NRC FORM 313
(10-87)
10 CFR 30, 32, 33, 34, 35 and 40

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED BY OMB
3150-0120
Expires: 6-30-89

APPLICATION FOR MATERIAL LICENSE

INSTRUCTIONS: SEE THE APPROPRIATE LICENSE APPLICATION GUIDE FOR DETAILED INSTRUCTIONS FOR COMPLETING APPLICATION. SEND TWO COPIES OF THE ENTIRE COMPLETED APPLICATION TO THE NRC OFFICE SPECIFIED BELOW.

APPLICATIONS FOR DISTRIBUTION OF EXEMPT PRODUCTS FILE APPLICATIONS WITH:

U.S. NUCLEAR REGULATORY COMMISSION
DIVISION OF FUEL CYCLE AND MATERIAL SAFETY, NMSS
WASHINGTON, DC 20555

ALL OTHER PERSONS FILE APPLICATIONS AS FOLLOWS. IF YOU ARE LOCATED IN:

CONNECTICUT, DELAWARE, DISTRICT OF COLUMBIA, MAINE, MARYLAND, MASSACHUSETTS, NEW HAMPSHIRE, NEW JERSEY, NEW YORK, PENNSYLVANIA, RHODE ISLAND, OR VERMONT, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION I
NUCLEAR MATERIALS SAFETY SECTION B
475 ALLENDALE ROAD
KING OF PRUSSIA, PA 19406

ALABAMA, FLORIDA, GEORGIA, KENTUCKY, MISSISSIPPI, NORTH CAROLINA, PUERTO RICO, SOUTH CAROLINA, TENNESSEE, VIRGINIA, VIRGIN ISLANDS, OR WEST VIRGINIA, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION II
NUCLEAR MATERIALS SAFETY SECTION
101 MARIETTA STREET, SUITE 2900
ATLANTA, GA 30323

IF YOU ARE LOCATED IN:

ILLINOIS, INDIANA, IOWA, MICHIGAN, MINNESOTA, MISSOURI, OHIO, OR WISCONSIN, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION III
MATERIALS LICENSING SECTION
799 ROOSEVELT ROAD
GLEN ELLYN, IL 60137

ARKANSAS, COLORADO, IDAHO, KANSAS, LOUISIANA, MONTANA, NEBRASKA, NEW MEXICO, NORTH DAKOTA, OKLAHOMA, SOUTH DAKOTA, TEXAS, UTAH, OR WYOMING, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION IV
MATERIAL RADIATION PROTECTION SECTION
611 RYAN PLAZA DRIVE, SUITE 1000
ARLINGTON, TX 76011

ALASKA, ARIZONA, CALIFORNIA, HAWAII, NEVADA, OREGON, WASHINGTON, AND U.S. TERRITORIES AND POSSESSIONS IN THE PACIFIC, SEND APPLICATIONS TO:

U.S. NUCLEAR REGULATORY COMMISSION, REGION V
NUCLEAR MATERIALS SAFETY SECTION
1450 MARIA LANE, SUITE 210
WALNUT CREEK, CA 94596

PERSONS LOCATED IN AGREEMENT STATES SEND APPLICATIONS TO THE U.S. NUCLEAR REGULATORY COMMISSION ONLY IF THEY WISH TO POSSESS AND USE LICENSED MATERIAL IN STATES SUBJECT TO U.S. NUCLEAR REGULATORY COMMISSION JURISDICTION.

1. THIS IS AN APPLICATION FOR *(Check appropriate item)*

- [ ] A. NEW LICENSE
- [ ] B. AMENDMENT TO LICENSE NUMBER _____
- [x] C. RENEWAL OF LICENSE NUMBER 21-24330-01

2. NAME AND MAILING ADDRESS OF APPLICANT *(Include Zip Code)*

STS CONSULTANTS LTD.
3340 Ranger Road
Lansing, MI 48906

3. ADDRESS(ES) WHERE LICENSED MATERIAL WILL BE USED OR POSSESSED.

STS Consultants Ltd.
3340 Ranger Road
Lansing, MI 48906

See Note #1, Item #3--Attached Sheet

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION | **TELEPHONE NUMBER**

Anthony Stockman, Construction Services Manager, STS Consultants | 517/321-4964

SUBMIT ITEMS 5 THROUGH 11 ON 8½ x 11" PAPER. THE TYPE AND SCOPE OF INFORMATION TO BE PROVIDED IS DESCRIBED IN THE LICENSE APPLICATION GUIDE.

5. RADIOACTIVE MATERIAL. a. Element and mass number, b. chemical and/or physical form, and c. maximum amount which will be possessed at any one time. See Note #2, Item #5

6. PURPOSE(S) FOR WHICH LICENSED MATERIAL WILL BE USED. See Note #3, Item #6

7. INDIVIDUAL(S) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING AND EXPERIENCE. See Note #4, Item #7.

8. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS. See Note #5, Item #8.

9. FACILITIES AND EQUIPMENT. See Note #6, Item #9.

10. RADIATION SAFETY PROGRAM. See Note #7, Item 10.

11. WASTE MANAGEMENT. See Note #8, Item 11.

12. LICENSEE FEES *(See 10 CFR 170 and Section 170.31)*
FEE CATEGORY 170.31.1J | AMOUNT ENCLOSED $ 120.00

13. CERTIFICATION *(Must be completed by applicant)* THE APPLICANT UNDERSTANDS THAT ALL STATEMENTS AND REPRESENTATIONS MADE IN THIS APPLICATION ARE BINDING UPON THE APPLICANT.

THE APPLICANT AND ANY OFFICIAL EXECUTING THIS CERTIFICATION ON BEHALF OF THE APPLICANT, NAMED IN ITEM 2, CERTIFY THAT THIS APPLICATION IS PREPARED IN CONFORMITY WITH TITLE 10, CODE OF FEDERAL REGULATIONS, PARTS 30, 32, 33, 34, 35, AND 40 AND THAT ALL INFORMATION CONTAINED HEREIN, IS TRUE AND CORRECT TO THE BEST OF THEIR KNOWLEDGE AND BELIEF.

WARNING: 18 U.S.C. SECTION 1001 ACT OF JUNE 25, 1948, 62 STAT. 749 MAKES IT A CRIMINAL OFFENSE TO MAKE A WILLFULLY FALSE STATEMENT OR REPRESENTATION TO ANY DEPARTMENT OR AGENCY OF THE UNITED STATES AS TO ANY MATTER WITHIN ITS JURISDICTION.

SIGNATURE - CERTIFYING OFFICER	TYPED/PRINTED NAME	TITLE	DATE
Marie K. Washburn	Marie K. Washburn	Radiation Safety Officer	4/26/89
Anthony T. Stockman	Anthony T. Stockman	Construction Services Manager	

FOR NRC USE ONLY

TYPE OF FEE	FEE LOG	FEE CATEGORY	COMMENTS	APPROVED BY
Rec	May 2	3P	CONTROL NO. 87308	CP
AMOUNT RECEIVED	**CHECK NUMBER**			**DATE**
$120	12463			5/8/89

STS CONSULTANTS, LTD.

LANSING, MICHIGAN

Note #1., Item #3.--Address(es) where Licensed Material will be used or possessed.

Licensed material may be used at the Licensee's facilities located at 3340 Ranger Road, Lansing, Michigan, and at temporary job sites located anywhere in the United States where the Nuclear Regulatory Commission maintains jurisdiction for regulating the use of licensed material.

Note #2., Item #5.--Radioactive Materials:

A. Element & Mass Number	B. Chemical &/or Physical Form	C. Maximum Number of Millicuries &/or Sealed Sources & Maximum Activity Per Source Which Will Be Possessed
1) Cesium 137	Sealed Source (Troxler Dwg. No. 102112)	No single source to exceed 10 millicuries
2) Americium 241	Sealed Source (Troxler Dwg. No. 102451)	No single source to exceed 50 millicuries
3) Cesium 137	Sealed Source (Campbell Pacific CPN-131)	No single source to exceed 10 millicuries
4) Americium 241	Sealed Source (Campbell Pacific CPN-131)	No single source to exceed 50 millicuries

Note #3., Item #6.--Purposes(s) for which Licensed Material will be used.

Sources 1 & 2 to be used in Troxler 3400 Series Moisture/Density Gauge for measuring moisture and density of construction materials.

Sources 3 & 4 to be used in CPN Model #MC Series Moisture/Density Gauge for measuring moisture and density of construction materials.

(Reference Note #2., Item #5.)

Note #4., Item #7.--Individual(s) responsible for Radiation Safety Program and their training and experience.

Attached are two resume's of supervisory personnel.

1. Radiation Safety Officer-Marie K. Washburn, STS Consultants, Ltd., Division 07. located at 3340 Ranger Road, Lansing, MI. (See attached resume')

2. Training Officer--Robert J. Hubbard, B.S., S.T.S. Consultants Corporate Safety & Hygienist Specialist (See attached resume')

Note #5., Item #8.--Training for individuals working in or frequenting restricted areas.

(See attached, "Nuclear Density Gauges", Page 4.1, Section 4; "Check Out Procedures For Nuclear Gauges", "Transportation of Nuclear Density Gauge", "Accident Procedures & Emergency Phone Numbers", and "S.T.S. Nuclear Safety Accident Procedure").

Note #6., Item #9.--Facilities & Equipment

See attached Storage Facilities Diagram.

Note #7., Item #10--Radiation Safety Program.

See attached Radiation Safety Training Program, Instructed by Robert J. Hubbard.

Note #8., Item #11.--Waste Management

Sealed sources to be returned to manufacturer for disposal.

STS Consultants Ltd.
Consulting Engineers
3340 Ranger Road
Lansing, Michigan 48906
(517) 321-4964

RESUME: Marie K. Washburn
Administrative Assistant
Radiation Safety Officer

EDUCATION

Baker Junior College of Business - Two year Liberal Arts Program
Nuclear Testing Equipment Training Course - Troxler Electronics
On-going Training Nuclear Testing Equipment - Corporate InHouse Training Program

EXPERIENCE

Present 1988 — Administrative Assistant: Business Correspondence, Accounting, Maintaining Personnel Database.

Radiation Safety Officer: All responsibilities pertaining to upkeep of N.R.C. License No.: 21-24330-01

A. Training Reinforcement
B. Security
C. Personnel Records
D. Leak Testing
E. Personnel Monitoring/Landauer
F. Transportation
G. Physical Inventory
H. Safety
I. Correspondence

1988 1986- — Junior Lab/Field Technician: Involved with all phases of construction material testing; earthwork, asphalt, concrete. Projects include: Lansing Wastewater Treatment Plant, Michigan State University Barns, East Lansing Paving Projects.

1986 1982 — Various Self-Employed Business'

TROXLER ELECTRONIC LABORATORIES, INC.

CONTROL NO. 0730

HEREBY CERTIFIES THAT

Marie K. Washburn

of

STS Consultants, LTD.

HAS SUCCESSFULLY COMPLETED THE TROXLER ELECTRONIC LABORATORIES, INC. TRAINING COURSE FOR THE USE OF NUCLEAR TESTING EQUIPMENT.

SUBJECTS INCLUDED IN THIS COURSE WERE AS FOLLOWS:

Radiological Safety

1. *Principles and practices of radiation protection.*
2. *Leak testing procedures.*
3. *Mathematics and calculations basic to the use and measurement of radioactivity.*
4. *Biological effects of radiation.*
5. *Radioactivity measurement standardization and monitoring techniques and instruments.*
6. *Accident and incident procedures.*
7. *Procedures for nuclear gauge storage and transportation.*
8. *General safety precautions.*

Gauge Operation

1. *Instrument theory*
2. *Operating procedures*
3. *Maintenance*
4. *Field application*
5. *Gauge calibration*

Thomas L Washburn
INSTRUCTOR

5/30/86
DATE

W.F. Troxler
PRESIDENT

№ 16439

RESUME OF RADIOACTIVE MATERIAL EXPERIENCE

ROBERT J. HUBBARD

S.T.S. CONSULTANTS, LTD.

I obtained a Bachelor of Science in Biology in 1974. Since that time, I have had ten years of experience in working with 3 types of nuclear density / moisture gauges (Seaman Nuclear, Troxler Electronics, Campbell Pacific Nuclear). During this time, I have performed routine maintenance, leak testing and managed the appropriate documentation records for our Northbrook office.

I have attended at least six separate gauge manufacturers one day training courses as well as a one week course in Radiation Safety taught by Professor Herman Cember at Northwestern University Technological Institute.

The various dates of instruction are offered below for your review. Certificates available upon request.

February 2, 1979	Seaman Nuclear one day course
June 12, 1979	Troxler Electronics one day course
January 29, 1981	Campbell Pacific Nuclear one day course
May 1, 1982	Certified Engineering Technician
June 5, 1982	Troxler Electronics one day course
August 21, 1986	Troxler Electronics one day course
April 6-10, 1987	Radiation Safety Course taught by Prof. Herman Cember at the Northwestern University Technological Institute.
September 17, 1987	One day course in Hazardous Materials Chemistry offered by the University of Toledo Division of Continuing Education

SECTION 4

NUCLEAR DENSITY GAUGES

Basic Requirements

Nuclear density gauges (NDG) are used in several applications within our construction monitoring services, such as field density testing of compacted earth fills, field density testing of asphalt paving, and moisture surveys of built-up roofs. Although the radiation sources used in nuclear density gauges are of relatively low intensity and well protected within the gauges, it is imperative that each operator be trained in and be familiar with proper operating and safety procedures so that neither the operator nor the general public is subjected to hazardous levels of radiation.

Because safety requirements vary somwhat depending on the type of source within the NDG and local state regulation, the following safety procedures are necessarily general. An operator will need to obtain additional information from the local STS Radiation Protection Officer. Before operating any NDG, the operator must check with the local Radiation Protection Officer to confirm that he/she has had the proper training.

General Safe Practices

1. Emergency Procedures — Emergency procedures regarding any damage or loss of an NDG are included on the radiological assistance sheet attached to each NDG. This sheet includes the names and telephone numbers of individuals to be notified immediately in the event of an accident. Do not go to the field with an NDG unless the radiological assistance sheet is attached.

2. Transportation — Safety measures to be used in transporting the NDG's in an STS or operator-owned vehicle include transporting the NDG in the manufacturer's shipping container. Shipping containers should be locked at all times. In addition, the shipping container should be away from the passenger compartment of the vehicle as far as possible and secured to prevent shifting during a sudden stop.

3. Preventing Damage — The operator must always remain alert to the danger of construction equipment running over the NDG. On the job site, always keep an NDG within your reach or safely stowed in a vehicle or construction office trailer. Remember, construction equipment operators often will not be able to see the NDG. Do not, even temporarily, place an NDG on a wall or other elevated structure from which it may fall and be damaged. Also, use only your fingertips on the keyboard pad. Small punctures from using a pencil, pen, or other sharp object to press the keypad can cause electrical short circuits.

4. Access — To prevent unauthorized access to the NDG, the NDG or the shipping container should be locked when not in use, or when not under user's direct supervision. If an NDG is to be stored on the job site, it should be placed inside the job construction trailer and the trailer should be locked when the NDG is not under the operator's observation. A "Caution - Radioactive Materials" sign should be posted on the outside of the trailer's entrance door.

5. Storage Security — To prevent unauthorized use or removal of an NDG from its storage place in an STS office or laboratory, the door to the storage area is to be locked at all times and only field technician supervisors are to have a key.

6. Servicing — The operator is not to tamper with or dismantle and remove any parts of an NDG without supervision. High voltage electrical sources are located within an NDG. All maintenance, repair, servicing, internal adjustments, or dismantling are to be performed by the manufacturer's service department or the Radiation Protection Officer.

7. Leak Tests — A leak test on each NDG is required to be performed every 6 months by the local Radiation Protection Officer.

8. Documentation — Each operator is required to keep with each NDG the required license, leak test certificate, emergency procedures, and the operator manual.

July 21, 1987

MEMO

TO: Construction Service Personnel

FROM: Bob Hubbard

RE: CHECK OUT PROCEDURE FOR NUCLEAR GAUGES

Recently the State of Illinois became an agreement state with the NRC. This means that the state will enforce safety requirements and regulations to limit exposure to radiation by all users of ionizing radiation in the State of Illinois. These regulations cover aspects of storage, transport, field use and record keeping. In light of this, the following procedures are in effect immediately.

Storage

1. All nuclears are required to be stored in the Construction Services building at night, unless previous arrangements are made with the Radiation Safety Officer.

2. Gauges are to be assigned the night before by the Construction Services Supervisor to specific job sites. After assignment, the gauge may be labeled with a "reserved" tag with the individual's name, job site name and date required.

3. Gauges must be signed out and signed in daily by the individual.

Transport

1. Gauges must be secured in their shipping case to prevent unauthorized removal while being transported in a vehicle. They are to be placed in such a spot (i.e. trunk, not passenger compartment) that the dose to the driver does not exceed 2 millirem/hour.

2. The driver must have in his possession a shipping paper that indicates the type and quantity of particular radioisotopes. This paper is to be visible within the passenger compartment during transport.

S.T.S. CONSULTANTS NUCLEAR METER CHECKOUT

When leaving with a nuclear, make sure that you have the following:

* Gauge in its case with a charger
* Drill Rod, sledge hammer, and Extractor Handle
* Calibration block and calibration papers
* Template for locating test

In addition, the following papers need to be either in the case or in your vehicle:

* Type A Certificate for the gauge case
* Standard Count Logbook
* Gauge calibration information
* Leak Test Information
* Copy of Nuclear License
* **Shippers Paper**
* **Accident Procedures with phone numbers**

TRANSPORT OF NUCLEAR

The following procedures must be followed when transporting gauges:

1) Gauge must be properly signed out from the store area.
2) Gauge box must be locked.
3) Secure gauge with chain & lock to bed of pickup truck. (If you are using a personal vehicle, gauge must be locked in the trunk as far away from you as possible.)
4) Shipping paper must be plainly visible within your vehicle either on the seat or on your visor or door.
5) **Maintain control of the gauge at all times. Never leave gauge unattended** - this can result in the immediate termination of employment.

ACCIDENT PROCEDURES & EMERGENCY PHONE NUMBERS

In the event that a gauge is lost, stolen, run over or involved in a vehicle accident **YOU MUST CALL THE OFFICE IMMEDIATELY !!**

If a gauge is damaged on a jobsite, stop the vehicle that hit the gauge and secure the area for a distance of 50 feet. Determine if the sources are physically intact. Keep all people involved in the accident present until you have called the office.

STS CONSULTANTS Phone No. 517/321-4964

Radiation Officer Marie K. Washburn Home Phone No. 517/743-3921

Dept. Manager Tony Stockman Home Phone No 517/694-1938

Dept. Supervisor Dennis Hickey Home Phone No. 517/694-3506

Revised 11/88 (OVER)

CONTROL NO 87308

S.T.S. NUCLEAR SAFETY ACCIDENT PROCEDURE

In the event that a nuclear gauge is lost, stolen, run over or physically damaged to the extent that the source shielding is damaged, you must contact the office and the Radiation Safety Officer immediately.

If a gauge is run over, stop the vehicle that hit the gauge, secure the area for a distance of 50 feet, and determine physically if the sources are intact. If the sources do not appear to be intact, stay upwind of the accident area and do not let anybody leave until a survey can be performed.

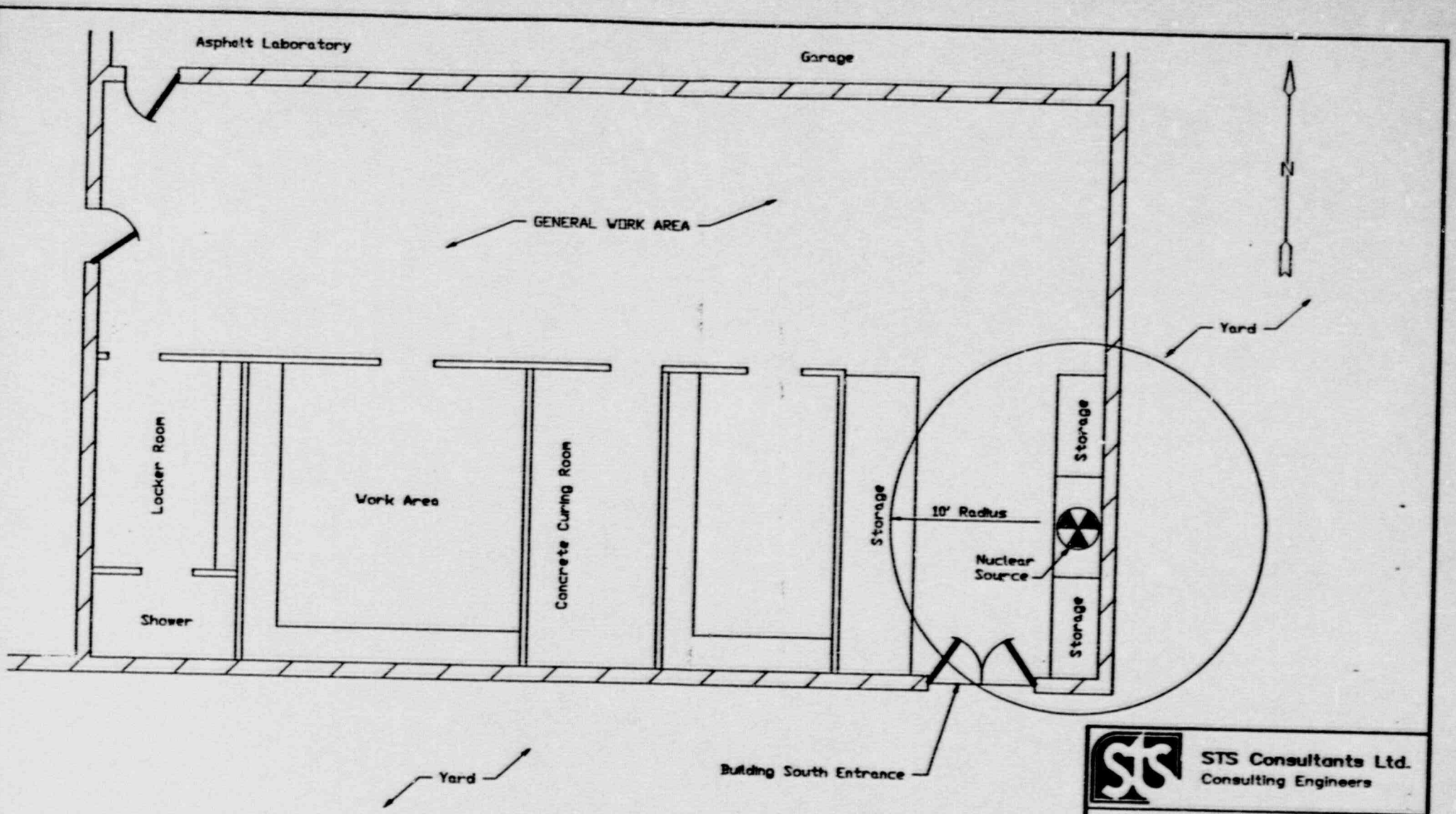
Phone calls to be made:

1. Local STS office and the Radiation Safety Officer.
2. Gauge manufacturer.
3. Licensing Agency (NRC or Agreement State Dept. of Nuclear Safety). Normally, this call will be done by the Radiation Safety Officer.

Any accident involving a whole body dose of 5 rems or more, a skin dose exceeding 30 rems or an extremity dose of 75 rems must be reported within 24 hours to the licensing agency. This type of incident includes the radioactive causing or threatening to cause damage to property in excess of $2,000.

STS OFFICE PHONE NO.	(Corporate)	(312) 272-6520	
	(Lansing)	(517) 321-4964	
Troxler Electronics	(Corporate)	(919) 549-8661	
	(Illinois)	(312) 695-0900	
Campbell Pacific Nuclear	(Corporate)	(415) 228-9770	
	(Ohio)	(614) 766-1276	
Nuclear Regulatory Commission	(Region 3)	(312) 932-2500	[24 Hour]
Illinois Dept. of Nuclear Safety		(217) 785-0600	[24 Hour]

Revised 11/88



STS Consultants Ltd.
Consulting Engineers

Designated
NUCLEAR STORAGE AREA

DRAWN BY	CJD	1/89	SCALE: NTS	FIGURE NO. 1
CHECKED BY	MW	1/89	STS DRAWING NO. STS9LDG	
APPROVED BY	BBS	1/89		

RADIATION SAFETY TRAINING PROGRAM

STS CONSULTANTS, LTD.

Instructor: Robert J. Hubbard

(Updated 3/02/89)

RADIATION SAFETY TRAINING PROGRAM
S.T.S. Consultants, Ltd.

Qualifications of S.T.S. Consultants Corporate Radiation Safety Training Officer.

A. A college degree at the bachelor level, or equivalent training and experience, in the physical or biological sciences or in engineering; and

B. At least 40 hours of training and experience in the safe handling of radioactive material, and in the characteristics of ionizing radiation , units of radiation dose and quantities, radiation detection instrumentation, and biological hazards of exposure to radiation appropriate to the type and forms of radioactive material to be used.

Outline of Training Course:

I. Employee Right to Know / Program Overview

II. Radiation Sources

III. Radiation Units and Terms

IV. Radioisotopes

V. Radiation Sources in Nuclear Density/Moisture Gauges

VI. Biological Effects of Radiation

VII. Personnel Safety Precautions

VIII. Regulatory Requirements / N.R.C & Agreement States

IX. Transportation and Shipping

X. Hands on Training showing proper use of the gauge

Examination conducted by training officer.

RESUME OF RADIOACTIVE MATERIAL EXPERIENCE

ROBERT J. HUBBARD

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RADIATION SAFETY TRAINING OUTLINE
(8 hours - Updated 3/2/89)

I. Employee Right to Know / Program Overview / Part 400, "Notices, Instructions, and Reports to Workers; Inspections"

A. Allow people to protect themselves from hazards through education in identifying specific hazards, evaluation of the health risk and providing means and controls to reduce exposure.
(To protect yourself, know the hazards.)

B. Provide specific training in radiation safety to minimize exposure to employees and general public.
(Don't leave your safety to other people.)

C. Stress need to secure and maintain control over the gauges during storage, transport and use.

D. Increase employee awareness of specific notices, warning signs for controlled areas, and proper use of film or TLD badges for radiation exposure.

E. Educate employees in the proper sign out (inventory control) from the authorized storage areas.

F. Review transport requirements and shipping paper.

G. Familiarize employees with proper procedures in the event of accident or theft.

H. Explain what is meant by ALARA.

II. Radiation Sources - Forms of energy

A. Natural Background Radiation (~100 mrem/year)
1. Primordial
2. Cosmic
3. Solar (Altitude factor)
4. Naturally occurring materials
(i.e. Radon Gas, soils and rocks, food)

B. Man-Made Industrial and Medical Sources
1. Fission products from nuclear reactors
2. X-rays
3. Radioisotopes
4. By-product materials

III. Radiation Units and Terms

A. Atomic Structure
   1. Protons, neutrons and electrons
   2. Atomic Mass and Number
   3. Alpha Particles
   4. Photons (Gamma)

B. Radioactivity
   1. Spontaneous disintegration of unstable atomic nuclei by emission of nuclear particles and electromagnetic radiation as they decay and ultimately transmute into more stable forms.
   2. Activity measured in curies. One curie equals 37 billion atomic transformations / second. Bequerel is one transformation / second.
   3. Radiation produces ionization of atoms and includes electromagnetic energy (gamma rays, X-rays), alpha and beta particles, hi velocity electrons, neutrons and other particles.

C. Radiation Units
   1. **Curie** or Bequerel - Unit of quantity of measuring amount of radioactive material.
   2. Roentgen - Unit of X-ray exposure
   3. Rad - Unit of Radiation Absorbed Dose
      - 100 ergs/gram in any medium
      - Measurement of energy absorption
   4. Quality Factor - Measures health risk toxicity
   5. **Rem** or Sievert - Normalizing unit for dose equivalent of radiation absorbed by the body. [Rads x quality factor]. A dose of 600 rem will usually result in death in 60 days.

IV. Radioisotopes or Radionuclides

A. Specific element - i.e. K, I, C

B. Specific **half-life** - Time in which activity or number of untransformed atoms decreases by one-half.

**	a. Beryllium 9	
	b. Nitrogen 16	7.4 seconds
**	c. Cesium 137	30 years
**	d. Americium 241	458 years
	e. Radium 226	1620 years
	f. Plutonium 239	24100 years

C. Specific type of radiation and energy emitted during transformation (decay).

* Note: Characteristics of radioisotopes can not be altered by chemical changes or by physical means such as turning off the electronics for the device.

V. Radiation Sources in Nuclear Density / Moisture Gauges

A. Types of Radiation in Density / Moisture Devices

1. **Gamma (X-rays)** - Electromagnetic energy; very penetrating; 99% of energy can be reduced with 2.5" of lead through absorption and elastic collisions. [QF=1]
   - Gauge uses Cesium 137 as source.
   - Measures density

2. **Alpha particles** (Helium 4): +2 charge and AMU = 4. Not considered penetrating under most conditions but is highly toxic if taken into viable tissue. Alpha particle energy is absorbed by atoms in target material resulting in ionization (excitation) of target material through mass/energy transfer. Can not travel very far in air and can not penetrate paper or surface skin. [QF=20]
   - Gauge uses Americium 241 as source of alpha particles.

3. **Neutrons** - Penetrating particle with AMU = 1. Absorbed by 19 collisions with hydrogen with AMU = 1 (thermalization). Can activate other particles and make them unstable. Stopped by 4" polyethylene. Fast neutron has QF =10 and energy >0.1 MeV. Thermalized or slow neutron has QF =2 with energy <1.0eV.
   - Gauge uses Beryllium 9 as target for alpha particles.
   - Beryllium emits fast neutrons
   - Measures moisture

4. **Beta** - Negatively charged electron (ionization) Stopped by 1/16 " of aluminium. QF = 1.
   - Intermediate step for Cesium.

B. Transformation (Decay) of Cesium & gauge detection
   - Higher counts means lower density.

C. Transformation (Decay) of Americium and detection
   - Higher counts means higher moisture.

D. Gauge exposure levels during operation

E. Source encapsulation

F. Sources of materials that result in gauge errors

G. Backscatter vs. Direct Readings

H. Importance of surface preparation

I. Calculation of Dose Exposure

VI. Biological Effects of Radiation

A. Dose is proportional to the amount of exposure

B. Radiation exposure vs. health risks
   - Chronic vs. Acute (Short term) Exposure
   - Symptoms of Acute Exposure

C. Allowable dose rates to different parts of the body

VII. Personnel Safety Precautions
- A. Radiation Dose Limits for Workers and the Public
  1. Upper annual limit for radiation workers is determined by the equation U.L.= 5(N-18) rems (where N is age in years).
  2. Public exposure limited to 2 mrem / one hour, 100 mrem / 7 consecutive days and 500 mrem/yr.
- B. Dosimeters - operation principle and proper care
- C. Protection from external radiation
  1. **Time** - effect of length of exposure.
  2. **Shielding** - Hydrogenous material affords protection against neutrons.
     - Dense material is best shielding against gamma radiation.
  3. **Distance** - Inverse square law

VIII. Regulatory Requirements / N.R.C. & Agreement States
- A. By-Products Materials Licensing - Specific Rules
- B. Storage Requirements
- C. Disposal of Sources
- D. Incidents and Reporting - Agency Notification
- E. Record Keeping
  1. Radioactive Materials License; Personnel Training records; Leak Test files; Inventory, receipt, and transfer records; Gauge Source certificate; Transport Package Certification
  2. Posting of "Notice to Employees"
  3. Posting of radiation signs and notices
- F. Leak Testing every six months without fail
- G. Availability of Parts 19 and 20 to employees
- H. Agreement States have authority to regulate, control and license radioactive materials used within their borders.

IX. Transportation and Shipping
- A. Checkout Procedure from storage area
- B. Transport Papers plainly visible in vehicle
- C. Labeling and Certifications of gauge case
- D. Three (3) locks between gauge and public.
- E. Locked and Secured to vehicle
- F. Emergency Procedures

X. Hands On Training showing proper use of the gauge:
- A. Demonstrate electronics, sources, and shielding
- B. Review instrument theory
- C. Demonstrate Field Calibration and Measurement
- D. Trouble shooting techniques
- E. Periodic maintenance and Leak Test Procedure
- F. Review checkout procedures
- G. Field Application with each person performing hands on training. Discuss roller patterns.

Examination conducted by training officer.

Resources

Berry, Richard L., Radiation Safety Manual, Humboldt Manufacturing, 1986.

Cember, Herman, Introduction to Health Physics, Pergamon Press, 1985.

Fire, Frank L., The Common Sense Approach to Hazardous Materials, 1986.

MC-3 Compaction Gauge Manual, Campbell Pacific Nuclear, 1986.

Troxler Nuclear Gauge Safety Training Manual, 1987.

Series 3400-B Instruction Manual, Troxler Electronics, 1988.

Working Safely with Nuclear Gauges, U.S. Nuclear Regulatory Commission, NUREG/BR-0133.

STS CERTIFYING EXAMINATION FOR RADIATION SAFETY

Name: _____ Date: _____

Office: _____ Score: _____

Examiner: _____

NOTE: A minimum of 85 points is required in order to be qualified as a nuclear density/moisture gauge operator. Use the back of the paper for additional answer space.

- -

1. What is meant by ALARA? (2 pts.)

2. The maximum permissible whole body dose to the public in an uncontrolled area is: (2 pts.)

   _____ mr in any _____ hour

   _____ mr in any _____ consecutive days

   _____ mr in any _____ year.

3. The goal of a personnel monitoring film badge is to: (2 pts.)
   A. Measure the amount of radiation exposure of the badge
   B. Protect the individual wearing the badge from radiation
   C. To record the amount of actual radiation exposure a person has received while wearing the badge.

4. The maximum permissible whole body dose for a person working with radiation sources is: (2 pts.)

   _____ mr per _____.

5. Because gamma radiation obeys the inverse square law, moving away from the source of radiation has what effect upon the intensity of the radiation? (2 pts.)

A. Increases it
B. Has no effect on it
C. Decreases it
D. None of these

6. Which is the most dangerous type of electromagnetic radiation due to its extreme penetrating ability (2 pts.)

A. Microwaves
B. Gamma Radiation
C. Ultra Violet
D. X-Rays

7. The areas of the body especially sensitive to radiation and the effects of radiation are the : (2 pts.)

A. Skin
B. Eyes
C. Bone & bloodforming organs
D. Gonads
E. All of these
F. None of these

8. Factors which must be taken into consideration when determining adequate protection from any source of radiation are: (2 pts.)

A. Time of exposure
B. Distance from source
C. Shielding of source
D. Activity of source
E. All of these
F. None of these

9. One can detect radiation by: (2 pts.)

A. Sight
B. Smell
C. Touch
D. Taste
E. All of these
F. None of these

10. The time required for the activity of a given radioactive species to decrease to half of its initial value due to radioactive decay is called: (2 pts.)

A. Half-value layer
B. Half-life
C. Decay activity time
D. Isotope disintegration

Indicate whether the following statements are true or false.
(2 points each for questions 11 to 24)

11. "Possess" means to receive, possess, use, transfer, or dispose of a source of radiation. T or F.

12. A nuclear density gauge may be sold as salvage material to the highest bidder when no longer needed. T or F.

13. Regulations require that leak testing of nuclear density gauges be performed every six months. T or F.

14. In the event that a nuclear density gauge is lost, stolen, or physically damaged to the extent that the source shielding is compromised, you must notify the licensing agency within 24 hours. T or F.

15. In general, it is permissible to transport the nuclear density gauge in the passenger area of a vehicle. T or F.

16. While transporting the nuclear density gauge in your vehicle from one test area to another on the same site, the gauge need not be locked and secured while in transit. T or F.

17. The U.S. N.R.C. or Agreement State inspector can stop any user or transporter of radioactive materials for an inspection at any time, without prior notification. T or F.

18. You must have the shipping paper plainly visible in your vehicle either on your dash, visor or seat whenever you are transporting a nuclear density device. T or F.

19. You must immediately report a lost film badge to your radiation safety officer. T or F.

20. The radioactive source material used in our nuclear density gauges can be used to produce a nuclear bomb device. T or F.

21. The source material used in our gauges are by-products of nuclear power plants. T or F.

22. It is permissible to place a properly locked nuclear density gauge in any area of the office , building, or trailer provided that it does not obstruct any fire exit. T or F.

23. Nuclear density gauges must be signed out from their designated storage area and inventory records must be maintained. T or F.

24. You can become radioactive by using an undamaged nuclear density device. T or F.

25. The greater the length of continuous time of exposure to radiation, the : (2 pts.)

A. Greater is the dose
B. Less of a hazard exists
C. Less chance of damage
D. Greater chance of becoming radioactive.

26. Avoid being within _____ feet of the nuclear density meter unnecessarily. (2 pts.)

27. The main advantage to an Agreement State Radiation Program over the federally controlled NRC program is: (2 pts.)

A. Control over medical radiation.
B. Control over radioactive material storage areas.
C. Control over industrial radiation.
D. Control over all types of nuclear & ionizing radiation.

28. The Agreement State's Department of Nuclear Safety or the federally controlled NRC program may: (2 pts.)

A. Inspect without warrant of search
B. Enter into agreements with local agencies with respect to inspection.
C. Require a person who possesses or uses ionizing radiation to keep records relating to receipt, transfer, use, and disposal.
D. All of these.
E. None of these.

29. Two company trucks are on a jobsite. One of the trucks leave. When you get ready to leave, you realize that your nuclear density moisture gauge is missing. What do you do? (2 pts.)

30. While at a jobsite, a piece of heavy machinery runs over your nuclear density moisture gauge. What do you do? (2 pts.)

31. Your Jr. High child asks you to demonstrate your nuclear density moisture gauge to the science class in order to show the peaceful and useful application of atomic energy. What do you do? (2 pts.)

32. Describe the S.T.S. nuclear density moisture gauge checkout procedure. (3 pts.)

33. How do you transport a nuclear density moisture gauge in a personal vehicle or company truck? (3 pts.)

34. What documents are required in your possession when transporting or using a nuclear density gauge? (3 pts.)

35. List all equipment you should have in your possession when you leave with a nuclear density moisture gauge. (2 pts.)

36. A higher relative density count indicates that more gamma rays have reached the detectors. This indicates that the soil is more or less dense.? _____ (1 pt.)

37. A higher relative moisture count indicates that more neutrons were detected by the gauge. This indicates that the soil is more or less moist? _____ (1 pt.)

Choose from the following list of terms to answer the questions. Indicate your choice by using the letter of the term. (2pts each)

A.	Rem	E.	Curie	I.	Alpha	M.	Radium
B.	Roentgen	F.	ALARA	J.	Neutron	N.	Hydrogen
C.	Rad	G.	Ion	K.	Gamma	O.	Americium
D.	Rat	H.	Quality Factor (QF)	L.	Internal	P.	Cesium

38. The amount of energy a mass of material absorbs when exposed to radiation. Quantifies radiation exposure on a physical basis. Unit of the radiation absorbed dose is the: _____.

39. Unit to measure the amount of radioactivity is the _____.

40. The product of RAD x QF is the normalizing unit for dose equivalent of radiation absorbed by the body and quantifies radiation exposure on a biological basis. Units are _____.

41. Relates absorbed dose to dose equivalent, based upon the ability and relative health risk of different types of radiation to damage living organisms. Term is _____.

42. _____ is the basic philosophy of radiation protection. It is based on the idea that the amount of exposure to radiation must be related to the benefit gained from such exposure, weighted against the biological risk of exposure.

43. _____ radiation is the result of ingestion or inhalation of radioactive material.

44. _____ particles consist of two protons and two neutrons emitted from the nucleus of certain radioactive atoms. This form of radiation is unable to penetrate the skin but is extremely damaging to viable tissue if taken internally.

45. This form of radiation can penetrate thick amounts of tissue or other materials. It is the most energetic form of radiation. It is called _____ radiation.

46. _____ is the radioactive source used in our nuclear density gauges to measure density. It emits _____ radiation.

47. _____ is the radioactive source used in our nuclear density moisture gauges to measure moisture. It decays with the emission of an alpha particle that combines with Beryllium. This in turn decays with the emission of a fast _____.

48. Our gauges measure the "slowed down" or thermalized neutrons. What is the most likely substance in soils that will cause thermalized neutrons? _____.

Answers to the STS Certifying Examination for Radiation Safety

1. To keep radiation exposure to both yourself and the public **A**s **L**ow **A**s **R**easonably **A**chievable.

2. 2 mr in any one hour
   100 mr in any seven consecutive days
   500 mr in any one year

3. C.
4. 5000 mr per year or 1250 mr per quarter
5. C.
6. B.
7. E.
8. E.
9. F.
10. B.
11. True
12. False
13. True
14. True
15. False
16. False
17. True
18. True
19. True
20. False
21. True
22. False
23. True
24. False
25. A.
26. three
27. D.
28. D.

29. Call the office and report the missing gauge. Try to stop the other truck and determine if they have the gauge.

30. Stop the machinery. Secure the area for minimum of 15 feet. Determine if the source has been compromised. Call the office to report the accident to your Radiation Safety Officer. Have office notify the regulatory authorities and gauge manufacturer.

31. Inform your child that you cannot physically demonstrate the nuclear density gauge but that you would be willing to discuss uses of atomic energy via notes and slides.

32. Get gauge assignment from supervisor. Sign gauge out from designated, locked storage area. Obtain necessary tools and

shipping forms.

33. Transport in original manufacturer case as far away from you as possible. Secure in locked trunk or to bed of truck.

34. Shippers Declaration of Hazardous Goods, copy of license, leak test record, Type A certificate, standard count record, calibration records, emergency procedures and phone numbers.

35. Gauge in its case, charger, drill rod, sledge hammer, extractor handle, calibration block, template for test.

36. Less dense.
37. More moist.

38. C. Rad
39. E. Curie
40. A. Rem
41. H. Quality Factor
42. F. ALARA
43. L. Internal
44. I. Alpha
45. K. Gamma
46. P. Cesium
    K. Gamma
47. O. Americium
    J. Neutron
48. N. Hydrogen