

RADIATION SAFETY



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TROXLER TRANSPORTATION GUIDE

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

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TRANSPORTATION GUIDE

OVERVIEW AND APPLICABILITY

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

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

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

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

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

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

TRAINING

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

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

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

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

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

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

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

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

Hazmat employee training must include the following:

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

Training records must include:

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

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

CERTIFICATE OF COMPETENT AUTHORITY

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

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

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

NOTE

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

TYPE A PACKAGES

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

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

MARKING TYPE A PACKAGES

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

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

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

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

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

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

LABELING TYPE A PACKAGES

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

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

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

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

INSPECTING PACKAGE BEFORE SHIPMENT

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

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



WARNING

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

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

SECURITY SEALS

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

SECURING PACKAGES IN VEHICLE

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

MINIMUM SEPARATION BETWEEN PACKAGES AND PEOPLE

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

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

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

SHIPPING PAPER PREPARATION AND RETENTION

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

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

For shipments by air the following additional requirements apply:

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

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

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

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

SHIPPER'S CERTIFICATION

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

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

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

“I declare that all of the applicable air transport requirements have been met.”

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

SHIPPING PAPER ACCESSIBILITY

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

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

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

EMERGENCY RESPONSE INFORMATION

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

EMERGENCY RESPONSE PHONE NUMBER

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

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

ACCIDENT NOTIFICATION REQUIREMENTS

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

EXCEPTED PACKAGES

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

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

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

- ◆ Packages containing a reportable quantity (RQ), which includes models 4301 and 4302, are subject to modified shipping paper requirements. An emergency response phone is not required on the shipping papers per §172.604(d). The applicable shipping paper description for the 4301 and 4302 models is shown below:
 - UN2911, Radioactive Material, Excepted Package, Instruments, 7, RQ
 - Am-241, 1 package x 0.37 GBq (10 mCi)
 - Dim L58 x W48 x H27 cm
- ◆ Shippers and carriers are subject to the hazmat employee training requirements.
- ◆ Shippers and carriers are subject to accident notification requirements.

RECORD RETENTION

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

Record	Retention
Hazmat employee training records including: <ul style="list-style-type: none"> • Employee name • Training completion date • Description, copy, or the location of the training materials used • Name and address of the person providing the training • Certification that the hazmat employee has been trained and tested 	A record of current training, inclusive of the preceding three years, in accordance with this section, shall be created and retained by each hazmat employer for as long as that employee is employed by that employer as a hazmat employee and for 90 days thereafter. [§172.704(d)].
IAEA Certificate of Competent Authority for special form radioactive material	1 year after the latest shipment [§173.476(a)]
Type A package testing methods and results	1 year after the latest shipment [§173.415(a)]
Shipping papers	2 years after date of shipment [§172.201(e)]
Package closure instructions provided by the package manufacturer	365 days after the package is offered for shipment [§173.22(a)(4)]

APPENDIX A

TYPE A PACKAGE TESTING RESULTS

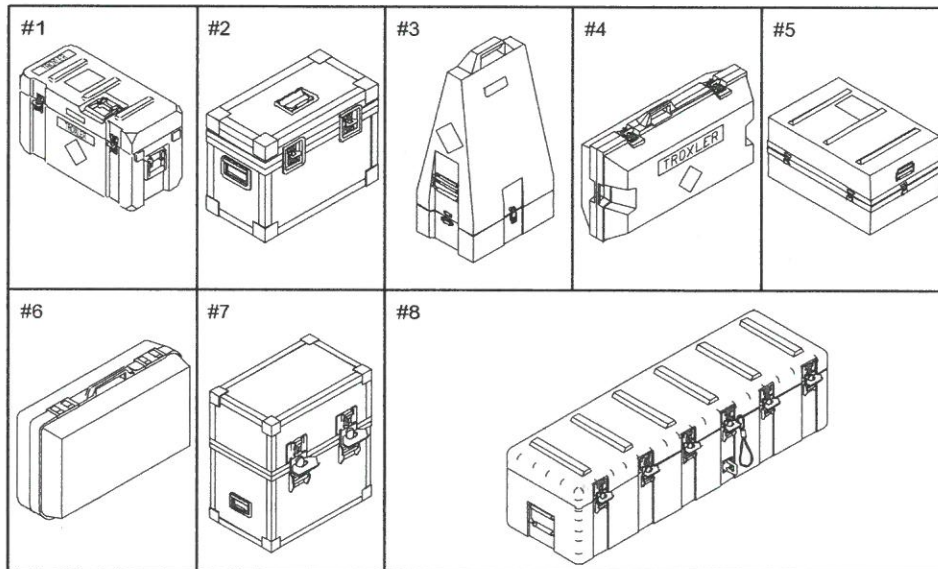
INSTRUCTIONS FOR FINDING TYPE A TESTING RESULTS FOR YOUR PACKAGE:

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

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

- Water Spray:** Subjected the package to a water spray simulating rainfall of approximately two inches per hour for one continuous hour.
Results: No physical damage to the package was observed, unless otherwise noted in footnotes.
- Vibration:** The package was vibrated with a displacement of 0.1" at approximately 12 Hz for a period of 24 continuous hours.
Results: No physical damage to the package was observed, unless otherwise noted in footnotes.
- Free Drop:** The package was dropped from a height of four feet onto a non-yielding surface from a position to cause maximum damage to the package.
Results: The case was scratched due to the abrasiveness of the concrete, but no other physical damage to the package was observed, unless otherwise noted in footnotes.
- Penetration:** The package was placed on a non-yielding surface. A 1-1/4" diameter, 13-pound steel cylinder with a hemispherical end was dropped in the vertical position from a height of 40" onto the package to a point to cause maximum damage to the package.
Results: No physical damage to the package was observed, unless otherwise noted in footnotes.
- Compression:** Package was placed on a non-yielding surface and subjected to a compressive load of at least 13 kilopascals multiplied by the vertically projected area of the package, in square feet, for 24 continuous hours.
Results: No physical damage to the package was observed, unless otherwise noted in footnotes.

PACKAGE DRAWINGS:



RESULTS OF TESTING

Consult the table below for applicable testing results, as described in the instructions on the previous page.

A in the table below indicates that the applicable test was performed. The results are on the previous page of this document unless otherwise stated in the referenced footnotes.

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

Notes:

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

APPENDIX B

PACKAGE CLOSURE INSTRUCTIONS

Ensure that all latches are securely closed on the package.

Models 3241, 3242, 3400 series, 4350 and 4640 closure instructions - Butterfly Twist Latch

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

Model 3216, 4301 and 4302 - Plastic Snap Latch

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

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

Ensure that all latches are securely closed on the package.

Models 3241, 3242, 3400 series, 4350 and 4640 closure instructions - Butterfly Twist Latch

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

Model 3216, 4301 and 4302 - Plastic Snap Latch

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

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

APPENDIX C

PRIVATE CARRIER BILL OF LADING FOR A 3400 SERIES GAUGE

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

NOTE

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

Your Company's Letterhead

BILL OF LADING

Shipper: ABC Paving Company
123 Main Street
Raleigh, NC

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

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

Shipper Name (Print): _____

Shipper Name (Signature): _____

APPENDIX D

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

NOTE

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


SB Freightways **BILL OF LADING**

		DATE SHIP DATE	P.O. NO.	SHIPPER NO.	
CONSIGNEE (TO) TROXLER ELECTRONIC LABS, INC		SHIPPER/CONSIGNOR (FROM) APEX TESTING COMPANY			
3008 CORNWALLIS RD		456 MAIN STREET			
RESEARCH TRIANGLE PARK, NC 27709		COLUMBIA, SC 27601			
PHONE NO.	EMERGENCY RESPONSE NUMBER* (REQUIRED IF HM COLUMN MARKED) 919-549-9539		ROUTE		
(SUBJECT TO CORRECTION)					
Number of Packages	HM *	Kind of Packaging, Description of Articles, Special Marks and Exceptions	Weight (lb)	Class or Rate Ref.	Cube (Optional)
1 case	x	UN 3332, Radioactive Material, Type A package, Special Form, 7, RQ Cs-137, 0.30 GBq (8.0 mCi) Am-241, 1.48 GBq (40 mCi) Radioactive Yellow II label, TI = 0.3			
		EMERGENCY PHONE: (919) 549-9539			
		ABC PAVING COMPANY			
THIS IS TO CERTIFY THAT THE ABOVE-NAMED MATERIALS ARE PROPERLY CLASSIFIED, DESCRIBED, PACKAGED, MARKED, AND LABELED AND ARE IN PROPER CONDITION FOR TRANSPORTATION ACCORDING TO THE APPLICABLE REGULATIONS OF THE DEPARTMENT OF TRANSPORTATION.					
SHIPPER/CONSIGNOR W. BROWN			CARRIER SB FREIGHTWAYS		
AUTHORIZED SIGNATURE			AUTHORIZED SIGNATURE		
DATE					

APPENDIX E

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

SHIPPER'S DECLARATION FOR DANGEROUS GOODS

Shipper Acme Paving Company 524 Rocky Road Chicago, IL 12345 USA		Air Waybill No. 548974 Page 1 of 1 Pages Shipper's Reference Number 85642			
Consignee Troxler Electronic Labs 3008 E. Cornwallis Road Research Triangle Park, NC 27709					
Two completed and signed copies of this Declaration must be handed to the operator		WARNING Failure to comply in all respects with the applicable Dangerous Goods Regulations may be in breach of the applicable law, subject to legal penalties.			
TRANSPORT DETAILS This shipment is within the limitations prescribed for: (delete non applicable) <table border="1" style="width: 100%;"> <tr> <td style="width: 50%; text-align: center;"> XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX </td> <td style="width: 50%; text-align: center;"> CARGO AIRCRAFT ONLY </td> </tr> </table>				XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	CARGO AIRCRAFT ONLY
XXXXXXXXXX XXXXXXXXXX XXXXXXXXXX	CARGO AIRCRAFT ONLY				
Airport of Departure Chicago, O'Hare		Shipment type: (delete non-applicable) <table border="1" style="width: 100%;"> <tr> <td style="width: 50%; text-align: center;">XXXXXXXXXXXX</td> <td style="width: 50%; text-align: center;">RADIOACTIVE</td> </tr> </table>		XXXXXXXXXXXX	RADIOACTIVE
XXXXXXXXXXXX	RADIOACTIVE				
Airport of Destination: Atlanta, Hartsfield					
NATURE AND QUANTITY OF DANGEROUS GOODS UN Number or Identification Number, Proper Shipping name, Class or Division (subsidiary risk), Packing Group (if required), and all other required information.					
<table border="1" style="width: 100%;"> <tr> <td style="width: 80%; padding: 5px;"> UN 3332, Radioactive Material, Type A Package, Special Form, 7, RQ Cs-137, 0.30 GBq (8 mCi) Am-241, 1.48 GBq (40 mCi) All packed in one Type A package II-Yellow, TI = 0.6, Dim L75 x W35 x H42 cm Special form certificates attached: </td> <td style="width: 20%; padding: 5px; vertical-align: top;"> Enter "RQ" only for gauges containing Am-241. Nuclides, activities, label category, transport index (TI), and dimension values depend on the gauge model. Attach special form certificates for international shipments. </td> </tr> </table>				UN 3332, Radioactive Material, Type A Package, Special Form, 7, RQ Cs-137, 0.30 GBq (8 mCi) Am-241, 1.48 GBq (40 mCi) All packed in one Type A package II-Yellow, TI = 0.6, Dim L75 x W35 x H42 cm Special form certificates attached:	Enter "RQ" only for gauges containing Am-241. Nuclides, activities, label category, transport index (TI), and dimension values depend on the gauge model. Attach special form certificates for international shipments.
UN 3332, Radioactive Material, Type A Package, Special Form, 7, RQ Cs-137, 0.30 GBq (8 mCi) Am-241, 1.48 GBq (40 mCi) All packed in one Type A package II-Yellow, TI = 0.6, Dim L75 x W35 x H42 cm Special form certificates attached:	Enter "RQ" only for gauges containing Am-241. Nuclides, activities, label category, transport index (TI), and dimension values depend on the gauge model. Attach special form certificates for international shipments.				
Additional Handling Information This shipment may be carried on passenger aircraft outside U.S. jurisdiction. Emergency response sheet attached to Dangerous Goods Declaration.					
Emergency Telephone Number (011) 919-549-9539		[Acme Paving Company]			
I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labelled/placarded, and are in all respects in proper condition for transport according to applicable International and National Governmental Regulations. I declare that all of the applicable air transport requirements have been met.		Name/Title of Signatory A. Brown, Shipping Manager Place and Date Chicago, IL August 1, 2011 Signature (see warning above)			

APPENDIX F

EMERGENCY RESPONSE INFORMATION EXAMPLE

TROXLER NUCLEAR GAUGE EMERGENCY RESPONSE INFORMATION REQUIRED FOR TRANSPORTATION

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

1. PROPER SHIPPING NAME

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

POTENTIAL HAZARDS

2. HEALTH HAZARDS

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

3. FIRE OR EXPLOSION

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

EMERGENCY ACTION

4. IMMEDIATE PRECAUTIONS

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

5. FIRE

- ◆ Do not move damaged packages; move undamaged packages out of fire zone.
- ◆ **Small Fires:** Dry chemical, CO₂ water spray or regular foam.
- ◆ **Large Fires:** Water spray, fog (flooding amounts)

6. SPILL OR LEAK

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

7. FIRST AID

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

APPENDIX G

SPECIAL FORM CERTIFICATE EXAMPLE



U.S. Department
of Transportation

Pipeline and
Hazardous Materials
Safety Administration

IAEA CERTIFICATE OF COMPETENT AUTHORITY
SPECIAL FORM RADIOACTIVE MATERIALS
CERTIFICATE USA/0502/S-96, REVISION 7

East Building, PHH-23
1200 New Jersey Avenue SE
Washington, D.C. 20590

This certifies that the sources described have been demonstrated to meet the regulatory requirements for special form radioactive material as prescribed in the regulations of the International Atomic Energy Agency¹ and the United States of America² for the transport of radioactive material.

1. Source Identification - QSA Global, Inc. Model Nos. X54 (Manufactured before January 1, 1998), X540 (Manufactured on or after February 17, 1981), and X540/1 (Manufactured on or after September 27, 2000).
2. Source Description - Tungsten inert gas or laser seal welded cylindrical single or double encapsulations. The outer encapsulation is made of titanium or stainless steel and the inner encapsulation, if used, is made of titanium, stainless steel, or aluminum. Approximate exterior dimensions are 5.5 mm (0.2 in.) maximum diameter and 15.15 mm (0.6 in.) in length (Model X54); and 5.66 mm (0.2 in.) in diameter and 7.64 mm (0.3 in.) in length (Models X540 and X540/1). Construction shall be in accordance with attached Amersham Drawing No. A10639, Issue C (model X54) or QSA Global Inc. Drawing No. R87527, Rev. G (Models X540 and X540/1).
3. Radioactive Contents - No more than 17.0 TBq (459.5 Ci) of Cobalt-60 (Model X54); or no more than either 20.0 TBq (540.5 Ci) of Cobalt-60, 17.0 TBq (459.5 Ci) of Iridium-192, or 5.56 TBq (150.3 Ci) of Selenium-75 (Models X540 and X540/1). The Co-60, Ir-192 and Se-75 are in the form of a metal.
4. Quality Assurance - Records of Quality Assurance activities required by Paragraph 310 of the IAEA regulations¹ shall be maintained and made available to the authorized officials for at least three years after the last shipment authorized by this certificate. Consignors in the United States exporting shipments under this certificate shall satisfy the applicable requirements of Subpart H of 10 CFR 71.
5. Expiration Date - This certificate expires October 31, 2012.

Make sure your
copy is current.

-
1. "Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised), No. TS-R-1 (ST-1, Revised," published by the International Atomic Energy Agency (IAEA), Vienna, Austria.
 2. Title 49, Code of Federal Regulations, Parts 100-199, United States of America.

APPENDIX H

TRANSPORT INDEXES FOR TROXLER GAUGES

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

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

GAUGE MODEL	NUCLIDES	ACTIVITY	CASE/ DRAWING #	TRANSPORT INDEX (TI)
1351, 1352, 2376	Cs-137	0.3 GBq	TRUNK/#2	0.2
3241-C, 3241-D	Am-241	3.0 GBq	WATER RES/#1	0.1
	Am-241	3.7 GBq	WATER RES/#1	0.5
	Am-241	11.1 GBq	WATER RES/#1	0.5
3241-M	Cf-252	3.7 MBq	WATER RES/#1	0.1
3216, 3217, 3218	Am-241	1.48 GBq	PLASTIC/#6	0.1
			PYRAMID/#3	0.1
3242	Cf-252	3.7 MBq	WATER RES/#1	0.4
3401	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1 or BLOWMOLD/#4	0.4
			TRUNK/#2, PYRAMID/#3, or ABS/#5	0.1
3411	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1	0.5
			TRUNK/#2, PYRAMID/#3, or ABS/#5	0.1
			BLOWMOLD/#4	0.4
3430	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1	0.3
3430M, 3440M	Cs-137 Cf-252	0.3 GBq 2.22 MBq	WATER RES/#1	0.6
3440	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1	0.6
			TRUNK/#2	0.5
3440-L	Am-241 Cs-137	0.56 GBq 0.3 GBq	WATER RES/#1	0.4
3430 Plus, 3440 Plus	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1	0.3
3450, 3451	Am-241 Cs-137	1.48 GBq 0.3 GBq	WATER RES/#1	0.3
4232	Cf-252	3.7 MBq	WATER RES/#1	0.4
4350	Am-241 Cs-137	0.15 GBq 0.3 GBq	WATER RES/#8	0.2
4430	Am-241 Cf-252	0.15 GBq 2.22 MBq	TRUNK/#7	0.1
4440 SERIES	Co-60 Cf-252	2.22 MBq 1.11 MBq	WATER RES/#1	0.1
4545	Cs-137	0.3 GBq	TRUNK/#2	0.2
4640 SERIES	Cs-137	0.3 GBq	WATER RES/#1 or TRUNK/#2	0.2

RADIATION SAFETY

ATOMIC STRUCTURE

The atom is the simplest unit into which an element can be divided and still retain the properties of the original element. Atoms of all elements are made up of three primary building blocks which are: electrons, neutrons and protons. The nucleus of an atom contains the protons and neutrons and the electrons orbit around the nucleus. The protons and neutrons are bound together in the nucleus by a large amount of energy while the electrons orbiting the nucleus are not bound tightly to the nucleus and can be removed from or added to an atom without expending much energy. Since an electron has a negative charge and a proton has a positive charge, an electrically neutral atom has the same number of protons and electrons. Once electrons are added to or taken away, so that the number of electrons is different from the number of protons, the atom would be electrically charged. Neutrons are electrically neutral and many scientists consider a neutron to be a combination of an electron and proton.

There are 92 naturally occurring elements and at least 13 man made elements. Each element has a specific number of protons which distinguishes it from all other elements. The number of protons an element has is the atomic number for the element. For example, hydrogen always has 1 proton so the atomic number for hydrogen is 1. Protons and neutrons have approximately the same mass. These particles are very small and weigh less than one billionth of a gram. The mass of an electron is approximately 1/1840 the mass of a neutron or proton. For practical purposes, it is generally not considered in the mass of an element. The mass of a neutron or proton is assigned a mass unit of 1. Therefore, the atomic mass of an atom is the total of the neutrons and protons.

RADIOACTIVITY

Isotopes are forms of the same element having identical chemical properties but differ in their atomic masses due to different numbers of neutrons in their respective nuclei and in their nuclear properties. For example, hydrogen has three isotopes, with masses of 1 (hydrogen), 2 (deuterium) and 3 (tritium) units, respectively. The first two of these are stable (non-radioactive), but the third (tritium) is a radioactive isotope. Changes in the number of neutrons, configuration in the nuclei, or energy in the nuclei can upset the balance and cause the nuclei to become unstable.

Unstable atoms will not remain so indefinitely. Eventually the nucleus will rearrange itself to achieve a more stable condition, ejecting a particle and/or energy in the process. This process is called radioactivity. The disintegration of nuclei in a given quantity of material is a measure of the radioactivity of the sample. The curie is the basic unit for measuring radioactivity and is equal to 37 billion disintegrations per second. Half-life is the time required for the activity of a given radioactive material to decrease to half of its initial value due to radioactive decay. The half-life is a characteristic property of each radioactive material and is independent of its amount or condition. The half-life tells us how long the radioactive material might last or the number of curies. For example, Cesium 137 has a half life of 30 years. If we have one curie of Cesium 137, in 30 years we would have one half curie. The amount of radioactivity is related to both the amount of material and the half life. For example, if we compare Cesium 137 and Cobalt 60, a pound of Cobalt 60 could emit as much radiation as 13 pounds of Cesium 137 since Cesium 137 has a longer half life. The larger the difference in half lives, the larger the difference in the amount of material to get the same radioactivity.

TYPES OF RADIATION

Alpha particles - Alpha particles consist of 2 neutrons and 2 protons. They are the least penetrating type of ionizing radiation. They do not penetrate the skin and can be stopped by a piece of thin paper or clothing. A health hazard may occur when alpha emitting materials are inhaled, swallowed or enter the body through a wound. Thus, alpha particles are an internal hazard only.

Beta particles - Beta particles are high-speed, charged particles with a moderate penetrating power. These particles have the characteristics of electrons and may be positively or negatively charged. Beta particles can travel several hundred times the distance of alpha particles in air, can penetrate skin and tissue, and require a few millimeters of aluminum to stop them. Thus, beta particles can be both an external and internal hazard.

Gamma rays - Gamma rays are electromagnetic radiation emitted from the nucleus of a radioactive atom. Gamma rays are the most penetrating type of radiation and can travel many meters in air and many centimeters in tissue. Gamma rays constitute both an internal and external hazard. x-rays are similar to gamma rays and can penetrate human tissue.

Neutron - Because of its lack of an electrical charge, the neutron is able to penetrate relatively easily into a nucleus. The velocity of free neutrons in various substances at ordinary room temperatures is approximately 7200 feet per second. Neutron radiations are classified on the basis of the kinetic energies of the neutrons. Neutrons emitted from a radioactive source are generally referred to as fast neutrons possessing high kinetic energies. Neutrons which are slowed down as a result of collisions with matter are called thermal neutrons. Since the hydrogen atom is the same size as a neutron, collisions of neutrons with hydrogen atoms provides the best system for slowing down neutrons. Fast neutrons lose energy in soft tissue mainly by repeated scatterings with hydrogen nuclei. The hydrogen nuclei are also scattered in the process and become recoil protons. Slow neutrons are captured in soft tissue and release energy.

RADIATION FROM NUCLEAR GAUGE SOURCES

The radioactive sources in a nuclear density gauge are Americium 241-Beryllium, located in a fixed position within the gauge and Cesium 137 located in the lower end of the source rod.

Americium 241 emits alpha particles which bombard the nuclei of the Beryllium atoms causing neutrons to be emitted. The fast neutrons provide the means for determining the moisture content of materials. Fast neutrons must be slowed down (thermalized) and reflected back to the gauge's detector tube in order to be read by the gauge. The gauge will not detect fast neutrons. Fast neutrons are slowed down by colliding with nuclei of other atoms. Many collisions are required to slow down a neutron, however, collisions with hydrogen atoms require the least number of collisions to slow down a neutron. The number of neutrons slowed down is related to the quantity of hydrogen atoms in the material being tested. In West Virginia, if organic materials are not present, the only hydrogen available is in the water in the materials being tested. Therefore, the gauge can be calibrated to determine the moisture content based on the quantity of neutrons slowed down (thermalized) and reflected back to the detector tube. In addition, neutrons are the only radiation that would be a health hazard from the Americium 241-Beryllium source since the alpha particles cannot penetrate the steel capsule around the source.

Cesium 137 emits gamma rays (photons) which penetrate the material being tested. Gamma rays are affected by the density of the material. When the gauge is operated in the backscatter mode, the source is near the surface of the material being tested. Gamma rays must be reflected back to the detector tubes in order to be counted. In the direct transmission position, gamma rays must penetrate the material from the source toward the detector tubes in order to be counted. With both the backscatter and direct transmission modes of testing, the quantity of gamma rays detected is reduced as the density of the material increases. This characteristic occurs since fewer gamma rays are able to penetrate denser materials. Therefore, a gauge is calibrated based on the quantity of gamma rays detected versus the density of the material.

A characteristic of radiation is that the quantity of radiation emitted at one time is pulsating and will vary for short periods of detection time. If radiation, however, is detected over a period of time, the quantity of radiation is very constant. For the gauge, readings of four minute duration show almost no variance, however, one minute readings are accurate enough for most testing other than standardization.

BIOLOGICAL EFFECTS OF RADIATION

Exposure is a measure of the amount of ionization that radiation produces. The basic unit of exposure is the roentgen. One roentgen (r) represents the amount of exposure necessary to produce a certain number of ions in one cubic centimeter of air. Dose is the quantity of radiation absorbed per unit mass by the body or any portion of the body. The rad is a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue. The rem is a measure of the dose of any ionizing radiation to body tissues in terms of its estimated biological effect relative to a dose of one roentgen (r) of x-rays. One millirem (mrem) equals 0.001 rem. The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions of irradiation. The following are considered to be equivalent to a dose of one rem:

1. A dose of 1 roentgen due to x-ray or gamma radiation.
2. A dose of 1 rad due to x-ray, gamma or beta radiation.
3. A dose of 0.1 rad due to neutrons or high energy protons.

4. A dose of 0.05 rads due to particles heavier than protons (alpha particles) and with sufficient energy to reach the lens of the eye.

Exposures are broken down into internal and external exposures. Beta, gamma and neutrons are both internal and external hazards, while alpha particles are only internal hazards. Internal exposures occur only when radioactive materials enter the body. There are four principal routes by which radioactive materials can enter the body. They are inhalation, ingestion, absorption and through wounds. Once radioactive atoms enter the body, there are additional considerations besides the type of radiation emitted. Radioactive materials behave chemically and metabolically just like their non-radioactive counterparts, so a radioactive element could end up in organs, bone marrow, etc. For example, a major concern in the area around fixed nuclear facilities is the release of radioiodine in the event of an accident. Iodine is taken up by the thyroid gland and so would radioiodine, thus increasing the risk of early thyroid problems such as thyroid cancer. For Iodine-131, the physical half life is 8 days and for Calcium-47 it is 4.9 days. Not all elements stay in the body for the same length of time. Some are taken up by organs and remain in the body for long periods of time while others pass right through. The biological half life is the time required for the body to reduce the amount of material to one half its original value. For example, iodine-131 has a biological half life of 138 days in the thyroid gland while only 7 days in the kidneys. Calcium-47 has a biological half life of 18,000 days in the bone. The effective half life combines the biological and physical half lives. It is used by health physicists to do calculations to determine the dose received from an internal radiation source. For iodine-131, the effective half life for the thyroid gland is 7.6 days and for calcium 4.9 days. These values are the same as the physical half life. This is because the biological half life is so large that most of the material would decay before much of it left the body, so in this case, the biological half life would not be applicable.

NATURAL RADIATION

Radiation from outer space and the sun are bombarding us every minute. The amount we are exposed to depends on where we live. If you live at high altitudes, you get less shielding from the atmosphere and you would get a higher dose than people living at sea level. The United States average is about 28 mrem per year average from radiation emitted by trace amounts of natural radioactivity present in all earth materials. The dose from terrestrial sources also varies depending on your habitat.

The food and water we ingest and the air we breathe contain small amounts of natural radioactive materials. We have as many as 40 different radioactive substances in our body all the time. For example, potassium-40 is the most significant source of radiation exposure within everyone's body. We get about 51 mrem from these natural sources. The total dose from natural radiation averages about 105 mrem per year.

In addition to the 105 mrem from natural sources, we receive an average of 101 mrem from other sources. Such activities as uranium mining and burning coal increase our exposure by about 5 mrem per year.

Living in masonry houses, living in better insulated houses, which restrict ventilation to remove airborne radioactivity, and living in solar homes that store heat in large masses of stone, are included in this category.

Another contributor to our exposures is from medical exposures resulting from diagnostic x-rays and ingestion of radioactive materials for diagnostic tests. This adds an average of 90 mrems per year to our exposure.

The fallout from nuclear weapons tests add about 5 mrem per year. The average exposure from all operations related to nuclear energy is about 0.3 mrem per year. Consumer products such as luminous wristwatches, color television sets, false teeth that contain uranium for a more natural color, smoke detectors, other electronic products that use radioactive materials, and gas lantern mantles that use an incandescent thorium salt, all add about 0.5 mrem per year.

The total average exposure we receive per year is about 206 mrems. The actual dose you receive each year can vary greatly, especially when radiation from medical sources is considered.

The Nuclear Regulatory Commission (NRC) has an established whole body radiation exposure of 5 rems per year for occupational radiation workers.

Users of nuclear density gauges should receive only a small fraction of the allowable NRC limit if gauges are used and handled properly. Our experience has been that a user will receive between 10 and 20 millirems per month working with a gauge. This would be about 2.5% to 5% of the allowable occupational exposure for a year.

The biological effects from radiation to occupational radiation workers, if exposures are maintained within the allowable limits, are considered to have no adverse affects.

The following sections are intended to show the biological effects of large quantities of radiation which an individual might receive in case of nuclear war or accidents with radioactive materials.

An acute exposure is one delivered over a relatively short period of time (a week or less). Short is relative to how fast the body can repair the damage to cells and tissues. About 90% of damage due to non-lethal exposures is repairable in time. A massive acute dose can produce visible effects within hours to days, such as nausea, vomiting, diarrhea, or even death. A chronic exposure is one that is delivered over a long period of time, such as years or a lifetime. Both acute and chronic doses increase the risks of late effects such as cancer or genetic defects. A whole body exposure is an exposure to the trunk of the body which involves most blood forming organs. Most risk estimates are based on whole body exposures or doses. A local exposure or organ dose is a localized dose and is not whole body.

BIOLOGICAL VARIABILITY

Some of the factors which determine biological damage are as follows:

1. The type of radiation involved. Is the radiation high energy gamma, beta, alpha particles, neutrons or low energy beta.
2. The total absorbed dose determines how much damage is done to tissues. The duration of exposure affects the biological damage to the body since the body can repair much of the damage, even while it is occurring, if spread over time. A whole body exposure that would be lethal may have very little biological effect if delivered to a hand, a selected organ or to the jaw.
5. Even under identical exposure conditions, no two individuals react the same. Factors that influence this include age, sex, health, rate of metabolism, size, weight, etc.

EARLY EFFECTS OF RADIATION

Early effects to large doses of radiation include nausea and vomiting. These symptoms can also be caused by emotional stress, tainted food, as well as radiation exposure. The lining of the intestines is very sensitive to radiation and a dose of several hundred rems can cause nausea and vomiting. A dose of several thousand rems can result in death within a matter of hours due to damage to the central nervous system. A dose of 50 rems or less may not produce any noticeable symptoms. A decrease in white blood cells may be detectable with a dose of 10-25 rems.

The sensitivity of particular cells and tissues to radiological damage depends on many complex factors. The most significant factor is how rapidly the cells are reproducing. A child's cells are reproducing at a rapid rate since the child is growing. White blood cells and certain lymph cells are among the most sensitive cells in the body. The bone marrow cells, which produce white blood cells, are very sensitive to radiation and radiation can lower the supply of white blood cells. The red blood cells, however, are not as sensitive to radiation. Skin cells and cells lining the intestines are sensitive to radiation. Cancer cells are also very sensitive. Radiation can cause cancer and can also cure cancer by radiation therapy. Brain cells are very resistant to radiation.

Biological variations among people make it impossible to predict the actual effect of a given dose. A prediction can only be made for a percentage of a normal population. The following table predicts the early effects to a given group of people:

<u>Acute Dose</u>	<u>Probable Effect</u>
0-25 rems	No obvious injury
25-50 rems	Possible blood changes but no serious injury
50-100 rems	Blood cell changes, some injury, no disability
100-200 rems	Injury, possible disability
200-400 rems	Injury and disability certain, death possible

400 rems

Fatal to 50%

600 rems or more

Fatal to 100%

LATE EFFECTS OF RADIATION

Because of all the environmental hazards, biological effects from radiation are difficult to tie down. Environmental hazards might include smoking, food additives, diet patterns, pollution, etc. The biological effects that can appear years after exposure can include various kinds of cancer and birth defects to offspring. It is important to distinguish between somatic and genetic effects. A somatic effect is one that affects the individual exposed. A person may receive a high exposure and suffer from temporary hair loss or develop cancer twenty years later. An unborn child receives a high exposure and is born deformed. These are examples of somatic effects of radiation exposures. If adults receive a high exposure and the children of these adults have an abnormally high incidence of deformities, these are genetic effects.

RADIATION PROTECTION PRINCIPLES

1. Time

Time is an important factor in radiation protection. The principle states that the shorter the time spent in a radiation field, the less radiation will be accumulated. For example, an exposure rate of 60 mrem/hr means that for each minute spent in the radiation field a person will receive 1 mrem/min. Obviously, the longer a person remains in a radiation field, the greater their exposure.

2. Distance

The farther a person is from a source of radiation, the lower the radiation dose. This principle is known as the inverse square law. The inverse square law for reduction of radiation intensity applies for point sources of x-ray, gamma and neutron radiation. Gamma ray and neutron sources whose dimensions are small in comparison to the distances involved are point sources. The inverse square law states that radiation intensity from a point source varies inversely as the square of the distance from the source. The inverse square law can be expressed mathematically as follows:

$$I_1/I_2 = R_2^2/R_1^2$$

Where I_1 is the radiation intensity at distance R_1 from the source and I_2 is the radiation intensity at distance R_2 from the source. The formula will show that doubling the distance from the source decreases the dose by a factor of four. The inverse square law does not apply to extended sources or radiation fields due to multiple sources.

3. Shielding is one of the most important principles for radiation protection. X-rays and gamma radiation requires dense materials in order to be absorbed. Lead has historically been used as one of the major shielding materials due to its dense quality. The following is a comparison of lead to other common materials for shielding:

1 inch of lead = 6 inches concrete
 19.8 inches wood (hardwood)
 8.4 inches earth

Alpha and beta particles are easily shielded and generally the containers for the radioactive source will provide the necessary shielding. Fast neutrons are poorly absorbed by most materials; therefore, it is necessary to slow them down for efficient absorption. Since the greatest transfer of energy takes place in collisions between particles of equal mass, hydrogenous materials are most effective for slowing down fast neutrons. Water, paraffin, and concrete are all rich in hydrogen and effective in neutron shielding. Once the neutrons have been reduced in energy, they may be absorbed by either boron or cadmium. When a boron atom captures a neutron, it emits an alpha particle, but because of the extremely short range of alpha particles, there is no additional hazard. Neutron capture by cadmium results in the emission of gamma radiation. Lead or a similar gamma absorber must be used as a shield against these gammas.

A complete shield for a neutron source may consist of: a thick layer of paraffin to slow down the neutrons, then a surrounding layer of cadmium to absorb the slow neutrons and an outer layer of lead to absorb both the gammas produced in the cadmium and those emitted from the source.

Tungsten and lead shielding in a nuclear gauge reduces the gamma radiation when the source is in the shielded position. There is no special shielding in the gauge for neutron radiation since the quantity of neutron radiation is small.

LEAK TESTS

The radioactive sources in a nuclear gauge are encapsulated to prevent contamination. This is required for a source to meet the NRC requirements for "Special Form".

The Cesium 137 metal and glass are molded into a bead. The bead is then enclosed inside a stainless steel capsule and the capsule is placed inside another stainless steel capsule that is fusion welded on the end of the source rod. The Americium 241:Beryllium source is molded into a pellet. The pellet is then fusion welded in two stainless steel capsules and then embedded in lead inside the gauge.

A leak test is performed to determine if the radioactive material is seeping out of the capsules. If a source is leaking, very serious contamination and health hazards could result. The radioactive material could get on and possibly in the body and/or the material could produce radiation hazards by being near individuals.

By wiping around the outside of the Americium source inside the gauge and the source cavity on the bottom of the gauge removes any possible radioactive material and analyzing the wipe for radiation, a check is made to ensure that the capsule isn't leaking.

The encapsulation process used in a nuclear gauge makes the possibility very remote that a source would be leaking. Therefore, the major hazard with a nuclear gauge is the radiation that is being continuously emitted.

SHIPPING PAPERS

When a nuclear gauge is being transported on a highway, shipping papers are required. Shipping papers describe the radioactive material being transported and aids in determining safety hazards in case of an accident. Enclosed is a copy of typical shipping papers used by West Virginia Division of Highways. The shipping papers include two sheets which are: Bill of Lading and Emergency Response Information.

The following are definitions of items found on the Bill of Lading.

Shipper and Consignee -- since the Division is both owner and shipper of the nuclear gauges, a permanent shipping paper is required to transport the gauge from project to project, etc. The shipping papers do not have to be changed each time a gauge is shipped.

Special Form n o s. (not otherwise specified) -- means that if the radioactive material were released from the package, a direct radiation hazard might exist but there would be little hazard due to radiotoxicity and little possibility of contamination. This may be the result of inherent properties of the material (such as metals or alloys) or acquired characteristics as through encapsulation.

Class 7 -- this number designates that the material being transported is radioactive.

UN3332 -- this number designates the radioactive material is in special form.

Sealed Source -- means any by-product material that is encased in a capsule designed to prevent leakage or escape of the by-product material.

Type A Package -- means packaging which is designed in accordance with the US Department of Transportation general packaging requirements, and which is adequate to prevent loss or dispersal of the radioactive contents, and to retain the efficiency of its radiation shielding properties if the package is subject to specified tests. The nuclear gauge in its shipping case meets the requirements for a Type A Package.

Radioactive Yellow II -- A package which has a radiation reading of more than 0.5 mrem/hr but not more than 50 mrem/hr at each point on the package surface and not exceeding 1.0 mrem/hr at three feet from each point on the external surface of the package. A nuclear gauge must be in its shipping case to meet the Radioactive Yellow II requirement.

Transport Index (TI) -- means the number placed on a package to designate the degree of control to be exercised by the carrier during transportation. The transport index to be assigned is the highest radiation dose rate in millirems per hour at three feet from any accessible external surface of the package

LOCATION OF SHIPPING PAPERS

A driver of a motor vehicle containing hazardous material and each carrier using such a vehicle, shall ensure that the shipping papers are readily available to and recognizable by authorities in the event of an accident or inspection.

The driver shall clearly distinguish the shipping paper from all other papers of any kind by distinctively tabbing or by having them appear first. When the driver is at the vehicle controls, the shipping papers shall be within his immediate reach while restrained by the lap belt. The papers shall be readily visible to a person entering the driver's compartment or in a holder which is mounted to the inside of the door on the driver's side of the vehicle. When the driver is not at the vehicle's controls, the shipping papers shall be in a holder which is mounted to the inside of the door on the driver's side of the vehicle or on the driver's seat in the vehicle.

DOSIMETERS

The Division supplies dosimeters to users of nuclear gauges. The dosimeters must be worn at all times when using or handling a gauge. The dosimeters are capable of measuring the whole body exposure of gammas, betas and neutrons. The enclosed "Notice to Employees" gives additional details on using the dosimeters.

Records of each individual's exposure to radiation is maintained at the Contract Administration Division. This information is available to each individual upon request.

STORAGE AREAS

Restricted area means any area access to which is controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials. A restricted area shall not include any areas used as residential quarters, although a separate room or rooms, in a residential building may be set apart as a restricted area.

Unrestricted area means any area access to which is not controlled by the licensee for purposes of protection of individuals from exposure to radiation and radioactive materials and any area used for residential quarters.

As stated in Part 20 of the NRC Regulations, the levels of radiation in an unrestricted area cannot exceed the following:

1. Radiation levels which, if an individual were continuously present in the area, could result in his receiving a dose in excess of two millirems per hour, or

2. Radiation levels which, If an individual were continuously present in the area, could result in his/her receiving a dose in excess of 100 millirems in any seven (7) consecutive days. This calculates to 0.595 millirems/hour.

All storage areas must have a radiation reading that is very near to the background radiation level for the area anywhere on the outside of the storage area.

POSTING AND LABELING

Placards are not required on vehicles transporting nuclear gauges.

Each area or room in which a gauge is stored shall be posted with a sign or signs bearing the radiation caution symbol and the words: "Caution Radioactive Material(s)".

The nuclear gauge shipping cases are properly labeled for transporting the gauge. A check should be made periodically to ensure that all labels are present and legible.

NRC Notice To Employees", the Division's Notice To Employees (MA-1), Regulatory Guide 8-13, and Part 21 of the NRC Regulations are to be posted in storage areas and in work areas and field offices where a gauge is being used.



**WEST VIRGINIA
DEPARTMENT OF TRANSPORTATION
190 Kanawha Boulevard East • Building Five • Room 109
Charleston, West Virginia 25305-0440 • 304/558-0444**

**Joe Manchin III
Governor**

November 3, 2011

BILL OF LADING

Shipper: West Virginia Division of Highways
190 Dry Branch Road
Charleston, West Virginia 25306

<u>Qty</u>	<u>Description</u>
1 case	UN3332, Radioactive material, Type A package, Special Form, 7, RQ Cs – 137, 0.30 GBq (8.0 mCi) Am – 241, 1.48 GBq (40.0 mCi) Radioactive Yellow II Label, TI = 0.3

*****EMERGENCY CONTACT: (919) 549-9539 *****

West Virginia Division of Highways

Shipper Name (Print): _____

Shipper Name (Signature): _____

TROXLER NUCLEAR GAUGE EMERGENCY RESPONSE INFORMATION
REQUIRED FOR TRANSPORTATION

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

1. PROPER SHIPPING NAME:

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

POTENTIAL HAZARDS

2. HEALTH HAZARDS

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

3. FIRE OR EXPLOSION

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

EMERGENCY ACTION

4. IMMEDIATE PRECAUTIONS

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

5. FIRE

- ◆ Do not move damaged packages; move undamaged packages out of fire zone.
- ◆ **Small Fires:** Dry chemical, CO₂ water spray or regular foam.
- ◆ **Large Fires:** Water spray, fog (flooding amounts)

6. SPILL OR LEAK

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

7. FIRST AID

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



REGULATORY GUIDE

OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE 8.13
(Task OP 031-4)

INSTRUCTION CONCERNING PRENATAL RADIATION EXPOSURE

A. INTRODUCTION

Section 19.12, "Instructions to Workers," of 10 CFR Part 19, "Notices, Instructions, and Reports to Workers; Inspections," requires that all individuals working in or frequenting any portion of a restricted area¹ be instructed in the health protection problems associated with exposure to radioactive materials or radiation, in precautions or procedures to minimize exposure, and in the regulations that they are expected to observe. The present 10 CFR Part 20, "Standards for Protection Against Radiation," has no special limit for exposure of the embryo/fetus.² This guide describes the instructions an employer should provide to workers and supervisors concerning biological risks to the embryo/fetus exposed to radiation, a dose limit for the embryo/fetus that is under consideration, and suggestions for reducing radiation exposure.

This regulatory guide takes into consideration a proposed revision to 10 CFR Part 20, which incorporates the radiation protection guidance for the embryo/fetus approved by the President in January 1987 (Ref. 1). This revision to Part 20 was issued in January 1986 for comment as a proposed rule. Comments on the guide as it pertains to the proposed Part 20 are encouraged. If the new Part 20 is codified, this regulatory guide will be revised to conform to the new regulation and will incorporate appropriate public comments.

Any information collection activities mentioned in this regulatory guide are contained as requirements in 10 CFR Parts 19 or 20, which provide the regulatory

¹Restricted area means any area that has controlled access to protect individuals from being exposed to radiation and radioactive materials.

²In conformity with the proposed revision to 10 CFR Part 20, the term "embryo/fetus" is used throughout this document to represent all stages of pregnancy.

basis for this guide. The information collection requirements in 10 CFR Parts 19 and 20 have been cleared under OMB Clearance Nos. 3150-0044 and 3150-0014, respectively.

B. DISCUSSION

It has been known since 1906 that cells that are dividing very rapidly and are undifferentiated in their structure and function are generally more sensitive to radiation. In the embryo stage, cells meet both these criteria and thus would be expected to be highly sensitive to radiation. Furthermore, there is direct evidence that the embryo/fetus is radiosensitive. There is also evidence that it is especially sensitive to certain radiation effects during certain periods after conception, particularly during the first 2 to 3 months after conception when a woman may not be aware that she is pregnant.

Section 20.104 of 10 CFR Part 20 places different radiation dose limits on workers who are minors than on adult workers. Workers under the age of 18 are limited to one-tenth of the adult radiation dose limits. However, the present NRC regulations do not establish dose limits specifically for the embryo/fetus.

The NRC's present limit on the radiation dose that can be received on the job is 1,250 millirems per quarter (3 months).³ Working minors (those under 18) are limited to a dose equal to one-tenth that of adults, 125 millirems per quarter. (See § 20.101 of 10 CFR Part 20.)

Because of the sensitivity of the unborn child, the National Council on Radiation Protection and Measurements (NCRP) has recommended that the dose equivalent

³The limit is 3,000 millirems per quarter if the worker's occupational dose history is known and the average dose does not exceed 5,000 millirems per year.

USNRC REGULATORY GUIDES

Regulatory Guides are issued to describe and make available to the public methods acceptable to the NRC staff of implementing specific parts of the Commission's regulations, to delineate techniques used by the staff in evaluating specific problems or postulated accidents, or to provide guidance to applicants. Regulatory Guides are not substitutes for regulations, and compliance with them is not required. Methods and solutions different from those set out in the guides will be acceptable if they provide a basis for the findings requisite to the issuance or continuance of a permit or license by the Commission.

This guide was issued after consideration of comments received from the public. Comments and suggestions for improvements in these guides are encouraged at all times, and guides will be revised, as appropriate, to accommodate comments and to reflect new information or experience.

Written comments may be submitted to the Rules and Procedures Branch, DRR, ADM, U.S. Nuclear Regulatory Commission, Washington, DC 20555. 4-1

The guides are issued in the following ten broad divisions:

- | | |
|-----------------------------------|-----------------------------------|
| 1. Power Reactors | 6. Products |
| 2. Research and Test Reactors | 7. Transportation |
| 3. Fuels and Materials Facilities | 8. Occupational Health |
| 4. Environmental and Siting | 9. Antitrust and Financial Review |
| 5. Materials and Plant Protection | 10. General |

Copies of issued guides may be purchased from the Government Printing Office at the current GPO price. Information on current GPO prices may be obtained by contacting the Superintendent of Documents, U.S. Government Printing Office, Post Office Box 37082, Washington, DC 20013-7082, telephone (202)275-2060 or (202)275-2171.

Issued guides may also be purchased from the National Technical Information Service on a standing order basis. Details on this service may be obtained by writing NTIS, 5285 Port Royal Road, Springfield, VA 22161.

to the unborn child from occupational exposure of the expectant mother be limited to 500 millirems for the entire pregnancy (Ref. 2). The 1987 Presidential guidance (Ref. 1) specifies an effective dose equivalent limit of 500 millirems to the unborn child if the pregnancy has been declared by the mother; the guidance also recommends that substantial variations in the rate of exposure be avoided. The NRC (in § 20.208 of its proposed revision to Part 20) has proposed adoption of the above limits on dose and rate of exposure.

In 1971, the NCRP commented on the occupational exposure of fertile women (Ref. 2) and suggested that fertile women should be employed only where the annual dose would be unlikely to exceed 2 or 3 rems and would be accumulated at a more or less steady rate. In 1977, the ICRP recommended that, when pregnancy has been diagnosed, the woman work only where it is unlikely that the annual dose would exceed 0.30 of the dose-equivalent limit of 5 rems (Ref. 3). In other words, the ICRP has recommended that pregnant women not work where the annual dose might exceed 1.5 rem.

C. REGULATORY POSITION

Instructions on radiation risks should be provided to workers, including supervisors, in accordance with § 19.12 of 10 CFR Part 19 before they are allowed to work in a restricted area. In providing instructions on radiation risks, employers should include specific instruc-

tions about the risks of radiation exposure to the embryo/fetus.

The instructions should be presented both orally and in printed form, and the instructions should include, as a minimum, the information provided in Appendix A (Instructor's Guide) to this guide. Individuals should be given the opportunity to ask questions and in turn should be questioned to determine whether they understand the instructions. An acceptable method of ensuring that the information is understood is to give a simple written test covering the material included in Appendix B (Pregnant Worker's Guide). This approach should highlight for instructors those parts of the instructions that cause difficulties and thereby lead to appropriate modifications in the instructional curriculum.

D. IMPLEMENTATION

The purpose of this section is to provide information to applicants and licensees regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which an applicant or licensee proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the NRC will use the material described in this guide to evaluate the instructional program presented to individuals, including supervisors, working in or frequenting any portion of a restricted area.

APPENDIX A

INSTRUCTOR'S GUIDE

EFFECTS ON THE EMBRYO/FETUS OF EXPOSURE TO RADIATION AND OTHER ENVIRONMENTAL HAZARDS

In order to decide whether to continue working while exposed to ionizing radiation during her pregnancy, a woman should understand the potential effects on an embryo/fetus, including those that may be produced by various environmental risks such as smoking and drinking. This will allow her to compare these risks with those produced by exposure to ionizing radiation.

Table 1 provides information on the potential effects resulting from exposure of an embryo/fetus to radiation and nonradiation risks. The second column gives the rate at which the effect is produced by natural causes in terms of the number per thousand cases. The fourth column gives the number of additional effects per thousand cases believed to be produced by exposure to the specified amount of the risk factor.

The following section discusses the studies from which the information in Table 1 was derived. The results of exposure of the embryo/fetus to the risk factors and the dependence on the amount of the exposure are explained.

1. RADIATION RISKS

1.1 Childhood Cancer

Numerous studies of radiation-induced childhood cancer have been performed, but a number of them are controversial. The National Academy of Science (NAS) BEIR report reevaluated the data from these studies and even reanalyzed the results. Some of the strongest support for a causal relationship is provided by twin data from the Oxford survey (Ref. 4). For maternal radiation doses of 1,000 millirems, the excess number of deaths (above those occurring from natural causes) was found to be 0.6 death per thousand children (Ref. 4).

1.2 Mental Retardation and Abnormal Smallness of the Head (Microcephaly)

Studies of Japanese children who were exposed while in the womb to the atomic bomb radiation at Hiroshima and Nagasaki have shown evidence of both small head size and mental retardation. Most of the children were exposed to radiation doses in the range of 1 to 50 rads. The importance of the most recent study lies in the fact that investigators were able to show that the gestational age (age of the embryo/fetus after conception) at the time the children were exposed was a critical factor (Ref. 7). The approximate risk of small head size as a function of gestational age is shown in Table 1. For a radiation dose of 1,000 millirems at 4 to 7 weeks after conception, the

excess cases of small head size was 5 per thousand; at 8 to 11 weeks, it was 9 per thousand (Ref. 7).

In another study, the highest risk of mental retardation occurred during the 8 to 15 week period after conception (Ref. 8). A recent EPA study (Ref. 16) has calculated that excess cases of mental retardation per live birth lie between 0.5 and 4 per thousand per rad.

1.3 Genetic Effects

Radiation-induced genetic effects have not been observed to date in humans. The largest source of material for genetic studies involves the survivors of Hiroshima and Nagasaki, but the 77,000 births that occurred among the survivors showed no evidence of genetic effects. For doses received by the pregnant worker in the course of employment considered in this guide, the dose received by the embryo/fetus apparently would have a negligible effect on descendants (Refs. 17 and 18).

2. NONRADIATION RISKS

2.1 Occupation

A recent study (Ref. 9) involving the birth records of 130,000 children in the State of Washington indicates that the risk of death to the unborn child is related to the occupation of the mother. Workers in the metal industry, the chemical industry, medical technology, the wood industry, the textile industry, and farms exhibited stillbirths or spontaneous abortions at a rate of 90 per thousand above that of workers in the control group, which consisted of workers in several other industries.

2.2 Alcohol

It has been recognized since ancient times that alcohol consumption had an effect on the unborn child. Carthaginian law forbade the consumption of wine on the wedding night so that a defective child might not be conceived. Recent studies have indicated that small amounts of alcohol consumption have only the minor effect of reducing the birth weight slightly, but when consumption increases to 2 to 4 drinks per day, a pattern of abnormalities called the fetal alcohol syndrome (FAS) begins to appear (Ref. 11). This syndrome consists of reduced growth in the unborn child, faulty brain function, and abnormal facial features. There is a syndrome that has the same symptoms as full-blown FAS that occurs in children born to mothers who have not consumed alcohol. This naturally occurring syndrome occurs in about 1 to 2 cases per thousand (Ref. 10).

TABLE 1
EFFECTS OF RISK FACTORS ON PREGNANCY OUTCOME

Effect	Number Occurring from Natural Causes	Risk Factor	Excess Occurrences from Risk Factor
RADIATION RISKS			
Childhood Cancer			
Cancer death in children	1.4 per thousand (Ref. 5)	Radiation dose of 1000 millirems received before birth	0.6 per thousand (Ref. 4)
Abnormalities			
Radiation dose of 1000 millirads received during specific periods after conception:			
Small head size	40 per thousand (Ref. 6)	4-7 weeks after conception	5 per thousand (Ref. 7)
Small head size	40 per thousand (Ref. 6)	8-11 weeks after conception	9 per thousand (Ref. 7)
Mental retardation	4 per thousand (Ref. 8)	Radiation dose of 1000 millirads received 8 to 15 weeks after conception	4 per thousand (Ref. 8)
NONRADIATION RISKS			
Occupation			
Stillbirth or spontaneous abortion	200 per thousand (Ref. 9)	Work in high-risk occupations (see text)	90 per thousand (Ref. 9)
Alcohol Consumption (see text)			
Fetal alcohol syndrome	1 to 2 per thousand (Ref. 10)	2-4 drinks per day	100 per thousand (Ref. 11)
Fetal alcohol syndrome	1 to 2 per thousand (Ref. 10)	More than 4 drinks per day	200 per thousand (Ref. 11)
Fetal alcohol syndrome	1 to 2 per thousand (Ref. 10)	Chronic alcoholic (more than 10 drinks per day)	350 per thousand (Ref. 12)
Perinatal infant death (around the time of birth)	23 per thousand (Refs. 13, 14)	Chronic alcoholic (more than 10 drinks per day)	170 per thousand (Ref. 15)
Smoking			
Perinatal infant death	23 per thousand (Refs. 13, 14)	Less than 1 pack per day	5 per thousand (Ref. 13)
Perinatal infant death	23 per thousand (Refs. 13, 14)	One pack or more per day	10 per thousand (Ref. 13)

For mothers who consume 2 to 4 drinks per day, the excess occurrences number about 100 per thousand; and for those who consume more than 4 drinks per day, excess occurrences number 200 per thousand. The most sensitive period for this effect of alcohol appears to be the first few weeks after conception, before the mother-to-be realizes she is pregnant (Refs. 10 and 11). Also, 17% or 170 per thousand of the embryo/fetuses of chronic alcoholics develop FAS and die before birth (Ref. 15). FAS was first identified in 1973 in the United States where less than full-blown effects of the syndrome are now referred to as fetal alcohol effects (FAE) (Ref. 12).

2.3 Smoking

Smoking during pregnancy causes reduced birth weights in babies amounting to 5 to 9 ounces on the average. In addition, there is an increased risk of 5 infant deaths per thousand for mothers who smoke less than one pack per day and 10 infant deaths per

thousand for mothers who smoke one or more packs per day (Ref. 13).

2.4 Miscellaneous

Numerous other risks affect the embryo/fetus, only a few of which are touched upon here. Most people are familiar with the drug thalidomide (a sedative given to some pregnant women), which causes children to be born with missing limbs, and the more recent use of the drug diethylstilbestrol (DES), a synthetic estrogen given to some women to treat menstrual disorders, which produced vaginal cancers in the daughters born to women who took the drug. Living at high altitudes also gives rise to an increase in the number of low-birth-weight children born, while an increase in Down's Syndrome (mongolism) occurs in children born to mothers who are over 35 years of age. The rapid growth in the use of ultrasound in recent years has sparked an ongoing investigation into the risks of using ultrasound for diagnostic procedures (Ref. 19).

APPENDIX B

PREGNANT WORKER'S GUIDE

POSSIBLE HEALTH RISKS TO CHILDREN OF WOMEN WHO ARE EXPOSED TO RADIATION DURING PREGNANCY

During pregnancy, you should be aware of things in your surroundings or in your style of life that could affect your unborn child. For those of you who work in or visit areas designated as Restricted Areas (where access is controlled to protect individuals from being exposed to radiation and radioactive materials), it is desirable that you understand the biological risks of radiation to your unborn child.

Everyone is exposed daily to various kinds of radiation: heat, light, ultraviolet, microwave, ionizing, and so on. For the purposes of this guide, only ionizing radiation (such as x-rays, gamma rays, neutrons, and other high-speed atomic particles) is considered. Actually, everything is radioactive and all human activities involve exposure to radiation. People are exposed to different amounts of natural "background" ionizing radiation depending on where they live. Radon gas in homes is a problem of growing concern. Background radiation comes from three sources:

	Average Annual Dose
Terrestrial - radiation from soil and rocks	50 millirem
Cosmic - radiation from outer space	50 millirem
Radioactivity normally found within the human body	25 millirem
	125 millirem*
Dosage range (geographic and other factors)	75 to 5,000 millirem

The first two of these sources expose the body from the outside, and the last one exposes it from the inside. The average person is thus exposed to a total dose of about 125 millirems per year from natural background radiation.

In addition to exposure from normal background radiation, medical procedures may contribute to the dose people receive. The following table lists the average doses received by the bone marrow (the blood-forming cells) from different medical applications.

*Radiation doses in this document are described in two different units. The rad is a measure of the amount of energy absorbed in a certain amount of material (100 ergs per gram). Equal amounts of energy absorbed from different types of radiation may lead to different biological effects. The rem is a unit that reflects the biological damage done to the body. The millirad and millirem refer to 1/1000 of a rad and a rem, respectively.

X-Ray Procedure

Average Dose*

Normal chest examination	10 millirem
Normal dental examination	10 millirem
Rib cage examination	140 millirem
Gall bladder examination	170 millirem
Barium enema examination	500 millirem
Pelvic examination	600 millirem

*Variations by a factor of 2 (above and below) are not unusual.

NRC POSITION

NRC regulations and guidance are based on the conservative assumption that any amount of radiation, no matter how small, can have a harmful effect on an adult, child, or unborn child. This assumption is said to be conservative because there are no data showing ill effects from small doses; the National Academy of Sciences recently expressed "uncertainty as to whether a dose of, say, 1 rad would have any effect at all." Although it is known that the unborn child is more sensitive to radiation than adults, particularly during certain stages of development, the NRC has not established a special dose limit for protection of the unborn child. Such a limit could result in job discrimination for women of child-bearing age and perhaps in the invasion of privacy (if pregnancy tests were required) if a separate regulatory dose limit were specified for the unborn child. Therefore, the NRC has taken the position that special protection of the unborn child should be *voluntary* and should be based on decisions made by workers and employers who are well informed about the risks involved.

For the NRC position to be effective, it is important that both the employee and the employer understand the risk to the unborn child from radiation received as a result of the occupational exposure of the mother. This document tries to explain the risk as clearly as possible and to compare it with other risks to the unborn child during pregnancy. It is hoped this will help pregnant employees balance the risk to the unborn child against the benefits of employment to decide if the risk is worth taking. This document also discusses methods of keeping the dose, and therefore the risk, to the unborn child as low as is reasonably achievable.

RADIATION DOSE LIMITS

The NRC's present limit on the radiation dose that can be received on the job is 1,250 millirems per quarter (3 months). * Working minors (those under 18) are limited to a dose equal to one-tenth that of adults, 125 millirems per quarter. (See § 20.101 of 10 CFR Part 20.)

Because of the sensitivity of the unborn child, the National Council on Radiation Protection and Measurements (NCRP) has recommended that the dose equivalent to the unborn child from occupational exposure of the expectant mother be limited to 500 millirems for the entire pregnancy (Ref. 2). The 1987 Presidential guidance (Ref. 1) specifies an effective dose equivalent limit of 500 millirems to the unborn child if the pregnancy has been declared by the mother; the guidance also recommends that substantial variations in the rate of exposure be avoided. The NRC (in § 20.208 of its proposed revision to Part 20) has proposed adoption of the above limits on dose and rate of exposure.

ADVICE FOR EMPLOYEE AND EMPLOYER

Although the risks to the unborn child are small under normal working conditions, it is still advisable to limit the radiation dose from occupational exposure to no more than 500 millirems for the total pregnancy. Employee and employer should work together to decide the best method for accomplishing this goal. Some methods that might be used include reducing the time spent in radiation areas, wearing some shielding over the abdominal area, and keeping an extra distance from radiation sources when possible. The employer or health physicist will be able to estimate the probable dose to the unborn child during the normal nine-month pregnancy period and to inform the employee of the amount. If the predicted dose exceeds 500 millirems, the employee and employer should work out schedules or proce-

*The limit is 3,000 millirems per quarter if the worker's occupational dose history is known and the average dose does not exceed 5,000 millirems per year.

dures to limit the dose to the 500-millirem recommended limit.

It is important that the employee inform the employer of her condition as soon as she realizes she is pregnant if the dose to the unborn child is to be minimized.

INTERNAL HAZARDS

This document has been directed primarily toward a discussion of radiation doses received from sources outside the body. Workers should also be aware that there is a risk of radioactive material entering the body in workplaces where unsealed radioactive material is used. Nuclear medicine clinics, laboratories, and certain manufacturers use radioactive material in bulk form, often as a liquid or a gas. A list of the commonly used materials and safety precautions for each is beyond the scope of this document, but certain general precautions might include the following:

1. Do not smoke, eat, drink, or apply cosmetics around radioactive material.
2. Do not pipette solutions by mouth.
3. Use disposable gloves while handling radioactive material when feasible.
4. Wash hands after working around radioactive material.
5. Wear lab coats or other protective clothing whenever there is a possibility of spills.

Remember that the employer is required to have demonstrated that it will have safe procedures and practices before the NRC issues it a license to use radioactive material. Workers are urged to follow established procedures and consult the employer's radiation safety officer or health physicist whenever problems or questions arise.



NOTICE TO EMPLOYEES

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

WHAT IS THE NUCLEAR REGULATORY COMMISSION?
The Nuclear Regulatory Commission is an independent Federal regulatory agency responsible for licensing and inspecting nuclear power plants and other commercial uses of radioactive materials.

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

WHAT RESPONSIBILITY DOES MY EMPLOYER HAVE?
Any company that conducts activities licensed by the NRC must comply with the NRC's requirements. If a company does not meet these requirements, it can be fined or have its license modified, suspended or revoked.
Your employer must tell you which NRC radiation requirements apply to your work and must post NRC Notices of Violation involving radiological working conditions.

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

WHAT IF I CAUSE A VIOLATION?
If you engaged in deliberate misconduct that may cause a violation of the NRC rules, you should report it. If it had not been detected, or if you have a safety concern, you should report it immediately to your supervisor or to your employer, who may be subject to enforcement action. If you report such a violation, the NRC will consider the circumstances surrounding your reporting in determining the appropriate enforcement action, if any.

HOW DO I REPORT VIOLATIONS AND SAFETY CONCERNS?
If you believe that violations of NRC rules or the terms of the license have occurred, or if you have a safety concern, you should report them immediately to the NRC. However, the NRC encourages you to raise your concerns directly to the licensee since the licensee has the primary responsibility for ensuring that the licensee is able to ensure safe operation of nuclear facilities. If you choose to report your concern directly to the NRC, you may report it to an NRC

inspector or call or write to the NRC Regional Office serving your area. You can learn more about the NRC's role in protecting your safety. For more information, call the NRC's toll-free SAFETY HOTLINE for reporting safety concerns. The NRC's toll-free SAFETY HOTLINE for reporting safety concerns is listed below. The addresses for the NRC Regional Offices and the toll-free telephone numbers are also listed below. You can also e-mail safety concerns to NRC.Allegation@nrc.gov.

WHAT IF I WORK WITH RADIOACTIVE MATERIAL OR IN THE VICINITY OF A RADIOACTIVE SOURCE?
If you work with radioactive materials or near a radiation source, the amount of radiation exposure that you are permitted to receive may be limited by NRC regulations. The limits on exposure for workers at NRC licensed facilities whose duties involve exposure to radiation are contained in sections 20.1201, 20.1207, and 20.1208 of Title 10 of the Code of Federal Regulations (10 CFR 20), depending on the part of the regulations to which your employer is subject. While working at a licensed facility, your employer should also keep your radiation exposure as far below those limits as is reasonably achievable.

MAY I GET A RECORD OF MY RADIATION EXPOSURE?
Yes. Your employer is required to make available to you the information in your dose records (as maintained under the provisions of 10 CFR 20.2106). In addition your employer is required to provide you with an annual report of the dose you received in that monitoring year. If the dose exceeds 100 millirem, or if you request an annual report.

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

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

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

HOW DO I CONTACT THE NRC?
Talk to an NRC inspector on-site or call or write to the nearest NRC Regional Office in your geographic area (see map below). If you call the NRC's toll-free SAFETY HOTLINE during normal business hours, your call will automatically be directed to the NRC Regional Office for your geographical area. If you have a safety concern, you may call the NRC's toll-free Operations and Headquarters Operations Center, which is manned 24 hours a day. You can also e-mail safety concerns to NRC.Allegation@nrc.gov.

CAN I BE FIRED FOR RAISING A SAFETY CONCERN?
Federal law prohibits an employer from firing or otherwise discriminating against you for bringing safety concerns to the attention of your employer or the NRC. You may not be fired or discriminated against because you engage in certain protected activities, including but not limited to:

- asking the NRC to enforce its rules against your employer;
- refusing to engage in activities which violate NRC requirements;
- requesting information or preparing to provide information to the NRC or your employer about violations of requirements or safety concerns, or
- asking for, or testifying, helping, or taking part in an NRC, Congressional, or any Federal or State proceeding.

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

HOW DO I FILE A DISCRIMINATION COMPLAINT?
If you believe that you have been discriminated against for bringing violations or safety concerns to the attention of the NRC, you may file a discrimination complaint with the NRC, the U.S. Department of Labor (DOL), or appropriate state entities. If you desire a personal remedy, a complaint may be filed with the

DOL pursuant to Section 211 of the ERA or with appropriate state entities. Your complaint to the DOL must describe in detail the basis for your belief that the employer discriminated against you on the basis of your protected activity, and it must be filed in writing either in person or by mail within 180 days of the date of the alleged discriminatory action or the date you received any notice in writing or otherwise of an adverse action or other action which occurred first. Additional information is available at the DOL web site at www.osha.gov. Filing an allegation, complaint, or request for action with the NRC does not extend the requirement to file a complaint with the DOL within 180 days. To do so, you may contact the Allegation Coordinator in the appropriate NRC Region, as listed below, who will provide you with the address and telephone number of the contact OSHA Regional office to receive your complaint. For more information on the NRC's authority under the U.S. Government listings for the address and telephone number of the appropriate OSHA Regional office.

WHAT CAN THE DEPARTMENT OF LABOR DO?
If your complaint involves a violation of Section 211 of the ERA by your employer, the DOL provides a process for obtaining a personal remedy. The DOL will notify your employer that a complaint has been filed and will investigate your complaint.

If the DOL finds that your employer has unlawfully discriminated against you, it may order that you be reinstated, receive back pay, or be compensated for any injury suffered as a result of the discrimination and be paid attorney's fees and costs. Relief will not be awarded to employees who engage in deliberate violations of the Energy Reorganization Act or the Atomic Energy Act.

WHAT WILL THE NRC DO?
The NRC will evaluate each allegation of harassment, intimidation, or discrimination. Following this evaluation, an investigator exists to initiate an investigation on the evaluation and, if applicable, the interview, the NRC will make a decision on the evaluation and will decide whether to pursue the matter further through an investigation. The assigned priority is based on the specifics of the case. The NRC may not pursue an investigation of low priority cases to the point that a conclusion can be made whether the harassment, intimidation, or discrimination actually occurred. Even if NRC decides not to pursue an investigation, it may file a complaint with the DOL. The NRC will monitor the results of the DOL investigation.

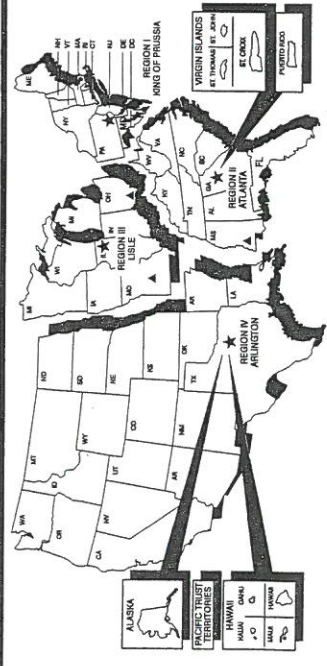
If the NRC or the DOL finds that unlawful discrimination has occurred, the NRC may suspend, revoke, or suspend the license of the licensee, impose a fine, or suspend, modify, or revoke your employer's NRC license.

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

REGION	ADDRESS	TELEPHONE
I	U.S. Nuclear Regulatory Commission, Region I 475 Atlantic Boulevard King of Prussia, PA 19406-1415	(800) 432-1156
II	U.S. Nuclear Regulatory Commission, Region II Sam Nunn Atlanta Federal Center 61 Forsyth Street, S.W., Suite 23785 Atlanta, GA 30303-8931	(800) 577-8510
III	U.S. Nuclear Regulatory Commission, Region III 2443 Warrenville Road, Suite 210 Lisle, IL 60532-4352	(800) 522-3025
IV	U.S. Nuclear Regulatory Commission, Region IV 612 East Lamar Blvd., Suite 400 Arlington, TX 76011-4125	(800) 952-9677

To report incidents involving fraud, waste, or abuse by an NRC employee or NRC contractor, telephone:
OFFICE OF THE INSPECTOR GENERAL
HOTLINE
1-800-233-3497

To report safety concerns or violations of NRC requirements by your employer, telephone:
NRC SAFETY HOTLINE
1-800-695-7403



▲ - Callaway Plant Site in Missouri and Grand Gulf Plant Site in Mississippi are under the purview of Region IV. The Portsmouth Gaseous Diffusion Plant in Ohio is under the purview of Region II.

Appendix H

Operating, Emergency, and Security Procedures

Operating Procedures

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

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

Emergency Procedures

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

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

NAME ¹	WORK PHONE NUMBER ¹	HOME PHONE NUMBER ¹
_____	_____	_____
_____	_____	_____
_____	_____	_____

Follow the directions provided by the person contacted above.

RSO and Licensee Management

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

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

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

- Reports to NRC must be made within the reporting time frames specified by the regulations.
- Reporting requirements to NRC are found in 10 CFR Parts 20.2201-2203 and 10 CFR Part 30.50.

Security Procedures

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

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

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

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

Using two chains is not the preferred method. To provide adequate security licensees

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

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

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

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

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

Securing a Portable Gauge at a Licensed Facility

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

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

1. The portable gauge or transportation case containing the portable gauge is stored inside a locked storage shed within a secured outdoor area, such as a fenced parking area with a locked gate;
2. The portable gauge or transportation case containing the portable gauge is stored in a room with a locked door within a secured building for which the licensee controls access by lock and key or by a security guard;
3. The portable gauge or transportation case containing the portable gauge is stored inside a locked, non-portable cabinet inside a room with a locked door, if the building is not secured;
4. The portable gauge or transportation case containing the portable gauge is stored in a separate secured area inside a secured mini-warehouse or storage facility; or
5. The portable gauge or transportation case containing the portable gauge is physically secured to the inside structure of a secured mini-warehouse or storage facility.

Securing a Portable Gauge in a Vehicle

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

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

A vehicle may be used for storage, however, it is recommended by NRC and DOT that this practice only be used for short periods of time or when a portable gauge is in transit. A portable gauge should only be kept in a vehicle overnight if it is not

practicable to provide temporary storage in a permanent structure. When a portable gauge is being stored in a vehicle, the licensee is specifically required to use a minimum of two independent physical controls to secure the portable gauge.

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

1. The locked transportation case containing the portable gauge is physically secured to a vehicle with brackets, and a chain or steel cable (attached to the vehicle) is wrapped around the transportation case such that the case can not be opened unless the chain or cable is removed. In this example, the locked transportation case would count as one control because the brackets would prevent easy removal of the case. The chain or cable looped only through the transportation case handle is not acceptable;
2. The portable gauge or transportation case containing the portable gauge is stored in a box physically attached to a vehicle, and the box is secured with (1) two independent locks; (2) two separate chains or steel cables attached independently to the vehicle in such a manner that the box cannot be opened without the removal of the chains or cables; or (3) one lock and one chain or steel cable is attached to the vehicle in such a manner that the box cannot be opened without the removal of the chain or cable; or
3. The portable gauge or transportation case containing the portable gauge is stored in a locked trunk, camper shell, van, or other similar enclosure and is physically secured to the vehicle by a chain or steel cable in such a manner that one would not be able to open the case or remove the portable gauge without removal of the chain or cable.

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

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

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

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

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

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

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

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