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# SES, Inc.
# Health Physics
# &
# Industrial Hygiene
# Support Services

**(rentatechs.com, doecore.com, onlinehazwoper.com)**

**1.0     Introduction**

Shawnee Environmental Services, Inc. (SES, INC.) is pleased to submit a proposal to YOUR COMPANY. This proposal is to provide staff augmentation support services.



SES, Inc. is a unique organization designed to fulfill the staff augmentation needs of the federal government, commercial and nuclear industry.  SES, INC. was conceptualized and organized in the year 2002. SES, INC. has developed a state-of-the-art expertise in technical internet Live-On-Line Training Program, support services and staff augmentation personnel.

SES, INC. services a diverse cross-section of the federal government including the DOE, DOD, and the commercial nuclear power industry.

SES, INC. has significant experience working in a high security and hazardous environment.

**Benefits to YOUR COMPANY by selecting the SES, INC. Team**

The SES, INC. is ideally suited to be your staff augmentation support contractor because:

- We offer personnel with DOE recognized expertise and certifications.
- SES, INC. can provide employee benefits that are exceptional in today's marketplace. This will enable us to recruit and retain superior performers.
- Our companies will have the corporate muscle to reach into the business elements for access to employees, referrals, and resumes to obtain proven individuals to meet your needs.
- The team is well recognized for excellence.

**2.0     Resumes of Key Personnel**

The method of selecting key personnel is based on the individual's qualifications, availability and expression of interest to support your project.  SES, INC. has interviewed applicants extensively to identify the people that are willing to mobilize in a timely manner to meet the schedule.  It is anticipated that the Sr. RadCon Technician category will comprise the largest skill set.  Therefore, more key personnel have been selected for that category.

**3.0  Identify the total number of personnel available to support staff augmentation requests**

3.1 Available Radiological Engineers and HPs/RCTs

3.1.1    Local Candidates

SES, INC. has a Live-On-Line Internet HP course that would give future prospects from the local areas YOUR COMPANY sites.

### 3.1.2  Candidate Training

SES, Inc. would like to require future candidates to have the DOE Core Exam as their main qualification of theory knowledge. This would give YOUR COMPANY easier identification of the skill level of the personnel to be hired.

### 3.1.3  Close Proximity Candidates

It has been SES, INC.'s experience that utilizing staff augmentation employees from the local region for work at your sites reduces turnover.  These people seem to adapt better to your work environment than hiring people who reside elsewhere.  We feel concentrating on local region people will benefit the project by lower attrition.  This will be especially apparent in the technician categories.

### 3.1.4  Recent Applicants

None submitted as yet.

### 3.1.5  Database

SES, INC. is continuing to add to its personnel database.

### 3.1.6  Radiological Employees

SES, INC. has technicians with extensive years of experience in commercial power plants and the DOE.

### 3.1.7  Jr. RadCon Techs

Bartlett Nuclear, Numanco, GTS Duratech, and EG&G Technical Services has hired directly from our graduates of our Radiation Control Technician Training School. We get calls regularly about when the next classes are graduating.

One of the downsides to the staff augmentation concept is difficulty in retaining personnel through the completion of the project. This is a particular concern for technicians.

### 3.1.8  RETENTION:
SES, INC. proposes to provide a one dollar per hour completion bonus (paid by YOUR COMPANY). This will be paid to technicians that complete the long term project. We feel this will greatly enhance retention and save YOUR COMPANY any additional on-site training expense.

## 4.0  Detailed Description of How Staff Augmentation will be Provided

4.1. The staff augmentation process will be approached at the point a requirement from YOUR COMPANY is sent to SES, INC...

4.1.1  The first step is to search the database for personnel that have been previously employed by SES, INC. or individuals whose job performance are known from other assignments. We are always most comfortable submitting individuals that have proven themselves to

be qualified candidates in the past.  SES, INC. prefers to hire people that we know are dependable and qualified.

4.1.2   Next, contact is made with SES, INC. Employees for referrals.  Many times individuals with skills similar to the requirement will be acquainted with top performers that may be available.  Referrals have proven to be an excellent source for staff augmentation personnel. SES, INC. has a cadre of some of the best contributors in the field.  This has been an excellent source of referrals.

4.1.3   Then we contact those candidates that have been identified as possessing the skills to meet the job description or requirement.  We discuss the job description with the candidate to determine if there is a match.  We discuss the duration of the assignment, compensation, and other specifics that may be important such as housing, transportation, work schedule, and overtime.

4.1.4   Once selected, the candidate is asked to commit to a report date.

4.1.5   Resumes of available personnel are e-mailed to YOUR COMPANY along with a billing rate and travel terms if applicable.

4.1.6   YOUR COMPANY reviews the resumes and selects prospective candidates.  The identified individuals are again contacted to verify availability.  Generally, a personal interview or telephone interview is arranged at this time with the YOUR COMPANY technical interface.  This interview further confirms that there is a match.

4.1.7   YOUR COMPANY selects a person to be brought on board.

4.1.8   The candidate is hired.  A new hire packet is completed which includes Rules of Conduct.

4.2.   Corporate Office

SES, Inc. Office

244 West Walnut Street
Hillsboro, Ohio 45133

4.2.1   Customer Satisfaction

SES, INC. ensures its customers are completely satisfied with personnel provided for job assignments.  SES, INC. will immediately remove any of its personnel with/without cause when notified of inadequate performance.

4.3 RECRUITING

Successful performance on any contract begins with the recruiting process.  During this process, both the applicant and the company assess each other's qualifications and potential for growth in the work relationship.  SES, INC. utilizes a number of methods to recruit:

4.3.1    Compensation

Our compensation plan was developed to complement our ability to recruit, hire, and retain a fully qualified workforce.  Our salary structure is validated with surveys from local and national labor markets and is proven to be competitive.  Likewise, our fringe benefits package is attractive to potential candidates, and we maintain reasonable and competitive benefit levels.  This measure is essential in the recruitment and retention of a qualified workforce.

4.3.2    Networking

Our most successful recruiting tool is networking.  SES, INC. has established a nation-wide network of technical contacts.  This includes employees, SES, INC. personnel in sister divisions, former SES, INC. employees, consultants and retirees.  These are individuals that we have interfaced with and know personally.  Through our network of contacts, we are able to recruit candidates with proven skills and capabilities.  It is a "word of mouth" method that minimizes the chances of getting poor performers.

Through our network, nearly all of the personnel we select for hire are known to us before they are hired.  The customer benefits by obtaining carefully screened candidates with proven track records that can perform exceptionally well.  This saves the customer time and money.

4.3.3    Internet

The Internet presence has become a useful tool to gain nationwide access to job seekers. This capability adds to our ability to recruit qualified candidates.  Our Internet web page provides a source of unsolicited resumes.  Access to Internet resume services allows focused searches for task specific candidates.

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 SES, Inc. Online PRICES

   Forty-Hour HAZWOPER: $200
   Twenty-Four-Hour General HAZWOPER: $120
   Twenty-Two-Hour HAZMAT: $110
   Sixteen-Hour Supplemental: $80
   Eight-Hour Refresher HAZWOPER: $36
   Operations HAZWOPER Training: $40
   Awareness HAZWOPER Training: $20

 IH COURSE PRICE LIST

   Asbestos Awareness: $40
   Bloodborne Pathogens: $40
   Confined Space: $40
   Fall Protection: $40
   Hearing and Conservation Safety: $40
   Heat Stress: $40
   Industrial Ergonomics: $40
   Office Ergonomics: $40
   Lead Awareness: $40
   Lock-Out Tag-Out: $40


 Rad Worker I and Rad Worker II Courses: $240 and $280

 respectively. Overall Rad Worker I and Overall Rad Worker

 II Requal Courses: $100 each.


  COURSE INFORMATION
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Our Forty-Hour HAZWOPER Training Package assists facilities in
complying with the employee training requirements of OSHA's HAZWOPER
regulation (29 CFR 1910.120), and helps employees avoid exposure to
hazardous materials. Hazardous materials and waste are part of many
work situations, and can be found on many types of job sites.

OSHA feels that it is so important for employees to know how to
recognize these potentially dangerous substances (as well as how to
handle and dispose of them properly). OSHA has mandated that anyone
working with these materials receive comprehensive training in this
area. In 1976, the U.S. Environmental Protection Agency (EPA) issued
the Resource Conservation and Recovery Act (RCRA) to regulate the
handling of hazardous waste "from cradle to grave".

Since then other regulations have followed, including OSHA's 29 CFR
1910.120, also known as HAZWOPER. As part of these regulations, there
are varying requirements for employee training, depending on an
employee's specific level of involvement with hazardous materials.

Billie W. Childers, Jr.
Training Program Manager
Shawnee Environmental Services, Inc.
Service Connected Disabled Veteran Run Co.
937-572-9704 [mailto:admin@shawneerct.com](mailto:admin@shawneerct.com)
http://www.onlinehazwoper.com & http://www.onlineIH.com

# SES, INC. HAZWOPER & IH TRAINING

## MODULE TRAINING OUTLINE

1) Forty-five minutes: Log in, go to Section List, Review Exam Guidelines, then go to Section List at bottom of page, and click on desired area of training at Section List. Review lesson plan and learning objectives.

2) Fifteen minutes: Student break.

3) Twenty-five minutes: HAZWOPER Training Video.

4) Ten minutes: Review training objectives from lesson plan manual and relating the objectives to the viewed HAZWOPER Training Video.

5) Ten minutes: Take Module multiple choice quiz.

6) Fifteen minutes: Student break.

7) **After completion of the modules in the Section List: course list, send an email to admin@shawneerct.com that you have completed your Coursework along with the SES HAZWOPER & IH Student Acknowledgement Form in the Training Report Area. You will receive your HAZWOPER/IH Certificate when you complete the form.**

8) **You will immediately receive an electronic certificate by email and SES will send a hard-copy and wallet card by mail in five business days.**

9) **Please note that our HAZWOPER & IH Training Program will let you start on the next module of a course list, but you will not be able to access and take that quiz until the two hours required for training have been met (i.e. two hours from taking last quiz).**

## Power Plant RP Techs Looking For DOE Job: Take DOE CORE Test. (doecore.com)

Download our Free DOE Core Short Study Guide and open up the door to jobs in the DOE world. Just go to our website shawneerct.com and click on the "How Site Works" tab and view bookmarks for easing browsing through our acrobat reader document. If you do not have acrobat reader go to this website for free download of acrobat reader. http://www.adobe.com/products/acrobat/readstep2.html

YOU CAN TAKE THE DOE CORE TEST LOCALLY BY TAKING THE PROCTORED EXAM ON YOUR COMPUTER OR ONE NEAR BY. CONTACT US AND WE CAN SHOW YOU HOW. Our email address is admin@shawneerct.com. Our phone number is 937-572-9704.

## SES, INC. will be offering a LIVE ON-LINE RP Tech CLASS

SES, Inc. has a signup list for the next LIVE-ON-LINE (Internet) Radiation Protection Technician/Radiation Control Technician Training class. Signup for the class is limited. Stude nts will be taken into the program on a first come, first serve basis. The class will be between 7:30 pm to 10:30 p m (EST). The class nights will be determ ined in advance. For more inform-ation please email us at admin@shawneerct.com.

## Forty Hour HAZWOPER Class

Shawnee Environmental Services, Inc. is offering online Forty Hour and Eight Hour (Refresher) HAZWOPER Courses. Cost is $200.00 and $36.00 respectively. Call or email us for details. 937 572-9704. For more information please email us at admin@shawneerct.com.

## *ON-LINE DOE RCT CORE TESTING (open bookmarks tab)*

To get started you must go to web address shawneerct.com. First you must register (It does not cost anything to register). Once you have registered and have you login ID and password please put away your ID and password for future reference. Next you must decide if you want to take the RCT course or challenge the DOE Overall Exam. The cost for each of the 13 module courses are $45 each (3 attempts to pass test per module). If a student fails the DOE Overall Core Exam and fails any one particular module, then the student should take that module for remediation prior to taking next attempt at Overall Core Exam. (see attached Short Core Study Guide)

If an individual fails any one test three times, that person is banned for six months from DOE Core qualification thru Shawnee Environmental Services, Inc. (SES, Inc.).
If an individual decides to challenge  the DOE Overall Core Exam (the cost is $250 for  three chances to pass a proctored exam) then that individual must contact SES, Inc. (937) 572-9704 or send email admin@shawneerct.com to arrange for a proctor for their exam.

Training Sets The Precedence

To take any exam the individual must log in on the Home page for shawneerct.com. Once the individual is logged in, then choose from the menu for Core Courses, Site Courses, or the DOE Overall Core Exam. To take the Overall Core Exam: the proctor registers for approval @ shawneerct.com. Send email to admin@shawneerct.com prior to exam start. The proctor is required to send email at the end of exam with the exam results. ÁÁÁ

Go to the training report and fillout the student acknowledgement. You will immediately receive electronic certificate from email admin@shawneerct.com.

Exam results are not final until student test challenges and the proctor's email have been received and reviewed by admin@shawneerct.com. When student passes exam, the proctor will be emailed the student's internet DOE Core Certificate. The proctor's name will be in our records for accountability. Each certificate will be serialized by SES, Inc. for easy verification by DOE Facility. Please note that during normal work hours Mon-Sunday 0800-1630 hrs test results and DOE Core Certificate emailing will take place in approximately four hours of daily work hours.

Proctor must be preapproved. For test result verification the following will be required:

1) Email from Proctor's email for student test results and verification of students picture identification.
2) Proctor registration.
3) Student results verified by database.

For more info contact:

Shawnee Environmental Services, Inc. (SES, Inc.)
244 West Walnut Street
Hillsboro, Ohio 45133
(937) 572-9704

admin@shawneerct.com

# Items needed for Live Online Class
# Radiation Control Technician Training

Computer with the following requirements:

1) Windows 98 SR2, Windows 2000, Windows ME, Windows 2003, Windows XP.
2) Internet Connection: Broadband DSL, Cable, or other high speed connection recommended.
3) 64 MB Memory minimum, 128 MB Memory recommended.
4) Pentium IV 800 Mhz or Faster.
5) 800 x 600 Truecolor Video.
6) PC Microphone and Speakers (basic headset with microphone recommended).
7) Internet Explorer 6.0.

Book: Chart of the Nuclides ordered by students.

Calculator:

## Casio FX-250/FX-260 Student Scientific w/Hard Keys



- 10 digit, 10 + 2 display
- 139 built-in mathematic functions
- Fraction functions
- Basic Scientific, Exponential & Trigonometric functions
- Single variable statistical calculations
- Order of operations M-D-A-S
- 6 levels of parentheses
- Polar-rectangular conversions
- Auto power off
- Hard plastic keys
- Slide-on hard case
- 2-7/8" x 3/4" x 5-3/4" WHL
- 3.6 ozs
- Uses 2-"AA" Batteries

   *SES, INC. is now offering on-line Health Physics Tech/Radiation Control Technician Continuing Training Program.*

   *If a technician wants credit toward his continuing education for NRRPT or any other group affiliation. SES, Inc. will allow technician or company group a refund of 10% of their module cost for each module that is completed. Please notice that an agreement must be made (in advance of taking any modules) with the technician or company group to receive a discount refund of 10%. After an agreement has been reached all modules taken thereafter will be on a refund basis.*

   *If in anyway SES, Inc. can be of service to an individual or a company in maintaining a qualification database for that company, please give us a call to help you in this area of our expertise.*

# ON-LINE SCHOOL INSTRUCTION  FOR RADIATION CONTROL TECHNICIAN

1) First register and keep your password and user ID in a safe place.
2) Look at the school curriculum and follow the module by module process.
3) All modules in section one must be completed prior to taking Overall Core Exam.
4) Each module has a 30 time limit when taking the exam. No proctor is required for modules prior to the Overall Core Exam (a 150 minute time-limit for exam). These modules are $45 each with three opportunities to pass each module. If a student fails any exam three times they are barred from the on-line school for six months. Pay by Master Card or Visa and download the study material. When you are ready take the exam. Please note that there is a 30 time-limit, which means all unanswered will be counted incorrect. Eighty percent is required to pass each exam.
5) After the Core modules are complete, then the Overall Core Exam $250 is the next step. This is a proctored exam. Normally we allow library officials to proctor. You have three opportunities to pass this exam for this one price.
6) After passing the Overall Core Exam, the student moves on to the Site modules in the same way as the Core modules. Complete all 19 modules before taking the Overall Site Exam. This is a proctored exam. Normally we allow library officials to proctor. The 19 site modules are $45 each as well with the Overall Site Exam costing $250 (a 150 minute time-limit for exam).
7) After completion of all the Core and Site, then the student can come to our onsite facility for 26 Job Performance Measures ($560). These JPMs can be complete in a weekend session.
8) The final phase of our program is the Forty-Hour HAZWOPER Course. This allows the graduate to work on Department of Energy sites. Currently we are offering this at our website for $200.
9) Prior to completion of our course we assist the student in resume writing and actual contact with employers. A number of employers hire directly from our course.
10) If we can be of further assistance please email us at admin@shawneerct.com or call 937-572-9704. We look forward to hearing from you.

# Why Train to be a Radiation Control Technician?

As Portsmouth and many other DOE Facilities through out the country are being decommissioned and restored back to the environment there is a great need for Radiation Control Technicians. As most of you might already know an RCT is usually the first to the job and the last to leave the job site. Are you capable of this type of responsibility?

## Objectives
•Once qualified as an RCT you can work any where providing a needed income for you and your family.
•First year earnings take home is $40-45,000 per year based upon person's resume (including tax free per diem).
•Within 2.5 years (5000 hrs) an RCT's pay can be as high as $70-80,000 per year take home pay (including tax free per diem).

## DOE RCT Requirements

•Training needed to be eligible for hire.
•Personnel have to be trained by qualified DOE Training Program.

## Cost Analysis

•Why doesn't the Subcontract companies hire and train new personnel?
•Answer:
    a) Company is unsure of the capabilities of the person hired.
    b) Less hassle from a human resource stand point if personnel fail course.
    c) Company is motivated to hire personnel that were strong performers in a class setting.

## Key Benefits

•There are many companies in the country that are looking for our kind of credentials.

## TO REACH YOUR GOAL

•Can you endure a six-month training program, if not, this is not for you.

•Course A costs $4,000.00 with the 40 Hour HAZWOPER Class.

•Course B costs $3,800.00 without the 40 Hour HAZWOPER Class.

•Our online course is taught in a live class twice a year via the internet. If you can not attend our two nightly classes which start in January and July, then you may take our course by self study.

## WHAT IS CLASS SCHEDULE?

•Classes will run on two evenings every week (7:30-10:30 pm EST).

•Location of class: Internet address: http://www.megameeting.com/

•Individuals who fail module tests three times on any one module will be removed from the course.

## WHAT are the requirements to take the course?

• Student must have high school diploma/GED with copy of same given to school prior to class startup.

## IF YOU ARE UP TO THE CHALLENGE PLEASE SEE INFORMATION BELOW.

- Please contact us and we will put you in contact with your local Education Assistance Counselor/Job Services Counselor to sign you up for the next available class in your area.
- Company:
  Shawnee Environmental Services, Inc.
  244 West Walnut Street
  Hillsboro, Ohio 45133
  phone: 937-572-9704
  email: admin@shawneerct.com
  website: https://www.rentatechs.com

# SHAWNEE ENVIRONMENTAL SERVICES, INC

# RADIATION CONTROL TECHNICIAN

# TRAINING PROGRAM

# CLASS CURRICULUM

RCTs are required to be trained to the level of knowledge and skills necessary for conducting their assigned tasks. Qualifying the technician for handling any situation that may arise may require a more extensive level of training. The initial training program ensures that RCTs are trained to meet performance requirements using a systematic approach to training. The amount of classroom instruction may vary depending on the initial knowledge and skill level of the trainee. Initial qualification is typically broken down into two phases.

**Phase I: Academic Training**

Phase I consists of a standard foundation of academic training, which encompasses specific learning objectives divided into two sections: Core Academics and Site Academics. Phase I lessons may be completed in any order, provided that prerequisite lessons (if applicable) are completed first. The Core Academics section consists of the following 13 lessons:

Basic Mathematics and Algebra (1.01)
Unit Analysis and Conversions (1.02)
Physical Sciences (1.03)
Nuclear Physics (1.04)
Sources of Radiation (1.05)
Radioactivity and Radioactive Decay (1.06)
Interaction of Radiation with Matter (1.07)
Biological Effects of Radiation (1.08)
Radiological Protection Standards (1.09)
As Low As Reasonably Achievable (ALARA) (1.10)
External Exposure Control (1.11)
Internal Exposure Control (1.12)
Radiation Detector Theory (1.13)

The Site Academics section includes the following 19 lessons:

Radiological Documentation (2.01)
Communication Systems (2.02)
Counting Errors and Statistics (2.03)
Dosimetry (2.04)
Contamination Control (2.05)
Airborne Sampling Program/Methods (2.06)
Respiratory Protection (2.07)
Radiological Source Control (2.08)
Environmental Monitoring (2.09)
Access Control and Work Area Setup (2.10)
Radiological Work Coverage (2.11)
Shipment and Receipt of Radioactive Material (2.12)
Radiological Incidents and Emergencies (2.13)
Personnel Decontamination (2.14)
Radiological Considerations for First Aid (2.15)
Radiation Survey Instrumentation (2.16)
Contamination Monitoring Instrumentation (2.17)
Air Sampling Equipment (2.18)
Counting Room Equipment (2.19)

RCT trainees shall be required to successfully complete examinations on the materials covered in each of the Core and Site Academic lessons. The minimum passing score for each examination shall be 80 percent. RCT trainees scoring 70–79 percent shall have the option of taking a second examination for the same lesson within 5 working days of the first examination or repeating the entire lesson with a subsequent exam. RCT trainees choosing to take a second examination must attain a minimum score of 80 percent or must repeat the entire lesson with the subsequent exam. RCT trainees scoring less than 70 percent on an examination shall retake the appropriate lesson with the subsequent exam, which shall be administered by way of classroom-based training. In all cases, the third and final attempt on any particular lesson shall be administered by way of classroom-based training.

## Phase II: JOB PERFORMANCE MEASURES (JPMS)

Phase II training consists of applied, on-the-job training that provides the RCT trainee with adequate job-performance skills. The objectives of the academic training in Phase I provide the basis for the skills and tasks to be performed in Phase II training, which uses a mixture of classroom and applied (hands-on) training. RCT trainees are taught to apply academic knowledge to specific tasks. Phase II consists of two parts: training and evaluation.

The training portion consists of instruction and on-the-job training conducted by the RCT trainer/instructor or designee, who should demonstrate the task to the RCT trainee and emphasize the critical elements of the task. The instructor should explain the importance of the task and the adverse effects if the task is not performed properly. RCT training may be given at any time or in any order, provided the prerequisite learning objectives from Phase I of the task have been taught, and the proficiency of the RCT trainee on those objectives has been documented.

Upon direction from the Health Physics Training Specialists, the basic task list for the applied phase training may include the following tasks:

Radiological Instrumentation
 After-calibration and daily source response of various radiation and contamination instruments
 Chi square and efficiency determinations for counting room equipment

Radiological Protection
 Performing a contamination survey
 Performing a radiation survey
 Obtaining air samples
 Performing a leak test on a radioactive source

Depending on job requirements and needs, other tasks may be necessary. When the actual task cannot be performed but is simulated, the conditions of the task performance, references, tools, and equipment should reflect the actual task to the fullest extent possible. RCT trainees should be given sufficient practice in performing the task before an evaluation is conducted. Once the RCT trainees have demonstrated the ability to perform a task, the trainees shall be evaluated using job performance measures that evaluate the knowledge and skills needed to accomplish the task. RCT trainees shall be evaluated on a satisfactory/unsatisfactory basis for each task. Once a trainee demonstrates task qualification and has obtained the required signatures, he or she may perform the task without direct supervision. Any applied training completed with less than 100 percent proficiency on critical steps shall constitute a failure. Failure of any tasks shall require remedial action, which may include a repeat demonstration of the task by the trainer/evaluator or allowing the RCT trainee to perform the task with direct supervision.

1.02.01- Identify the commonly used unit systems of Measurement and the base units for mass, length and time in each system:

## English system        SI system

```
Length----Foot-------------------Meter

Mass------Pound------------------Kilogram

Time------Second-----------------Second
```

1.02.02---Identify the values and abbreviations for SI prefixes:

## SI Prefixes

```
mega------10e6--------M

kilo------10E3--------k

hecto-----10E2--------h (have not used)

deka------10E1--------da (have not used)

deci------10E-1-------d

centi-----10E-2-------c

milli-----10E-3-------m

micro-----10E-6-------u

nano------10E-9-------n

pico------10E-12------p
```

## Metric Subsystems

```
            CGS MKS

Length-----centimeter-------meter

Mass-------gram-------------kilogram

Time-------second-----------second
```

1.02.03-Given a measurement and the appropriate conversion factors or conversion factor table, convert the measurement to the specified units.


See chart in RCT study guide


1.02.04-Using the formula provided, convert a given temperature measurement to specified units.


**F to C = C = [(F-32)/1.8]**

**C to F = F = [C X 9/5] + 32**

**C to K = K = C + 273.15**


1.03.01-Define the following terms as they relate to physics:


Work- A force acting through a distance.

Force- Is any action on an object that can cause the object to change speed or direction.

Energy- Is defined as the ability to do work.


1.03.02- Identify and describe four forms of energy:

Kinetic energy----Energy of motion an object possesses.

Potential energy—Indicates how much energy is stored as a result of the position of an object.

Thermal energy----Or heat, describes the energy that results from the random motion of molecules.

Chemical energy---The energy that is derived from atomic and molecular interactions in which new substances are produced.

1.03.03- State the Law of Conservation of Energy:

   The total amount of energy in a closed system remains
   unchanged, it can be converted from one form to another:

1.03.04- Distinguish between a solid, a liquid, and a gas in terms of
   shape and volume:

## State--------Shape----------Volume

   Solid-------------Definite------------Definite

   Liquid------------Indefinite----------Definite

   Gas---------------Indefinite----------Indefinite

1.03.05- Identify the basic structure of the atom, including the
   Characteristics of subatomic particles:

## The Bohr Model

   Atom--------the fundamental building block of matter.

   Nucleus-----the central core of the atom and it contains
            protons and neutrons (nuclear forces hold the
            nucleus together).

   Protons-----positively charged (+1).
            -each element is determined by the number of
            -protons in its nucleus.

   Neutrons----neutrally charged (0).
            -the number of neutrons determines the isotope
            (Isotopes are atoms which have the same number of
            protons, but different number of neutrons.) in
            an element.
            -does not affect the chemical properties of
            element.

   Electrons---negatively charged (-1).
            -small mass-(1/1840) of proton.
            -the number of electrons is normally equal to
            number protons.
            -the number of electrons in the outermost shell
            determines the chemical behavior or properties
            of the atom.

1.03.06- Define the following terms:

Atomic Number-------- the number of protons in the nucleus of an element.
It is represent by the symbol z

Atomic Mass Number--- sum of the number of protons and neutrons in the nucleus.
It is represent by the symbol A

Atomic Mass---------- the actual mass of an atom of a Particular isotope expressed in Atomic Mass Units (AMU).

Atomic Weight-------- the weighted average of the isotopic of an element, based on the percent abundance of its naturally occurring isotopes.

1.03.07- Identify what each symbol represents in the $_Z^A X$ notation:

A------Mass number (Number of protons + neutrons)

X------Symbol for element

Z------Atomic number (Number of protons)

1.03.08- State the mode of arrangement of the elements in the Periodic Table:

Is an arrangement of the elements in order of increasing atomic number.

Periodic Law- the properties of the elements are repetitive or recurring functions of their atomic numbers.

1.03.09- Identify periods and groups in the Periodic Table in terms or their layout.

Periods—rows or horizontal sections (increasing neutron number).

Groups or Families – column or vertical sections (increasing proton number)

Since the number of electrons is equal to the number of protons, the structure of the Periodic Table directly relates to the number and arrangement of electrons in the atom.

1.03.10—Define the terms as they relate to atomic structure:

<u>Valance Shell</u>---the highest occupied energy level in a
ground state atom.

The number of electrons in the valence shell
determines the chemical properties
or behavior of the atom.

<u>Valence Electron</u>-the electrons contained in the valance shell.


1.04.01-Identify the definitions of the following terms:

<u>Nucleon</u> -----neutrons and protons in the nucleus (particles).

<u>Nuclide</u>------a species of atom characterized by the
constitution of its nucleus, which is specified
its atomic mass and atomic number or by its
number of protons, number of neutrons and energy
content.

<u>Isotope</u>------nuclides which have the same number of protons
but different number of neutrons.


1.04.02-Identify the basic principles of the mass-energy equivalence
concept:

<u>$E=mc^2$</u>--------expresses the equivalence of mass and energy
meaning that mass may be transformed to
energy and vice versa (mass-energy).

<u>Mass energy</u>--implies that mass and energy are
Interchangeable.

<u>Pair Annihilation</u>-----two particles with mass, a positron and
an electron, collide and are transformed
into two rays of electromagnetic energy.
An example of mass to energy conversion
or mass-energy.


1.04.03-Identify the definitions of the following terms:

<u>Mass Defect</u>-----the difference between the total mass of an
atom and the sum of the masses of the
individual protons, neutrons, and electrons.

Binding Energy--the energy that binds the nucleus together
                  -is the energy equivalent of mass defect.


Binding energy per nucleon- the total binding energy of a
                              nuclides is divided by the total
                              number of nucleons in the nucleus
                              this represents the average energy
                              must be supplied in order to
                              remove a nucleon from the nucleus.



1.04.04---Identify the definitions of the following terms:

Fission-----the splitting of the nucleus into at least two
            smaller nuclei with an accompanying.
            release of energy.
           -The new element is unstable (N/P too high)

Critical energy for fission- the energy required to drive
                              the nucleus to the point of
                              separation.

Criticality-the condition in which the neutrons produced by
            fission are equal to the number of neutrons in
            in the previous generation.

Fusion------the act of combining or fusing two or more atomic
            nuclei.
           -fusion builds atoms.


1.05.01---Identify the following four sources of natural background
          radiation including the origin, radionuclides, variables and
          contribution to exposure:


Terrestrial radiation-in soil (uranium and thorium) in water
                        (K-40)- dependends on location ---
                        exposures = 28 mrem.

Cosmic radiation------primary and secondary rays- depends on
                        altitude exposure = 27 mrem.

Internal emitters-----soil\water, food cycle-K40 most abundant
                        in man-exposure = 39 mrem.


Inhaled radionuclides-uranium, thorium, and radon-dependent on
                        location exposure = 200 mrem.



1.05.02---Identify the following four sources of artificially produced
          radiation and the magnitude of dose received from each.

<u>Nuclear fallout</u>-debris which settles to the earth as the result of nuclear blast                              – exposure = <1 mrem.
<u>Medical exposures</u>-from X-ray        - exposure = 75 mrem.
<u>Consumer products</u>-TV, watches, and etc- exposure = 10 mrem.
<u>Nuclear facilities</u>- power plants     - exposure = <1 mrem.


Total Background Radiation
The average annual total effective dose to the general population (non-smokers) from naturally occurring and man-made sources is about 620 mrem.




1.06.01---Identify how the neutron to proton ratio is related to
          nuclear stability:

        Nuclear stability is governed by the particular combination
                       and arrangement of neutrons to protons in
                       in a given nucleus.

        Nuclear force is independent of charge.

        As elements increase in Z numbers the neutron to proton
        ratio gradually increases.

        At high atomic numbers there are no completely stable
        nuclei.


1.06.02---Identify the definition of the following terms:

        <u>Radioactivity</u>-the property of certain nuclides to
                       spontaneously emit radiation (the emission
                       of particles or energy from the nucleus).

        <u>Radioactive decay</u>-the process by which a nucleus spontaneously
                       disintegrates by one or more discrete energy
                       steps until a stable is reached.

        <u>Parent</u>- the nuclid before the decay.

        <u>Daughter</u>- the nuclid after decay.

        <u>Naturally radioactive</u>- occurs in nature.

        <u>Artificially radioactive</u>- man-made isotope.

1.06.03---Identify the characteristics of alpha, beta and gamma
         radiation.


        <u>Alpha</u>- particulate radiation (from the nucleus - consist of
             two protons and two neutrons)
               -only relatively heavy radioactive nuclides decay by
                alpha emission.
               -least penetrating.
               -stopped by paper.

         <u>Beta</u>- particulate radiations (from the nucleus).
               -charge of -1 and mass of 5.49E-4 amu.
               -nuclide that has an excess number of neutrons will decay
                by beta emission.

         <u>Gamma</u>-from an excited nuclei (still electrically neutral).
               -comes from the nucleus.
               -electromagnetic radiation called photons or x-ray.
               -lead used to stop gamma.


   1.06.04--- Given simple equations identify the following radioactive
          decay modes:

        Heavy radionuclides generally decay by alpha and beta minus
        emission.

        Lighter radionuclides (activation and fission products).
        Decay by beta plus (positron) or electron capture (K-capture).

## Know Equation Not Given

<u>Alpha decay</u> -      $^{A}_{Z}X => {}^{A-4}_{Z-2}Y + {}^{4}_{2}$ alpha




<u>Beta decay</u> -       $^{A}_{Z}X => {}^{A}_{Z+1}Y$ + +beta - minus + antineutrino (are

                     neutral uncharged particles)

                     -changing a neutron to a proton

                     -excess number of neutrons


   <u>Positron Decay</u>-   Low n/p ratio or too many protons
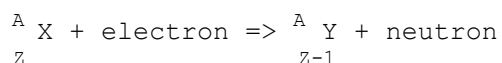
                     -changes a proton into a neutron

                     $^{A}_{Z}X => {}^{A}_{Z-1}Y$ + +beta + plus + neutrino (neutral

                     uncharged particles)

Electron Capture- Low n/p ratio or too many protons

-changes a proton into a neutron by capturing a electron from the K-shell.


(this mode of decay is called K-capture)
-Characteristic X-rays are formed.

$$^A_Z X + electron => {}^A_{Z-1} Y + neutron$$


1.06.05---Identify two aspects associated with the decay of radioactive nuclide:

Pattern of decay

Modes of decay

Types of emissions involved

Energies of the emissions involved

Rate of decay

1.06.06---Identify differences between natural and artificial radioactivity:

Natural-occurs in nature

Artificial-Man-made reactions

1.06.07----Identify why fission products are unstable:

Fission products are nuclear fragments. Directly resulting from fission, have too large a proportion of neutrons to protons for stability:

Predicting Mode Of Decay

Nuclides below the line of stability will usually undergo beta-minus decay.

Nuclides above the line of stability will usually undergo positron decay of electron capture.


1.06.08---Identify the three naturally-occurring radioactive families and the end product of each:


Uranium
Thorium          **All go to Lead (Pb)**
Actinium

## Artificial Series

Neptunium series (was in nature at one time)


1.06.09---Given nuclide, locate its block on the Chart of Nuclides and
         identify the following:

         Atomic number, atomic mass, natural percent abundance,
         stability, half-life, and types and energies of radioactive


         (Study the Chart of the Nuclides)


1.06.10---Given the Chart of Nuclides, trace the decay of a radioactive
          nuclide and identify the stable end-product.

         (Study the Chart of the Nuclides)


         Chart of Nuclides

         In arranging the nuclides in chart form, the number of
         neutrons (N) is plotted horizontal on the x-axis
         against the number of protons (atomic number, z)
         on the y-axis (vertical)


1.06.11---Identify the definition of the following units:


         Curie-it was based on the disintegrations per second
         occurring in the quantity of radon gas in equilibrium
         with one gram of radium

         -About 37 billion atoms dps (3.7E10) or 2.22E12 dpm


         Curie--------Ci---------3.7E10 dps------2.22E12 dpm


            Millicurie----mCi----3.7E7 dps-----2.22E9 dpm

            Microcurie----uCi----3.7E4 dps----2.22E6 dpm

            Nanocurie-----nCi----3.7E1 dps----2.22E3 dpm

            Picocurie-----pCi----3.7E-2dps----2.22 dpm


## Becquerel Superunits

         Becquerel----Bq----1 dps----60 dpm

1.06.12---Identify the definition of specific activity:


The activity per unit mass of radioactive substance and is

reported in units such as curies per gram (Ci/g)


1.06.13---Identify the definition of half-life:


The time that is required for the activity present to be
reduced to one-half:


1.06.14---Calculate activity using the formula for radioactive decay:


$A_{Final} = A_{Original}$ X $e^{-lamda(t)}$; lamda = .693/half-life or

$A_{Final} = A_{Original}$ X $(1/2)^n$ ; n = time/half-life.


1.06.15A--Identify the definition of the following:

Exposure---Is a measure of the ability of photons (x and
gamma) to produce ionization in air.

The unit of exposure is roentgen (R) which is 2.58E-4
Coulombs/kg of air.

Absorbed Dose- Units of dose measure the amount of radiation
energy absorbed or deposited per unit of mass.

### Units

The Rad-(radiation absorbed dose) old CGS unit-definition is
that amount of any radiation which deposits of 100
ergs of energy in one gram of any material.

The Gray-SI derived unit-equivalent to the deposition of one
joule of energy per kilogram = 100 Rad.

Quality Factor (Q) used to relate the absorbed dose of various
kinds of radiation to the biological damage caused to the
exposed tissue.
    ----Converts the absorbed dose (Rad or Gray) to a unit
    of dose equivalence.

    Formula------H = DQ
    H  = dose equivalent (Rem or Sievert)
    D  = absorbed dose (Rad or Gray)
    Q  = Quality factor (QF)

Quality Factors

> X-Rays, Gamma Rays, Positrons, Electrons (Including Beta particles)--1
> Slow Neutron ---3
> Fast Neutron and protons--10
> Alpha particles----------20

Dose Equivalent (H) is a measurement of the dose equivalent by multiplying the absorbed dose by the quality factor.

Rem- Acronym for Roentgen Equivalent Man
> ---Rad x Q
Sievert-SI derived unit
> ---Gray x Q
> --- = 100 rem

1.07.01---Identify the definitions of the following terms:

Ionization---Any process which results in the removal of an electron from an electrically neutral atom.

Excitation---Any process that adds enough energy to an electron of an atom so that it occupies a higher energy state than its lowest bound energy state (ground state)

> -Atom is still electrically neutral

Bremsstrahlung--Is the radioactive energy loss of moving charged particles as they interact with the matter through which they are moving.

> -X-rays are emitted

> -Called braking radiation

> -Is enhanced for high z materials and high energy electrons

1.07.02---Identify the definitions of the following terms:

Specific ionization is the number of ion pairs formed by the particle per path length.

Linear energy transfer (LET)--Is the average energy locally deposited in an absorber resulting from a charged particle per unit distance of travel:

> LET-less than or equal to stopping power

> Stopping power-Of an absorber is its ability to remove energy from a beam of charged particles:

Range--Of a particle in an absorber is the average depth of penetration of the charged particle into the absorber before it loses all its kinetic energy and stops.

Only has meaning for charged particles whose energy is kinetic energy, which is lost continuously along their path.

W- Value---The average amount of energy needed to create an ion pair in a given medium.

1.07.03---Identify the two major mechanisms of energy transfer for alpha particulate radiation:

Ionization
Excitation

1.07.04---Identify the three major mechanisms of energy transfer for beta particulate radiation:

Ionization
Excitation
Bremsstrahlung

1.07.05---Identify the three major mechanisms by which gamma photon radiation interacts with matter:

Photoelectric Effect--Is an all or nothing energy loss, the gamma ray impacts all of its energy to an orbital electron of some atom:(takes place near the nucleus), results in ionization of atom, kinetic energy given to the freed electron.

Compton Scattering---The gamma ray interacts with an orbital electron of some atom and only part of the energy is transferred to the electron (knocking electron away from the atom) and the gamma ray continues on with less energy:

- Take place mostly on valence electron
- Medium energy photon

Pair Production--A gamma photon simply disappears in the vicinity of a nucleus one negative (electron) charged and one positively (positron) charged. Particles are emitted:

- Has to possesses greater the 1.022 MeV of Energy.

- Two particles of .511 MeV each arise at the site of the annihilation (the 2 electron annihilate each other). The fate of the annihilation gammas is either

photoelectric absorption or Compton scattering followed by photoelectric absorption.

- High energies.

1.07.06---Identify the four main categories of neutrons as they are classified by kinetic energy:

Thermal neutron---- ~0.025 eV to <0.5 eV

Intermediate neutron-----0.5 eV to 100 KeV

Fast neutron------------100KeV to 20 MeV

Relativistic neutron----->20MeV

1.07.07---Identify three possible results of neutron capture for slow (thermal)neutrons:

Gamma

Charged Particles

Fission

1.07.08---Identify elastic and inelastic scattering interactions for fast neutrons:

Elastic scattering-- occurs when a neutron strikes a nucleus (of approximately the same mass as that of the neutron). The neutron transfers some or all of its kinetic energy to the nucleus.

---No gamma is given off.

---Causes ionization and excitation.

Inelastic scattering-- occurs when a neutron strikes a nucleus, the neutron interacts with the nucleus, transfers energy to the nucleon inside, and then exits with a small decrease in energy.  The nucleus is left in an excited state emitting gamma radiation (which can cause ionization)

1.07.09---Identify the characteristics of materials best suited to shield.

Alpha----Paper

Beta-----low Z and low-density material (rubber aluminum, plastic)High Z will cause Bremsstrahlung productions.

Neutron--Fast-Hydrogenous material to slow neutron down (oil,
        plastic, and water).
        Slow--boron or cadmium.

1.08.01---Identify the function of the following cell structures:

Cell Membrane--It helps to regulate the concentration of
water, salts, and organic matter which form the interior
environment of the cell.

Cytoplasm--Is a jelly like substance in which the nucleus is
suspended.

Mitochondria---The power plants of both plant and animal cells
        supplies the energy for all the activities of the
        cell.

Lysosomes--Contains the digestive enzymes that break down
large molecules.

Nucleus-----Directs cellular activity and contains the
hereditary Factors.

DNA---------Material making up the chromosomes and serves an
the master blueprint for the cell.

Chromosomes-Consist of highly convoluted supercoils of DNA and
associated protein:

1.08.02---Identify effects of radiation on cell structures:

Cell membrane-----3k to 5k Rads to rupture the cell membrane.

Cytoplasm---------Radiation effects are negligible compared to
        Observed effects on structures, which are
        Suspended within it.

Mitochondria------Few thousand rad to disrupt their function:

Lysosome----------500 to 1k Rads will rupture lysosome

Nucleus-----------Most sensitive part of the cell (effect DNA
1$^{st}$)

1.08.03---Identify the law of Bergonie and Tribondeau:

       The radiosensitivity of a tissue is directly proportional to
       its Reproductive capacity and inversely proportional to its
       degree of Differentiation.


1.08.04---Identify factors which affect the radiosensitivity of cells:

       Cells that have a high division rate, high metabolic rate,
       non-Specialized type, and are well nourished.


1.08.05---Give a list of types of cells; identify which are most or
least radiosensitive:


           Radiosensitive (Cell that are damaged easily)

       Germinal (reproductive) Cells

       Hematopoietic (Blood forming) tissues, red bone marrow, spleen
       lymph, epithelium of the skin.


           Radioresistant (do not damage easily)

       Bone

       Liver

       Muscle

       Nervous tissue


1.08.06---Identify primary and secondary reactions on cells produced by
ionizing radiation:

       Primary- If the molecules breaks up the fragment are called
       free radicals and ions, and are not chemically stable (they
       are electrically neutral structures with one unpaid electron
       (water=H + OH) $H_2o = H+OH$

       Secondary--They can combine and produce hydrogen peroxide
       ($H_2 O_2$)
       Which is a chemical poison and is the most harmful free
       radical product.

1.08.07---Identify the following definitions and give examples of each:

      <u>Stochastic effect</u>--Are those in which the probability within a population of the effect occurring increases with dose:

            ---Without threshold

            ---Cancer and genetic are examples

      <u>Non-Stochastic</u>--Are those in which the severity of the effect varies with the dose:

            ---With Threshold

            ----Cataracts, skin ulcerations (burns) deletion of blood-forming cells and impairment of fertility.

1.08.08---Identify the LD 50/30 value for humans:

      The dose of radiation expected to cause death within 30 days to 50% of those exposed without medical treatment (300 to 500 Rads or usually stated as 450 Rads)

1.08.09---Identify the possible somatic effects of chronic exposure to radiation:

      Chronic radiation exposure-involve a low dose over a relatively long period of time:

            ---Cancer, Cataracts (600 to 900 R), life span shortened.

            ---Observed if dose is greater than 10 Rads.

1.08.10---Distinguish between the three types of the acute radiation syndrome, and identify the exposure levels and the symptoms associated with each:

<div align="center"><u>**Syndrome:**</u></div>

      Hematopoietic system---200 to 1,000 rad

      Gastrointestinal tact---1k to 5k rad---includes loss of weight in illness stage.

      Central nervous system--over 5k rad---death result from respiratory failure or brain edema.

### Progress through four stages:

Prodromal stage---nausea, vomiting, diarrhea, anorexic
(loss of appetite) and fatigue.

Latent Phase---Between the prodromal stage and the onset of
later stages.

Illness---Same as prodromal stage+ ulcerations about the
mouth, fever and etc.

Recovery or death - above 1K Rads death is probably certain
(usually at 600 Rads).

1.08.11---Identify risks of radiation exposure to the developing
embryo and fetus:

Most of the major organs in humans are developed during the
period from the second to the sixth week post conception.

Doses as low as 25 Rad have shown to be effective in producing
development changes.

A dose of 400 to 600 rad during the first trimester or
pregnancy is sufficient to cause fetal death and abortion.

1.08.12---Distinguish between the term somatic and heritable
(or genetic) as they apply to biological effects:

Somatic Effect individual, not passed on.

Heritable or genetic- There is no threshold for genetic
Mutation resulting from exposure to ionizing radiation.

1.09.01---Identify the role of advisory agencies in the development of
recommendations for radiological control:

ICRU--Formed in 1925, in 1928 adopted the definition of
Roentgen.

ICRP--Adopted 1st set of Radiation Protection Recommendation.

NCRP--Formed in 1929 and served as the basis fro protection
during the Manhattan Project.
-Provides recommendations to other agencies now (NCRP
report).

1.09.02---Identify the role of regulatory agencies in the development of standards and regulations for radiological control:

> AEC(Atomic Energy Act)--In 1954 was given the responsibility of regulating the atomic energy industry.

> NRC--Took over the licensing and regulatory functions.

> ERDA--Assumed responsibility of energy research and development.

> ERDA was replaced in 1977 by the US Department of Energy (DOE) (Radiation protection- Radiological control manual).

1.09.03---Identify the purpose and scope of the DOE Radiological Control Manual:

> There should not be any occupational exposure of workers to ionizing radiation without the expectation of and overall benefit from the activity causing the exposure.

> The Radiological Control Manual is the main document for control of work place.

1.09.04---Identify the definitions of the terms "shall" and "should" as used in DOE documentation:

> Shall---Identifies those elements and requirements that have been considered and found by DOE to be mandatory unless prior approval of an alternative approach is obtained from DOE.

> Should---Means the contractor has the responsibility of either following the provision or may demonstrate technical equivalency by an alternative solution.

1.10.01---Describe the assumption on which the current ALARA philosophy is based:

> ALARA- As Low As Reasonable Achievable.

> ALARA philosophy-The cautious assumption that a proportional relationship exits between dose and effect with a non-threshold concept.

1.10.02---Identify the ALARA philosophy for collective personnel exposure and individual exposure:

Individual dose- Is defined as the total dose received by a radiological worker due to occupational exposure.

Collective dose- Is defined as the total individual dosed in a group or a population.

The DOE would like to see an overall reduction in both individual and collective doses used as the basis for determining the effectiveness of a facilities ALARA program.

1.10.03---Identify the scope of an effective radiological ALARA program:

The ALARA program must be incorporated in everyday, routine function as well as non-routine, higher risk tasks.

The risk associated with projected radiation exposures should be small when compared to the benefit derived.

1.10.04---Identify the purposes for conducting pre-job and\or post-job AlARA reviews:

Pre-Job ALARA- For every task involving radiological work, sufficient radiation protection controls should by specified in procedures and work plans to define and meet requirements.

-Applicable ALARA practices shall be factored into the plans and procedures.

Pre-Job Briefing- The technician will identify the effective dose reduction measures for the conditions:

-Procedures will be reviewed.
-Worker qualifications verified.
-Emergency procedures will be discussed.

Post-Job ALARA-Unusual exposure events are investigated
-Ensure the overall effectiveness of job planning and implementation:

Post-Job Briefing-Gives the RCT and the workers the opportunity to critique the work performance.

1.10.05---Identify RCT responsibilities for ALARA implementation:

If the RCT notices the worker not following good radiological work practices on the spot corrections should be made.

Exercise Stop Work Authority if one of the following:

1-Inadequate radiological control.

2-Radiological controls not being implemented.

3-Radiological control hold point not being satisfied.

1.11.01---Identify the four basic methods for minimizing personnel external exposure:

 1-Reduce the amount of source material.

 2-Reduce the amount of time of exposure to the source of radiation.

 3-Increase the distance from the source of radiation.

 4-Reduce the radiation intensity by using shielding.

1.11.02---Using the exposure Rate=6cen equation, calculate the gamma exposure rate specific radionuclides:

 Exposure Rate = 6CEN

 C = source activity in Ci.

 E=Gamma energy in MeV[(Gamma 1x %) + (Gamma 2 x %). + etc,]

 N=Number of gammas per disintegration (photon yield).

1.11.03---Identify "source reduction" techniques for minimizing personnel external exposures:

 1-Allow natural decay to reduce source strength.

 2-Decon the equipment or material.

 3-Reduce the source material in the system by flushing equipment.

 4-Discharge or remove the resin or filtering media.

 5-Move the radioactive source.

1.11.04---Identify "time-saving" techniques for minimizing personnel external exposures:

1-Pre-Job briefing.

2-Review job history files.

3-Pre-stage all tools and equipment.

4-Pre-assemble equipment and tools outside the area.

5-Use time limiting devices.

6-Use communication devices.


7-Use a team of workers instead of one individual.

8-Use experienced personnel.


1.11.05---Using the stay time equation, calculate an individual's allowable dose equivalent or stay time:

## Know Equation Not Given

X =(R/t)
R/t = dose rate
T = length of time exposed

Stay Time = H(allowable) minus H(received)/ dose equivalent rate.

Have to use Q factor on dose equivalent.

1.11.06---Identify "distance to radiation sources" techniques for minimizing personnel external exposures:

1. Remote handling tools/remote control devices.
2. Remote observation by cameras or indicators.
3. Move work to another location.
4. Maximize the distance.
5. Posting of areas.
6. Extendable instruments.


1.11.07---Using the point source equation (inverse square law), calculate the exposure rate or distance for a point source of radiation:


## Know Equation Not Given

$I_1 \times d^2 = I_2 \times d^2$


1.11.08---Using the line source equation, calculate the exposure rate or distance for a line source or radiation:

# Know Equation Not Given

$I_1 \times d_1 = I_2 \times d_2$

Valid to a point that is the L/2 Transition pt, beyond which the point source formula should be used.

1.11.09---Identify how exposure rate varies depending on the distance from a surface (plane) source of radiation:

When the distance to the plane source is small compared to the longest dimension, then the exposure rate falls off a little slower than L/d.

As the distance from the plane source increases, then the exposure rate drops off at a rate approaching L/d squared.

1.11.10---Identify the definition of "mass attenuation coefficient" and "linear attenuation coefficient":

<u>Linear attenuation coefficient</u> is the probability of a photon interaction per path Length: Has units of cm-1.
.

<u>Mass attenuation coefficient</u> is the quantity obtained by dividing the linear attenuation coefficient by the physical density. Has units of cm2/mg.
.

1.11.11---Identify the definition of "density thickness":

Is a value equal to the product of the density of the absorbing material and its thickness [in units or mg/cm (squared).

1.11.12---Identify the density-thickness values, in mg/cm (squared), for the skin, lens of the eye and the whole body:

Skin-----7 mg/cm (squared).

Lens of eye-300 mg/cm (squared).

Whole Body-1000 mg/cm (squared).

1.11.13---Calculate shielding thickness or exposures rates for gamma/x-ray radiation using the equations:

## Know Equation Not Given

One half-value layer-as the amount of shielding material required to reduce the radiation intensity to one-half of the unshielded value:

$I_{shielded} = I_{unshielded} \times (1/2)^n$ ;exponent n = number of HVLs

HVL= shield thickness in cm/HVL thickness in cm.

One tenth-value layer-as the amount of shielding material required to reduce the radiation intensity to one-tenth of the unshielded value:

$I_{shielded} = I_{unshielded} \times (1/10)^n$; exponent n = number of TVLs

TVL = Shield thickness in cm / TVL thickness in cm.

1.12.01---Identify four ways in which radioactive materials can enter the body:

1. Inhalation (Material enter the body in the air that is breathed).
2. Ingestion (Materials enter the body through the mouth).
3. Absorption (Material enters the body through intact skin).
4. Entry through wounds:

   Penetration- Materials enter through existing wounds.

   Injection- Materials enter through wounds incurred on the job.

1.12.02---Given a pathway for radioactive materials to enter the body, identify method to prevent or minimize entry by that pathway:

1. Inhalation- Assessment of conditions, use of engineering controls, respiratory protection equipment.
2. Ingestion- Proper radiological controls and work practices.
3. Absorption- Assessment of conditions and protective clothing.
4. Entry through wounds- Not allowing contamination near a wound by work restriction or proper radiological controls if an injury occurs in a contaminated area.

1.12.03---Identify the definition and distinguish between the terms "Annual Limit on Intake" (ALI) and "Derived Air Concentration" (DAC).

Annual Limit on Intake- The quantity of a single radionuclide, which, if inhaled or ingested in one year, would irradiate a person, represented by reference man to limiting value for control of the workplace.

Derived Air Concentration- The quantity obtained by dividing the ALI for any given radionuclide by the volume of air breathed by an average worker during a working year.

1.12.04---Identify the basis for determining Annual Limit on Intake (ALI)

    1. The metabolic process for the isotopes.
    2. The annual dose limit.
    3. Reference man (metabolic process).

1.12.05---Identify the definition of "reference man":

    Defines the physiological makeup of an average man in terms of factors required for dose calculations and includes such items as height and other dimensions, mass, size and mass of organs.

1.12.06---Identify a method of using DACS to minimize internal exposure potential:

    1. Posting of airborne radioactivity areas.
    2. Minimizing the stay of workers in airborne areas.
    3. Respiratory protection equipment.

1.12.07---Identify three factors that govern the behavior of radioactive materials in the body:

    1.Chemical form- Solubility.
    2.Location-------Pathways.
    3.Body's need ---Intake and incorporation vs. elimination.

1.12.08---Identify the two natural mechanisms which reduce the quantity radionuclides in the body:

    1. Normal Biological Elimination- Materials are eliminated through the normal biological elimination processes of exhalation, perspiration urination and defecation.

    2. Biological half-life- the time required to reduce amount of material in the body to one-half of its original value (Independent of the physical or radiological half-life).

3. <u>Radioactive Decay</u>- The amount of time required for one half of the material in the body to decay (called radiological or physical half-life).

1.12.09---Identify the relationship between the physical, biological and effective half-lives:

<u>Physical or radiological half life</u>- the amount of time required for one half of the material in the body to decay.

<u>Biological half life</u>-The time required to reduce the amount of material in the body one-half of its original valve.

<u>Effective half life</u>- The combined processes of biological elimination and physical decay results in the removal of radioactive materials at a faster rate than the individual reduction rate produced by either method.

1.12.10---Given the physical and biological half lives, calculate the effective half-life:

## Know Equation Not Given

$T_{effective\ \frac{1}{2}\ life} = T_{biological\ \frac{1}{2}\ life} \times T_{physical\ \frac{1}{2}\ life} / T_{biological\ \frac{1}{2}\ life} + T_{physical\ \frac{1}{2}\ life}$

### <u>Hint: Top (times) over Prostate (plus).</u>

1.12.11---Given a method used by medical personnel in increase the elimination rate of radioactive materials from the body, identify how and why that method works:

<u>Blocking agent</u>- Saturates the metabolic processes in a specific tissue with the stable element and reduces uptake of the radioactive forms of the element.

<u>Diluting agent</u>- A compound that includes a stable form of the nuclide of concern. This will reduce the body incorporating radioactive atoms.

<u>Mobilizing agent</u>- A compound that increases the natural turnover process, thus releasing some forms of radioisotopes from body tissues.

<u>Chelating agent</u>- A compound that acts on insoluble compounds to form a soluble complex ion, which can then be removed through the kidneys.

1.13.01---Identify the three fundamental laws associated with electrical charges:

    1. Opposite electrical charges of equal value cancel each other out.
    2. Opposite electrical charges attract each other.
    3. Like electrical charges repel each other.

1.13.02---Identify the definition of current, voltage and resistance and their respective units:

Current- The movement, or flow, of electrons past a given point in a circuit.

-Measured in units called amperes.

Voltage- The electrical potential difference that causes electrons to flow in a circuit.

-Measured in units called volts.

Resistance- The electrical quantity that opposes electron flow in a circuit:

-Measured in units called ohms.

1.13.03---Select the function of the detector and readout circuitry components in a radiation measurement system:

### Types of detectors

Ionization- The incident radiation creates ion pairs in the detector.

-GM tubes, GeLi detector used in multichannel analyzer.

Excitation- The incident radiation excites the atom of the detector material.

-TLD, and scintillation detectors.

Chemical- The incident radiation caused ionization or excitation of detector media thereby causing chemical changes.

-Film badges.

1.13.03---Select the function of the detector and readout circuitry components in a radiation measurement system:

Readout Circuitry- Measures and analyzes the produced effect and provides a usable output indication.

1.13.04---Identify the parameters that affect the number of ion pairs collected in a gas-filled detector:

> 1. Type of radiation.
> 2. Energy of the radiation.
> 3. Quantity of radiation.
> 4. Detector size.
> 5. Type of detector size.
> 6. Type of detector gas.
> 7. Detector gas pressure.
> 8. Voltage potential across the electrodes.
> 9. Effect of voltage potential on the detector process.

1.13.05---Given a graph of the gas amplification curve, identify the regions of the curve:

### Know RIPLGC

### Rest In Peace Little Gray Cat.

1.13.06---Identify the characteristics of a detector operated in each of the useful regions of the gas amplifications curve:

> Ion Chamber Detectors- All ions are collected before they can recombine.
> -Output current will be relatively independent of small fluctuations in the power supply.
> -The ion chamber response is directly proportional to the dose rate.
> -Yields the true exposure rate.
>
> Proportional Detectors-The avalanche caused by a single ionization results in single very large pulse.

1.13.07---Identify the definition of the following terms:

> Resolving time- The time from the initial measured pulse until another pulse can be measured by the electronics.
>
> Dead Time------ Is time from the initial pulse until another pulse can be produced in the detector.
>
> Recovery Time-- The time from the initial full size pulse to the next full size pulse produced by the detector.

1.13.08---Identify the methods employed with gas-filled detectors to discriminate between various types of radiation and various radiation energies:

## Discrimination

1. Physical discrimination- Shielding-The most common method of discriminating.

2. Detector gas fill- Each type of radiation has a specific ionization factor in a particular gas.

3. Electronic discrimination- Analyzing pulse heights is the primary method of electronic discrimination.

1.13.09---Identify how a scintillation detector and associated components operate to detect and measure:

1. Scintillation detector- Measure radiation by analyzing the effects of the excitation of the detector material by the incident radiation.

2. Scintillation- Is the process by which a material emits light when excited.

### Scintillation Detector Components:

The phosphor or fluor-organic crystals, organic liquids, inorganic crystals, and inorganic powders.

The photomultiplier- Is to detect the scintillations and to provide an output signal proportional to the amount of scintillations.

## Construction

Photocathode- Is to convert the light photons to electrons (Photoelectrons).

Dynode Assembly- Used to amplify the signal.
        -Some time called Photo-multiplier.

Anode- Collect the electrons and generates an output pulse.

Voltage divider network- Splits the high voltage supply into the various potentials required by the dynodes.

Shell- Supports the other component and seals the tube from stray light and seals the tube from stray light and stray electric/magnetic fields.

1.13.10---Identify how neutron detectors detect neutrons and provide an electrical signal:

### Slow Neutron Detection:

Boron Activation- Neutrons strike an atom of Boron-10; an alpha particle is emitted. This alpha particle then produces ionization, which can be measured.

Fission Chambers- Neutron will cause an atom of U-235 to fission, with the two fission fragments produced having a high kinetic energy and causing ionization to the material they pass through.

Scintillation- Incorporating lithium-6 in the crystal.

Activation Foils- Have the ability to absorb neutrons of a specific energy and become radioactive through the radioactive capture process.

### Fast Neutron Detection:

Proton Recoil (Ion Chamber/Proportional)- When fast neutrons undergo elastic scatterings with hydrogen atoms, they frequently strike the hydrogen atom with enough force to knock the proton nucleus away from the orbiting electron.

1.13.11---Identify the principles of detection, advantages and disadvantages of a GeLi detector and an HPGe detector:

### Principle of Operation

In a semiconductor electrons move from the valance to conduction leaving holes, which are filled by other electrons (this is called electron-hole pairs) this is used to measure radiation in an ion chamber.

GeLi Systems

Advantages-High resolution.
-Short response time.

Disadvantages-can only be used for gamma photon detection.
-This system is required to be kept cool.

HPGe's Systems

Advantages-more portable:
-Can be allowed to rise to room temperature, and then
be returned to and stabilized at liquid nitrogen
temperature range.

Disadvantages-Tend to be fairly expensive.

**INSTRUCTIONS FOR USING CONVERSION FACTOR TABLES**

The tables that follow include conversion factors that are useful to the RCT. They are useful in making a single conversion from one unit to another by using the guide arrows at the top of the page in accordance with the direction of the conversion. However, when using the tables to develop equivalent fractions for use in unit analysis equations, a better understanding of how to read the conversion factors given in the table is required.

The conversions in the table have been arranged by section in the order of fundamental units, followed by derived units:

Length
Mass
Time
Area
Volume
Density
Radiological
Energy
Fission
Miscellaneous (Temperature, etc.)

The easiest way to read a conversion from the table is done as follows. Reading *left to right,* "one (1) of the units in the left column is equal to the number in the center column of the unit in the right column." For example, look at the first conversion listed under **Length**. This conversion would be read from left to right as "1 angstrom is equal to E-8 centimeters," or

$$1\text{Å} \quad 10^8 \; centimeters \; = \; \frac{1 \; \text{Å}}{10^8 \; centimeters}$$

Another conversion would be read from left to right as "1 millimeter (mm) is equal to 1E-1 centimeters," or *1 mm = 0.1 cm*. This method can be applied to any of the conversions listed in these tables when reading *left to right.*

If reading *right to left*, the conversion should be read as "one (1) of the unit in the right column is equal to the inverse of (1 over) the number in the center column of the unit in the left column." For example, using the conversion shown previously, the conversion reading right to left would be "1 inch is equal to the inverse of 3.937E-5 (1/3.937E-5) micrometers," or

$$1 \; inch \quad \frac{1}{3.937E \, 5 \; 4m} \quad 2.54E4 \; 4m$$

# SHAWNEE ENVIRONMENTAL SERVICES, INC.

## *DOE CORE TEST CONVERSION TABLE*

| Multiply # of | by | to obtain # of |
|---|---|---|
| to obtain # of | by | DividC # of |

### LCngth

| | | |
|---|---|---|
| angstroms (Å) | $10^{-8}$ | cm |
| Å | $10^{-10}$ | m |
| micrometer (4m) | $10^{-3}$ | mm |
| 4m | $10^{-4}$ | cm |
| 4m | $10^{-6}$ | m |
| 4m | $3.937 \times 10^{-5}$ | in. |
| mm | $10^{-1}$ | cm |
| cm | 0.3937 | in. |
| cm | $3.2808 \times 10^{-2}$ | ft |
| cm | $10^{-2}$ | m |
| m | 39.370 | in. |
| m | 3.2808 | ft |
| m | 1.0936 | yd |
| m | $10^{-3}$ | km |
| m | $6.2137 \times 10^{-4}$ | miles |
| km | 0.62137 | miles |
| mils | $10^{-3}$ | in. |
| mils | $2.540 \times 10^{-3}$ | cm |
| in. | $10^{3}$ | mils |
| in. | 2.5400 | cm |
| ft | 30.480 | cm |
| rods | 5.500 | yd |
| miles | 5280 | ft |
| miles | 1760 | yd |
| miles | 1.6094 | km |

*DOE CORE TEST CONVERSION TABLE*

| Multiply # of | by | to obtain # of |
|---|---|---|
| to obtain # of | by | DividC # of |

### Mass

| | | |
|---|---|---|
| mg | $10^{-3}$ | g |
| mg | $3.527 \times 10^{-5}$ | oz avdp |
| mg | $1.543 \times 10^{-2}$ | grains |
| g | $3.527 \times 10^{-2}$ | oz avdp |
| g | $10^{-3}$ | kg |
| g | 980.7 | dynes |
| g | $2.205 \times 10^{-3}$ | lb |
| kg | 2.205 | lb |
| kg | 0.0685 | slugs |
| kg | $9.807 \times 10^{5}$ | dynes |
| lb | $4.448 \times 10^{5}$ | dynes |
| lb | 453.592 | g |
| lb | 0.4536 | kg |
| lb | 16 | oz avdp |
| lb | 0.0311 | slugs |
| dynes | $1.020 \times 10^{-3}$ | g |
| dynes | $2.248 \times 10^{-6}$ | lb |
| u (unified--$^{12}$C scale) | $1.66043 \times 10^{-27}$ | kg |
| amu (physical--$^{16}$0 scale) | $1.65980 \times 10^{-27}$ | kg |
| oz | 28.35 | g |
| oz | $6.25 \times 10^{-2}$ | lb |

NOTE:  Mass to energy conversions under miscellaneous.

# SHAWNEE ENVIRONMENTAL SERVICES, INC.

## *DOE CORE TEST CONVERSION TABLE*

| Multiply # of | by | to obtain # of |
|---|---|---|
| to obtain # of | by | DividC # of |

|  | **TimC** |  |
|---|---|---|
| days | 86,400 | sec |
| days | 1440 | min |
| days | 24 | hours |
| years | $3.15576 \times 10^7$ | sec |
| years | 525,960 | min |
| years | 8766 | hr |
| years | 365.25 | days |

|  | **ArCa** |  |
|---|---|---|
| barns | $10^{-24}$ | $cm^2$ |
| circular mils | $7.854 \times 10^{-7}$ | $in.^2$ |
| $cm^2$ | $10^{24}$ | barns |
| $cm^2$ | 0.1550 | $in.^2$ |
| $cm^2$ | $1.076 \times 10^{-3}$ | $ft^2$ |
| $cm^2$ | $10^{-4}$ | $m^2$ |
| $ft^2$ | 929.0 | $cm^2$ |
| $ft^2$ | 144 | $in^2$ |
| $ft^2$ | $9.290 \times 10^{-2}$ | $m^2$ |
| $in.^2$ | 6.452 | $cm^2$ |
| $in.^2$ | $6.944 \times 10^{-3}$ | $ft^2$ |
| $in.^2$ | $6.452 \times 10^{-4}$ | $m^2$ |
| $m^2$ | 1550 | $in.^2$ |
| $m^2$ | 10.76 | $ft^2$ |
| $m^2$ | 1.196 | $yd^2$ |
| $m^2$ | $3.861 \times 10^{-7}$ | sq mi |

# SHAWNEE ENVIRONMENTAL SERVICES, INC.

## *DOE CORE TEST CONVERSION TABLE*

| Multiply # of | by | to obtain # of |
|---|---|---|
| to obtain # of | by | DividC # of |

### **VolumC**

| | | |
|---|---|---|
| $cm^3$ (cc) | 0.99997 | ml |
| $cm^3$ | $6.1023 \times 10^{-2}$ | in.$^3$ |
| $cm^3$ | $10^{-6}$ | $m^3$ |
| $cm^3$ | $9.9997 \times 10^{-4}$ | liters |
| $cm^3$ | $3.5314 \times 10^{-5}$ | ft$^3$ |
| $m^3$ | 35.314 | ft$^3$ |
| $m^3$ | $2.642 \times 10^2$ | gal |
| $m^3$ | $9.9997 \times 10^2$ | liters |
| in.$^3$ | 16.387 | $cm^3$ |
| in.$^3$ | $5.787 \times 10^{-4}$ | ft$^3$ |
| in.$^3$ | $1.639 \times 10^{-2}$ | liters |
| in.$^3$ | $4.329 \times 10^{-3}$ | gal |
| ft$^3$ | $2.832 \times 10^{-2}$ | $m^3$ |
| ft$^3$ | 7.481 | gal |
| ft$^3$ | 28.32 | liters |
| ft$^3$ | 1728 | in.$^3$ |
| gal (U.S.) | 231.0 | in.$^3$ |
| gal | 0.13368 | ft$^3$ |
| liters | 33.8147 | fluid oz |
| liters | 1.05671 | quarts |
| liters | 0.26418 | gal |
| gm moles (gas) | 22.4 | liters (s.t.p.) |

*DOE CORE TEST CONVERSION TABLE*

| Multiply # of | by | to obtain # of |
|---|---|---|
| to obtain # of | by | DividC # of |

**DCnsity**

| | | |
|---|---|---|
| cm$^3$/g | $1.602 \times 10^{-2}$ | ft$^3$/lb |
| ft$^3$/lb | 62.43 | cm$^3$/g |
| g/cm$^3$ | 62.43 | lb/ft$^3$ |
| lb/ft$^3$ | $1.602 \times 10^{-2}$ | g/cm$^3$ |
| lb/in.$^3$ | 27.68 | g/cm$^3$ |
| lb/gal | 0.1198 | g/cm$^3$ |

**Radiological Units**

| | | |
|---|---|---|
| becquerel | $2.703 \times 10^{-11}$ | curies |
| curies | $3.700 \times 10^{10}$ | dis/sec |
| curies | $2.220 \times 10^{12}$ | dis/min |
| curies | $10^3$ | millicuries |
| curies | $10^6$ | microcuries |
| curies | $10^{12}$ | picocuries |
| curies | $10^{-3}$ | kilocuries |
| curies | $3.700 \times 10^{10}$ | becquerel |
| dis/min | $4.505 \times 10^{-10}$ | millicuries |
| dis/min | $4.505 \times 10^{-7}$ | microcuries |
| dis/sec | $2.703 \times 10^{-8}$ | millicuries |
| dis/sec | $2.703 \times 10^{-5}$ | microcuries |
| kilocuries | $10^3$ | curies |
| microcuries | $3.700 \times 10^4$ | dis/sec |
| microcuries | $2.220 \times 10^6$ | dis/min |
| millicuries | $3.700 \times 10^7$ | dis/sec |
| millicuries | $2.220 \times 10^9$ | dis/min |
| R | $2.58 \times 10^{-4}$ | C/kg of air |
| R | 1 | esu/cm$^3$ of air (s.t.p.) |
| R | $2.082 \times 10^9$ | ion prs/cm$^3$ of air (s.t.p.) |

# SHAWNEE ENVIRONMENTAL SERVICES, INC.

## *DOE CORE TEST CONVERSION TABLE*

| Multiply # of | by | to obtain # of |
|---|---|---|
| to obtain # of | by | DividC # of |

| | **Radiological Units** (continuCd) | |
|---|---|---|
| R | $1.610 \times 10^{12}$ | ion prs/g of air |
| R (33.7 eV/ion pr.) | $7.02 \times 10^4$ | MeV/cm$^3$ of air (s.t.p.) |
| R (33.7 eV/ion pr.) | $5.43 \times 10^7$ | MeV/g of air |
| R (33.7 eV/ion pr.) | 86.9 | ergs/g of air |
| R (33.7 eV/ion pr.) | $2.08 \times 10^{-6}$ | g-cal/g of air |
| R (33.7 eV/ion pr.) | z98 | ergs/g of soft tissue |
| rads | 0.01 | gray |
| rads | 0.01 | J/kg |
| rads | 100 | ergs/g |
| rads | $8.071 \times 10^4$ | MeV/cm$^3$ or air (s.t.p.) |
| rads | $6.242 \times 10^7$ | MeV/g |
| rads | $10^{-5}$ | watt-sec/g |
| rads (33.7 eV/ion pr.) | $2.39 \times 10^9$ | ion prs/cm$^3$ of air (s.t.p.) |
| gray | 100 | rad |
| rem | 0.01 | sievert |
| sievert | 100 | rem |
| 4Ci/$^3$ (4Ci/ml) | $2.22 \times 10^{12}$ | dpm/m$^3$ |
| 4Ci/cm$^3$ | $2.22 \times 10^9$ | dpm/liter |
| dpm/m$^3$ | 0.4505 | pCi/m$^3$ |

| | **EnCrgy** | |
|---|---|---|
| Btu | $1.0548 \times 10^3$ | joules (absolute) |
| Btu | 0.25198 | kg-cal |
| Btu | $1.0548 \times 10^{10}$ | ergs |
| Btu | $2.930 \times 10^{-4}$ | kW-hr |
| Btu/lb | 0.556 | g-cal/g |
| eV | $1.6021 \times 10^{-12}$ | ergs |

# SHAWNEE ENVIRONMENTAL SERVICES, INC.

## *DOE CORE TEST CONVERSION TABLE*

| Multiply # of | by | to obtain # of |
|---|---|---|
| to obtain # of | by | DividC # of |
| | **EnCrgy (continuCd)** | |
| eV | $1.6021 \times 10^{-19}$ | joules (abs) |
| eV | $10^{-3}$ | keV |
| eV | $10^{-6}$ | MeV |
| ergs | $10^{-7}$ | joules (abs) |
| ergs | $6.2418 \times 10^5$ | MeV |
| ergs | $6.2418 \times 10^{11}$ | eV |
| ergs | 1.0 | dyne-cm |
| ergs | $9.480 \times 10^{-11}$ | Btu |
| ergs | $7.375 \times 10^{-8}$ | ft-lb |
| ergs | $2.390 \times 10^{-8}$ | g-cal |
| ergs | $1.020 \times 10^{-3}$ | g-cm |
| gm-calories | $3.968 \times 10^{-3}$ | Btu |
| gm-calories | $4.186 \times 10^7$ | ergs |
| joules (abs) | $10^7$ | ergs |
| joules (abs) | 0.7376 | ft-lb |
| joules (abs) | $9.480 \times 10^{-4}$ | Btu |
| g-cal/g | 1.8 | Btu/lb |
| kg-cal | 3.968 | Btu |
| kg-cal | $3.087 \times 10^3$ | ft-lb |
| ft-lb | 1.356 | joules (abs) |
| ft-lb | $3.239 \times 10^{-4}$ | kg-cal |
| kW-hr | $2.247 \times 10^{19}$ | MeV |
| kW-hr | $3.60 \times 10^{13}$ | ergs |
| MeV | $1.6021 \times 10^{-6}$ | ergs |

NOTE:  Energy to mass conversion under miscellaneous

# SHAWNEE ENVIRONMENTAL SERVICES, INC.

## *DOE CORE TEST CONVERSION TABLE*

| Multiply # of | by | to obtain # of |
|---|---|---|
| to obtain # of | by | DividC # of |
| | **Fission** | |
| Btu | $1.28 \times 10^{-8}$ | grams $^{235}$U fissioned[b] |
| Btu | $1.53 \times 10^{-8}$ | grams $^{235}$U destroyed[b,c] |
| Btu | $3.29 \times 10^{13}$ | fissions |
| fission of 1 g $^{235}$U | 1 | megawatt-days |
| fissions | $8.9058 \times 10^{-18}$ | kilowatt-hours |
| fissions[b] | $3.204 \times 10^{-4}$ | ergs |
| kilowatt-hours | $2.7865 \times 10^{17}$ | $^{235}$U fission neutrons |
| kilowatts per kilogram $^{235}$U | $2.43 \times 10^{10}$ | average thermal neutron flu× in fuel[b,d] |
| megawatt-days per ton U | $1.174 \times 10^{-4}$ | % U atoms fissioned[e] |
| megawatts per ton U | $2.68 \times 10^{10}/E$[f] | average thermal neutron flu× in fuel[b] |
| neutrons per kilobarn | $1 \times 10^{21}$ | neutrons/cm$^2$ |
| watts | $3.121 \times 10^{10}$ | fissions/sec |

---

[b] At 200 MeV/fission.

[c] Thermal neutron spectrum ($\underline{I}$ = 0.193).

[d] õ(fission = 500 barns).

[e] At 200 MeV fission, in $^{235}$U-$^{238}$U mi×ture of low $^{235}$U content.

[f] E = enrichment in grams $^{235}$U/gram total. No other fissionable isotope present.

## *DOE CORE TEST CONVERSION TABLE*

| Multiply # of | by | to obtain # of |
|---|---|---|
| to obtain # of | by | DividC # of |

### MiscCllanCous

| radians | 57.296 | degrees |
|---|---|---|
| eV | $1.78258 \times 10^{-33}$ | grams |
| eV | $1.07356 \times 10^{-9}$ | u |
| erg | $1.11265 \times 10^{-21}$ | grams |
| proton masses | 938.256 | MeV |
| neutron masses | 939.550 | MeV |
| electron masses | 511.006 | keV |
| u (amu on $^{12}$C scale) | 931.478 | MeV |

### TCmpCraturC

$$°C \quad \frac{(°F\ 32)}{1.8} \qquad\qquad °C \quad (°F\ 32)\left(\frac{5}{9}\right)$$

$$°F \quad 1.8(°C) + 32 \qquad\qquad °F \quad \left(\frac{9}{5}\right)(°C) + 32$$

$$°K \quad °C + 273.16$$

### WavClCngth to EnCrgy ConvCrsion

keV = 12.40/Å
eV = $1.240 \times 10^{-6}$/m

# AREA CONVERSION

## Acre to feet

1 acre = $43{,}560\text{ft}^2$

M4 C8
05/03/03 05:14:53

M4 C8
05/03/03 05:19:12
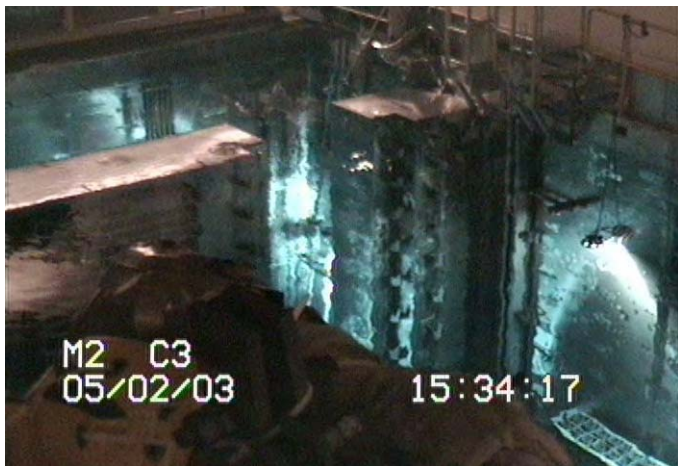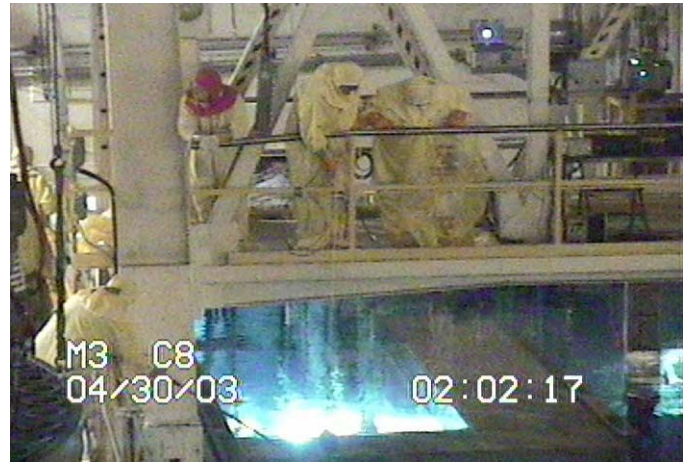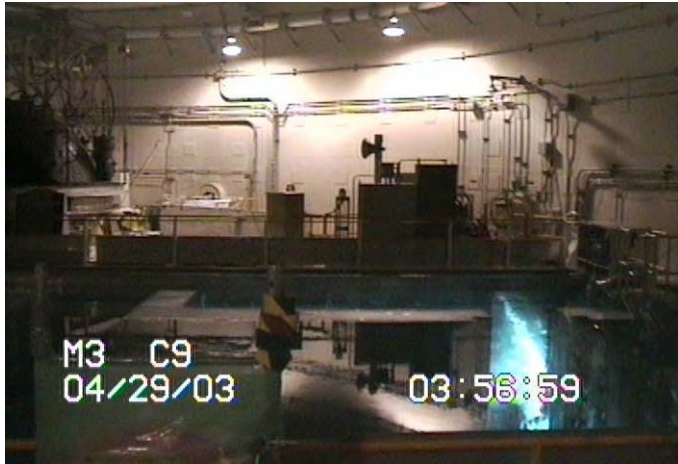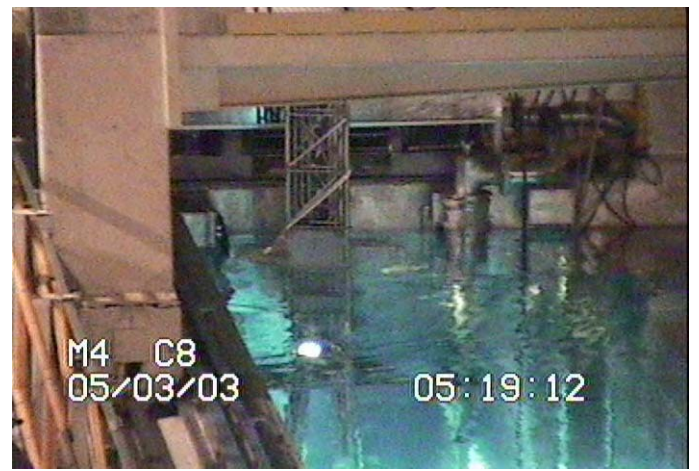
# SHAWNEE ENVIRONMENTAL SERVICES, INC.

244 West Walnut Street
Hillsboro, OH 45133
(937) 572-9704
Fax: (202) 351-0511
## Security Questionnaire

Shawnee Environmental Services is required to ask for the following information based upon the security background checks of all personnel working at Nuclear Power Plants.

1.     Have you ever had a DUI?  Yes or No? (circle one)
       If yes, what city, state and date of infraction?

       _____

2.     Have you ever been convicted of a felony?  Yes or No? (circle one)
       If yes, what was date of conviction and date of release from incarceration?

       _____

       _____

       Student print full name and Social Security Number (Verified by Notary).

       _____  _____

       Notary Public print full name, signature, and embossed.

       _____

       _____

## STUDENT ACKNOWLEDGEMENT
## OF RCT APPRENTICESHIP

I understand, that when I graduate from Radiation Control Technician Training, I will have a two and a half year apprenticeship as a junior radiation control technician (Junior RCT). Shawnee Environmental Services, Inc. (SES, Inc.) will assist in job placement for my first job. Graduates may feel free to contact SES for career counseling.

I understand that the permanent/long-term positions, as Junior RCT is only a transitional position toward gaining status as a Senior RCT. I understand that by applying for and attending this training that I am aware that these jobs are located out of my immediate area of residence. If I turn down work outside of my home of residence, I will not hold SES responsible for lack of job placement. I also accept that by my declining these positions that I am still responsible for any contract payments due SES, Inc.

Date:_____

Student Name:_____; Student Signature:_____

SES, Inc. Health Physics Training Specialist Name:_____

SES, Inc. Health Physics Training Specialist Signature:_____

## SES, Inc. is a Service-Connected Disabled Veteran Run Business

If you want a challenging career that allows you to see the rest of the United States, the Health Physics Industry is for you.

Shawnee Environmental Services, Inc. offers a student loan program for students wishing to take the in-class training program.

**Enroll today for our next Live on-line Radiation Control class. Our on-Line RCT Course costs $4,000.00. SES, Inc. has student loans for our students.**

---

**Shawnee Environmental Services**

Billie W. Childers, Jr.
Training Program Manager

ph (937) 572-9706

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Email: admin@shawneerct.com

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# Radiation Control Technician Training Program

**Training Sets The Precedence**
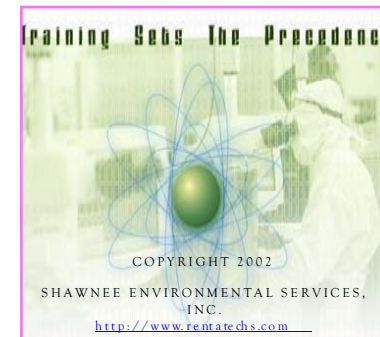
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# Radiation Control/Health Physics Technicians are the backbone of the Nuclear Industry!

## Why Train to be a Radiation Control Technician?

As many Department of Energy (DOE) Facilities are decommissioned and restored back to the environment, there is a great need for Radiation Control Technicians (RCTs). The commercial nuclear power industry needs RCTs as well. SES, Inc. trains the student in area of basic mathematics, calculator use, basic atomic structure, up to and including the use of radiation detection instruments. This course is recognized and approved by the Department of Energy. Bartlett Nuclear recognizes and reimburses the student for passing the DOE Overall Core Exam. Of course the RCT must be working for Bartlett to receive reimbursement.

**Spent Fuel Pool Bridge allows personnel to position fuel and control rods during refueling activities on the Spent Fuel Floor.**

## A brief description of the Radiation Control Technician Training Program:

Radiation Control Technicians (RCTs) are required to be trained to the level of knowledge and skills necessary for conducting their assigned tasks. Qualifying the technician for handling any situation that may arise may requires a more extensive level of training. The initial training program ensures that RCTs are trained to meet performance requirements using a systematic approach to training. The amount of classroom instruction may vary depending on the initial knowledge and skill level of the trainee. Initial qualification is typically broken down into two phases:

Phase One: Academic Training

- Consists of a standard foundation of academic training which encompasses specific learning objectives divided into two sections: Core Academics (13 modules and Core Overall Exam) and Site Academics (19 modules and Site Overall Exam).

- RCT trainees shall be required to successfully complete examinations on the materials covered in each of the Core and Site Academic modules. Three opportunities are given per test to achieve 80% on each exam. If a student fails to achieve 80% after three opportunities, then the student is dropped from the course.

Phase Two: Job Performance Measures (JPMs)

- Consists of applied on-the-job scenario training that provides the RCT trainee with the adequate job performance skills. The objectives of the academic training in Phase One provides the basis for the skills and tasks to be performed in Phase Two training. Phase Two uses a mixture of classroom and applied (hands on) training. RCT trainees are taught to apply academic knowledge to specific tasks.

## Student Career Objectives:

The student graduates with Certificates of Department of Energy for Core Academics, Site Academics (including Job performance Measures), and Forty-Hour Hazardous Waste Operations Emergency Response (HAZWOPER) Training.

- 5000 hours of apprenticeship toward becoming an ANSI 3.1 Senior Health Physics Technician. While working apprenticeship, the Junior RCT/Junior Health Physics Technician earns $40 to 45,000.00 take home pay.

- Once a Junior RCT/HP attains Senior RCT/HP status, the now recognized Senior RCT/HP can be hired by many DOE Sites and Commercial Nuclear Power Plants. Senior Contract RCT/HP Technicians earns $70 to 80,000.00 take home.

- If our graduates choose to apply for power plant permanent HP Techs positions, our graduates can earn $70 to 80,000.00 per year gross.

- If our graduates choose to continue their education into a bachelors degree, our graduates can earn $80 to 100,000.00 per year gross as a Radiological Engineer/ALARA Technicians.

- Further promotions to Supervisor and Health Physics Manager can attain gross pay of >$100,000.00 per year.

Our six month program can provide a new career for you. The requirements to take our course are a high school diploma or GED and you have met our security questionnaire. If you are unemployed or low income, you may qualify for free tuition through the Work Force Investment Act Program. SES, Inc. offers a student loan program for in-class students.

- Course cost is $4,000.00 with the Forty-Hour HAZWOPER class included. Without HAZWOPER: $3,800.00.

# "Acceptable Experience and Training for HP Technicians at Nuclear Power Plants"

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## INTRODUCTION

In commercial nuclear power stations, health physics (radiation protection) technicians are primarily responsible for evaluating station radiological conditions and for supporting the work of other station departments in radiological areas. Stations are committed (via Technical Specifications and other modes) to ensuring that technicians in "responsible positions" (i.e., technicians who must make significant radiation protection decisions on their own, without immediate review by supervisors) are qualified as "technicians" in accordance with designated industry standards. Qualification, in this sense, consists of meeting the experience and training criteria specified in the applicable standards. Unfortunately, these criteria are quite general, and major differences in interpretation exist throughout the nuclear power industry. A more consistent approach to interpreting the qualification criteria would benefit utilities and contractors.

The guidelines proposed here provide a means for evaluating the experience and training of health physics technicians versus industry standards. Particular attention is directed towards the amount of experience that can be "credited" for work at non-commercial nuclear facilities and for jobs at commercial power facilities that are related to but are not the same as health physics technicians. These guidelines are intended to be used to assist with the evaluation of an individual's background for consideration as a "senior technician," but they are only one means of doing so. In addition, the individual's technical knowledge should be evaluated through either oral or written testing, past work performance should be evaluated through previous observation or reference checks, and on-the-job performance should be confirmed by supervision. All of the above should be a part of the qualification process for health physics technicians assigned to responsible positions.

## INDUSTRY STANDARDS

For personnel selection and training, most nuclear power plants are committed to using the criteria in one of the versions of the American National Standard for Selection and Training of Nuclear Power Plant Personnel -- either ANSI N18.1-1971 or its replacement, ANSI/ANS 3.1-1978. ANSI/ANS 3.1 was

revised in 1981 and again in 1987. The 1981 revision incorporated "lessons learned" from the Three Mile Island accident, and the 1987 revision incorporates systematic training through job task analysis. The 1987 version of ANSI/ANS 3.1 may be adopted in the future as more commercial power plants revise their training programs; however, at the current time, most power plants are using the criteria in the 1978 version.

ANSI N18.1-1971 does not include qualification criteria specifically for health physics technicians. Instead, the standard includes a generic "Technicians" job category, the qualifications for which are stated as follows (Section 4.5.2):

*Technicians in responsible positions shall have a minimum of two years of working experience in their specialty. These personnel should have a minimum of one year of related technical training in addition to their experience.*

This generic technician qualification formula was modified and expanded in ANSI/ANS 3.1-1978 (Section 4.5.2), as follows:

*Technicians shall have three years of working experience in their specialty of which one year should be related technical training. They should possess a high degree of manual dexterity and ability and should be capable of learning and applying basic skills.*

In contrast to earlier versions, the "Technicians" category in ANSI/ANS 3.1-1987 includes qualification criteria specifically for "Radiation Protection" (Section 4.5.3.2), which are itemized as follows:

1. *Education: High School Diploma*
2. *Experience: Minimum experience for this position:*
    1. *Radiation Protection which shall include:*       *2 years*
    2. *Nuclear Power Plant*                    *1 years*
    3. *On site*                         *3 months*
3. *Training: As specified in Section 6.*

The "Section 6" criteria cover initial and continuing training after an individual is employed as a technician but not pre-employment training.

Despite the fact that the qualification criteria have become more specific with each revision, there is still plenty of room for interpreting "experience" and "related technical training." There is even room for disagreement over what constitutes a "year."

## DEFINITION OF A "YEAR"

Although the "normal" work year of 50 weeks consists of approximately 2000 hours, due to the extended shifts worked at nuclear power plants during outages (up to 72 hours per week), 2000 hours can be accumulated in much less than a year -- in only 28 weeks at 72 hours per week. Is such a compressed period really a full year's worth of experience? Probably not, and so a compromise between time worked and the passage of the calendar is needed. A maximum of 50 hours per week should be accepted as counting towards experience. Stated another way, a "year" consists of 2000 hours worked in no less than 40 weeks. With this definition, in order to have two years of "experience," a technician would need at least 80 weeks of employment and a documented 4000 hours of acceptable health physics experience.

## CREDITED TIME ALLOWANCES

With the advent of training and qualification programs accredited by the National Academy for Nuclear Training (Institute of Nuclear Power Operations), there is the temptation to consider personnel who have completed their instruction and qualification as being capable of functioning in responsible positions. However, the experience requirements of the ANSI/ANS standards are justifiable, and they should be adhered to because of the "having been there before" factor. Much like a pilot, regardless of the amount of simulator time a person may have, a given number of solo hours are required to confirm how an individual will react under actual conditions. Nevertheless, not all of these solo hours must be accumulated in the same plane or on the same job -- similar aircraft and similar jobs are acceptable substitutes, provided that allowances are made for the amount of experience that can be credited towards the desired qualification. Using this rationale, Table 1 presents guidelines for accepting commercial and non-commercial nuclear experience towards qualification as a senior health physics technician. The reasoning behind these guidelines is explained in the following sections.

### Navy Engineering Laboratory Technician (ELT)

Time spent in the U.S. Navy as a qualified Engineering Laboratory Technician (ELT) during non-overhaul periods may be accepted on a one for-one basis, but with a limit of one year due to the nature of work aboard ships at sea. During operational periods, an ELT performs primarily chemistry duties and only routine radiological controls coverage. There is, however, some minor maintenance coverage and significant drills, which can justify the acceptance of up to one year of this time.

**Table 1:**
**Guidelines for Acceptable Experience for Health Physics Technicians in "Responsible" Positions at Nuclear Power Stations**

| Job/Experience Type | Credit |
|---|---|
| Navy ELT (non-overhaul) | 1:1 up to l year |
| Navy ELT (overhaul) | 1:1 no limit |
| Shipyard/Tender RadCon | 1:1 no limit |
| National Laboratory | 1:1 no limit |
| Fuel Reprocessing/Plutonium Production | 1:1 no limit |
| NPP Sr. or Jr. HP Tech | 1:1 no limit |
| NPP Dosimetry Tech | 1:1 up to 6 months |
| NPP Respiratory Protection Tech | 1:1 up to 6 months |
| NPP Count Room Tech | 1:1 up to 6 months |
| NPP Control Point Monitor | 1:1 up to 3 months |
| NPP Laundry Monitor | 1:1 up to 3 months |
| NPP Decon (with surveys) | 1:1 up to 3 months |
| NPP General Employee Training HP Instructor | 1:1 up to 6 months |
| NPP HP Tech Instructor | 1: 1 up to 1 year |
| Radioactive Facility Decommissioning | Case-by-case |
| Miscellaneous HP Work at Other Facilities | Case-by-case |

The actual duties associated with each job should be reviewed to confirm the acceptability of the experience. **A *minimum* of 6 to 12 months of health physics job coverage experience should be required for qualification as a senior technician.**

**T**ime spent as an ELT during overhaul periods may be counted in addition to non-overhaul time on a one-to-one basis with no limit. During overhaul periods, ELTs provide radiological controls coverage for major inspection and repair operations (e.g., steam generator work, refueling, and primary system valve/piping replacement). However, a review of the actual work performed is recommended to ensure that the job coverage involved justifies the time credited towards experience as a health physics technician.

## Shipyard and Tender RadCon Personnel

**S**everal "RadCon" job categories, both civilian and military, involve substantial health physics experience. The civilian categories consist primarily of RadCon Monitors at the naval shipyards, while the Navy qualifications include RadCon Shift Supervisors (ELTs) and RadCon Monitors (various rates) on submarine and destroyer tenders with nuclear support facilities. By the very nature of the work involved -nuclear plant overhaul and repair -- shipyard and tender RadCon jobs may be accepted on a one-for-one basis with no limit, but subject to review to determine that the actual duties and job coverage provided are acceptable towards senior health physics technician status. In the case of tender personnel, the time spent in the home port and on rotation should be evaluated in the same manner as for ELTs -- non-overhaul time should be limited to one year of acceptance but there should be no limit for times of major radiological support activities.

## National Laboratories

The national laboratories operate a variety of facilities with broad scope radioactive material programs, including accelerators, research reactors, and high-level radioisotope facilities. Due to the scopes of the programs at these facilities, the problems encountered by the health physics technician may be similar to those of a commercial power reactor. Thus, the time for work in a health physics capacity at one of the major national labs (e.g., Argonne, Fermi, Oak Ridge, Los Alamos, etc.) may be accepted on a one-for-one basis with no limit. However, actual job duties must be reviewed to confirm the appropriateness of the experience.

## Fuel Reprocessing/Plutonium Production

The problems and work in fuel reprocessing plants and plutonium production facilities (Idaho, Hanford, and Savannah River) are perhaps the most similar to those at commercial nuclear power plants. Gross contamination and high dose rates are to be expected, and major amounts of work are performed under adverse radiological conditions. This time may be accepted on a one-for-one basis with no limit.

## Commercial Nuclear Power Plants
 -- Health Physics Job Coverage

Obviously, since junior and senior health physics technician positions at nuclear power stations involve exactly the type of work for which the individual is being evaluated, this time is acceptable on a one-for-one basis with no limit. However, "health physics technician" is a broad category at some plants; therefore, the precise work covered and duties performed should be evaluated for acceptability, especially if the individual has worked for short periods of time at many different facilities.

## Commercial Nuclear Power Plants
 -- Other HP-Related Jobs

The experience acceptance limitations given in Table 1 for commercial nuclear plant job functions related to health physics, but not directly involved with job coverage, were derived from estimates of the percentage of a technician's job that would be associated with a given function. These percentages were then applied to the two-year requirement to arrive at the acceptance limits, as follows:

| | | | |
|---|---|---|---|
| **Dosimetry** | 25% | x 2 yrs = | 6 mos |
| **Respiratory protection** | 25% | x 2 yrs = | 6 mos |
| **Counting room** | 25% | x 2 yrs = | 6 mos |
| **Control point** | 12.5% | x 2 yrs = | 3 mos |
| **Laundry monitoring** | 12.5% | x 2 yrs = | 3 mos |

| | | |
|---|---|---|
| **Decontamination** | 12.5% | x 2 yrs = 3 mos |
| **General Employee Trng** | 25% | x 2 yrs = 6 mos |
| **HP Tech training** | 50% | x 2 yrs = 12 mos |

**T**his rationale can be applied to any HP -related position in commercial nuclear power plants. The positions listed in Table 1 are the primary job functions for which experience can be credited; however, there will be exceptions (e.g., the plant that trains chemists to provide self-coverage or to perform emergency back shift health physics duties). **Regardless of the total amount of time accepted for "other HP-related jobs," a minimum of 6 to 12 months of actual job coverage experience (depending upon the capabilities of the individual and the hazards associated with the jobs to be covered) should be obtained before an individual is considered qualified for senior technician duties.**

## Decommissioning

**C**redit for health physics coverage of decommissioning activities must be determined on a case-by-case basis, depending on the type of facility and the radiological problems involved. Obviously, if the decommissioning is that of a power reactor or fuel reprocessing plant, the problems encountered would be similar to those in a commercial nuclear power station. However, many radium use facilities, research reactors, and contaminated laboratories are being decommissioned; therefore, the problems associated with each facility should be examined to determine if and how much time can be credited.

## Miscellaneous Health Physics Work

**T**he job categories and facilities listed in Table 1 are by no means the only ones that are acceptable for crediting towards experience as a health physics technician at a nuclear power plant. Other positions, such as commercial chemistry technicians, emergency planners, university and research reactor technicians, radiographers, and pharmaceutical company HP's, involve experience that can be applied on a case-by-case basis. These should be evaluated on the basis of the amounts of radioactive material used, isotopes involved, dose rates encountered, and specific work performed.

# CREDITED TRAINING ALLOWANCES

**T**able 2 presents guidelines for acceptable related technical training for a senior health physics technician. The table is quite straightforward, except for the following:

1. The Health Physics Certificate from Eastern Idaho Vocational Technical School is limited to nine months credit because the program of study is nine months long.

2. Any B.S. or advanced degree in a science or engineering is accepted since, traditionally, these have been accepted toward supervisory positions. These degrees certainly provide a background that should enable the individuals to grasp the technical aspects of health physics work.
3. U.S. Navy ELT training consists of six months at Nuclear Power School, six months of operator qualification, and six months of health physics and chemistry training/qualification. Taken as a whole, this may be considered equivalent to the Associate degree programs being given in colleges and universities.
4. Non-university, Industry (vendor) training may be accepted if the course material, length of study, and course testing methods are evaluated and related to health physics.
5. For utility-sponsored training, the time spent in training is usually already included in the time credited as "experience" and should not be counted twice.

**Table 2:**
**Guidelines for Acceptable Related Technical Training for Health Physics Technicians in "Responsible" Positions at Nuclear Power Plants**

| Training | Credit |
|---|---|
| Eastern Idaho Vocational Technical (Certificate Program in Rad Prot) | 9 months |
| Central Florida Community College (A.S. degree in Radiation Protection) | 1 year |
| Other Associate degrees in Rad Health | 1 year |
| B.S. or advanced degree in Rad Health | 1 year |
| B.S./advanced degree in science/engineer | 1 year |
| Navy Engineering Laboratory Tech | 1 year |
| Non-university health physics courses | Case-by-Case |
| Utility -sponsored training programs | $\leq$ Year |

# CONCLUSION

**T**hrough discussion amongst the utilities and contractors involved in the selection and qualification of health physics technicians, hopefully, experience and training criteria can be applied more uniformly and consistently. **The guidelines presented here are, obviously, not "etched in stone".** They are suggestions only, but they may, in the future, eliminate some of the confusion on the part of health physics personnel concerning selection and qualification standards.

## The Authors

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## EDITOR'S NOTES

**M**r. Barley is currently the President of Rosebar Associates, (602-563-0636) an independent consulting firm that provides radiation protection and managerial consulting services to both the commercial nuclear power industry and Department of Energy clients.

**M**r. Hiatt is currently the President – Technical Services of Bartlett Nuclear, Inc. and has served as the Chair of the American Board of Health Physics (ABHP) Part 1 Certification Exam Panel as a member of the ABHP Part 2 Certification Exam Panel.

### SES Rentatechs.com Job Board Web Ads/Job Postings

### Employer Membership Fees

| Days | Fee |
|------|------|
| 30 | $6.00 |
| 180 | $30.00 |
| 360 | $50.00 |

### Featured Employer Membership Fees

| Days | Fee |
|------|------|
| 30 | $15.00 |
| 180 | $60.00 |

*Note the "Featured Employer" includes employer banner on Rentatechs.com Job Board and SES Training Website. Banner must be ≤25k.

### Job Postings

| Jobs | Fee |
|------|------|
| 1 | $7.00/Job |
| 2-4 | $6.00/Job |
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| 10-14 | $4.00/Job |
| 15-29 | $3.00/Job |
| 30-59 | $2.00/Job |
| 60-99 | $1.00/Job |

### Featured Job Postings

| Jobs | Fee |
|------|------|
| 1 | $10.00/Job |
| 2-4 | $8.00/Job |
| 5-9 | $6.75/Job |
| 10-14 | $5.50/Job |
| 15-29 | $4.00/Job |
| 30-59 | $2.75/Job |
| 60-99 | $1.50/Job |

## Resume Search

| Resumes | Fee |
|---|---|
| 1 | $7.50/Resume |
| 5 | $1.75/Resume |
| 10 | $1.00/Resume |
| 25 | $.80/Resume |
| 50 | $.70/Resume |
| 100 | $.60/Resume |
| 200 | $.50/Resume |
| 300 | $.40/Resume |
| 400 | $.30/Resume |
| 500 | $.20/Resume |