Training Sets The Precedence

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 $20 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 $150 for three chances to pass a proctored exam) then that individual must contact SES, Inc. (937-572-9704/9706 or 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 must be approved by admin@shawneerct.com prior to exam start to give individual's user ID access to testing database. When student takes exam, the results will be reviewed by student where any challenges may be emailed to 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 placed on the certificate 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.

Information required for Proctor:

Full Name:____

Company working for:

____

Credentials (NRRPT, CHP, Company Recruiter/Notary Public):

____

Mailing Address:

____

____

____

Email Address (required):

____

Phone number:

____

Proctor will be given an ID number. For test result verification the following will be required:

1) Email from Proctor's email for student test results and verification of students social security number with picture identification.
2) Proctor's confidential ID number.
3) Student results verified by database.

For more info contact:

Shawnee Environmental Services, Inc. (SES, Inc.)
116 Broadway Street
Seaman, Ohio 45679
(937) 572-9704/9706
admin@shawneerct.com

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 half 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 50%. 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 $20 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 MasterCard 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 questions will be counted incorrect. Eighty percent is required to pass each exam.
5) After the Core modules are complete, then the Overall Core Exam $150 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 $20 each as well with the Overall Site Exam costing $150 (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 ($520). These JPMs can be complete in a weekend session (two twelve hour days). Fees can be part of student loan.
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 site for $400. Soon we will be offering this online for the same price with exception of completing the Dress out Practical with Level A equipment for Decon Station setup for exiting a Hot zone.
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 937-572-9706. 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 $35-40k 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 $60-70k 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 your 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 (at our facility) with the 40 Hour Hazwoper Class (Which is $114 per module with last payment of $124: 35 modules).
•Course B costs $3,600.00 without the 40 Hour Hazwoper Class (Which is $105 per module with last payment of $135: 34 modules).
•An online course is available on shawneerct.com for a fraction of the cost: $1860 including a 40 Hour Hazwoper Class. (Which is $20 per module with Overall Core Exam and Overall Site Exams $150 each. The Hazwoper class is $400 and the onsite JPMs are $520.)

WHAT IS CLASS SCHEDULE?

•Classes will run on Monday and Wednesdays or Tuesday and Thursdays 5:00 pm to 9:00 pm on each night. Internet class to be determined.
•Location of class will be announced as students enroll by location.
•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.
116 Broadway Street
Seaman, Ohio 45679
phone: 937-572-9704/9706
email: admin@shawneerct.com
website: shawneerct.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 Core Module 2 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) + 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 result from the random motion of molecules.

Chemical energy---The energy that is derived from atomic an molecules 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 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 it's nucleus.

Neutrons----Neutrally charged (0)
The number of neutrons determine the isotope (are atoms which have the same number of protons, but different number of neutrons) an element:

Does not affect the chemical properties of element.

Electrons---Negatively charged (-1)
-Small mass-1/1840 of proton
-The number of electron 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 to protons in the nucleus of an element.
It is represented by the symbol Z.

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 (AMUs).

Atomic Weight-------- The weighted average of the isotopic of an element, based on the percent abundance of it's naturally occurring isotopes.

1.03.07- Identify what each symbol represents in the $^{A}_{z}X$ notation:

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

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

X------Symbol for element

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:

Valance Shell----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.

Valence Electron-The electrons contained in the valance shell.

1.04.01-Identify the definitions of the following terms:

Nucleon -----Neutrons and Protons in the nucleus(particles)

Nuclide------A species of atom characterized by the constitution of it's nucleus, which is specified it's atomic mass and atomic number or by it's number or protons, number of neutrons and energy content.

Isotope------Nuclides which have the same number of protons but different number of neutrons.

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

E=mc(square)-----expresses the equivalence of mass and energy Meaning that mass may be transformed to Energy and vice versa (mass-energy).

Mass energy------Implies that mass and energy are Interchangeable.

Pair Annihilation-----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:

Mass Defect-----The difference between the total mass of an Atom and the sum of the masses of the Individual protons and neutrons.

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 Nuclei's

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)- dependent on location --- exposure = 28mrem.

Cosmic----- 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.

Nuclear fallout-debris which settles to the earth as the result of nuclear blast => Exposure= <1 mrem.

Medical exposures-From X-ray => Exposure is 53 mrem.

Consumer products-TV, watches and etc. => Exposure is 10 mrem.

Nuclear Facilities- Power plants => Exposure is <1 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 ration gradually increases.

At the high atomic number there are no completely stable nuclei.

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

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

Radioactive decay-The process by which a nucleus spontaneously disintegrates by one or more discrete energy steps until a stable is reached.

Parent- The nucleus before the decay

Daughter-The nucleus after decay.

Naturally radioactive- Occur in nature.

Artificially Radioactive- Man made reaction.

1.06.03---Identify the characteristics of Alpha, Beta and Gamma radiations

Alpha- Particulate radiations (from the nucleus - consist of Two protons and two neutrons)
-Only relatively heavy radioactive nuclides decay by alpha emission.
-Least penetrating
-Stopped by paper

Beta- 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.

Gamma- 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 - Emission.

Lighter radionuclides (Activation and fission products) Decay by beta +(positron) or electron capture (K-capture)

Know Equation Not Given

Alpha decay - ${}^{a}_{z}x \Rightarrow {}^{a-4}_{z-2}Y + {}^{4}_{2}\text{alpha}$

Beta decay - ${}^{a}_{z}x \Rightarrow {}^{a}_{z+1}Y$ +beta - minus + antineutrino (are neutral Uncharged particles)

-Changing a neutron to a proton

-Excess number of neutron

Positron Decay- Low n:p ratio or too many protons

- Changes a proton into a neutron

$^{A}_{z}X = ^{a}_{z-1}Y$ + Beta +(positron) + 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-ray 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:

The nuclear fragments. Directly resulting from fission have too Large of 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 on gram of radium

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

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

Millicurie----mCi----3.7E7-----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:

$A_{final} = A_{original} \times e^{-lamda(t)}$;lamda=.693/half-life or $A_{final} = A_{original} \times (1/2)^{n}$;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 any radiation 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 of Sievert)
D = absorbed dose (Rad or Gray)
Q = Quality factor

Quality Factors

X-Rays, Gamma Rays, Positrons, Electrons (Including Beta particles)

Slow Neutron ---3
Fast Neutron and protons--10
Alpha particles-----------20

Dose Equivalent (H) 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-ray 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:

LET- is less than or equal to stopping power.

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 none energy loss, the gamma ray impacts all of its energy to an orbital electron of some atom:(takes place near the nucleus)

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:
(Gamma and Electron)

- Take place mostly on valence electron
- Medium energy photon

Pair Production--A gamma photon simply disappears in the vicinity charged and one positively charged:

- Has to possesses greater the 1.022 MeV of Energy.

- Two gammas 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---- ~0.025 eV to <0.5 eV

Intermediate-----0.5 eV to 100 KeV

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

Relativistic----->20MeV

1.07.07---Identify three possible results of neutron capture for slow 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 all of its kinetic energy to the nucleus knocking it away from the electrons.

---No gamma is given off

----Causes ionization and excitation

Inelastic scattering Occurs when a neutron strikes a large nucleus, the neutron penetrates 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 organice matter which form the interior Environment 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:

10.08.04---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)
H2o=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:

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

---Without threshold

---Cancer and genetic are examples

Non-Stochastic--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 shorten

---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:

Syndrome

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 by 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 demonstrating 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 in both 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:

Stop Work Authority Exercise:

1-Inadequate radiological control:

2-Radiological controls not being implemented

3-Radiological controls 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:(in feet)R/hr= 6CEN;(in meters)R/hr= .5CEN

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:

(Not Given Know Equation)

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 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"

Linear attenuation coefficient is the probability of a photon interaction per path Length: Has units of length (exponent of -1)

Mass attenuation coefficient is the probability of a photon interaction per path length: Has units of length (exponent of 1)

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

Is a value equals 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:

(Equations not given, KNOW equation)

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
    1. Penetration- Materials enter through existing wounds:
    2. Injection- Materials enter through wounds incurred on the job;

1.12.02---Given a pathway for radioactive materials into 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:

   (1) 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)

2. Radioactive Decay- 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:

Physical or radiological half life- the amount of time required for One half of the material in the body to decay:

Biological half life-The time required to reduce the amount of material in the body one-half of its original valve:

Effective half life- 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:

Formula not given - Know the formula; hint: tit(times) over prostate(plus)

$T_{effective\ ½\ life} = T_{biological\ ½\ life} \times T_{physical\ ½\ life} / T_{biological\ ½\ life} + T_{physical\ ½\ life}$

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:

Blocking agent- Saturates the metabolic processes in a specific tissue with the stable element and reduces uptake of the radioactive forms of the element:

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

Mobilizing agent- A compound that increases the natural turnover process, thus releasing some forms of radioisotopes from body tissues:

Chelating agent- 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:
2. 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, which can be

-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: 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 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:

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

$$1\text{Å} = 10^{-8}\ centimeters \Rightarrow \frac{1\ \text{Å}}{10^{-8}\ centimeters}$$

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

$$1\ inch = \frac{1}{3.937E-5\ \mu m} = 2.54E4\ \mu m$$

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Length

angstroms (Å)	10^{-8}	cm
Å	10^{-10}	m
micrometer (µm)	10^{-3}	mm
µm	10^{-4}	cm
µm	10^{-6}	m
µm	3.937×10^{-5}	in.
mm	10^{-1}	cm
cm	0.3937	in.
cm	3.2808×10^{-2}	ft
cm	10^{-2}	m
m	39.370	in.
m	3.2808	ft
m	1.0936	yd
m	10^{-3}	km
m	6.2137×10^{-4}	miles
km	0.62137	miles
mils	10^{-3}	in.
mils	2.540×10^{-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

SHAWNEE ENVIRONMENTAL SERVICES, INC.

DOE CORE TEST CONVERSION TABLE

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Mass

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

NOTE: Mass to energy conversions under miscellaneous.

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Time

days	86,400	sec
days	1440	min
days	24	hours
years	3.15576×10^{7}	sec
years	525,960	min
years	8766	hr
years	365.25	days

Area

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

SHAWNEE ENVIRONMENTAL SERVICES, INC.

DOE CORE TEST CONVERSION TABLE

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Volume

cm^3 (cc)	0.99997	ml
cm^3	6.1023×10^{-2}	$in.^3$
cm^3	10^{-6}	m^3
cm^3	9.9997×10^{-4}	liters
cm^3	3.5314×10^{-5}	ft^3
m^3	35.314	ft^3
m^3	2.642×10^{2}	gal
m^3	9.9997×10^{2}	liters
$in.^3$	16.387	cm^3
$in.^3$	5.787×10^{-4}	ft^3
$in.^3$	1.639×10^{-2}	liters
$in.^3$	4.329×10^{-3}	gal
ft^3	2.832×10^{-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.)

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Density

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

Radiological Units

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

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Radiological Units (continued)

R	1.610×10^{12}	ion prs/g of air
R (33.7 eV/ion pr.)	7.02×10^{4}	MeV/cm^3 of air (s.t.p.)
R (33.7 eV/ion pr.)	5.43×10^{7}	MeV/g of air
R (33.7 eV/ion pr.)	86.9	ergs/g of air
R (33.7 eV/ion pr.)	2.08×10^{-6}	g-cal/g of air
R (33.7 eV/ion pr.)	≈98	ergs/g of soft tissue
rads	0.01	gray
rads	0.01	J/kg
rads	100	ergs/g
rads	8.071×10^{4}	MeV/cm^3 or air (s.t.p.)
rads	6.242×10^{7}	MeV/g
rads	10^{-5}	watt-sec/g
rads (33.7 eV/ion pr.)	2.39×10^{9}	ion prs/cm^3 of air (s.t.p.)
gray	100	rad
rem	0.01	sievert
sievert	100	rem
μCi/^{3} (μCi/ml)	2.22×10^{12}	dpm/m^3
μCi/cm^3	2.22×10^{9}	dpm/liter
dpm/m^3	0.4505	pCi/m^3

Energy

Btu	1.0548×10^{3}	joules (absolute)
Btu	0.25198	kg-cal
Btu	1.0548×10^{10}	ergs
Btu	2.930×10^{-4}	kW-hr
Btu/lb	0.556	g-cal/g
eV	1.6021×10^{-12}	ergs

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Energy (continued)

eV	1.6021×10^{-19}	joules (abs)
eV	10^{-3}	keV
eV	10^{-6}	MeV
ergs	10^{-7}	joules (abs)
ergs	6.2418×10^{5}	MeV
ergs	6.2418×10^{11}	eV
ergs	1.0	dyne-cm
ergs	9.480×10^{-11}	Btu
ergs	7.375×10^{-8}	ft-lb
ergs	2.390×10^{-8}	g-cal
ergs	1.020×10^{-3}	g-cm
gm-calories	3.968×10^{-3}	Btu
gm-calories	4.186×10^{7}	ergs
joules (abs)	10^{7}	ergs
joules (abs)	0.7376	ft-lb
joules (abs)	9.480×10^{-4}	Btu
g-cal/g	1.8	Btu/lb
kg-cal	3.968	Btu
kg-cal	3.087×10^{3}	ft-lb
ft-lb	1.356	joules (abs)
ft-lb	3.239×10^{-4}	kg-cal
kW-hr	2.247×10^{19}	MeV
kW-hr	3.60×10^{13}	ergs
MeV	1.6021×10^{-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**	←←←←←	**Divide # of**

Fission

Btu	1.28×10^{-8}	grams ^{235}U fissioned[b]
Btu	1.53×10^{-8}	grams ^{235}U destroyed[b,c]
Btu	3.29×10^{13}	fissions
fission of 1 g ^{235}U	1	megawatt-days
fissions	8.9058×10^{-18}	kilowatt-hours
fissions[b]	3.204×10^{-4}	ergs
kilowatt-hours	2.7865×10^{17}	^{235}U fission neutrons
kilowatts per kilogram ^{235}U	2.43×10^{10}	average thermal neutron flu× in fuel[b,d]
megawatt-days per ton U	1.174×10^{-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	1×10^{21}	neutrons/cm^2
watts	3.121×10^{10}	fissions/sec

[b] At 200 MeV/fission.
[c] Thermal neutron spectrum ($\alpha = 0.193$).
[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.

Multiply # of	→→→→→	**by**	→→→→→	**to obtain # of**
to obtain # of	←←←←←	**by**	←←←←←	**Divide # of**

Miscellaneous

radians	57.296	degrees
eV	1.78258×10^{-33}	grams
eV	1.07356×10^{-9}	u
erg	1.11265×10^{-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

Temperature

$$^\circ C = \frac{(^\circ F - 32)}{1.8} \qquad ^\circ C = (^\circ F - 32)\left(\frac{5}{9}\right)$$

$$^\circ F = 1.8(^\circ C) + 32 \qquad ^\circ F = \left(\frac{9}{5}\right)(^\circ C) + 32$$

$$^\circ K = ^\circ C + 273.16$$

Wavelength to Energy Conversion

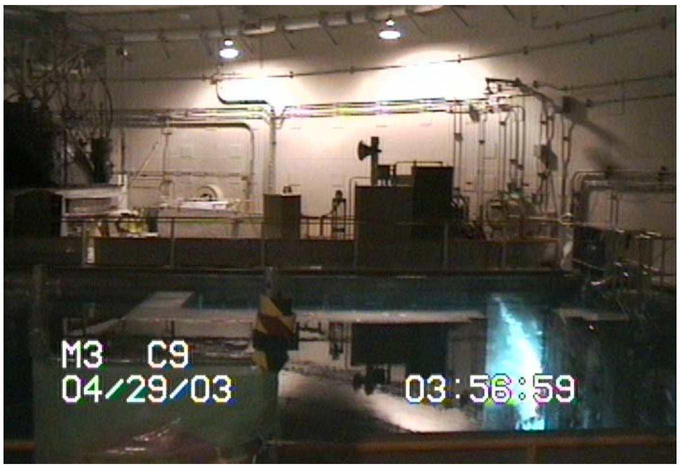
keV = 12.40/Å
eV = 1.240×10^{-6}/m

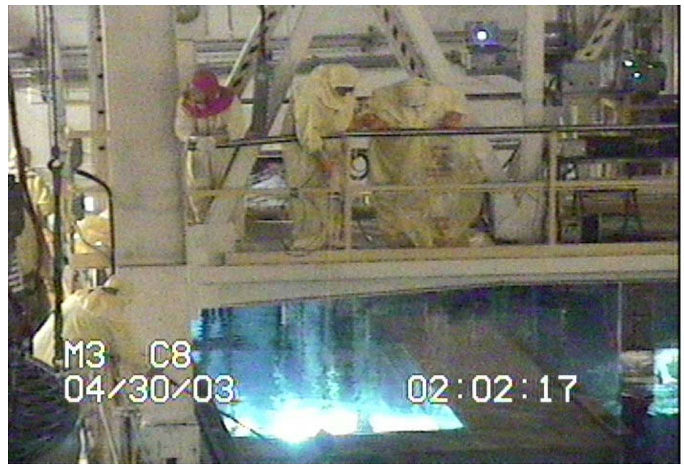
AREA CONVERSION

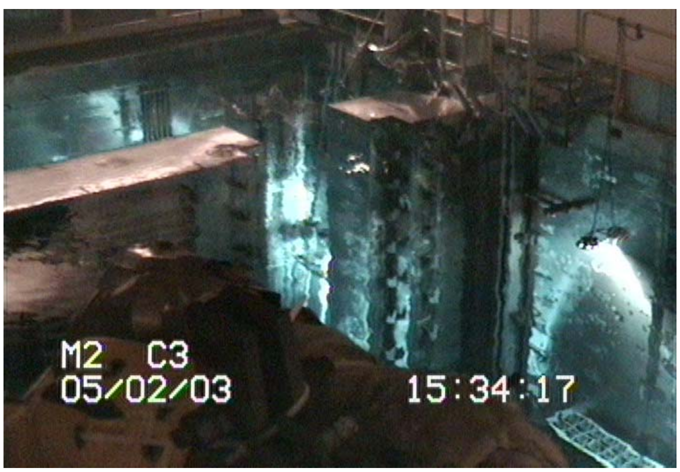
Acre to feet

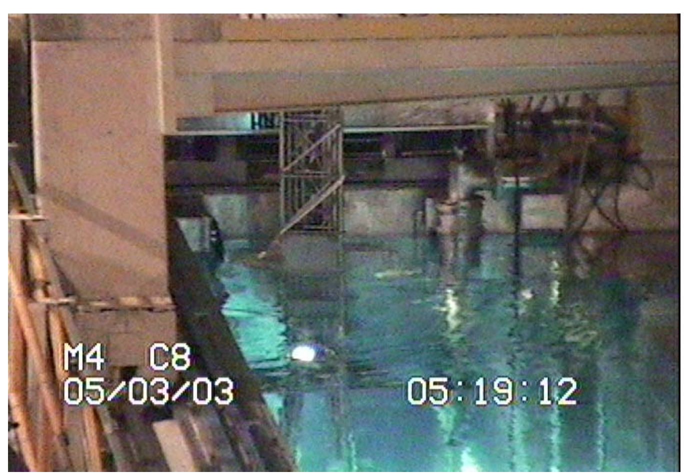
1 acre = $43{,}560 ft^2$

Outage for refueling the reactor. Radiation Control Techs at work. This high tech job is for you.









SHAWNEE ENVIRONMENTAL SERVICES, INC.

116 Broadway Street
Seaman, OH 45679
(937) 572-9704/9706

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.

__________________________ ____________________

Witness print full name and signature.

____

____

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 contracts 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 our live-class training program.

Our Live on-line Radiation Control Technician Training available for those who cannot attend our classes in Cincinnati and Lancaster, Ohio. Our RCT Course can be funded through our student loan program.

Organization

Shawnee Environmental Services, Inc.
116 Broadway Street
Seaman, Ohio 45679-9570
Website: http://www.shawneerct.com

Phone: 937-572-9706
Fax: 937-386-2834
Email: admin@shawneerct.com

Radiation Control Technician Training Program

SHAWNEE ENVIRONMENTAL SERVICES, INC.

Website: shawneerct.com
Contact by email
admin@shawneerct.com
Tel: 937-572-9706

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.

Refuel Bridge allows personnel to position fuel and control rods during refueling activities on the Refuel 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 (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 $35 to 40,000.00 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 $60 to 65,000.00 take home.
- If our graduates choose to apply for power plant permanent HP Techs positions, our graduates can earn $60 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 live-class students.

- Course cost is $4,000.00 (onsite live class) with the Forty-Hour HAZWOPER class included. Without HAZWOPER: $3,600.00.

STUDENT CONTRACT FOR PAYMENT OF RADIATION CONTROL TECHNICIAN TRAINING

For training received, I promise to pay Shawnee Environmental Services, Inc. $2000 and interest at the rate of 10% per annum. This interest is waived on the overall balance when $2000 is paid in full by the eighteen month anniversary of the class start date. For example if class starts January 7th, 2004, then balance of loan ($2000 – test fees paid during class = $1340) is due July 7th, 2005. Details of the loan are as follows:

1. I will faithfully attend the Radiation Control Technician Training Class.

2. I will pay twelve monthly installments of $55 each, after graduation.

3. I will pay the first installment on July 7th, 2004, and a similar installment on the first day of each month after that until principal and interest have been paid in full.

4. Payments will be applied first on interest and then on principal.

5. I will pay the entire amount of principal and interest within eighteen months from the start of the Radiation Control Technician Training Class.

6. I may prepay all or any part of the principal without penalty.

7. If I am more than 90 days late in making any payment, Shawnee Environmental Services, Inc. may declare that the entire balance of unpaid principal is due immediately, together with the interest that has accrued.

Date:_________________

Student Name:______________________; Student Signature:_____________________

Cosigner Name:_____________________; Cosigner Signature:____________________
Collateral offered
Description:____
____
____
Title Number:____(Title attached)
Owner of Collateral (print name):________________________________
Owner of Collateral (signature):_________________________________
Date:_______________
Shawnee Environmental Services, Inc. Loan Officer Signature:___________________________
Notary Public Signature:_________________________; Expiration of commission:__________

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

Article by Jerry W. Hiatt and William H. Barley
Bartlett Nuclear, Inc. 60 Industrial Park Road; Plymouth, MA 02360
Reprinted from Radiation Protection Management Journal
Vol.5 No.5 (Sept/Oct 1988), pp. 70-74.

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 N18.1-1971or 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.**

Time 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

Several "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**

This 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

Credit 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

The 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

Table 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	≤ Year

CONCLUSION

Through 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

William H. Barley is the Vice President -Technical Services for Bartlett Nuclear, Inc. He has more than 18 years of experience with nuclear service companies, the U.S. Nuclear Regulatory Commission, and utilities. Mr. Barley holds a B.S. degree in Chemical Engineering from Pennsylvania State University, and he is certified (power reactor) by the American Board of Health Physics.

Jerry W. Hiatt is the Manager -- Technical Services for Bartlett Nuclear, Inc. He has more than 13 years of utility, USNRC, and consulting experience. Mr. Hiatt holds a B.S. degree in Biology (Health Physics Option) from Virginia Polytechnic Institute and State University, and he is certified (power reactor) by the American Board of Health Physics. He currently serves on the Health Physics Society's Federal and State Legislative Committee and is on the Board of Directors of the Nuclear Suppliers Association.

EDITOR'S NOTES

Mr. 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.

Mr. 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.

Banner Advertising:

Banner Advertising is a great way to get attention and promote your company, a product or service.

Here's an Example:

Your banner ad will be placed into a rotating cycle of banner ad's for our website.

Shawnee Environmental Services, Inc. also gives once a month report of statistics concerning your banner as seen below.

	Today		This month		This year		Total	
	Shows	Clicks	Shows	Clicks	Shows	Clicks	Shows	Clicks
Total:	8	1	8	1	8	1	8	1
Unique hosts:	2	1	2	1	2	1	2	1

How big of a Banner Ad do I get?

The Banner Ad will be 468 pixels (width) x 60 pixels (height). That means your ad will show up as a .gif image with the following dimensions:

Design is Free!

The creation of your image is included with your Banner Ad Registration Fee at no additional charge. (You can make you own, if you desire; maximum dimensions are 468 pixels (width) x 60 pixels (height), .gif format, 25k max).

Once we receive your electronic registration form, we will contact you and begin the design of your banner ad, based on your input.

Can my Banner Ad be "linked" to another website?

Yes! Your banner ad can be made into a "click able" (hyper linked) image, such that when a user clicks on it, they are taken to the web site of your choice. Alternately, if you have a business listing on the internet, your Banner Ad can be linked to it, like the following example:

Does my Banner Ad have to be "linked" to another website?

No. If you desire to not have a hyper linked image, your banner ad will simply not be "click able".

What are the rates to place my Banner Ad on these web pages?

The cost for your banner ad is $500/year.

If you do not have a website, we can create a stand-alone web page on shawneerct.com for your firm that the banner ads mentioned above would be hyper linked into. The stand alone web page would be written based on your input, with an imbedded form-mail query that your prospective clients could fill out to find out more info about your services; the e-mail from the form-mail would go to any e-mail address you would specify.

Compare these rates to any other form of 24 hour a day advertising.

For more information please send us an email at admin@shawneerct.com or call us at 937-572-9704.