detecting and measuring ionizing radiation. Gauges use GM tubes to help measure density.

Genetic effects: Effects from radiation exposure that are seen in the offspring of the individual.

Gray (Gy): This SI unit is used to measure a quantity called absorbed dose. This relates to the amount of energy actually absorbed in some material and is used for any type of radiation and any material. It does not describe the biological effects of the different radiations. On gray is equivalent to 100 rads.

Half-life: The time during which one-half of a given quantity of a radionuclide undergoes radioactive decay into another nuclear form. A half-life can last from millionths of a second to billions of years.

Half-thickness: The thickness of a slab material that reduces by half the intensity of radiation incident on one side of the slab.

HAZ-MAT Training: Hazardous Materials training required for all individuals preparing or transporting gauges. Initial training is covered in the Gauge Safety Certification class and must be renewed every three years. APNGA promotes and recommends renewal every year.

Health Physics: A interdisciplinary science that includes elements of physics, biology, chemistry, statistics and electronic instrumentation focusing on providing information used to protect individuals from the effects of ionizing radiation.

Helium-3 Detector Tube: A helium-3 gas filled tube used to measure thermalized neutrons. Used in a gauge to determine moisture content.

IAEA: International Atomic Energy Agency.

IAEA Certificate/Certificate of Competent Authority/Special Form Certificate: A certificate that confirms the manufacture and encapsulation of radioactive material into an impervious container. See: Sealed Source.

Irradiation: Exposure to radiation.

Ingestion: Swallowing radionuclides by eating or drinking.

Inhalation: Breathing in radionuclides.

Internal exposure: An exposure received from a source of ionizing radiation inside of the body.

Inverse Square Law: The relationship that states that electromagnetic radiation intensity is inversely proportional to the square of the distance from a point source. In other words, roughly speaking, as you double your distance from a radioactive source your exposure is reduced to ¼.

Ion: A charged atom or particle. An atom that has fewer or more electrons than protons. Nuclear radiation can cause ionization.

Ionization: A process in which an atom loses or gains one or more electrons thereby forming an ion.

Ionizing radiation: Radiation that is sufficiently energetic to ionize the matter (remove electrons from the atoms thereby producing ions) through which it moves. Alpha, beta, gamma and neutron are all forms of ionizing radiation.

Irradiation: Exposure to radiation.

Isotope: A variation of a element with the same number of protons, but different number of neutrons.

Leak test/Wipe Test: A required test for all gauges to ensure that radioactive contaminants are not escaping the special form encapsulation.

Lethal dose (50/30): The dose of radiation expected to cause death within 30 days to 50% so exposed without medical treatment. The generally accepted level for a lethal dose is 400 rem over a short period of time.

Molecule: A combination of two or more atoms that are chemically bonded. A molecule is the smallest unit of a compound that can exist by itself and retain all of its chemical properties.

Natural background radiation: Radiation that exists naturally in the environment. It includes cosmic and solar radiation, radiation radioactive materials present in rocks and soil, and radioactivity that is inhaled or ingested.

Neutron: Neutral sub-atomic particle located in the nucleus of an atom/element.

Non-Agreement State: A state under the direct rules and regulations of the NRC.

Nondestructive testing: Testing that does not destroy the object under examination.

Non-ionizing radiation: Having lower energy and longer wavelengths than ionizing radiation it is not strong enough to affect the structure of atoms, but it is strong enough to heat tissue and cause harmful biological effects. Examples are radio waves, microwaves, visible light and infrared.

Notice to Employees Poster: A required information poster that must be available/posted for all employees of a company using gauges. This poster can be obtained from the licensing agency.

NRC: Nuclear Regulatory Commission. Federal licensing and regulatory body that oversees the use of radioactive materials in the United States.

Nuclear energy: The heat energy produced by the process of nuclear fission within a nuclear reactor or by radioactive decay.

Nuclear reactor: A device in which a controlled , self-sustaining nuclear chain reaction can be maintained with the use of cooling to remove generated heat.

Nucleus: The central part of an atom that contains the neutrons and protons. The nucleus is the heaviest part of the atom.

Occupational exposure: Radiation exposure obtained during work around a gauge.

Penetrating radiation: Radiation that can penetrate the skin and reach internal organs and tissues. Photons (x-rays & gamma rays) and neutrons are penetrating radiations. Alpha and beta particles are not considered penetrating radiation.

Photon: A discrete packet of pure electromagnetic energy that, when interacting at the molecular or atomic level, acts more like a particle rather than an energy wave. Photons have no mass and travel at the speed of light. Gamma rays and x-rays are photons.

Placards/Placarding: Radioactive lll labels that must be used displayed on the outside of a vehicle for higher quantity devices. Moisture density gauges are Radioactive ll and therefore do not require placarding. DO NOT PLACARD A VEHICLE that is transporting a moisture density gauge as those covered by this website.

Proton: A small positively charged particle found in the nucleus. The number of protons in a given atom determines the chemical identity of the element.

Quality Assurance: Planned and systematic actions necessary to provide adequate confidence that a facility, structure, system or component will perform satisfactorily and safely in service.

Quality Control: Actions necessary to control and verify that a material, process or product meets specified requirements.

Quality Factor (QF): A numerical factor describing the average effectiveness of a particular type or energy of radiation in producing biological effects on humans. The multiplier assigned to a given type of radiation. Multiply the Q x rad to determine rem. A factor that converts the absorbed dose (rad or gray) to biological damage/dose equivalent (rems).

Rad (radiation absorbed dose): A basic unit of absorbed dose that measures the energy absorbed by the body. It does not describe the biological effects of different radiations. One rad equals the dose delivered to an object of 100 ergs of energy per gram of material. It is being replaced by the gray (Gy), which is equivalent to 100 rad.

Radiation: Energy in transit in the form of high speed particles and electromagnetic waves. Electromagnetic waves, including visible light, radio, television, ultra violet (UV) and microwaves, are all types of radiation that do not cause ionizations of atoms

because they do not carry enough energy to separate molecules or remove electrons form atoms. These are all forms of non-ionizing radiation. Ionizing radiation is a very high energy form of electromagnetic radiation that has enough energy to remove tightly bound electrons from their orbits around atoms. Alpha, beta, gamma ray and neutron radiation are all ionizing radiation.

Radiation dose: The quantity of radiation energy deposited into an object or medium, divided by the mass of the object or medium. The radiation dose is ionizing radiation. Ionizing radiation doses can be expressed as an absorbed dose, equivalent dose, or effective dose. The basic unit of absorbed dose is the rad or its SI equivalent, the gray (Gy).

Radiation exposure: The act of being exposed to radiation. Also referred to as irradiation. Formally in radiation detection and measurement, radiation exposure is related to the ability of photons to ionize air.

Radiation sickness: See Acute Radiation Syndrome (ARS).

Radiation source: Radioactive material packaged to use the radiation it emits.

Radiation warning symbol: A universally recognized magenta or black trefoil on a yellow background that must be displayed where radioactive materials are present or where certain doses of radiation could be received.

Radioactive: Elements that are unstable and transform spontaneously (decay) through the emission of ionizing radiation, a process known as radioactive decay.

Radioactive contamination: Radioactive material distributed and in contact with some person, equipment or area. Requires decontamination efforts.

Radioactive decay: The spontaneous disintegration of the nucleus of an atom.

Radioactive material: Any material that contains radioactive atoms.

Radioactivity: Process of spontaneous transformation/breakdown of the nucleus, generally with the emission of alpha or beta particles, usually accompanied by gamma rays. This process is described as decay of the atom.

Radiography: The use of radiation to create images of a subject, especially the internal features of a subject. An example of medical radiography is a dental x-ray. Industrial radiography includes x-rays of pipes and reinforced concrete construction.

Radioisotope: Isotopes of an element that have an unstable nucleus.

Radiological: Related to radioactive materials or radiation. The radiological sciences focus on the measurement and effects of radiation.

Radiological dispersal device (RDD): Also known as a dirty bomb. A device to spread radioactive material for malevolent purposes. The objective of such a device would be to cause social disruption and panic.

Radioisotope: A radioactive/unstable isotope that undergoes spontaneous transformation, emitting radiation.

Radionuclide: An atom with an unstable nucleus which undergoes radioactive decay. A radioactive nuclide.

Radium: A naturally occurring radioactive material (NORM) formed by the decay of uranium and thorium. It occurs at low levels in virtually all rock, soil, water, plants and animals. Radon is a decay product of radium.

Radon: A naturally occurring radioactive gas found in rock, soil and water throughout the United States. Radon is the largest source of exposure to people from naturally occurring radiation.

Reciprocity: The act of one licensing agency honoring the license of another agency. Companies desiring to use their gauges outside of their own state must notify and receive permission to carry the gauge into another state. License holders in a NRC regulated state can use their gauges in another NRC state without obtaining reciprocity permission. License holders in an Agreement State may also need to obtain reciprocity before entering a NRC regulated area such as a military installation.

Regulations: The rules and requirements of a license. All license holders must maintain, review and update a copy of the regulations from their regulatory agency.

REM (Roentgen equivalent, man): The special unit of dose equivalent. Not all radiation has the same biological effect, even for the same amount of absorbed dose. The dose equivalent in rem is equal to the absorbed dose in rad multiplied by the quality factor that accounts for the biological effect of the radiation. (1 rem = 0.01 sievert). This relates the absorbed dose in human tissue to the effective biological damage of the radiation. To determine the equivalent dose (in rem) you multiply the absorbed dose (rad) times the quality factor (Q).

RQ – Reportable Quantity: An EPA designation that establishes thresholds for quantities of radioactive materials used in gauges. An RQ designation must appear on the Type A Package Label and shipping papers for gauges that contain Am241 in excess of 10mCi. All moisture density gauges exceed this limit and must therefore show the designation.

Roentgen: A unit of measure to exposure to gamma and x-rays. It is that amount of gamma or x-rays required to produce ions carrying 1 electrostatic unit of electrical charge in 1 cubic centimeter of dry air under standard conditions. Named for Wilhelm Roentgen, discoverer of x-rays in 1895.

Safety: Prevention of damage, human error and other inadvertent acts that result in accidental radiation exposure.

Sealed source: A radioactive source, sealed in an impervious container that has sufficient mechanical strength to prevent contact with and dispersion of the radioactive material under the conditions of use and wear for which it was designed. May be classified “Special Form” on shipping papers and packages.

Security: Prevention of theft, sabotage and other malevolent acts involving radiation sources.

Shielding: Any effective material between a radiation source and a potentially exposed person that reduces exposure.

SI: International System of Units, also known as the metric system.

Sievert (Sv): The sievert is a SI unit used to derive a quantity called dose equivalent or equivalent dose. This relates the absorbed dose in human tissue to the effective biological damage of the radiation. Not all radiation has the same biological effect, even for the same amount of absorbed dose. To determine equivalent dose (Sv), you multiply absorbed dose (Gy) by a quality factor (Q) that is unique to the type of incident radiation. One sievert (sv) is equivalent to 100rem.

Somatic health effects: The harm that an exposed individual suffers during their lifetime such as radiation induced cancer or sterility. Does not include later generation genetic effects.

Special Form Certificate: A certificate that confirms the manufacture and encapsulation of radioactive material into an impervious container. See: Sealed Source.

Special form radioactive material: Defined in 10 CFR Part 71 as radioactive material that exists as a single solid piece or is encapsulated material that meets certain other requirements.

Stable nucleus: The nucleus of an atom in which forces among its particles are balanced.

Stochastic effect: An effect regardless of dose that assumes there is always some small probability of adverse effects. The effect increases with dose. Cancer is a stochastic effect.

Survey meter: A device used to detect and measure the presence of ionizing radiation.

TEDE - Total Effective Dose Equivalent: The sum of effective dose equivalent from external radiation and the committed effective dose inhaled and ingested radioactive material. Quoted in units of rem.

Terrestrial radiation: Radiation emitted by naturally occurring radioactive materials in the earth. Examples: Uranium, thorium & radon.

TLD: Thermoluminescent Dosimeter. Personnel dosimetry used to measure radiation dose.

Total Body Radiation Syndrome: The response of an organism to acute total body radiation exposure to all organs constituting the organism.

Total Effective Dose Equivalent (TEDE): See TEDE

Transuranic: Pertaining to elements with atomic numbers higher than uranium (92).

Type A Package: The approved case that the gauge must be stored and shipped in.

Type A Package Label: A label that indicates the type of case used to store and ship the gauge.

Unstable nucleus: A nucleus that contains an uneven number of protons and neutrons and seeks to reach equilibrium between them through radioactive decay. Example: The nucleus of a radioactive atom.

Whole Body Count: The measure and analysis of the radiation being emitted from a person's entire body, detected by a counter external to the body.

Whole Body Exposure: An exposure of the body to radiation, in which the entire body, rather than an isolated part, is irradiated by an external source.

Well logging: The practice of measuring the properties of the geologic strata through which a well has been drilled and recording the results as a function of depth.

X-ray: Electromagnetic radiation emitted from the outer shell of the atom. Is best shielded by lead or steel. Can cause external or internal hazards.

Yellow ll Radioactive Label: The radioactive label designated for gauges, two of which must adorn opposite sides of the gauge case. The label must display the hazard class – 7, contents – Cs137 & Am241, activity in becquerels & millicuries, and Transport Index (TI).

Appendices

Attachments/Forms/Checklists/Links

Full Table of Contents Index

Attachments/Forms/Checklists/Links

Because regulatory forms and procedures can vary from state to state we have listed the majority of these attachments as "examples", although many may in fact be valid for your use. Always check with your state regulatory agency for their version. Go to the "View My State" section on the APNGA home page to access your state.

Note: Your Web browser's security settings may not allow you to follow the links in PDF documents. If the links in this manual do not work on your computer, the information is also contained on the APNGA website (www.apnga.com) under the Industry column.

ALARA Philosophy and Commitment Example

Annual Audit Checklist Example

Bill of Lading – Common Carrier Example

Bill of Lading – Private Carrier Example

Bill of Lading – R&L Carriers

Company Individual Authorized to Sign Example

Daily Utilization Log Example

Disposal Procedure Example

Decommissioning Form Example

Emergency Procedures Example

Emergency Responder Info Sheet

Emergency Response Sheet Example

Emergency Response Wallet Cards

FEDEX Dangerous Goods Form Link

Gauge Operating Procedures Example

Gauge Service Record Example

IAEA Certificate of Competent Authority Example

Inventory Instructions Example

Inventory Sheet Example

Leak Test Instructions Example

License Application Checklist Example

License Application for Gauge – Go to "View My State" & Select your State. An example/worksheet is provided as an attachment.

License Application NRC Form 313

License Application Worksheet Example

Media/Reporter Info Sheet

Member of Public (MOP) Dose Calculation Sheet Example

New RSO Article

Notice to Employees Poster – NRC – Spanish Version

Notice to Employees Poster – NRC – English Version

Notice to Employees – Agreement State Version – Go to "View My State"

NRC Service Personnel Background Clearance Notice

NRC License Application Form 313

NRC Gauge Security Requirements

NRC Inspection Procedures

NRC Reciprocity Form 241

NRC 2 Independent Tangible Barriers Notice

Operating Procedures Example

Periodic Table

Personnel Dosimetry Cumulative History Form Example

Personnel Monitoring Declaration of Pregnancy Form Example

Personnel Monitoring Declaration of Pregnancy Acknowledgement Example

Personnel Monitoring Individual Exposure Record Example

Personnel Monitoring Instructions Example

Poster and Notice Requirements Example

Radiation Safety Program Example

Radioactive Scrap Info Poster

Reciprocity Contacts

RSO Responsibilities Example

Service Providers and Quantities of Concern

Shipping and Receiving Procedures Example

SI Unit Conversion

SSD – Sealed Source and Device Info/Numbers – Visit Manufacturer's Websites

Storage Area Drawing

Table of Contents (Full Version) for APNGA Training Manual

The CFR's – Code of Federal Regulations

Training Requirements (NRC)

Transfer or Disposal Form

Transfer Procedures Example

When to Notify the Agency Example

Full Table of Contents