

Reference Guide



General Technical Base Qualification Standard

U.S. Department of Energy
National Nuclear Security Administration



Revision History

Draft 1: August 2005

This is the initial version of this guide. This guide was developed as part of the development of the GTB online course. Technical information was based upon a 2005 NNSA GTB reference guide that was revised and enhanced based upon subject matter expert input from NNSA, the Office of Environment Safety and Health, and the Office of Independent Oversight and Performance Assurance.

Revision 1: September 2005

Revised to correct editorial errors, some minor enhancements to technical material, and provide better consistency with associated computer based course.

Revision 2: August 2006

Revised to correct editorial errors, some minor enhancements to technical material, and provide better consistency with associated computer based course.

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Acronyms

AC	Administrative Control
ACGIH	American Conference of Industrial Hygienists
ALARA	As Low As Reasonably Achievable
ANSI	American National Standards Institutes
ANS	American Nuclear Society
BEI	Biological Exposure Indices
Bq	Becquerel
CAA	Clean Air Act
CAM	Corrective Action Management
CBDPP	Chronic Beryllium Disease Prevention Program
CDC	Center for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act - Superfund Act
CFR	Code of Federal Regulation
Ci	Curie
CRD	Contractor Requirements Documents
CSE	Cognizant System Engineer
CSO	Cognizant Secretarial Officer
CWA	Clean Water Act
DART	Days Away, Restricted or Transferred
DEAR	Department of Energy Acquisition Regulation
DNA	Deoxyribonucleic acid
DNFSB	Defense Nuclear Facilities Safety Board

DP	Office of Defense Programs
DSA	Documented Safety Analysis
EA	Environmental assessments
EH	Office of Environment, Safety, and Health
EIS	Environmental Impact Statement
EM	Office of Environmental Management
EMS	Environmental Management Systems
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-To-Know Act
ES&H	Environment, safety, and health
FEM	Field Element Manager
FFCA	Federal Facility Compliance Act
FHA	Fire Hazards Analysis
FRAM	Responsibilities and Authorities Manual
FSAR	Final Safety Analysis Report
Gy	Gray
HAZWOPER	Hazardous Waste Operations and Emergency Response
HEPA	High Efficiency Particulate
HLW	High Level Waste
IDLH	Immediately Dangerous to Life or Health
IH	Industrial Hygiene
ISM	Integrated Safety Management
ISMS	Integrated Safety Management System
ISO	international Organization for Standardization

LCO	Limiting Conditions for Operation
LCS	Limiting control settings
LDR	Land Disposal Restrictions
LLW	Low Level Waste
LLMW	Low Level Mixed Waste
MeV	Million Electron Volts
MSDS	Material Safety Data Sheet
MSHA	Mine Safety and Health Administration
NEPA	National Environmental Policy Act
NESR	Nuclear Explosive Safety Rule
NFPA	National Fire Protection Association
NIH	National Institute for Health
NISOH	National Institute for Occupational Safety and Health
NNSA	National Nuclear Security Administration
NPDES	National Pollutant Discharge Elimination System
NPH	Natural Phenomena Hazard
NRC	Nuclear Regulatory Commission
OE	Occupational Emergency
ORPS	Occurrence Reporting and Processing System
OSHA	Occupational Safety and Health Administration
PDSA	Preliminary Documented Safety Analysis
PEL	Permissible Exposure Limit
PISA	Potential Inadequate Safety Analysis
PPA	Pollution Prevention Act
PPE	Personal Protective Equipment

PSO	Program Secretarial Officer
Q	Quality Factor
QA	Quality Assurance
QAP	Quality Assurance Program
USQ	Unreviewed Safety Question
RAD	Radiation Absorbed Dose
RCRA	Resource Conservation and Recovery Act
REM	Roentgen Equivalent Man
SDWA	Safe Drinking Water Act
S&S	Safeguards and Security
SAR	Safety Analysis Report
SARA	Superfund Amendment and Reauthorization Act
SC	Safety Class
SER	Safety Evaluation Report
SI	Scientific International
SL	Safety Limit
S/RIDs	Standards/requirements identification documents
SNM	Special Nuclear Materials
SR	Surveillance Requirement
SS	Safety Significant
SSC	Systems, structures and components
STEL	Short Term Exposure Limit
Sv	Seivert
SWDA	Solid Waste Disposal Act
STP	Site Treatment Plan

TLV	Threshold Limit Value
TRU	Transuranic
TSCA	Toxic Substances Control Act
TSR	Technical Safety Requirement
TWA	Time Weighted Average
WIPP	Waste Isolation Pilot Plant
WSS	Work Smart Standards

PURPOSE

The purpose of this reference guide is to provide a single document that contains the information required for a DOE technical employee to successfully complete the General Technical Base (GTB) Qualification Standard. In addition to providing information essential to meeting the qualification requirements some references and additional background material is provided.

SCOPE

This reference guide has been developed to address the competency statements in the October 2001 edition of DOE-STD-1146-2001, General Technical Base Qualification Standard. Competency statements and supporting knowledge and/or skill statements from the qualification standard are shown in contrasting bold italics, while the corresponding information associated with each statement is provided below it. The qualification standard for the GTB contains 20 competency statements. This reference guide addresses all 20 statements.

Every effort has been made to provide the most current information and references available as of September 2005. However, the candidate is advised to verify the applicability of the information provided.

Please direct your questions or comments related to this document to the NNSA Service Center, Training and Development Department.

ACKNOWLEDGEMENT

This guide was developed as part of the development of the GTB online course. Technical information for the course was based upon a 2005 NNSA GTB reference guide that was revised and enhanced based upon subject matter expert input from NNSA, the Office of Environment Safety and Health, and the Office of Independent Oversight and Performance Assurance.

TECHNICAL COMPETENCIES

Competency 1: Basic Nuclear Theory

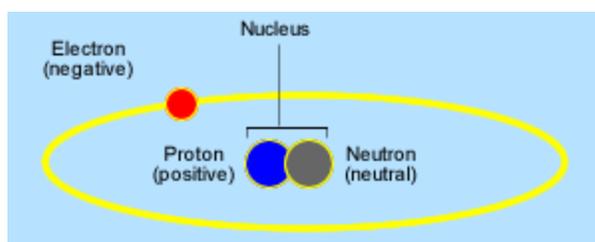
1. Personnel shall demonstrate a familiarity level knowledge of basic nuclear theory and principles.

Background: Basic Nuclear Theory and Principles

Atoms are the building blocks of all matter. The periodic table identifies atoms by their chemical symbol. The atoms in the table are arranged such that atoms with similar chemical properties are grouped in columns.

1																	2
H																	He
3	4											5	6	7	8	9	10
Li	Be											B	C	N	O	F	Ne
11	12											13	14	15	16	17	18
Na	Mg											Al	Si	P	S	Cl	Ar
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
Cs	Ba	*La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
87	88	89	104	105	106	107	108	109	110	111	112	113					
Fr	Ra	+Ac	Rf	Ha	Sg	Ns	Hs	Mt	110	111	112	113					
58	59	60	61	62	63	64	65	66	67	68	69	70	71				
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
90	91	92	93	94	95	96	97	98	99	100	101	102	103				
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr				

Each atom is made up of “elementary particles” including protons, neutrons, and electrons. Protons and neutrons are located within the nucleus, while electrons “orbit” the nucleus.



The electron has a negative charge, the proton a positive charge, and the neutron no charge.

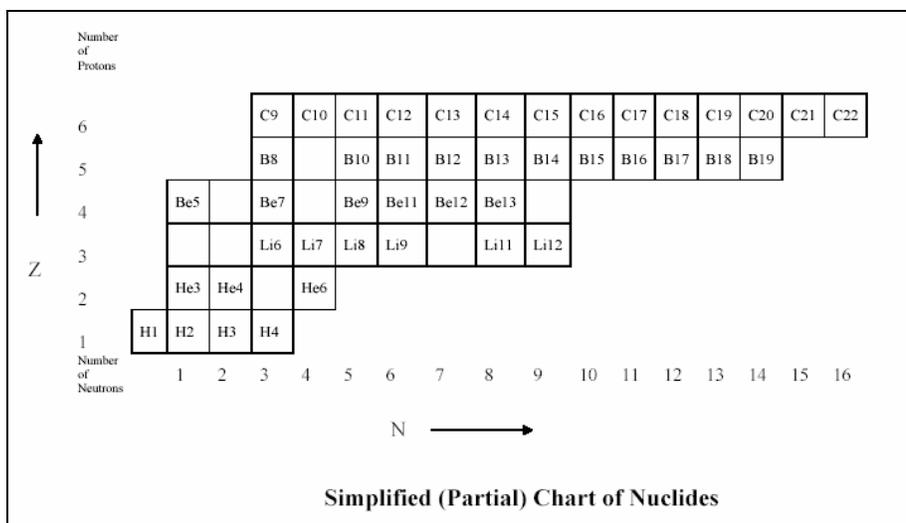
Scientists have determined that these “elementary particles” are actually made up of even more elementary particles (e.g., quarks). However, for this course, protons, neutrons, and electrons are adequate for describing atomic and nuclear theory.

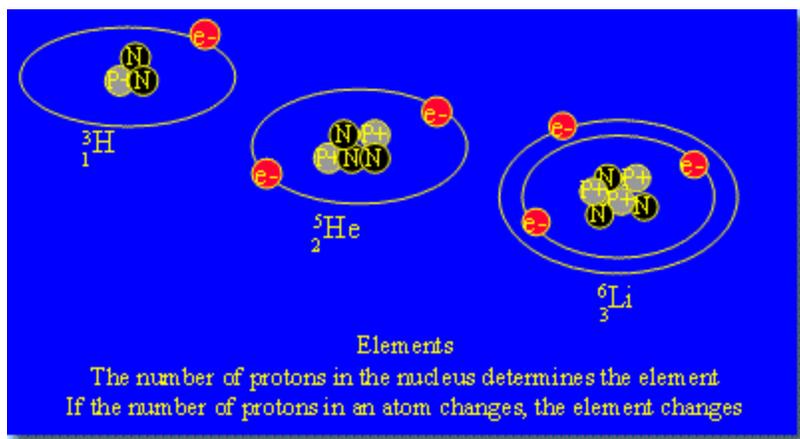
An atom typically has the same number of electrons as protons and, therefore, has a neutral (0) electric charge (and, therefore, is a neutral atom).

An atom can gain or lose electrons in chemical reactions or by impact with energetic particles resulted in an unbalanced electric charge (different number of protons and electrons). These atoms are called ions.

The number of protons that an atom has defines its chemical attributes. An atom with a given number of protons is called an element (for example, the element hydrogen contains 1 proton and the element carbon contains 6 protons).

However, a given element, e.g., carbon, can contain different numbers of neutrons. Atoms with the same number of protons but different numbers of neutrons are isotopes of an element. Each element has several different isotopes. A term related to isotope is nuclide. It refers to an atom with a specific number of protons and neutrons. The chart of nuclides below provides a logical arrangement of the isotopes. Isotopes of an element are in the same rows.





There are several different methods/nomenclatures utilized to identify atomic nuclides. The following are examples:

One commonly utilized nomenclature is: ${}^A_Z X$, where “A” represents the mass number, i.e., the total number of protons and neutrons and “Z” represents the atomic number (i.e., number of protons), and “X” the chemical symbol for the element.

For example, ${}^4_2\text{He}$ is a helium atom with 2 protons and an atomic number of 4 (from 2 neutrons plus 2 protons).

Alternative nomenclatures are:



Note: Since a given atom has a unique number of protons (e.g., the He atom has 2 protons, U has 92 protons), it is not essential to identify the number of protons in the nuclide symbol.

1.a. Describe the three forces that are found within a nucleus.

Gravitational forces, electrostatic forces, and nuclear forces act in the nucleus of an atom.

Gravitational Forces

Gravitational forces exist between all bodies with mass. Gravitational forces tend to attract all nucleons (a nucleon is a proton or neutron) toward each other within a nucleus; however, the magnitude of this attractive force is extremely small compared to the electrostatic and nuclear forces in the nucleus.

Electrostatic Forces

Electrostatic forces exist between charged particles (protons +1) within a nucleus. Protons develop a strong repulsive force between other protons in the same nucleus due to their like charge. If only the electrostatic (repulsive) and the gravitational (attractive) forces in a nucleus are considered, the protons in a nucleus should repel one another and cause the nucleus to break apart.

Nuclear Force

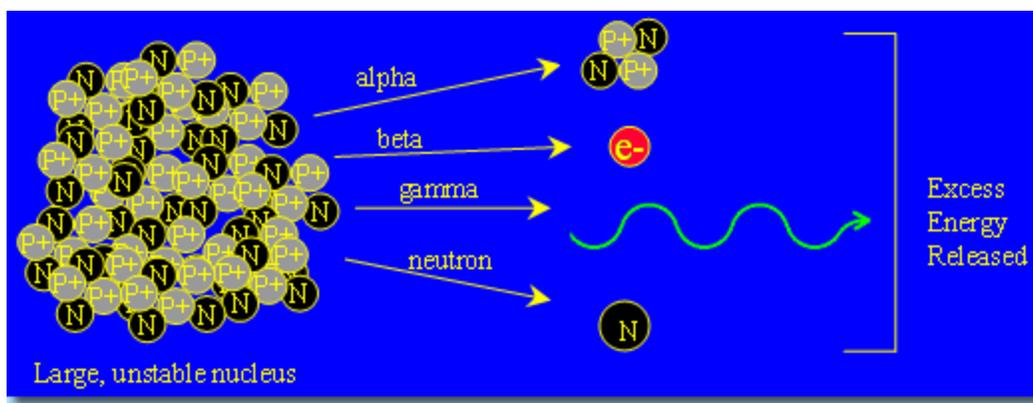
A strong attractive nuclear force exists between all nucleons regardless of charge. This is the binding energy that holds the nucleons in a nucleus so that despite repulsive electrostatic forces between protons the nucleus stays together. The nuclear force makes a stable nucleus possible. The nuclear force only acts in a very short range (e.g., within the nucleus) but is very strong as compared with the electrostatic forces within the nucleus (and the electrostatic forces are much stronger than the gravitational forces).

1.b. Define mass defect and binding energy and discuss their relationship.

When nuclear masses are measured and compared with the masses of the constituent nucleus in free state, the mass of the nucleus is always less than that of the mass of the constituent nucleons. This difference in mass, Δm , is known as the mass defect (also called the nuclear mass defect). In Einstein's mass energy equation, $E = \Delta mc^2$ where Δm = mass defect, the mass defect Δm which is lost in the formation of stable nucleus is converted into energy. This amount of energy must be released when nucleons are combined to form a stable nucleus. This is the binding energy that holds the nucleons in a nucleus so that despite strong repulsive forces between protons they are forced to unite in the nucleus.

1.c. Describe the following processes, and trace the decay chain for a specified nuclide on the chart of the nuclides: Alpha decay, Beta-minus decay, Beta-plus decay, and Electron capture

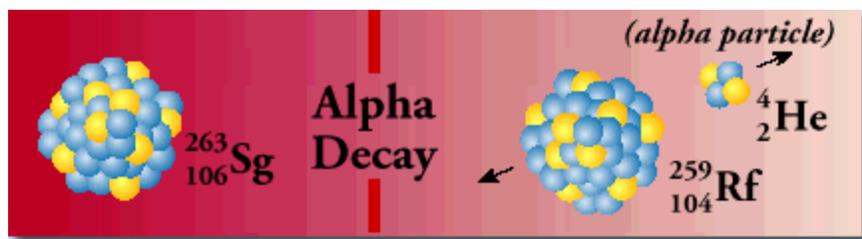
Unstable nuclide can release energy by several mechanisms, i.e., alpha decay, beta decay, expulsion of a neutron, or emitting gamma rays.



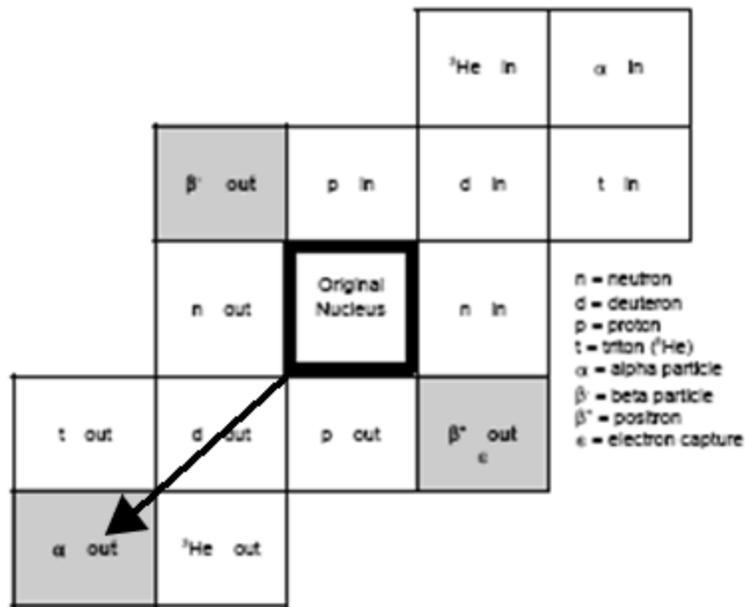
Alpha Decay The emission of an alpha (α) particle, or He-4 nucleus, is a process called α decay. Since α particles contain protons and neutrons, they must come from the nucleus of an atom. The nucleus that results from alpha decay will have a mass and charge different from those of the original nucleus. A change in the nucleus's charge means that the element has been changed into a different element.

Alpha Decay Example

The mass number, A , of an α particle is four, so the mass number, A , of the decaying nucleus is reduced by four. The atomic number, Z , of ${}^2_2\text{He}$ is two, and therefore the atomic number of the nucleus, the number of protons, is reduced by two. This can be written as an equation analogous to a chemical reaction. For example, for the decay of an isotope of the element seaborgium, ${}^{263}_{106}\text{Sg}$, ${}^{263}_{106}\text{Sg} \rightarrow {}^{259}_{104}\text{Rf} + {}^4_2\text{He}$. The atomic number of the nucleus changes from 106 to 104, giving rutherfordium an atomic mass of $263 - 4 = 259$. Alpha decay typically occurs in heavy nuclei where the electrostatic repulsion between the protons in the nucleus is large. Energy is released in the process of alpha decay. Careful measurements show that the sum of the masses of the daughter nucleus and the α particle is a bit less than the mass of the parent isotope. Einstein's famous equation, $E = mc^2$, which says that mass is proportional to energy, explains this fact by saying that the mass that is lost in such decay is converted into the kinetic energy carried away by the decay products.

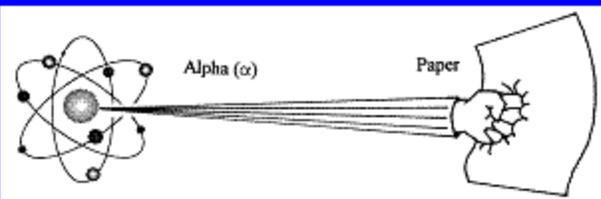


Nuclear interactions (including decays) can be shown as a change of position in the table of isotopes. The Alpha decay results in a change of the position (two down and two to the left) reflecting a decrease in two neutrons and two protons.



Characteristics	Range	Shielding	Hazards	Sources
Particulate Large mass 2 protons 2 neutrons +2 charge	1 to 2 inches in air	Paper Outer layer of skin	Internal	Plutonium Uranium Americium





Alpha Radiation (α) characteristic

Beta (β) Particles

Beta (β) particles are particulate radiation emitted from the nucleus of an unstable atom. The beta particle has the mass of an electron and can have a negative charge of -1 (beta minus) or a positive charge of $+1$ (beta plus). Since the mass of an electron is a tiny fraction of an atomic mass unit, the mass of a nucleus that undergoes β decay is changed by only a tiny amount. The mass number is unchanged. The nucleus contains no electrons.

β minus decay occurs when a neutron is changed into a proton within the nucleus. An unseen neutrino accompanies each β minus decay. The number of protons, and thus the atomic number, is increased by one.

Characteristics	Range	Shielding	Hazards	Sources
Particulate Small mass -1 charge	Up to 12 ft./Mev Up to 10 ft. in air for U-238	Plastic Glass Aluminum Wood	Internal Can be skin & eyes	Tritium (H-3) Strontium-90 Protactinium-234 Fission and activation products

Beta (β) Particle Penetration

Beta Radiation (β) characteristics

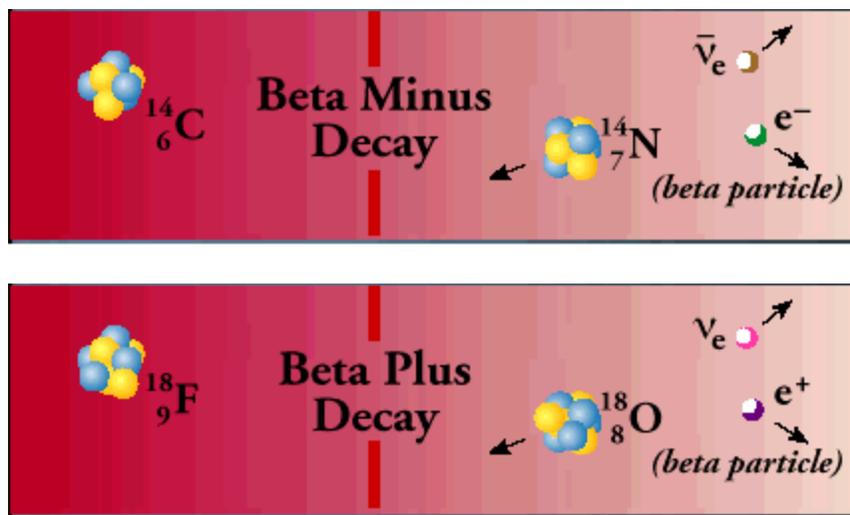
Beta Decay Example

For example, the isotope ${}^6_6\text{C}^{14}$ is unstable and emits a β particle, becoming the stable isotope ${}^7_7\text{N}^{14}$.

The source of the energy released in β decay is explained by the fact that the mass of the parent isotope is larger than the sum of the masses of the decay products. Mass is converted into energy just as Einstein predicted.

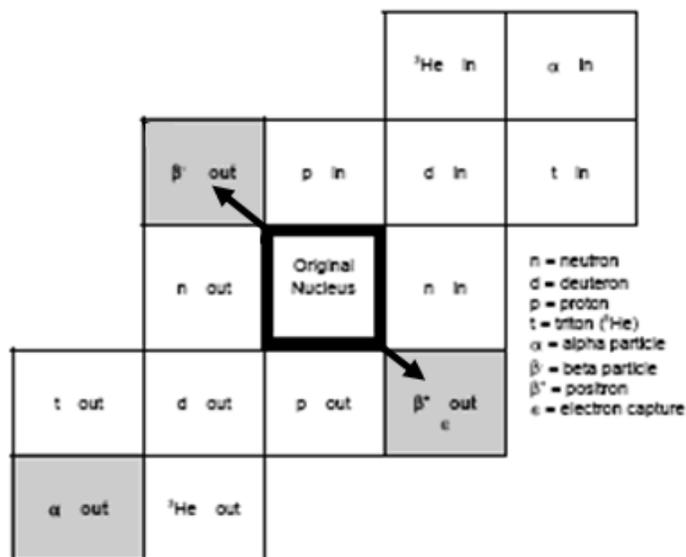
During beta-plus decay, a proton in an atom's nucleus turns into a neutron, a positron, and a neutrino. The positron and neutrino fly away from the nucleus, which now has one less proton than it started with. Since an atom loses a proton during beta-plus decay, it changes from one element to another. For example, after undergoing beta-plus decay, an atom of carbon (with 6 protons) becomes an atom of boron (with 5 protons).

Although the numbers of protons and neutrons in an atom's nucleus change during beta decay, the total number of particles (protons + neutrons) remains the same.



Beta minus decay results in a change in position one up and one to the left in the chart of nuclides (reflecting a loss of a neutron and a gain of a proton in the nucleus [neutron loses an electron and changes into a proton]).

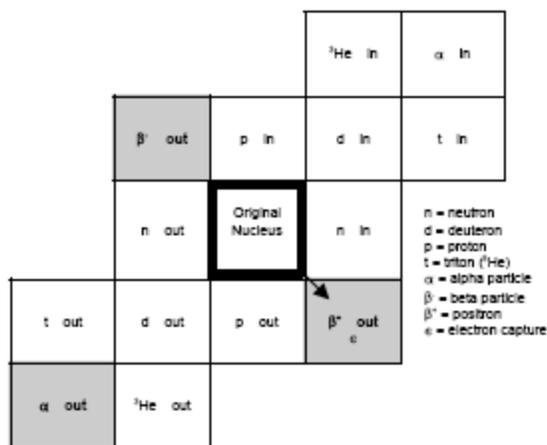
Beta plus decay results in a change in position one down and one to the right in the chart of nuclides (reflecting a gain of a neutron and a loss of a proton in the nucleus [proton loses an electron and changes into a neutron]).



Electron Capture

Another way that the nucleus of an atom with too few neutrons may gain one more neutron is to capture one of the negatively charged electrons orbiting about the nucleus. This effectively cancels the positive charge on one of the protons, turning it into a neutron. This process is called electron capture.

Electron capture results in a change in position one down and one to the right in the chart of nuclides (similar to a beta plus decay).



Gamma Ray emission

An important means by which a nucleus releases excess energy is by emitting a photon/electromagnetic radiation called a gamma ray. The gamma rays can have a very high energy. An atom can also release x-ray as a result of interactions with the electron shell surrounding the nucleus. The difference between gamma rays and x-rays is that gamma rays originate from the nucleus while x-rays originate from the electron shell.

1.d. Define the following terms: Radioactivity, Radioactive decay constant, Curie, Radioactive half-life, Radioactive equilibrium

Discovery of radioactivity

In 1896, Henri Becquerel was working with compounds containing the element uranium. He found that photographic plates covered to keep out light became fogged, or partially exposed, when these uranium compounds were anywhere near the plates. This fogging suggested that some kind of ray had passed through the plate coverings. Several materials other than uranium were also found to emit these penetrating rays. Materials that emit this kind of radiation are said to be radioactive and to undergo radioactive decay.

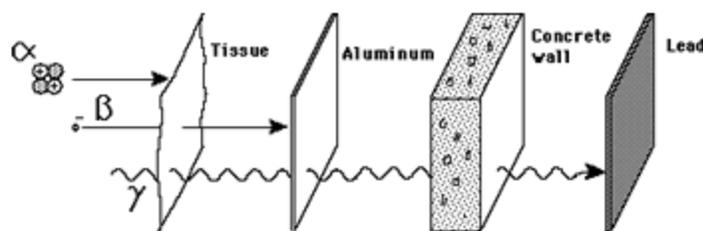
Definition of Radioactivity

Radioactivity is defined as the spontaneous decay or disintegration of an unstable atomic nucleus accompanied by the emission of radiation.

Properties of Radioactive Material

In 1899, Ernest Rutherford discovered that uranium compounds produce three different kinds of radiation. He separated the radiations according to their penetrating abilities and named them α , β , γ (gamma) radiation, after the first three letters of the Greek alphabet.

The α particle can be stopped by a sheet of paper. Rutherford later showed that an alpha particle is the nucleus of a He atom, ${}^4_2\text{He}$. Beta particles were later identified as high-speed electrons. Six millimeters of aluminum are needed to stop most β particles. Several millimeters of lead are needed to stop γ rays, which proved to be high-energy photons. Alpha particles and γ rays are emitted with a specific energy that depends on the radioactive isotope. Beta particles, however, are emitted with a continuous range of energies from zero up to the maximum allowed for by the particular isotope.



Radioactive Decay Constant

The radioactive decay constant, λ (λ) is the probability that an atom of a specific radioactive isotope will decay per unit time. The units for radioactive decay constant are inverse time such as 1/sec, 1/hr, 1/yr, etc. For a given number of atoms (N) of a radioactive isotope, the activity (A) is given by the expression $A = \lambda N$. The activity of a pure radionuclide depends on the radioactive decay constant and the initial activity (A_0), and it decreases exponentially as a function of time, according to the expression $A(t) = A_0 e^{-\lambda t}$.

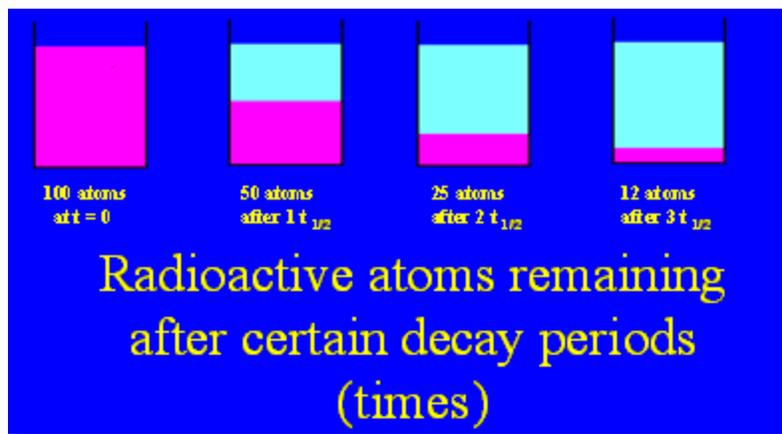
Curie

A curie (Ci) is a unit of measure used to describe the activity (A) or spontaneous disintegration of atoms in a specimen and is defined as the activity of 1 gram of ${}_{88}\text{Ra}^{226}$, which is 3.7×10^{10} disintegrations per second. ${}_{88}\text{Ra}^{226}$ is the isotope that Marie and Pierre Curie isolated and studied in 1898. In SI units, activity is expressed in becquerels (Bq), and 1 Bq has been defined as 1 disintegration per second. Thus, $1 \text{ Ci} = 3.7 \times 10^{10} \text{ Bq}$.

Radioactive Half-Life

The time required for half of the atoms in any given quantity of a radioactive isotope to decay is the half-life of that isotope. It is related to the radioactive decay constant (half life ($t_{1/2}$) = $0.693/\lambda$) Each particular isotope has its own half-life. For example, the half-life of ${}^{238}\text{U}$ is 4.5 billion years. That is, in 4.5 billion years, half of the ${}^{238}\text{U}$ on earth will have decayed into other

elements. In another 4.5 billion years, half of the remaining ^{238}U will have decayed. One fourth of the original material will remain on earth after 9 billion years. The half-life of ^{14}C is 5,730 years, thus it is useful for dating archaeological material. Nuclear half-lives range from tiny fractions of a second to many, many times the age of the universe.



Radioactive Equilibrium

Radioactive equilibrium (more accurately called secular equilibrium) for a decay chain occurs when the each radionuclide decays at the same rate it is produced. At equilibrium, all radionuclides decay at the same rate. This equilibrium state can be reached for a decay series where the parent radionuclide (first one in the decay chain) is long lived compared to the rest of the decaying daughter products. Understanding the equilibrium for a given decay series helps scientists estimate the amount of radiation that will be present at various stages of the decay.

Example

For example, as ^{238}U begins to decay to ^{234}Th , the amount of thorium and its activity increase. Eventually the rate of thorium decay equals its production. Its concentration then remains constant. As thorium decays to ^{234}Pa , the concentration of ^{234}Pa and its activity rise until its production and decay rates are equal. When the production and decay rates of each radionuclide in the decay chain are equal, the chain has reached radioactive equilibrium. Equilibrium occurs in many cases. However, if the half-life of the decay product is much longer than that of the original radionuclide, equilibrium cannot occur.

1.e. Describe the following neutron/nucleus interactions:

- **Elastic scattering**
- **Inelastic scattering**

Elastic neutron scattering

The sum of the kinetic energy of the particle (neutron) and target (e.g., nucleus) before and after the collision is constant. Essentially, the elastic collision is similar to the collision of billiard balls.

Elastic scattering can occur with heavy or light nuclei. Elastic scattering of neutrons with light nuclei is effective at lowering the kinetic energy of the neutron because much of the energy is transferred to the light nuclei (this is called moderating).

Inelastic Scattering

A neutron may strike a nucleus and form a compound nucleus instead of bouncing off as in elastic scattering. This nucleus is unstable and emits a neutron of lower energy together with a gamma photon that takes up the remaining energy. This process, called inelastic scattering, occurs mostly at high neutron energies in heavy materials, but at lower energies elastic scattering becomes a more important reaction for neutron energy loss provided there are light nuclei present. Light nuclei materials (such as water and graphite) are used to moderate neutrons in nuclear reactors to enhance nuclear fission.

1.f. Compare and contrast capture (absorption), fission, and particle ejection nuclear reactions.

Capture (Absorption) Reactions

Most absorption reactions result in the loss of a neutron coupled with the production of a charged particle or gamma ray. When the product nucleus is radioactive, additional radiation is emitted at some later time. Radiative capture, particle ejection, and fission are all categorized as absorption reactions.

Radiative capture is the absorption of a neutron by the target nucleus, resulting in an excited nucleus that subsequently releases its excitation energy in the form of a gamma ray.

Particle Ejection

Particle ejection occurs when a neutron is absorbed by a target nucleus, resulting in the formation of a compound nucleus. The compound nucleus immediately ejects a particle (for example, alpha or proton).

Nuclear Fission

Nuclear fission is a process in which an atom splits and releases energy, fission products, and neutrons. The neutrons released by fission can, in turn, cause the fission of other atoms. This is described in greater detail under competency 2.

Radiative Capture

Radiative capture is the absorption of a neutron by the target nucleus, resulting in an excited nucleus that subsequently releases its excitation energy in the form of a gamma ray. Therefore gamma radiation is produced in the shielding of neutrons.

Competency 1 - References/Additional Reading

DOE-HDBK-1019, DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory

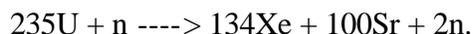
Competency 2: Basic Fission Process

2. Personnel shall demonstrate a familiarity level knowledge of the basic fission process and results obtained from fission.

Background: Basic Fission Process

Fission

Fission is a nuclear process in which a neutron is absorbed by a heavy nucleus which splits into two smaller nuclei. Thermal neutrons (neutrons with lower energy levels) are most effective in producing a fission reaction. An example of a fission reaction that was used in the first atomic bomb and is still used in nuclear reactors is



The products shown on the right hand side in the above equation (fission fragments and neutrons) are only one set of many possible product nuclei. Fission reactions can produce any combination of lighter nuclei so long as the number of protons and neutrons in the products sum up to those in the initial fissioning nucleus. The fission of one uranium atom releases about 200 million electron volts, the large portion of which is the kinetic energy released as heat due to friction when fission fragments slow down and give up their energy within a short distance from the fission site. Neutrons are also released during the fission reaction.

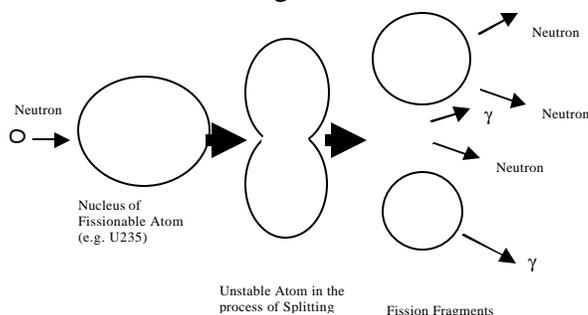
Fission is a process that has been occurring in the universe for billions of years. Fission is not only used to produce energy for nuclear bombs, it is also used peacefully everyday to produce energy in nuclear power plants.

Energy Release

A great amount of energy can be released in fission because for heavy nuclei, the summed masses of the lighter product nuclei is less than the mass of the fissioning nucleus.

2.a. Explain the Fission Process using the Liquid Drop Model of Nucleus

The liquid drop model considers the fissioning of a nucleus similar to the splitting of a liquid drop.



Initially, the nucleus is in an undistorted ground state with nuclear forces that are greater than the repulsive electrostatic forces of the protons in the nucleus. After a neutron is absorbed by the nucleus, a compound nucleus forms in an excited state. The measure of how far the energy level of a nucleus is above its ground state is called the excitation energy. For fission to occur, the excitation energy must be above a particular value for that nuclide. The critical energy (E_{crit}) is the minimum excitation energy required for fission to occur. The excitation energy added to the nucleus is equal to the binding energy of the neutron plus the kinetic energy of the neutron.

If the excitation energy is greater than the critical energy for a nucleus then the nucleus may begin to oscillate and become distorted. If the oscillations are severe enough, the nucleus may become dumb-bell shaped. The attractive nuclear forces in the neck of the nucleus may become saturated and because they can only act over a short distance the repulsive electrostatic forces in each end of the “dumb-bell” shaped nucleus may overcome them. When this occurs the nucleus splits or fissions at its weakest point.

2.b Compare and contrast the characteristics of fissile material, fissionable material, and fertile material.

Fissile material

Fissile material is any material fissionable by neutrons of any energy, including slow or thermal. The three primary fissile materials are ^{233}U , ^{235}U , and ^{239}Pu .

Fissionable material

Fissionable material is composed of nuclides for which fission with neutrons is possible. All fissile nuclides fall into this category. However, also included are those nuclides that can be fissioned only with high energy neutrons.

^{238}U is an example of a material that is fissionable but is not fissile.

Fertile material

Fertile material is material, which is not itself fissile material, but which can be converted into a fissile material by irradiation in a reactor is called fertile material. There are two basic fertile materials, ^{238}U and ^{232}Th . When these fertile materials capture neutrons, they are converted into fissile ^{239}Pu and ^{233}U , respectively.

2.c. Discuss the various energy releases that results from the fission process.

For fission of uranium or plutonium, energies released are around 200 MeV. The majority of the energy is released in the kinetic energy of the fission fragments. Other energy is released via the kinetic energy of neutrons, decay of fission products, neutrino energy and prompt gamma energy.

MeV stands for million electron volts and is a measure of energy. It is equivalent to about 10^{-13} Joules. Although this is a very small amount of energy, in a typical commercial nuclear power reactor about 10^{19} of these fissions occur per second resulting in about 1000 mega Joules per second of energy being released (i.e., 1000 MegaWatts).

Energy released in the fission of a U - 235 nucleus appears in the form given in the following table.

Kinetic Energy of Fission Fragments	168 Mev
Kinetic Energy of Fission Neutrons	5 Mev
Prompt Gamma Ray Energy	7.5 Mev
Decay of Fission Fragments	14.5 Mev
Neutrinos Energy	12 Mev
TOTAL	~207 Mev

2.d. Define criticality and explain how it is detected.

Nuclear criticality refers to the precise state of an assembly of fissile or fissionable material in which one neutron from each fission event causes one subsequent fission. If less than one additional fission results, the assembly is sub-critical. If more than one new fission is caused by each fission, the assembly is supercritical.

Another way of describing critical, subcritical, or supercritical assemblies is:

Subcritical: The number of neutrons produced by fission is less than the number lost by escape and absorption.

Critical: The number of neutrons produced by fission equals the number lost by escape and absorption.

Supercritical: The number of neutrons produced by fission is greater than the number lost by escape and absorption.

On the average, about 2.5 neutrons come from the fission of a ^{239}Pu nucleus. Not all neutrons produced in a fission event interact with other nuclei, however. Almost all the neutrons appear immediately in the fission process (prompt neutrons), but a few, something less than 1 percent, do not. The latter are called delayed neutrons; the delay in their appearance can range from less than a second to almost a minute.

The term critical means that the assembly uses all neutrons, including those delayed, to maintain criticality. The delayed fraction, under this condition, permits convenient control because small changes in the reactivity of a system are manifest with times characteristic of the delay periods. If, however, only the prompt neutrons are necessary for criticality, the system does not have this controllability. Such a system is said to have achieved prompt criticality, and the power output will rise very rapidly.

Criticality is detected by a rise in the radiation field. In the case of an accidental criticality, this rise will be rapid. Some process facilities use neutron detectors, some use gamma detectors.

Criticality Experiments use neutron measurements to precisely monitor the experimental system. If the neutron level is decreasing, the system is subcritical. If the neutron level is increasing, the system is supercritical.

DOE requires that areas where there is a potential for a criticality to occur have criticality detectors and a criticality alarm system. The purpose of a criticality alarm system is to alert personnel in a facility if a criticality accident occurs. Criticality alarm systems are installed in accordance with ANSI/ANS 8.3, "Criticality Accident Alarm System," in facilities where a criticality accident is credible. If a criticality accident occurs, large amounts of neutron and gamma radiation are released.

2.e. List five factors that affect criticality.

Note: although the General Technical Qualification question only asks for five factors, nine commonly identified factors are listed below.

The factors that affect criticality are

- density and concentration,
- moderation,
- reflection,
- neutron absorbers (also known as poison),
- Interaction/Separation,
- mass,
- volume,
- geometrical shape, and
- enrichment

Density

The quantity of fissionable material required for criticality is dependent on the material density. As the density of a system is reduced, escape (leakage) of neutrons from the material before interaction is more likely, and more material is required for criticality.

Moderation

When fissionable material is in solution, or present as finely divided particles, the presence of a neutron moderator, such as water or a hydrocarbon, can effect a significant reduction in the amount of fissile material required for criticality. The interaction of neutrons with light nuclei, such as hydrogen, lithium, beryllium, or carbon, reduces the neutron energy after only a few collisions. Slow neutrons interact more readily with nuclei, and therefore they have a greater probability of causing fission in ^{235}U or ^{239}Pu nuclei. There is an optimum degree of moderation because if the ratio of hydrogen nuclei to uranium nuclei becomes too large, neutron capture in the hydrogen becomes competitive with fission in the uranium.

Reflection

Fissile material can also be surrounded by other material that reflect neutrons back into the fissile volume, increasing their opportunity for nuclear interaction.

Neutron Absorbers

Some materials such as cadmium and boron are effective neutron absorbers. Such neutron absorbers may be used to provide criticality control in vessels of large volume or in locations where many vessels are in close proximity and there is concern about neutron interaction occurring between vessels.

Interaction and Separation

Neutrons can escape one fissile item and cause fission in a nearby fissile item. The number of items, size of the items, and distance between the items all affect this parameter. When items are closer together, neutron leakage is reduced and less material is required for criticality.

Mass

The amount of fissile material. Usually reported as the amount of Uranium or Plutonium in grams or Kilograms.

Volume

The space occupied by the fissile mass and associated materials. Large volumes reduce the neutron leakage and are more likely to be critical.

Geometrical Shape

The shape of an assembly of fissile material is also a significant parameter in preventing criticality. Thin cylinders and thin slabs are less likely to be critical than spheres, cylinders of about the same height and diameter and cubes. As the shape gets closer to a sphere, neutron leakage is reduced and less material is required for criticality

Note: a container whose size and shape is such that it cannot hold the minimum of fissionable material necessary for criticality it is said to be geometrically favorable

Enrichment

The amount of fissile isotopes relative to the total amount of the element. Highly enriched uranium has more ²³⁵U atoms than uranium ore. The higher the enrichment the less material is required to achieve criticality. Enrichment is usually given as the ratio of the fissile isotope to the total element, in mass percent.

2.f Identify the hazards that results from an unwanted criticality.

An unwanted criticality is also referred to as a nuclear criticality accident, which is an unintentional, uncontrolled nuclear fission chain reaction. If a criticality accident occurs, it releases a large amount of energy in the form of radiation and heat. Reactor facilities are designed for intentional, controlled criticalities and therefore have adequate radiation shielding and containment of the fissionable material to ensure worker safety. Because fissionable material

processing facilities are not designed with the shielding and containment of a reactor facility, a criticality accident can pose serious health and safety risks to the workers.

2.g. Explain the double contingency principle as it relates to criticality control.

The double contingency principle states that process designs should incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible. Proper application of the double contingency principle provides assurance that no single error or loss of a control will lead to the possibility of a criticality accident.

2.h. Discuss the potential hazards associated with accidental/unwanted criticality.

Operations with significant quantities of fissionable materials could present the risk of a criticality accident. A criticality accident may expose workers to high, potentially lethal, levels of neutron and gamma radiation and result in a loss of containment, releasing radioactive isotopes into the environment.

Competency 2 - References/Additional Reading

DOE-STD-1158-2002, Self-Assessment Standard for DOE Contractor Criticality Safety Programs

DOE-HDBK-1019/2-93; DOE Fundamentals Handbook Nuclear Physics and Reactor Theory

ANSI/ANS-8.3-1986, Criticality Accident Alarm System

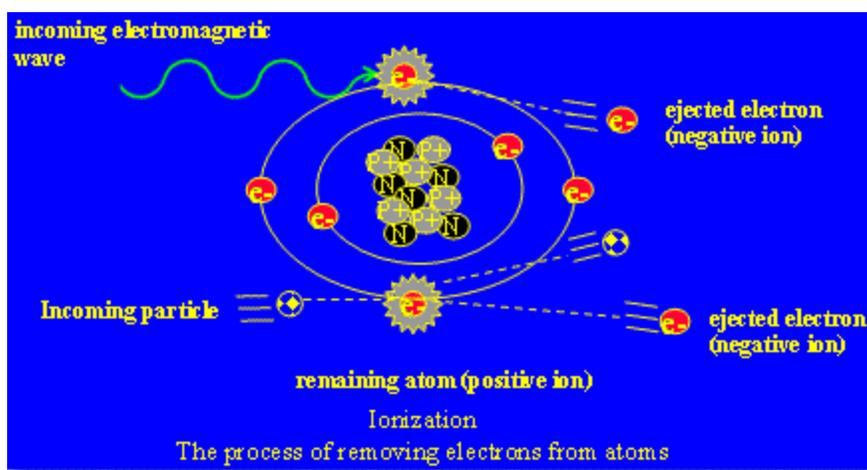
Competency 3: Radiological Controls and Theory

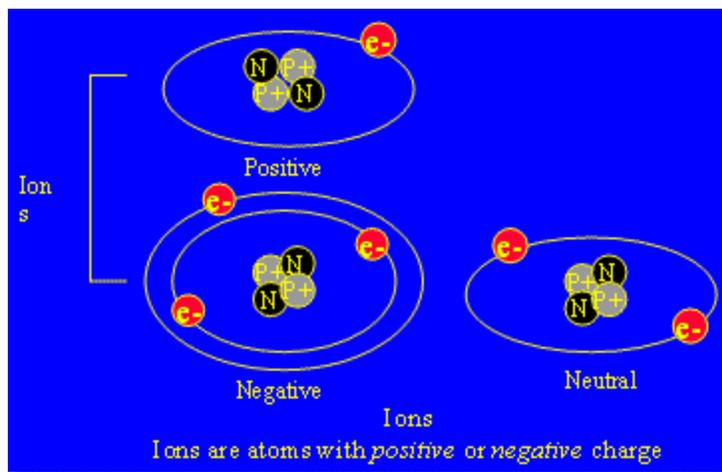
3. **Personnel shall demonstrate a familiarity level knowledge of radiological controls and theory.**

3.a. **Describe ionizing radiation**

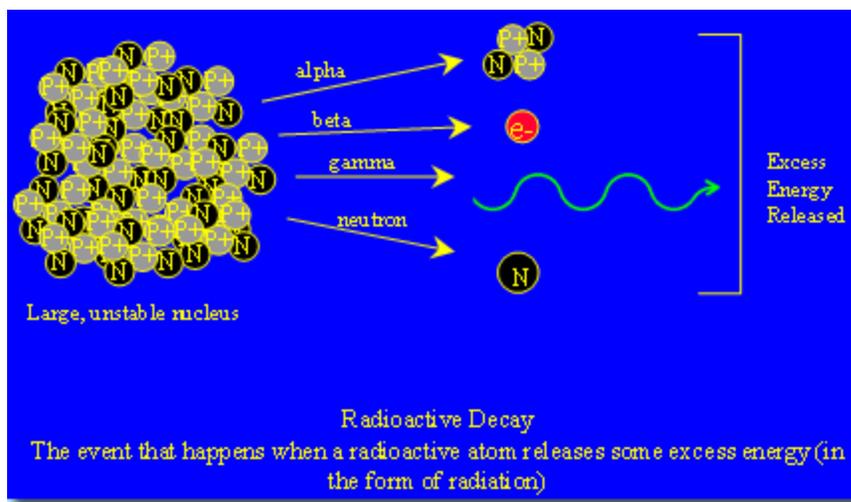
Radiation is defined as the emission and movement of energy through space and or matter. Ionizing radiation is defined as radiation capable of causing the creation of ions as it passes through matter by stripping strip electrons from an atom). Ions may be created directly by charged particles (α , β^- or β^+) interacting with the orbital electrons or they may be created indirectly during reactions involving uncharged particles (e.g., neutrons), gamma photons or X-ray photons. Low energy photons (or electromagnetic radiation) such as visible light or AM radio signals do not have enough energy to cause ionization and are referred to as non-ionizing radiation. The distinction between ionizing and non-ionizing radiation is important because ionization is the primary mechanism by which radiation causes biological damage.

In this document we will only discuss ionizing radiation, it will be referred to simply as radiation.





One source of radiation is the nuclei of unstable atoms. For these unstable (radioactive) atoms to become more stable, the nuclei eject or emit subatomic particles and high-energy photons (gamma rays). A nucleus may be unstable (and therefore undergo radioactive decay) due to it having too many (or too few) neutrons or protons. This process is called radioactive decay. Unstable isotopes of radium, radon, uranium, and thorium, for example, exist naturally. Others are continually being made naturally or by human activities such as the splitting of atoms in a nuclear reactor. Either way, they release ionizing radiation. The major types of radiation emitted as a result of spontaneous decay are alpha and beta particles, and gamma rays. X-rays, another major type of radiation, arise from processes outside of the nucleus.



3.b Describe how nuclear radiation is generated.

Nuclear radiation can occur naturally or it can be man-made. Naturally occurring radiation may also be referred to as natural background radiation, and it accounts for the majority of the radiation dose received by the average citizen. The three major sources for naturally occurring radiation exposure are:

- cosmic radiation
- terrestrial radiation (including radon)
- internal sources

Cosmic radiation

Cosmic radiation consists of gamma photons and charged particles emitted from the sun and other stars.

Terrestrial Radiation

Terrestrial radiation is radiation originating from material in the earth's crust that contains radioactive elements such as uranium, radium, and thorium.

Internal Sources

Internal sources are naturally occurring radioactive isotopes such as ^{40}K , ^{14}C , and ^{24}Na that are present in food and water.

Radon

Radon is a naturally occurring gas that is produced when radium in the earth's crust undergoes radioactive decay. Radon gas travels up through the soil and tends to collect in buildings and homes. If radon is inhaled and it subsequently decays while in the lungs, it results in a radiation exposure to the lung tissue.

3.c. Describe each of the following forms of radiation in terms of structure, electrostatic charge, interactions with matter, and penetration potential:

- **Alpha**
- **Gamma**
- **Beta**
- **Neutron (slow and fast)**

Alpha Particles

Alpha particles are energetic, positively charged particles (helium nuclei) that rapidly lose energy when passing through matter. They are commonly emitted in the radioactive decay of the heaviest radioactive elements such as uranium, radium, and by some manmade elements. Alpha particles lose energy more rapidly in matter than most radiation because they are relatively heavy and have an electronic charge of two. Alpha particles do not penetrate very far; however, they can cause damage over their short path through tissue. These particles are usually completely absorbed by the outer dead layer of the human skin, so alpha emitting radioisotopes are not a hazard outside the body. However, they can be very harmful if they are ingested or inhaled. Alpha particles can be stopped completely by a sheet of paper.

Beta Particles

Beta particles are fast moving, positively or negatively charged electrons emitted from the nucleus during radioactive decay. Humans are exposed to beta particles from man-made and

natural sources such as tritium, ^{14}C , and ^{90}Sr . Beta particles are more penetrating than alpha particles, but are less damaging over equally traveled distances. Beta particles are more penetrating because they are much smaller and only singly charged and therefore do not interact as strongly. Some beta particles are capable of penetrating the skin and causing radiation damage; however, as with alpha emitters, beta emitters are generally more hazardous when they are inhaled or ingested. Beta particles travel appreciable distances in air, but can be reduced or stopped by a layer of clothing or by a few millimeters of a substance such as aluminum.

Gamma Rays

Like visible light and x-rays (that are emitted from the electron shell of an atom), gamma rays (that are emitted from nuclei) are weightless packets of energy called photons. Gamma rays often accompany the emission of alpha or beta particles from a nucleus. They have neither a charge nor a mass and are very penetrating. One source of gamma rays in the environment is naturally occurring ^{40}K . Man-made sources include ^{239}Pu and ^{137}Cs . Gamma rays depending on their energy can easily pass completely through the human body or be absorbed by tissue, thus constituting a radiation hazard for the entire body. Several feet of concrete or a few inches of steel or lead may be required to stop the more energetic gamma rays.

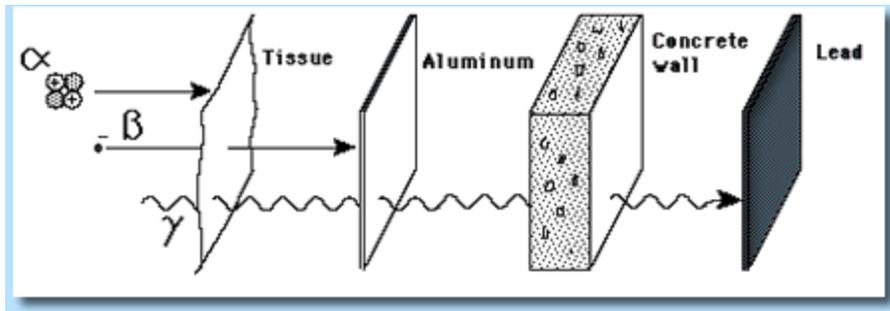
Neutron (Slow and Fast)

Neutrons originate from the nucleus. They do not have an electron charge but are relatively massive as compared to beta particles. They are about $\frac{1}{4}$ as massive as alpha particles. One large source of neutrons is from nuclear fission (e.g., in nuclear reactors). Neutrons are very penetrating because they lack electronic charge. However, they are also damaging because of their mass. Therefore, when they do interact with an atom they can cause a large amount of ionization. Neutrons are more effectively slowed down when they interact with light atoms (such as water) rather than heavy atoms. Shielding of neutrons generally consist of light nuclei such as water or hydrogenous material.

3.d Discuss the types of materials that are best suited for shielding radiation

- **alpha**
- **gamma**
- **beta**
- **neutron (slow and fast)**

Alpha: Any material (e.g., thin paper is effective)
Gamma: Lead or other heavy material such as steel
Beta: Clothing or a few millimeters of alumina
Neutron: Light atomic material such as water



3.e. Describe the biological effects and the primary hazard(s) of each radiation type.

Biological Effects: General

Effects of Exposure

The method by which radiation causes damage to human cells is by ionization of atoms in the cells. Atoms make up the cells that make up the tissues of the body. Any potential radiation damage begins with damage to atoms. Potential biological effects depend on how much and how fast a radiation dose is received. Large enough doses can cause immediate health effects up to death. The health effect is proportional to the dose received. Low or moderate exposures can increase the risk of cancer due to damaged cells that are improperly repaired. The probability of a cancer is due to the magnitude of the received dose; however the severity of the health effect is not correlated to the dose received. There is no detectable difference in appearance between radiation-induced cancers and genetic effects and those due to other causes.

Chronic Exposure

Chronic exposure is continuous or intermittent exposure to low levels of radiation over a long period of time. Chronic exposure is considered to produce only effects that can be observed some time following initial exposure. These include genetic effects and other effects such as cancer, precancerous lesions, benign tumors, cataracts, skin changes, and congenital defects.

Acute Exposure

Acute exposure is exposure to a large, single dose of radiation, or a series of doses, for a short period of time. Large acute doses can result from accidental or emergency exposures or from special medical procedures (radiation therapy). In most cases, a large acute exposure to radiation can cause both immediate and delayed effects. For humans and other mammals, acute exposure, if large enough, can cause rapid development of radiation sickness, evidenced by gastrointestinal disorders, bacterial infections, hemorrhaging, anemia, loss of body fluids, and electrolyte imbalance. Delayed biological effects can include cataracts, temporary sterility, cancer, and genetic effects. Extremely high levels of acute radiation exposure can result in death within a few hours, days, or weeks.

Risks of Health Effects

All people are chronically exposed to background levels of radiation present in the environment. Many people also receive additional chronic exposures and/or relatively small acute exposures. For populations receiving such exposures, the primary concern is that radiation could increase the risk of cancers or harmful genetic effects.

The probability of a radiation-caused cancer or genetic effect is related to the total amount of radiation accumulated by an individual. Based on current regulatory policy, any exposure to radiation is assumed to be harmful (or can increase the risk of cancer); however, at very low exposures, the estimated increases in risk are very small and are indeterminate from the effect of other environmental factors (smog, diet, genetics, etc). For this reason, cancer rates in populations receiving very low doses of radiation may not show increases over the rates for unexposed populations (additional cancers will be masked by much higher rate of natural cancers).

The “Linear non-threshold” model has been adopted by DOE as applicable for characterizing the risk of health effects.

Biological Effect for each Radiation Type

Alpha - Alpha particles are not considered an external radiation hazard because they are easily stopped by the dead layer of skin. If an alpha emitter is inhaled, ingested, absorbed or injected into the body it will emit alpha particles in contact with living cells and cause significant damage to a localized area. Thus alpha particles are primarily considered as an internal radiation hazard. Because the penetration power of an alpha particle is very limited, all of the particle’s energy is deposited within a small distance. An alpha particle’s +2 charge causes the displacement of many orbital electrons as the particle passes through tissue. This results in the creation of many ion pairs which can directly cause cell damage (i.e., break a DNA strand) or subsequently form free radicals which can indirectly damage cells through chemical reactions (i.e., H_3O^+ radical attacks DNA and breaks strand).

Beta - Beta particles are considered an external radiation hazard to the skin and eyes, but they do not have enough penetration power to present a hazard to internal organs from an external source. If a beta emitter is inhaled, ingested, absorbed or injected into the body it can emit beta particles in contact with living cells and cause significant damage to a localized area. Thus beta particles are primarily considered as an internal radiation hazard. The mechanism for biological damage is the same as that of an alpha particle which is described above.

Gamma - Gamma radiation easily penetrates the whole body, therefore it is primarily considered as an external radiation hazard. If a gamma emitter is inhaled, ingested, absorbed or injected into the body it will emit gamma photons which will also cause a radiation exposure to the whole body. Although gamma radiation is uncharged, high energy photons will interact with matter and cause ion pairs to form. The ion pairs will subsequently cause biological damage as described in the section regarding alpha radiation.

Neutron - Neutron radiation easily penetrates the whole body, therefore it is primarily considered as an external radiation hazard. Although neutron radiation is uncharged, neutrons will interact with matter and cause ion pairs to form. The ion pairs cause biological damage as previously described.

3.f. Discuss radiation dose and how it is measured, including the terms:

- **RAD**
- **REM**
- **Roentgen**
- **International Standard Units (SI)**

Radiation dose is a measure of the effect of radiation on a material. Different units are used depending upon the effect and material being considered.

Roentgen is a measure of exposure (in air) and applies only to x and gamma radiation (indirectly ionizing radiation)

Rad (from Radiation Absorbed Dose) is a measure of the amount of energy from all types of radiation imparted to matter;

Rem (from Radiation Equivalent Man) takes into account the ability of the specific type of radiation in causing damage to living tissue.

SI units

Gray (Gy) is the SI unit for rad: 100 rads equals one gray

Seivert (Sv) is the SI unit for Rem: 100 Rems equals one Seivert

Biological Effect

A measurement of energy absorbed per unit mass does not tell the entire story, however. A relative biological factor “Quality factor” (Q) takes into account the energy absorbed (dose) and the biological effect on the body due to the different types of radiation. This factor is used to convert absorbed dose to effective dose (rem or in SI units, Seivert). The quality factor ranges from 1 to 20.

Sievert

One sievert is equal to one gray multiplied by a relative biological effective factor, Q, and a factor that takes into account the distribution of the radiation energy, N. Specifically, if E represents the radioactive dose equivalent in sieverts, and D is the absorbed dose in grays, then $E = QND$.

Correct Units Usage

The sievert is the correct unit to use when you wish to monitor the biological danger of radiation.

The gray is the correct unit to use when you wish to monitor energy absorbed per unit mass. Prior to the sievert, the unit used to monitor the biological effectiveness of radiation was called the rem, short for roentgen equivalent man. Similar to the difference between the rad and the gray, the difference between the rem and the sievert is a proportionality factor: 100 rems equal one sievert.

Note: Non SI units are still used in the US.

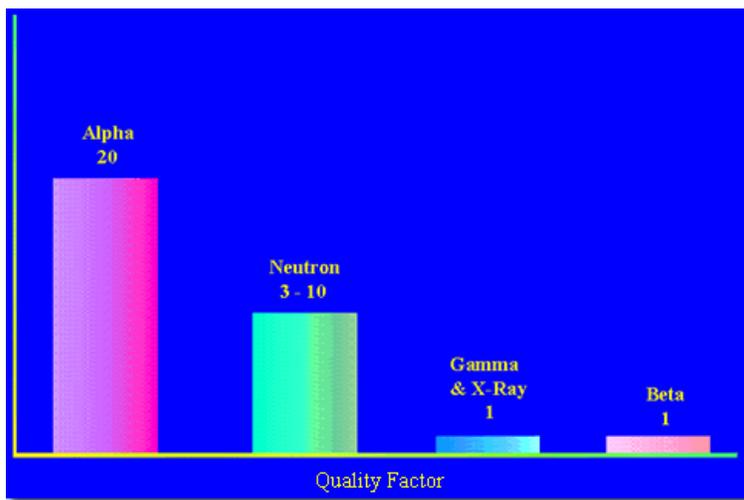
Furthermore, roentgen is used to define the amount of charge produced in a cubic centimeter of air by indirectly ionizing radiation only (X and gamma). It is a very important concept for instrumentation purposes

3.g Define quality factor and describe how it is used.

The quality factor is a dimensionless numerical value given to each type of radiation based upon its potential to cause biological damage. As stated above, the Q is used to relate the absorbed dose to the dose equivalent. Thus, $rem = Q \times rad$ or for SI units, $Sv = Q \times Gy$.

Approximate Quality Factors for Various Forms of Radiation

Type of radiation	Quality factor	Absorbed dose equal to a unit dose equivalent
	(Q)	
X-, gamma, or beta radiation	1	1
Alpha particles, multiple-charged particles, fission fragments and heavy particles of unknown charge	20	0.05
Neutrons of unknown energy	10	0.1
Protons	10	0.1



3.h. Define the term ALARA and describe the basic methods for achieving ALARA.

As Low As is Reasonably Achievable (ALARA)

ALARA is an approach used for radiation protection to manage and control exposures (individual and collective to the work force and to the general public) and releases of radioactive material to the environment so that the levels are as low as is reasonable taking into account social, technical, economic, practical, and public policy considerations. As used in 10 CFR 835, Occupational Radiation Protection, ALARA is not a dose limit, but a process whose objective is attaining doses as far below the applicable limit of this part as is reasonably achievable.

Engineering controls should be the primary method to control exposure (e.g., enclosed hoods). Administrative controls should be the next method to control exposures (e.g., postings). Personnel protective equipment is the last method (e.g., respirators).

Basic protective measures (external dose)

Basic protective measures used to minimize external dose include

- minimizing time in radiation areas;
- maximizing the distance from a source of radiation;
- using shielding whenever possible;
- reducing the amount of radioactive material (source reduction);

Basic protective measures (internal dose)

Basic protective measures to minimize internal radiation include

- Containment
- Ventilation
- Filtration

As previously stated, install or use engineering controls followed by administrative controls as the primary methods to control internal exposure. Personal protective equipment is the last choice for controlling internal exposure.

Competency 3 - References/Additional Reading

DOE-STD-1098-99, DOE Standard, Radiological Control

DOE-HDBK-1130-98-CN2; DOE Handbook Radiological Worker Training

DOE-HDBK-1122-99 Radiological Control Technical Training

DOE-HDBK-1131-98; General Employee Radiological Training

10 CFR 835, Occupational Radiation Protection

Competency 4: Contamination Control and Theory

4. Define contamination and describe three types of contamination

Radioactive contamination is the presence of radioactive material in an unwanted place. Radioactive contamination can be fixed, removable, or airborne.

Fixed contamination

Fixed contamination is contamination that cannot be easily removed from surfaces. It cannot be removed by casual contact. It may be released when the surface is disturbed (e.g., buffing, grinding, using volatile liquids for cleaning, etc.). Over time it may weep, leach, or otherwise become loose or removable.

Removable contamination

Removable contamination is contamination that can easily be removed from surfaces. Any object that comes in contact with it may become contaminated. It may be transferred by casual contact, wiping, brushing, or washing.



Airborne contamination

Airborne contamination is contamination suspended in air. Air movement across removable contamination could cause the contamination to become airborne.

4.b. Describe three ways to control contamination

The three ways to control contamination (and/or exposure from contamination) are:

- Prevention
- Engineering Controls
- Personal Protective Equipment

Prevention

- Establish a solid routine maintenance program for operating systems to minimize failures and leaks that lead to contamination.
- Repair leaks as soon as identified to prevent a more serious problem
- Stage areas to prevent contamination spread from work activities.
- Cover piping/equipment below a work area to prevent dripping contamination onto cleaner areas.
- Cap contaminated pipes or systems when not in use.
- Minimize the equipment and tools taken into and out of contamination areas.
- Use good housekeeping practices: clean up during and after jobs. Good housekeeping is a prime factor in an effective contamination control program. Each radiological worker should keep his/her work area neat and clean to control the spread of contamination.
- Do not violate contamination area ropes or barricades.
- Do not pass items out of contamination areas without following site procedures.
- Ensure ventilation systems are operating as designed (i.e., no unauthorized modifications).
- Ensure that the proper entry, exit, and equipment control procedures are used to avoid the spread of contamination.
- Comply with procedures.

Engineering Controls

Ventilation

- Systems and temporary spot ventilation (e.g., temporary enclosures with high efficiency particulate air [HEPA] filters) are designed to maintain airflow from areas of least contamination to areas of most contamination (e.g., clean to contaminated to highly contaminated areas).
- A slight negative pressure is maintained on buildings/rooms/enclosures where potential contamination exists.
- HEPA filters are used to remove radioactive particles from the air.

Containment

- Permanent and temporary containments are used for contamination control. Examples include vessels, pipes, cells, glove bags, glove boxes, tents, huts, and plastic coverings.



Fixatives

- Used to hold contamination in place

Misting

- Used to control dust

Personal Protective Measures

Sometimes engineering controls cannot eliminate contamination. Personal protective measures, such as protective clothing and respiratory equipment, will be used at this point.



Protective clothing

Protective clothing is required for entering areas containing contamination and airborne radioactivity levels above specified limits to prevent personnel contamination.

The amount and type of protective clothing required is dependent on work area radiological conditions and the nature of the job.

Personal effects such as watches, rings, jewelry, etc., should not be worn.

Full protective clothing generally consists of coveralls, cotton liners, rubber gloves, shoe covers, rubber overshoes, and hood.

Respiratory protection equipment

This equipment is used to prevent the inhalation of radioactive materials

4.c. Describe how contamination is detected

Contamination monitoring equipment is used to detect fixed and removable radioactive contamination on personnel and equipment.

- Removable contamination is generally monitored by swiping surfaces with a material and counting the material on a radiation counting device.
- Airborne radioactivity is monitored using specialized equipment that varies depending on the radiation type and if the contamination is particulate or gaseous.

Examples of Monitoring Equipment



Alpha Continuous Air Monitor



Beta Continuous Air Monitor

Geiger Mueller (GM) probes (e.g., "pancake" type) are most often used with handheld radiation survey instruments for detecting contamination on personnel or equipment. While personnel monitoring equipment can be used to detect beta and gamma radiation, it is most sensitive to alpha radiation.

Appropriate actions to take if contamination is indicated are to:

- Remain in the area.
- Notify radiological control personnel.
- Minimize cross-contamination (e.g., put a glove on a contaminated hand).

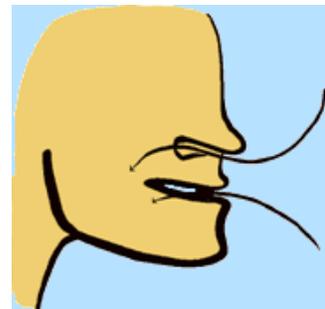
4.d. Describe three ways contamination could enter the body and the methods used to prevent internal contamination

Note: Although the “knowledge and skills” statement implies that there are three ways, there are actually four ways.

The four ways that contamination can enter the body is through inhalation, ingestion, absorption and injection (i.e., via a wound).

Inhalation

Internal contamination via inhalation can occur when airborne contamination is breathed in. Methods to reduce and/or prevent contamination include use of respirators (e.g., air purifying respirators or positive pressure or demand supplied air respirators).



Ingestion

Internal contamination via ingestion occurs when radioactive material is swallowed. Methods to prevent ingestion include restrictions on eating and drinking in contaminated areas.



Absorption

Internal contamination via absorption occurs when skin comes in contact with radioactive material. Methods to prevent absorption are to cover the skin (e.g., gloves) and not touching uncovered skin with material that may be contaminated (no scratching you nose when in anti-c's).



Injection

Injection of radioactive material can occur when working in a contaminated area with an existing cut or wound that exposes tissue below the skin. Methods to prevent the injection of radioactive material are to restrict personnel with wounds from working in contaminated areas or covering the wound and elimination of sharps in contamination areas.

4.e. Describe the methods used for internal dose determination

Bioassay samples, lung counting, and wound counting are three methods used in monitoring for internal contamination.

Bioassay

A routine bioassay program is required by 10 CFR 835 for personnel if there is a likelihood that an intake of radioactive material could occur that would exceed specific limits as specified in 835.402 (c).

Bioassay programs use urine samples, fecal samples, and nasal and mouth smears to determine the committed effective dose equivalent (CEDE) from internal contamination. Fecal samples are the most sensitive bioassay method for detecting internal plutonium contamination. The type of bioassay samples collected and the CEDE will depend on many factors such as: the radionuclide involved, the chemical form of the material, the route of entry, and the elapsed time since the intake occurred.

Air sampling

Worker doses may also be calculated using air sampling data where the area is well understood and good records of all entries are maintained to include duration.

Lung Counters

Lung counters are used to detect inhaled radioactive material in the lungs. The lung counter has a limited capacity for detecting internal contamination because it can only measure gamma rays. The amount of inhaled plutonium must be estimated from the measured amount of gamma rays emitted from americium (plutonium decay product). Lung counts can be used in conjunction with bioassay samples to determine CEDE.

Wound Counters

Wound counters measure gamma and x-rays emitted by radionuclides deposited in a wound. Wound counts are primarily used as a tool to determine if internal contamination of a wound has occurred and to determine the success of subsequent decontamination efforts.

4.f. Describe the types of personnel protective equipment

Personnel protective equipment (PPE) used for radiological purposes can be divided into two main types:

- Protection against internal contamination
- Protection against external contamination or sources.

Respiratory protection is used to protect personnel from inhaling or ingesting radioactive material. Respirators that supply breathing air or self-contained breathing apparatus are examples of respiratory equipment used to prevent internal contamination. Protection factors are assigned to respiratory protection equipment, which are used to determine the maximum level of airborne radioactive contamination that the equipment can protect against. Examples of equipment used to protect against external contamination or radiation sources include anti-contamination clothing (protection against skin contamination), safety glasses (protection against beta to eyes), lead aprons (protection against gamma to major organs), and lead-lined gloves (protection against skin contamination and gamma to hands). Requirements to use personal protective equipment are included in radiological work permits and on postings at area entry points. Full protective clothing used at DOE facilities usually includes coveralls, shoe covers, gloves, and hood.

4.g. Describe the potential effects of radioactive contamination outside of radiation areas

Note: the technical qualification standard inappropriately states “outside of radiation areas.” The correct statement is “outside of contamination areas”

Contamination area means any area where contamination levels are greater than the values specified in Appendix D of 10 CFR 835, Occupational Radiation Protection, but less than or equal to 100 times those levels. Appendix D values range from 20 decays per minute per 100 square centimeter area to 5000 dpm/100 cm² depending on the radionuclide. Note: Any area where contamination levels are greater than 100 times the values specified in Appendix D of 10 CFR 835 is a “high contamination area.”

The primary concern is that radioactive contamination above regulatory limits located outside of contamination areas may not have proper controls to prevent its dispersal and may have an adverse health effect on workers or the public.

Competency 4 - References/Additional Reading

DOE-STD-1098-99, DOE Standard, Radiological Control

DOE-HDBK-1130-98-CN2; DOE Handbook Radiological Worker Training

DOE-HDBK-1122-99 Radiological Control Technical Training

DOE-HDBK-1131-98; General Employee Radiological Training

10 CFR 835, Occupational Radiation Protection

DOE-HNBK-1129-99, Tritium Handling and Safe Storage

Competency 5: Radiation Detection Methods and Principles

5. Personnel shall demonstrate a familiarity level knowledge of basic radiation detection methods and principles

5.a. Describe the proper use and function of thermoluminescent dosimeters and pocket ion chambers.

Thermoluminescent dosimeters

Thermoluminescent dosimeters (TLDs) are used to measure the external radiation dose received by radiation workers (personnel with the potential to receive >100 mrem/yr whole body effective dose equivalent from occupational exposures). A typical whole body dosimeter contains several TLDs.

Each TLD contains material that absorbs and stores the energy of the applicable radiation and when heated gives off the energy as ultraviolet light in proportion to the quantity of radiation exposure received. By measuring the ultraviolet light given off by the TLD, the effective dose equivalent received by the wearer of the TLD can be calculated



Whole body dosimeters

Whole body dosimeters are worn on the chest area between the waist and the neck with the picture (and the beta window) facing out.

Extremity TLDs

In addition to whole body TLDs, extremity TLDs are worn by workers who receive significant dose to their lower arms/hands and lower legs (for example those who work in glove boxes or directly handle radioactive materials) and must be monitored for extremity exposure by 10 CFR 835.



Self-Reading Dosimeters

Self reading dosimeters are required for workers entering high or very high radiation areas where they could receive >10% of an administrative control level in one workday.

They are used to measure gamma or x-ray radiation and are used in conjunction with whole body TLDs. The advantage of a self-reading dosimeter over a whole body TLD is that it can be read by the workers so that they can closely monitor their radiation exposure while they are working in a radiation field. Self-reading dosimeters are worn adjacent to whole body TLDs. A self-reading dosimeter and TLD are required for entering a high radiation area or very high radiation area.

In the past most sites utilized “Pocket ion chamber dosimeters” for self-reading dosimeters. Now most sites use electronic self-reading detectors. Some of these detectors also have an alarm feature that will alarm when the detectors reaches an integrated dose reaching an administratively set limit.

5.b. State the purpose and function of the following radiation monitoring systems:

- **Criticality**
- **Area**
- **Process**
- **Airborne**
- **Criticality**

Criticality Alarm System

The purpose of a criticality alarm system is to alert personnel in a facility if a criticality accident occurs. Criticality alarm systems are installed in accordance with ANSI/ANS 8.3, Criticality Accident Alarm System, in facilities where a criticality accident is credible. If a criticality

accident occurs, large amounts of neutron and gamma radiation are released. The criticality alarm system detects the radiation and activates audible and visual alarms.

Area

The purpose of a real-time area radiation monitoring system is to alert personnel in an area of a facility if the radiation/dose rate in that area increases above a preset level. Area radiation monitoring that is not real-time is meant to identify long-term radiation levels and trends. Frequently occupied locations that have the potential for unexpected increases in dose rates should be equipped with area radiation monitors.

Process

The purpose of a process monitoring system is to alert personnel if a process has been jeopardized to the extent that radioactive contamination could result. If set points are exceeded, the process is shutdown and alarms are activated.

Airborne

The purpose of a real-time airborne radiation monitoring system is to alert personnel in an area of a facility if the air becomes contaminated with radioactive material. Airborne radiation monitoring systems typically pass air through a filter and then detect any radiation emitted from airborne particulate material deposited on the filter. Airborne radiation monitoring that is not real-time is meant to identify long-term radiation levels and trends.

Competency 5 - References/Additional Reading

DOE-STD-1098-99, DOE Standard, Radiological Control

DOE-HDBK-1130-98-CN2; DOE Handbook Radiological Worker Training

DOE-HDBK-1122-99 Radiological Control Technical Training

DOE-HDBK-1131-98; General Employee Radiological Training

10 CFR 835, Occupational Radiation Protection

Competency 6: Contamination Control and Theory

6. Personnel shall demonstrate a familiarity level knowledge of the requirements documents for radiological control practices, procedures, and limits

6.a. Discuss the purpose and general requirements of 10 CFR 835.

10 CFR 835 is a rule promulgated by DOE that implements radiation protection guidance for occupational exposure in federal agencies. The purpose section of the rule states: "...The final rule helps to ensure that DOE facilities are operated in a manner such that occupational radiation exposure to workers is maintained within acceptable limits and as far below these limits as is reasonably achievable. This final rule codifies existing DOE radiation protection directives. This final rule provides nuclear safety requirements which, if violated, will provide a basis for the assessment of civil and criminal penalties under the Price-Anderson Amendments Act of 1988."

10 CFR 835 provides requirements for a radiation protection program including:

- Internal and External Exposure Standards
- Monitoring of Individuals and Areas
- Entry Control
- Posting and labeling
- Records
- Reports to Individuals
- Radiation Safety Training
- Design and Control
- Radioactive contamination control
- Sealed Radioactive Source Control
- Emergency Exposure Situations

Internal and External Exposure Standards

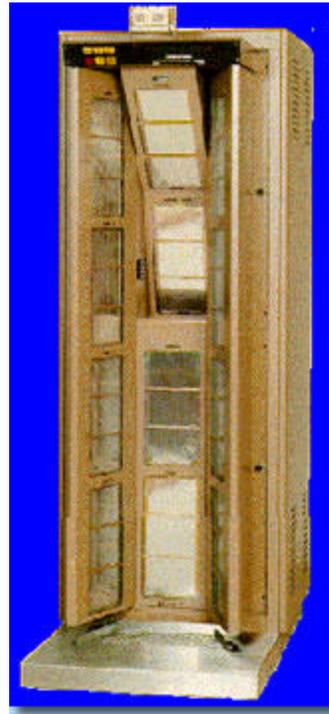
Identifies all exposure limits for workers, embryo/fetus and public entering radiological areas.

Monitoring of Individuals and Areas Identifies:

- Internal and external dosimetry requirements for personnel entering controlled areas
- Workplace surface and airborne contamination monitoring requirements, and
- Radioactive material transportation package receipt survey requirements.

Entry Control

Identifies graded controls for entry into radiological areas, high and very high radiation area.



Posting and labeling

Identifies the required posting types and related information to provide workers with a knowledge of the radiological hazards in their workplace. Labeling requirements identify radioactive material to allow workers to handle appropriately. Postings regarding the presence of radiation and radioactive materials will generally identify type of area, hazards that may be present in the area, and requirements for entry into the area.

Records/Reports to Individuals

Identifies the records required to document safe work practices required by the 10 CFR 835. Also includes annual and termination dose reporting requirements for monitored individuals.

Radiation Safety Training

Identifies a graded approach to ensuring all workers have appropriate knowledge skills and abilities to perform radiological work.

Design and Control

Provides design requirements and dose objective for facilities. Includes requirement for preference of physical design features versus administrative controls.

Radioactive contamination control

Identifies requirement for working in areas with potential contamination potential. Also identifies release requirements for material being removed from radiological areas into controlled areas.

Sealed Radioactive Source Control

Identifies requirements for sealed source identification and leak testing.

Emergency Exposure Situations

Identifies requirements for personnel receiving doses as part of an authorized emergency exposure. Requirements for Nuclear accident dosimetry are also included.

6.b. Discuss the purpose and general requirements of DOE Order 5400.5, Radiation Protection of the Public and the Environment.

The purpose of this Order is to establish standards and requirements for DOE operations to:

- Maintain radiation exposures and radioactive contamination to members of the public within the limits established by this Order through management of real and personal property
- Minimize potential exposures to members of the public as far below the limits as is reasonably achievable
- Ensure that DOE facilities have the capabilities, consistent with the types of operations conducted, to monitor routine and non-routine releases
- Assess doses to members of the public
- Protect the environment from radioactive contamination to the extent practical

6.c. Referring to DOE-STD-1098-99, Radiological Control, locate and discuss the following requirements:

- **Access training**
- **Dose limits**
- **Posting types and use**
- **Access requirements**

DOE-STD-1098-99 provides guidance for a radiation protection program. It is not required to be followed by a contractor unless invoked in a contract.

Access Training

Access training guidance is found in Chapter 6 of the Standard where it states that “each individual shall demonstrate knowledge of radiation safety training topics... commensurate with the hazards Prior to be permitted unescorted access to radiological areas.”

Dose Limits

Information and guidance regarding dose limits can be found in Chapter 2, Radiological Standards, Part 1, Administrative Control Levels and Dose Limits, articles 211 through 216, and appendix 2A. Dose limits specified include:

- Administrative control levels

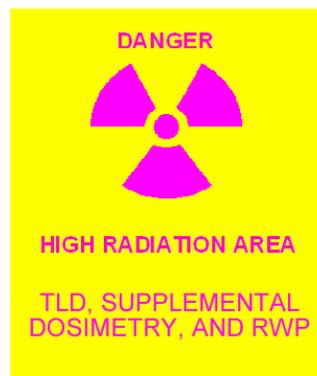
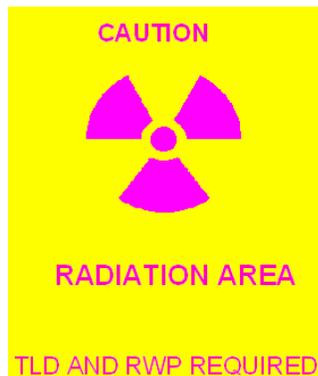
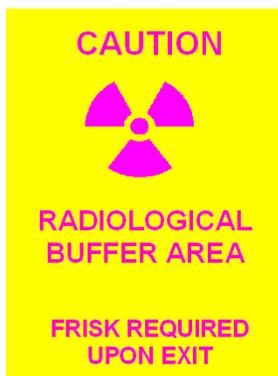
- Lifetime control level
- Occupational Dose limits
- Member of the public limit
- Embryo/Fetal Dose Controls

Posting Types and Use

Information and guidance regarding radiological postings can be found in chapter 2, Radiological Standards, Part 3, Posting, Articles 231 through 237.

Posting types include:

- Controlled Area
- Radiological Buffer Area
- Radiation Area
- High Radiation Areas
- Very High Radiation Area
- Contamination Area
- High Contamination Area
- Airborne Radioactivity Area
- Radioactive Material Area



Access Requirements

Entry and exit requirements are stipulated in Chapter 3, Conduct of Radiological Work, Part 3, Entry and Exit Provisions, Articles 331 through 336.

Some examples include:

1. DOE regulations for occupational radiation protection require that individuals complete radiation safety training commensurate with the hazards and required controls:

- a. Prior to unescorted access to controlled areas and
 - b. Prior to receiving occupational dose during access to controlled areas (whether escorted or not)
2. Written procedures should be implemented to ensure the effectiveness and operability of barricades, devices, alarms, and locks. Determination of the effectiveness of these control devices should also consider individual training and response. Weekly inspections of the physical access controls to high and very high radiation areas should be performed to verify controls are adequate to prevent unauthorized entry.
3. Exit points from contamination, high contamination, or airborne radioactivity areas should include the following:
- a. Step-off pad located outside the exit point, contiguous with the area boundary
 - b. Step-off pads maintained free of radioactive contamination
 - c. Designated containers inside the area boundary for the collection of protective clothing and equipment
 - d. Contamination monitoring equipment located as close to the step-off pad as background radiation levels permit

Note: protective clothing is needed in areas with loose contamination.

Competency 6 - References/Additional Reading

DOE-STD-1098-99, DOE Standard, Radiological Control

DOE-HDBK-1130-98-CN2; DOE Handbook Radiological Worker Training

DOE-HDBK-1122-99 Radiological Control Technical Training

DOE-HDBK-1131-98; General Employee Radiological Training

10 CFR 835, Occupational Radiation Protection

DOE O 5400.5 Chg 2, Radiation Protection of the Public and the Environment

Competency 7: Radioactive and Hazardous Waste

7. Personnel shall demonstrate a familiarity level knowledge of the sources and types of radioactive and hazardous waste associated with DOE facilities.

7.a. Compare and contrast the material classification criteria for the following:

- **Low-level radioactive waste**
- **Hazardous waste**
- **Transuranic waste**
- **High-level radioactive waste**
- **Mixed hazardous waste**

Note: Additional definitions are provided at end of this competency.

Low-Level Radioactive Waste (LLW)

Low-level radioactive waste is radioactive waste that is not high level radioactive waste, spent nuclear fuel, transuranic waste, byproduct material (i.e., uranium and thorium mill tailings or waste from processed ore), or naturally occurring radioactive material. LLW with a hazardous component (e.g., hazardous chemical) is “mixed waste.”

Note: Radioactive waste is defined as any garbage, refuse, sludges, and other discarded material, including solid, liquid, semisolid, or contained gaseous material that must be managed for its radioactive content.

NRC regulations divide LLW into four classes based on physical stability and potential radiation hazard posed to the public if the waste is disposed in a near-surface disposal facility.

- Class A wastes contain low concentrations of radioactive materials and do not present a significant radiological hazard for the public.
 - Class A wastes are usually segregated from other waste classes at the disposal site because they tend to be composed of materials with little physical stability whose deterioration over time could lead to subsidence and threaten the integrity of the disposal system.
- Class B wastes contain significant concentrations of radioactive materials that will be a radiation hazard for up to 100 years.
 - To ensure the integrity of the disposal system, more rigorous waste form stability requirements are applied to Class B wastes than to segregated Class A wastes.
 - Access at a Class B disposal site must be controlled for at least 100 years.

- Class C wastes contain significant concentrations of radioactive materials that will be a radiation hazard for up to 500 years.
 - Class C wastes must meet the same rigorous waste form stability requirements as are applied to Class B wastes.
 - Intruder barriers, such as concrete covers, with an effective life of at least 500 years, must be installed at a Class C disposal site
- Wastes with concentrations of radioactive materials above those allowed in Class C are called “Greater than Class C” wastes and are generally considered unacceptable for near-surface disposal.

While the NRC does not directly regulate DOE low-level wastes or DOE low-level waste disposal facilities, NRC regulations are important because:

- Some DOE wastes may be disposed or treated at commercial LLW facilities that are regulated by the NRC; and
- DOE LLW facilities have adopted waste acceptance criteria that rely on the NRC LLW classification system.

The following are examples of minimum requirements for all classes of waste and are intended to facilitate handling at the disposal site and provide protection of health and safety of personnel at the disposal site.

1. Waste must not be packaged for disposal in cardboard or fiberboard boxes.
2. Liquid waste must be solidified or packaged in sufficient absorbent material to absorb twice the volume of the liquid.
3. Solid waste containing liquid shall contain as little free standing and noncorrosive liquid as is reasonably achievable, but in no case shall the liquid exceed 1% of the volume.
4. Waste must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and must not be readily capable of detonation or of explosive decomposition or reaction at normal pressures and temperatures, or of explosive reaction with water.

Hazardous Waste

A waste with properties that make it dangerous, or capable of having a harmful effect on human health and the environment. Under the Resource Conservation and Recovery Act (RCRA) program, hazardous wastes are specifically defined in 40 CFR Part 261 as solid wastes that meet a particular listing description, have been mixed with materials that meet a particular listing description, or exhibit at least one of the four characteristics of hazardous waste, which are toxicity, corrosivity, ignitability, and reactivity. RCRA defines solid waste as any garbage, refuse, sludge, or other discarded material, regardless of whether it is physically solid, liquid, semisolid, or contained gas, unless it is excluded.

Transuranic (TRU) Waste

Transuranic waste is radioactive waste containing more than 100 nanocuries (3700 becquerels) of alpha-emitting transuranic isotopes per gram of waste, with half-lives greater than 20 years, except for: (1) high-level radioactive waste; (2) waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the Environmental Protection Agency, does not need the degree of isolation required by the 40 CFR Part 191 disposal regulations; or (3) waste that the Nuclear Regulatory Commission has approved for disposal on a case-by-case basis in accordance with 10 CFR Part 61.

High-level Waste

High-level waste (HLW) is the highly radioactive waste material resulting from the reprocessing of spent nuclear fuel, including liquid waste produced directly in reprocessing and any solid material derived from such liquid waste that contains fission products in sufficient concentrations; and other highly radioactive material that is determined, consistent with existing law, to require permanent isolation.

Note: Unlike the NRC definition, the DOE definition of HLW does not encompass irradiated nuclear fuel. Instead, DOE defines “spent nuclear fuel” as a separate waste category.

Spent Nuclear Fuel

Fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.

Mixed Hazardous Waste (Better known as simply “mixed waste.”)

Radioactive waste that contains both source, special nuclear, or by-product material and a hazardous component that is subject to the Resource Conservation and Recovery Act (RCRA) [DOE M 435.1-1]

Note: any LLW that exhibits a hazardous characteristic or has a component that is a listed hazardous waste would be a mixed waste. Every DOE HLW is mixed waste because all DOE HLW has been determined to either exhibit a hazardous characteristic or contain listed hazardous wastes.

Additional Definitions

Source material:

(1) Uranium or thorium, or any combination thereof, in any physical or chemical form or (2) ores which contain by weight one-twentieth of one percent (0.05%) or more of: (i) Uranium, (ii) thorium or (iii) any combination thereof. Source material does not include special nuclear material.

Special Nuclear Material

1. Plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material which is determined, pursuant to the provisions of section 51 [of the Atomic Energy Act of 1954, as amended], to be special nuclear material, but does not include source material; or
2. any material artificially enriched by any of the foregoing, but does not include source material.

By-Product Material

1. Any radioactive material (except special nuclear material) yielded in or made radioactive by exposure to the radiation incident to the process of producing or utilizing special nuclear material, and
2. the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content.

RCRA Waste

The Resource Conservation and Recovery Act includes logic, lists, and analytical test that are useful in determining whether a waste meets the regulatory definition of “hazardous.”

7.b. Describe potential sources for the following types of waste in a DOE facility:

- **Low-level radioactive waste**
- **Hazardous waste**
- **Transuranic waste**
- **High-level radioactive waste**
- **Mixed hazardous waste**

Low-Level Radioactive Waste

At DOE, LLW is generated during processing of nuclear materials used in nuclear weapons production and energy research and development activities.

Examples of LLW include equipment and personal items that have become contaminated with radioactive material, such as protective shoe covers, protective clothing, wiping rags, mops, filters, and tools. Certain process residuals, such as reactor water treatment residues, also may be LLW.

Hazardous Waste

Examples of sources of hazardous waste include:

Maintenance shop activities

- acids,
- solvents,
- paints,
- oils,
- rags contaminated with hazardous cleaning compounds,

Construction or Decommissioning Activities

- Metals
- Contaminated Debris
- Removal of Lead-based Paints
- Solvents

Production Activities:

- Refrigerants
- Chemicals used in metal plating activities
- Quenching bath sludge
- Water Treatment

Transuranic Waste

Transuranic waste is generated from plutonium processing in basic special nuclear material research to develop, prove, and implement technology for existing and/or future plutonium processing needs, and from the provision of support to national defense and energy programs.

High-Level Radioactive Waste

In 1992, DOE ceased all chemical reprocessing of spent nuclear fuel, which is the source of HLW. Before 1992, DOE generated HLW at the Hanford Site, the Savannah River Site, and the Idaho National Laboratory. All HLWs generated by DOE are considered mixed wastes. Commercial reprocessing of nuclear power reactor spent fuel was conducted from 1966 through 1972 at the West Valley Demonstration Project site. In 1980, Congress directed DOE to decommission and cleanup the site. The HLW at West Valley has been vitrified and is being stored on site, awaiting disposal in a federal geologic repository.

Spent Nuclear Fuel

Spent nuclear fuel (SNF) consists of nuclear fuel that no longer has enough fissionable material (usually uranium, but other elements can also be used) to efficiently release nuclear energy in a reactor.

During operation, fissionable atoms split into two or more, smaller and lighter elements—like cesium and strontium. Meanwhile, other uranium atoms do not split but are converted into transuranic elements (beyond uranium on the periodic table of elements) such as plutonium and americium.

Since the new elements do not normally contribute to the generation of energy, the fuel becomes less efficient over time and, at some point, must be removed from the reactor, spent fuel is still extremely radioactive and poses severe health risks if it is not properly contained.

Mixed Hazardous Waste

DOE Low-Level Mixed Waste (LLMW) is generated, projected to be generated, or stored, at 37 DOE sites in 22 states as a result of research, development, and production of nuclear weapons. Waste management activities will require management of an estimated 226,000 m³ of LLMW over the next 20 years.

Other sources of LLMW at DOE sites are decommissioning and site remediation as well as nuclear energy research and scientific research.

Examples of LLMW

- Radioactively contaminated elemental lead in the form of sheets, lead-lined blankets and gloves, bricks, shot, wire, and other shielding.
- Radioactively contaminated lead batteries
- Radioactively contaminated cadmium-, silver-, and mercury-containing material
- Elemental mercury contaminated with radioactive material
- Mercury-contaminated hydraulic oil containing radioactive material

Mixed Hazardous Waste (continued)

HLWs are classified as mixed wastes, unless a demonstration showing otherwise has been made, because they are highly corrosive and contain toxic metals. Some HLWs may also contain spent solvents, which meet a listing description in 40 CFR Part 261. HLWs generated by DOE are located at the Hanford Site, the Savannah River Site, and the Idaho National Laboratory. Also, HLW from commercial reprocessing of nuclear power reactor spent fuel is located at the West Valley Demonstration Project site.

7.c. *Discuss the various types of storage, treatment, and disposal used to manage the following types of waste:*

- ***Low-level radioactive waste***
- ***Hazardous waste***
- ***Transuranic waste***
- ***High-level radioactive waste***
- ***Mixed hazardous waste***

DOE must safely store the wastes generated by its current operations, as well as a significant backlog of waste generated in the past. Storing different types of waste presents the Department's Waste Management Program with a considerable challenge because each type of waste must meet technical and regulatory requirements.

Hazardous chemical waste is generally stored pending treatment, or disposal. Hazardous waste from DOE activities can not be disposed of at municipal and commercial landfills.

Short-term storage of mixed waste is provided at many facilities for up to 90 days before the wastes are shipped off-site for treatment or disposal. Waste is often stored to accumulate sufficient quantities to facilitate treatment or disposal.

Some LLW and mixed wastes must be stored for longer periods in anticipation of better treatment processes or while awaiting the availability of treatment facilities. In other cases, radioactive wastes may be placed in long-term storage to allow the level of radioactivity in the waste to decay. Many DOE sites and installations store waste temporarily until disposal sites are available and can accept the waste. Departmental guidance/Orders normally limit storage to one year to minimize buildup of a legacy problem.

Low-level waste must be stored until it can be treated and/or disposed.

LLW is usually disposed at selected disposal facilities in pits, trenches or shafts. Liquid wastes are treated to separate the radioactive component or solidified so that no free liquid remains prior to disposal.

Some liquid, low-level waste is mixed with fly ash or cement and poured into metal containers. Once the waste has hardened, the drums are placed in concrete vaults where they await authorized disposal.



Hazardous waste is generally accumulated for a short time on site and subsequently sent to permitted commercial facilities for treatment and disposal.

Waste with no disposal path is packaged and placed in permitted storage awaiting the development of appropriate treatment. On occasion, waste may be stored in permitted areas to accumulate sufficient quantities to facilitate treatment.

The Land Disposal Restrictions (LDR) portion of RCRA is intended to greatly limit the land disposal of hazardous waste.

DOE has established a national TRU program to strategically plan the characterization, transport and disposal of TRU waste in accordance with regulatory requirements.

DOE temporarily stores most TRU waste in a method that allows for easy retrieval. To protect the groundwater under storage areas, the waste is placed in containers and stacked on concrete pads. These containers are then enclosed in a protective vinyl cover and the area is backfilled with soil providing stable storage. The containers can be easily retrieved for future processing and disposal.

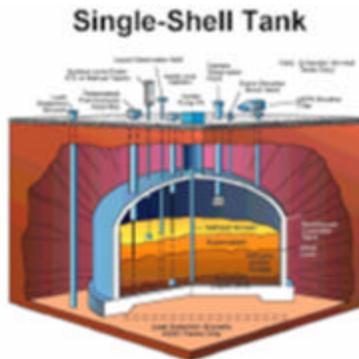
DOE has built the Waste Isolation Pilot Plant (WIPP) to permanently dispose TRU waste including mixed TRU waste. The next page provides a brief overview of WIPP.

The WIPP is a geologic repository licensed to safely and permanently dispose of TRU radioactive waste left from the research and production of nuclear weapons. WIPP began operations on March 26, 1999, after more than 20 years of scientific study, public input, and regulatory review.

The WIPP is located in the remote Chihuahuan Desert of southeastern New Mexico, about 80 kilometers (50 miles) from Carlsbad, New Mexico. The repository consists of disposal rooms mined 655 meters (2,150 feet) underground in a 600 meter-thick (2,000 feet) salt formation that has been stable for more than 200 million years. The TRU waste currently stored at 23 locations nationwide will be shipped to and disposed of at WIPP over the next 35 years.



DOE stores its high-level waste (primarily liquid wastes resulting from nuclear fuel reprocessing) in tanks at the Idaho National Laboratory, Idaho; Savannah River, South Carolina; and Hanford, Washington sites. At the Hanford Site, some of the original single-shell tanks that have begun to leak have been replaced by double-shell, carbon-steel tanks. These range in volume from 500,000 to approximately one million gallons each. The double-wall is actually a tank within a tank.



Highly sensitive monitoring equipment is installed in the space between the tank walls to detect any leaks that might occur.

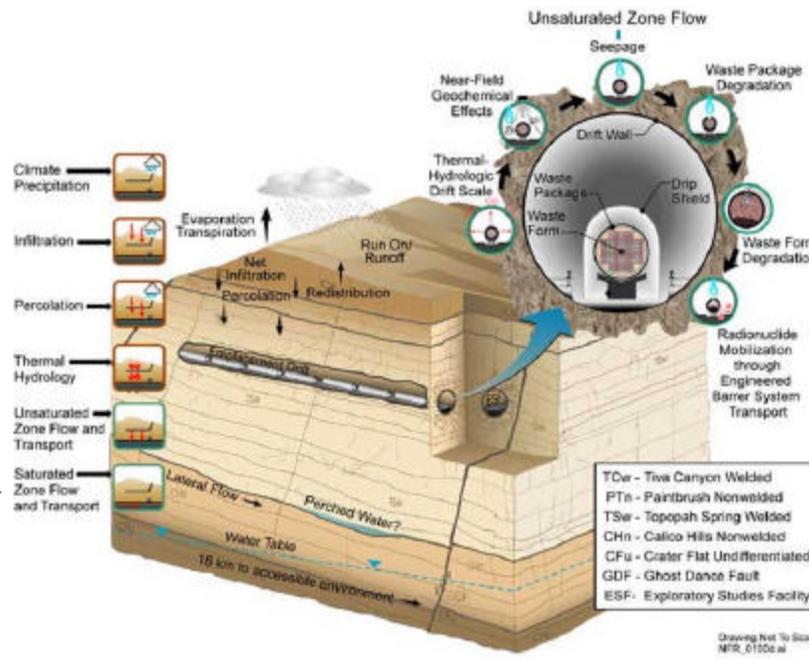
At the Savannah River Site, high-level liquid waste is being removed from the tanks and converted (vitrified) to a solid-waste form suitable for permanent disposal. DOE reduces the volume of high-level waste that it vitrifies by pre-treating the stored high-level waste to separate many of the non-radioactive substances from the radioactive ones. The remaining less radioactive waste will be solidified for disposal. When DOE solidifies high-level waste into glass logs through vitrification, granular calcine, or concrete-like saltstone, the waste still needs to be stored awaiting final disposal.

DOE plans to eventually ship and permanently store high level waste at the Yucca Mountain Project located in Nevada.



AIP_Z181_Fig. 1-18-00

The high-level waste will be stored about 1000 feet below the ground in a manner to minimize degradation of waste packages. DOE has performed detailed analysis to determine the safety of permanent storage of HLW at Yucca Mountain



Mixed Hazardous Waste

A large portion of DOE's waste inventory consists of waste that contains both radioactive and chemically hazardous components. Mixed wastes are required to be treated, stored and disposed in compliance with all regulatory requirements applicable to both their radioactive component and their chemically hazardous component.

LDR treatment standards apply to mixed wastes, but compliance is not always appropriate or possible because of the radioactive characteristics of mixed wastes.

In compliance with the Federal Facility Compliance Act of 1992, DOE has worked with state and federal regulators to develop site-specific treatment plans for achieving compliance with LDR treatment standards for low-level mixed wastes (discussed in more detail in Competency 10).

DOE sites are storing some low-level mixed wastes in accordance with these site-specific plans pending development of appropriate treatment technologies.

DOE also has worked with EPA to obtain variances from the federal LDR treatment standards for specific mixed wastes, such as batteries that contain hazardous metals.

Disposal facilities for mixed wastes are limited. DOE operates mixed waste disposal facilities at the Hanford Site and the Nevada Test Site.

Until a new lined, combined-use facility is operational at the Hanford Site (projected for 2007), receipt of mixed LLW for disposal from off site generators is limited to 5,000 cubic meters.

Currently, the NTS RCRA Permit restricts disposal of mixed LLW to only that which is generated at the NTS facility. A permit modification has been requested.

DOE sends mixed LLW from many of its sites to the only commercial disposal facility permitted to receive it, which is located in Utah.

Competency 7 - Supporting Knowledge 'C' - References/Additional Reading

DOE O 435.1 **Radioactive Waste Management**

DOE M 435.1- Radioactive Waste Management Manual

10 CFR 261 "Identification and Listing of Hazardous Waste." July 1, 2004.

Atomic Energy Act, 1954

Waste Isolation Pilot Plant (WIPP) Land Withdrawal Act (LWA), Public Law 102-579

Low-Level Radioactive Waste Policy Amendments Act of 1985

Yucca Mountain Site Suitability Evaluation , OE/RW-0549 February 2002

Federal Facility Compliance Act of 1992

10 CFR 61 "Licensing Requirements for Land Disposal of Radioactive Waste"

Competency 8: Environmental Protection, Restoration and Waste Management Issues

- 8. Personnel shall demonstrate a familiarity level knowledge of orders, standards, and regulations related to environmental protection, restoration, and waste management issues**
- 8.a. Discuss the purpose of the following environmental regulations as they apply to the Department and the contractors that operate its facilities:**
- **National Environmental Policy Act (NEPA)**
 - **National Pollution Discharge Elimination System (NPDES)**
 - **Resource Conservation and Recovery Act (RCRA)**
 - **Comprehensive Environmental Response, Compensation, and Liability Act-Superfund Act (CERCLA)**

National Environmental Policy Act (NEPA)

The Act establishes national environmental policy and goals for the protection, maintenance, and enhancement of the environment; and it provides a process for implementing these goals within the federal agencies. Section 102 requires federal agencies to incorporate environmental considerations in their planning and decision-making through a systematic interdisciplinary approach. Specifically, all federal agencies are to prepare detailed statements assessing the environmental impact of and alternatives to major federal actions significantly affecting the environment. These statements are commonly referred to as environmental impact statements (EISs). Further, NEPA requires DOE to set up procedures to assure the public is informed about the environmental consequences of proposed agency actions and to place environmental factors on an equal footing with other considerations for government projects, such as economics, defense, etc.

Environmental assessments (EAs) are another type of NEPA document that provide less detailed analysis than EISs. An EA is prepared to determine if an EIS is required, or if a finding of no significant impact can be issued. A third type of NEPA review, a Categorical Exclusion, may be appropriate when a proposed action fits within a typical class of actions that an agency has determined do not individually or cumulatively have a significant effect on the human environment. As a first step in determining which kind of a NEPA document to develop, DOE utilizes may develop an Environmental Checklist and an Action Description Memorandum which can be performed relatively quickly at low cost.

National Pollutant Discharge Elimination System (NPDES)

The NPDES program is an element of the Clean Water Act (CWA) designed to impose effluent limitations on, or otherwise to prevent, discharges of “pollutants” into any “waters of the United States” from any “point source.” The NPDES is a permit program:

1. requiring dischargers to disclose the volume and nature of their discharges;
2. authorizing Environmental Protection Agency (EPA) or the states to specify the limitations to be imposed on such discharges;
3. imposing on dischargers an obligation to monitor and report as to their compliance or noncompliance with limitations so imposed;
4. authorizing EPA or state and citizen enforcement in the event of non-compliance.

Resource Conservation and Recovery Act (RCRA)

RCRA is a regulatory statute designed to provide “cradle to grave” control of hazardous waste by imposing management requirements on generators and transporters of hazardous wastes and upon owners and operators of treatment, storage, and disposal facilities. RCRA applies mainly to active facilities and does not address the serious problem of abandoned and inactive sites. RCRA amended the Solid Waste Disposal Act (SWDA); therefore, the two terms are sometimes used synonymously. Subtitle A of RCRA declares that the generation of hazardous waste is to be reduced or eliminated as expeditiously as possible, and land disposal should be the least favored method for managing hazardous wastes. Additionally, all waste that is generated must be handled to minimize the present and future threat to human health and the environment.

RCRA goals:

- Protect human health and the environment from the hazards posed by waste disposal;
- Conserve energy and natural resources through waste recycling and recovery;
- Reduce or eliminate, as expeditiously as possible, the amount of waste generated, including hazardous waste;
- Ensure that wastes are managed in a manner that is protective of human health and the environment.

Comprehensive Environmental Response, Compensation, and Liability Act - Superfund Act (CERCLA)

In 1980, Congress enacted the Comprehensive Environmental Response, Compensation, and Liability Act, usually referred to as CERCLA or Superfund. CERCLA’s most basic purposes are to provide funding and enforcement authority for cleaning up the thousands of hazardous waste sites created in the U.S. in the past which are now abandoned and inactive and to respond to hazardous substance spills.

8.b. Using references, discuss the purpose of the following environmental regulations as they apply to the Department and the contractors that operate its facilities:

- **Clean Water Act (CWA)**
- **Clean Air Act (CAA)**
- **Emergency Planning and Community Right-To-Know Act (EPCRA)**
- **Federal Facility Compliance Act (FFCA)**
- **Pollution Prevention Act of 1990 (PPA)**
- **Safe Drinking Water Act (SDWA)**
- **Superfund Amendment and Reauthorization Act (SARA)**
- **Toxic Substances Control Act (TSCA)**

Clean Water Act (CWA)

The goals of the CWA are:

- To improve surface water quality to fishable and swimmable
- To eliminate the discharge of pollutants into the navigable waters
- To prohibit the discharge of toxic pollutants in toxic amounts
- To provide Federal financial assistance for construction of publicly owned waste treatment works
- To expeditiously develop and implement programs to control non-point sources of pollution

To accomplish its goals, the CWA establishes requirements including

- That all point sources meet technology-based effluent limitations established by EPA
- That each State adopt water quality standards for each water body within its boundaries, subject to EPA approval
- That facilities discharging pollutants into navigable waters from point sources obtain permits from EPA or an approved state (NPDES permitting program)

Clean Air Act (CAA)

The purposes of the CAA are

- to protect and enhance the quality of the nation's air resources so as to promote the public health and welfare and the productive capacity of its population;
- to initiate and accelerate a national research and development program to achieve the prevention and control of air pollution;
- to provide technical and financial assistance to state and local governments in connection with the development and execution of their air pollution prevention and control programs;
- to encourage and assist the development and operation of regional air pollution prevention and control programs

Emergency Planning and Community Right-To-Know Act (EPCRA)

EPCRA was enacted as a freestanding provision of the Superfund Amendments and Reauthorization Act. EPCRA requires state and local governments to develop emergency plans for responding to unanticipated environmental releases of a number of acutely toxic materials known as extremely hazardous substances. Additionally, the statute has established an information collection and transfer program. Businesses covered by EPCRA are required to notify state and local emergency planning entities of the presence and quantities in inventory of such substances at their facilities and to notify federal, state, and local authorities of planned and unplanned environmental releases of those substances.

Federal Facility Compliance Act (FFCA)

The Federal Facility Compliance Act of 1992 establishes that federal facilities do not have sovereign immunity from state enforcement of state environmental laws under the solid and hazardous waste provisions of the RCRA. Thus, federal facilities are obligated to pay fines and penalties assessed by states. Additionally, provisions of the Act give EPA broader enforcement authority at federal facilities. The Act created a new mixed-waste provision requiring reports on the national inventory of all mixed-waste on a state-by-state basis and on the nation's inventory on mixed-waste treatment capacities and technologies. As a result of these reporting requirements DOE sites have developed, obtained approval from the state, and committed to compliance with a site treatment plan (STP). The STP addresses technologies and capacities to treat mixed waste to meet the land disposal requirements.

The FFCA clarifies how certain RCRA requirements and sanctions apply to the management of hazardous and mixed wastes at Federal facilities. Before the FFCA was passed, Federal facilities were required to comply with RCRA regulations, but they had sovereign immunity from fines and penalties for certain violations.

The FFCA contains the following provisions affecting DOE facilities:

- Waiver of sovereign immunity from enforcement of solid and hazardous waste requirements. This provision obligates Federal facilities to pay fines and penalties assessed by states or EPA for noncompliance with solid and hazardous waste requirements.
- Limitation on the civil liability of a Federal employee for noncompliance with solid and hazardous waste requirements committed while the employee is acting within the scope of his/her official duties.

DOE had to:

1. Prepare and submit a national inventory report identifying the volume, characteristics, treatment capacity, and available treatment technologies for DOE's mixed wastes;
- and

2. Prepare and submit site treatment plans (STPs) that include the approach and schedule for developing the needed treatment capacity and treating mixed wastes at each DOE site where mixed wastes were generated or stored.

Today, many DOE facilities are still operating under the provisions of an STP while they await either the development of a treatment technology that is appropriate for their mixed wastes or the availability of mixed waste treatment and disposal capacity.

Pollution Prevention Act of 1990 (PPA)

The PPA states, “the Congress hereby declares it to be the national policy of the United States that pollution should be prevented or reduced at the source whenever feasible; pollution that cannot be prevented should be recycled in an environmentally safe manner, whenever feasible; and disposal or other release into the environment should be employed only as a last resort and should be conducted in an environmentally safe manner.”

Safe Drinking Water Act (SDWA)

The SDWA was enacted to regulate drinking water systems. The act required EPA to set national standards for levels of contaminants in drinking water, and created a program for states to regulate underground injection wells and for the protection of sole source aquifers.

Superfund Amendment and Reauthorization Act (SARA)

The Superfund Amendments and Reauthorization Act of 1986 revised the CERCLA cleanup standards, strengthened the CERCLA settlement and enforcement provisions, and created a larger revenue base for financing and replenishing the Superfund. SARA did not, however, alter CERCLA’s fundamental program elements.

Toxic Substances Control Act (TSCA)

The TSCA has two main regulatory features: first, acquisition of sufficient information by EPA to identify and evaluate potential hazards from chemical substances; second, regulation of the production, use, distribution, and disposal of such substances where necessary. The main provisions of the Act include pre-manufacture notification, inventory list, reporting requirements, and testing requirements. Additionally, TSCA specifically regulates polychlorinated biphenyl, chlorofluorocarbons, and asbestos.

8.c. Using references, discuss the purpose and general requirements of the following DOE Orders:

- **DOE Order 5400.1, General Environmental Protection Program**
- **DOE O 451.1B, National Environmental Policy Act Compliance Program**
- **DOE O 435.1, Radioactive Waste Management**

DOE Order 5400.1, General Environmental Protection Program

Note: DOE Order 5400.1 was cancelled by DOE O 450.1, Chg 1 Environmental Protection Program (January 24, 2005).

The objective of DOE O 450.1 is to implement sound stewardship practices that are protective of the air, water, land, and other natural and cultural resources impacted by DOE operations and by which DOE cost effectively meets or exceeds compliance with applicable environmental; public health; and resource protection laws, regulations, and DOE requirements.

This objective must be accomplished by implementing Environmental Management Systems (EMSs) at DOE sites. An EMS is a continuing cycle of planning, implementing, evaluating, and improving processes and actions undertaken to achieve environmental goals.

Although several recognized EMS frameworks exist, most are based on the International Organization for Standardization (ISO) 14001 EMS standard.

DOE O 451.1B, National Environmental Policy Act Compliance Program

The objective of this order is to establish DOE internal requirements and responsibilities for implementing the National Environmental Policy Act (NEPA) of 1969, the Council on Environmental Quality Regulations Implementing the Procedural Provisions of the NEPA (40 CFR parts 1500-1508), and the DOE NEPA Implementing Procedures (10 CFR 1021). The goal of establishing the requirements and responsibilities is to ensure efficient and effective implementation of DOE's NEPA responsibilities through teamwork. A key responsibility for all participants is to control the cost and time for the NEPA process while maintaining its quality.

DOE O 435.1, Radioactive Waste Management

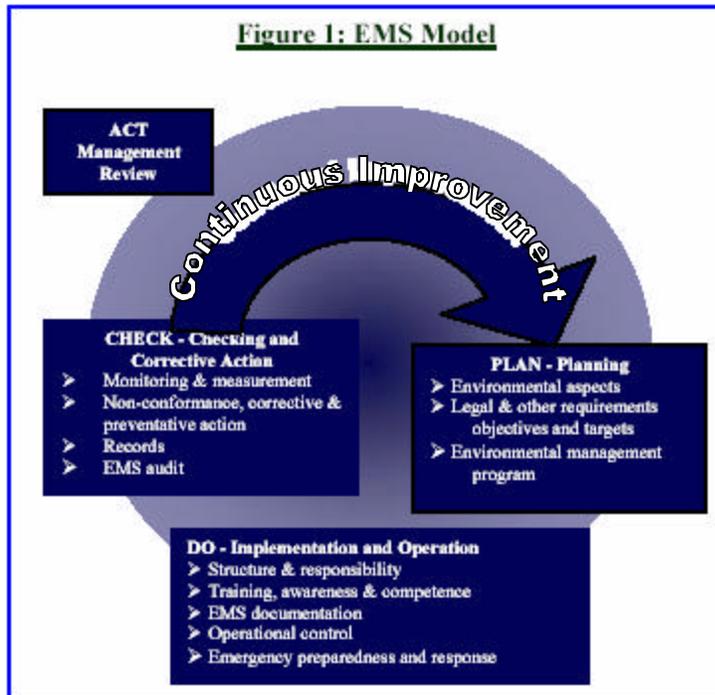
The purpose of this order is to establish policies, guidelines, and minimum requirements by which DOE manages its radioactive and mixed waste and contaminated facilities. In accordance with O 435.1, Waste management activities must be systematically planned.

8.d. *Using references, discuss the purpose and applicability of International Standard ISO 14001, Environmental Management Systems.*

ISO 14001 is the cornerstone standard of the ISO 14000 series. It specifies a framework of control for an environmental management system against which an organization can be certified by a third party.

ISO14001 is the framework upon which organizations most frequently choose to

base their EMS, and, this is proving to be the case with U.S. Federal facilities. ISO 14001 has not been accepted by DOE as a method for meeting DOE O 450.1 requirements for establishing an EMS. However, DOE O 450.1 does not prescribe the type of EMS framework that DOE elements must use.



Competency 8 References/Additional Reading

DOE O 450.1, Chg 1 Environmental Protection Program

DOE O 451.1B, National Environmental Policy Act Compliance Program

DOE O 435.1, Radioactive Waste Management

International Standard, ISO 14001, Environmental Management Systems.

Competency 9: Hazardous Waste Operations and Emergency Response

9. Personnel shall demonstrate a familiarity level knowledge of the purpose and content of 29 CFR 1910.120, Hazardous Waste Operations and Emergency Response

Using 29 CFR 1910.120 as a reference, discuss its purpose as it applies to the Department and the contractors that operate its facilities with respect to

- **cleanup operations**
- **corrective actions**
- **voluntary clean-up operations**
- **operations involving hazardous wastes**
- **emergency response operations**

Introduction

29 CFR 1910.120 is an Occupational Safety and Health Administration (OSHA) standard for hazardous waste operations and emergency response (or HAZWOPER). DOE contractors are required by DOE O 440.1A to meet 19 CFR 1910, including 1910.120

This regulation applies to operations involving hazardous waste and therefore applies to many of the operations at DOE sites. It also provides requirements for emergency response operations for releases of, or substantial threats of releases of, hazardous substances without regard to the location of the hazard and again, therefore applies to DOE sites.

Cleanup Operations (voluntary and mandated), Corrective Actions And Operations involving Hazardous Waste

29 CFR 1910.120, Hazardous Waste Operations and Emergency Response, applies to:

- DOE contractors involved in cleanup operations
- DOE contractors operating treatment, storage, and disposal facilities
- Support contractors completing RCRA corrective actions
- DOE contractor involved in voluntary cleanup operations

1910.120 requires that employers develop and implement a written safety and health program for their employees involved in hazardous waste operations. The program shall be designed to identify, evaluate, and control safety and health hazards, and provide for emergency response for hazardous waste operations.

The written safety and health program shall incorporate the following:

- Organization Structure
- Comprehensive Workplan
- Training of employees
- Medical Surveillance of employees

Organization Structure

The organizational structure part of the program shall establish the specific chain of command and specify the overall responsibilities of supervisors and employees.

Comprehensive Workplan

The comprehensive workplan part of the program shall address the tasks and objectives of the site operations and the logistics and resources required to reach those tasks and objectives.

Training

All employees working on site (such as but not limited to equipment operators, general laborers and others) exposed to hazardous substances, health hazards, or safety hazards and their supervisors and management responsible for the site shall receive training meeting the requirements of this paragraph before they are permitted to engage in hazardous waste operations that could expose them to hazardous substances, safety, or health hazards.

Medical Surveillance

The medical surveillance program shall be instituted by the employer for employees:

- who are or may be exposed to hazardous substances or health hazards at or above the established permissible exposure limit, above the published exposure levels for these substances, without regard to the use of respirators, for 30 days or more a year
- who wear a respirator for 30 days or more a year
- who are injured, become ill or develop signs or symptoms due to possible overexposure involving hazardous substances or health hazards from an emergency response or hazardous waste operations
- Members of HAZMAT teams

29 CFR 1910.120 provides some specific requirements for: monitoring of atmospheric condition, engineering controls, and handling drums and containers.

Monitoring of atmosphere conditions

Monitoring shall be performed where there may be a question of employee exposure to hazardous concentrations of hazardous substances in order to assure proper selection of engineering controls, work practices and personal protective equipment so that employees are

not exposed to levels which exceed permissible exposure limits, or published exposure levels if there are no permissible exposure limits, for hazardous substances.

Monitoring shall be conducted during initial entry to a hazardous waste site

Engineering controls, work practices, and personal protective equipment

Engineering controls, work practices, personal protective equipment, or a combination of these shall be implemented to protect employees from exposure to hazardous substances and safety and health hazards.

Handling drums and containers

Drums and containers used during the clean-up shall meet the appropriate DOT, OSHA, and EPA regulations for the wastes that they contain.

When practical, drums and containers shall be inspected and their integrity shall be assured prior to being moved. Drums or containers that cannot be inspected before being moved because of storage conditions (i.e., buried beneath the earth, stacked behind other drums, stacked several tiers high in a pile, etc.) shall be moved to an accessible location and inspected prior to further handling.

Unlabeled drums and containers shall be considered to contain hazardous substances and handled accordingly until the contents are positively identified and labeled.

Emergency Response Operations

Emergency response or responding to emergencies means a response effort by employees from outside the immediate release area or by other designated responders (i.e., mutual aid groups, local fire departments, etc.) to an occurrence which results, or is likely to result, in an uncontrolled release of a hazardous substance. Responses to incidental releases of hazardous substances where the substance can be absorbed, neutralized, or otherwise controlled at the time of release by employees in the immediate release area, or by maintenance personnel are not considered to be emergency responses within the scope of this standard. Responses to releases of hazardous substances where there is no potential safety or health hazard (i.e., fire, explosion, or chemical exposure) are not considered to be emergency responses.

An emergency response plan shall be developed and implemented to handle anticipated emergencies prior to the commencement of hazardous waste operations. The plan shall be in writing and available for inspection and copying by employees, their representatives, OSHA personnel and other governmental agencies with relevant responsibilities.

Elements of an emergency response plan. The employer shall develop an emergency response plan for emergencies which shall address, as a minimum, the following:

- Pre-emergency planning.

- Personnel roles, lines of authority, training, and communication.
- Emergency recognition and prevention.
- Safe distances and places of refuge.
- Site security and control.
- Evacuation routes and procedures.
- Decontamination procedures which are not covered by the site safety and health plan.
- Emergency medical treatment and first aid.
- Emergency alerting and response procedures.
- Critique of response and follow-up.
- PPE and emergency equipment.

9.b. Using 29 CFR 1910.120 as a reference, discuss the role of the Department in the identification and assessment of and reaction to potential risks posed by hazardous wastes that exist at Department sites.

All suspected conditions that may pose inhalation or skin absorption hazards that are immediately dangerous to life or health (IDLH), or other conditions that may cause death or serious harm, shall be identified during a preliminary survey and valuated during a detailed survey. Examples of such hazards include, but are not limited to, confined space entry, potentially explosive or flammable situations, visible vapor clouds, or areas where biological indicators such as dead animals or vegetation are located.

The following monitoring shall be conducted during initial site entry when the site evaluation produces information that shows the potential for ionizing radiation or IDLH conditions, or when the site information is not sufficient reasonably to eliminate these possible conditions:

- Monitoring with direct-reading instruments for hazardous levels of ionizing radiation
- Monitoring the air with appropriate direct-reading test equipment (i.e., combustible gas meters, detector tubes) for IDLH and other conditions that may cause death or serious harm (combustible or explosive atmospheres, oxygen deficiency, toxic substances)
- Visually observing for signs of actual or potential IDLH or other dangerous conditions

An ongoing air-monitoring program shall be implemented after site characterization has determined the site is safe for the start-up of operations.

Once the presence and concentrations of specific hazardous substances and health hazards have been established, the risks associated with these substances shall be identified. Employees who will be working on the site shall be informed of any risks that have been identified.

Competency 9 References/Additional Reading

29 CFR 1910.120, Hazardous Waste Operations and Emergency Response.

Competency 10: Federal Facilities Compliance Act

10. Personnel shall demonstrate a familiarity level knowledge of potential personal and organizational liability associated with the Federal Facilities Compliance Act (FFCA).

10.a. Using the FFCA as a reference, discuss the Department's liabilities associated with the FFCA, including the following:

- **Federal agency liability**
- **Federal employee liability**
- **Civil penalties**
- **Criminal penalties**
- **RCRA**

The Federal Facility Compliance Act of 1992 establishes that federal facilities do not have sovereign immunity from state enforcement of state environmental laws under the solid and hazardous waste provisions of the RCRA. Thus, federal facilities are obligated to pay fines and penalties assessed by states.

The waiver of sovereign immunity in the FFCA gives states and EPA authority to sue DOE for civil fines and penalties for violations at DOE sites of hazardous and solid waste requirements.

States have always had authority to seek injunctions to compel Federal facilities to comply with solid and hazardous waste requirements, but issuing civil fines and penalties is new.

The FFCA precludes the use of criminal sanctions, such as fines and imprisonment, against DOE for violations of solid and hazardous waste requirements.

The FFCA clarifies that EPA has authority under section 3008(a) of RCRA to initiate administrative enforcement actions against DOE in the same manner and under the same circumstances as it would initiate such an action against any other person. Notwithstanding, before an administrative order is finalized, DOE must be given an opportunity to confer with the EPA Administrator.

The FFCA clarifies that that a Federal employee cannot be held personally liable for any civil penalties imposed with respect to violations of solid and hazardous waste requirements if the violation occurs as a result of actions of the employee that were within the scope of his/her official duties.

The FFCA further clarifies that Federal employees are subject to criminal sanctions, including fines or imprisonment, for violations of Federal or state solid or hazardous waste laws.

10.b. Discuss the purpose and application of Site Treatment Plans

Site treatment plans were required to be developed as part of the FFCA. Site treatment plan identify how facilities are going to treat mixed waste with existing technologies or develop technologies where they do not exist or need modification.

FFCA provided for a three-year delay, until October 6, 1995, before states could impose fines or penalties on DOE facilities for storing mixed wastes longer than the RCRA land disposal restrictions (LDR) program allows, provided that during the delay, DOE completed the following tasks:

1. Prepare and submit a national inventory report identifying the volume, characteristics, treatment capacity, and available treatment technologies for DOE's mixed wastes; and
2. For each DOE site where mixed wastes were generated or stored, prepare and submit a Site Treatment Plan (STP) containing the approach and schedule for developing the needed treatment capacity and for treating mixed wastes at the site.

DOE completed both tasks necessary to qualify for the FFCA's three-year enforcement delay. Today, many DOE facilities are still operating under the provisions of an STP while awaiting either the development of a treatment technology that is appropriate for their mixed wastes or the availability of mixed waste treatment and disposal capacity.

Competency 11: Integrated Safety Management

11. ***Personnel shall demonstrate a familiarity level knowledge of the Department's philosophy and approach to implementing Integrated Safety Management***

11.a. ***Explain the objective of ISM.***

DOE manages its safety efforts through a program called the integrated safety management system (ISMS). The objective of ISMS is to incorporate safety into management and work practices at all levels, addressing all types of work and all types of hazards to ensure safety for the workers, the public, and the environment. To achieve this objective, DOE has established guiding principles and core safety management functions.



11.b. ***Describe how the seven guiding principles in the ISM policy are used to implement ISM philosophy***

The seven guiding principles are:

- line management responsibility for safety
- clear roles and responsibilities
- competence commensurate with responsibilities
- balanced priorities
- identification of safety standards
- tailor hazard controls to work
- operations authorization

Guiding Principles 1-3

- Line Management Responsibility for Safety,
- Clear Roles and Responsibilities, and
- Competence Commensurate with Responsibilities.

The first three guiding principles relate to responsibilities intrinsic in all five core functions,

These interrelated guiding principles help ensure the management structure has personnel who focus on safe accomplishment of mission, understand their assignments, and can carry out the core safety management functions correctly and efficiently.

Guiding Principle 4: Balanced Priority

Protecting the public, workers, and the environment is a top priority whenever the Department plans and performs work. Critical to this objective is providing adequate resources and ensuring that those resources are effectively allocated. Each organizational level (i.e., DOE Headquarters, DOE field element, and contractor) should, therefore, establish a method for ensuring a proper balance among competing priorities of the organization (e.g., budget, schedule, safety, quality).

Guiding Principle 5: Identification of Safety Standards

The terms and conditions that define DOE safety expectations for its contractors are set forth as contract requirements. DEAR 970.5204-2 requires the contractor to comply with the requirements of applicable Federal, State, and local laws and regulations (including DOE Regulations) in developing and implementing controls, unless the appropriate regulatory agency has granted relief in writing.

DOE has identified safety requirements in Rules and DOE Orders and has developed a wide variety of associated Technical Standards, Guides, and Manuals; in addition, DOE encourages the use of national consensus technical standards.

In addition to complying with the requirements of applicable Federal, State, and local laws and regulations (including DOE Regulations) in developing and implementing controls, as required by DEAR 970.5204-2(a) (List A), the contractor must comply with the requirements of applicable DOE directives appended to the contract [List B at DEAR 970.5204-2(b)].

Guiding Principle 6: Hazard Controls Tailored to Work

As with the set of standards and requirements, the derived controls should be tailored to the work and the associated hazards, in accordance with Guiding Principle 6. The controls should encompass all aspects of the work (including potential abnormal or emergency situations) and each phase of work performance (e.g., preparation, review, authorization, and execution). Emphasis should be on designing the work and/or controls to reduce or eliminate the hazards and to prevent accidents and unplanned releases and exposures.

Guiding Principle 7: Operations Authorization

DOE and the contractor should formally agree on the need for authorization agreements for those nuclear and significant hazard facilities that must perform work safely without any undue risk to the worker, the public, and the environment.

The contractor's ISMS description should clearly identify the roles of the contractor and DOE in authorizing work at appropriate levels. Understanding DOE and contractor roles with respect to authorizing work and changes to the work is essential for successful implementation of the ISMS. DOE G 450.4-1B provides a discussion on authorization protocols and authorization agreements and provides elementary information and guidance for consideration in the development of contractor ISMSs.

11.c. Describe the five core safety management functions in the ISM policy and discuss how they provide the necessary structure for work activities.

The five core safety management functions are

- define scope of work
- analyze hazards
- develop/implement hazard controls
- perform work
- perform feedback and improvement

Core Function 1: Define Scope of Work

DOE and the contractor identify and prioritize work and allocate resources. The contractor's role in this core function is generally to translate broad missions into specific work packages. DOE provides performance expectations by strategic plans, goals, and objectives, and through program execution guidance.

A well-defined scope of work is critical to the success of an ISMS because it:

- sets the stage for the scope and depth of hazards identification/analysis;
- is the foundation for the budget formulation/allocation process;
- is the primary factor in establishing expectations and accountability.

A fundamental objective of this core function is to identify the scope, schedule, and costs of activities necessary to achieve DOE missions and expectations in a safe and environmentally sound manner.

Core Function 2, Analyze Hazards

Section 9.3.1 of DOE P 411.1, Safety Management Functions, Responsibilities, and Authorities (FRAM) requires that the field element manager (FEM) ensure that the contractor's analysis covers the hazards associated with the work and is sufficient for selecting safety standards.

Section 9.3.1 also requires that the Office of Environment, Safety, and Health (EH) monitor and provide technical support on hazard identification and analysis activities as requested or directed by the Cognizant Secretarial Officer (CSO) to ensure that the standards are sufficient to facilitate selection of the appropriate safety standards. EH is also required to provide guidance for and interpretation of requirements for all DOE elements on hazard analyses.

Core Function 3, Develop/Implement Hazard Controls

The terms and conditions that define DOE safety expectations for its contractors are set forth as contract requirements. Department of Energy Acquisition Regulations (DEAR) 970.5204-2 requires the contractor to comply with the requirements of applicable federal, state, and local laws and regulations (including DOE regulations) in developing and implementing controls, unless the appropriate regulatory agency has granted relief in writing.

Core Function 3, Develop/Implement Hazard Controls (continued)

DOE has identified safety requirements in rules and DOE Orders and has developed a wide variety of associated technical standards, guides, and manuals. Additionally, DOE encourages the use of national consensus technical standards. In addition to complying with the requirements of applicable federal, state, and local laws and regulations (including DOE Regulations) in developing and implementing controls, as required by DEAR 970.5204-2(a) (list A), the contractor must comply with the requirements of applicable DOE directives appended to the contract. Environment, safety, and health (ES&H) requirements appropriate for work conducted by a contractor may be determined using a DOE-approved process to evaluate the work and the associated hazards and to identify an appropriately tailored set of standards, practices, and controls. When such a process is used, the set of tailored ES&H requirements must be reviewed for adequacy and approved by the contracting officer.

Core Function 4, Perform Work

DOE and the contractor identify and implement safety controls before starting work. Once work begins, it is performed according to those safety controls. Accordingly, each contractor's ISMS should have a process to confirm adequate preparation, including adequacy of controls before authorizing work to begin at the facility, project, or activity level. DEAR 970.5223-1(b)(7) requires that DOE and the contractor establish and agree on the conditions and requirements to be satisfied to initiate and conduct operations. These conditions and requirements are included in the contract and are therefore binding on the contractor. The formality and rigor of the review process and the extent of documentation and level of authority for agreement should be based on the hazard and complexity of the work being performed. The process should ensure programs

addressing all applicable functional areas are implemented adequately to support safe performance of the work.

Core Function 5, Perform Feedback and Improvement

Feedback and improvement complete the ISMS loop by connecting practical experiences of work conducted to planning for future work. The feedback and improvement function is intended to identify and correct processes or deviations that lead to unsafe or undesired work outcomes, confirm that the desired work outcomes were obtained safely, and provide managers and workers with information to improve the quality and safety of subsequent similar work.

Mechanisms that support these goals include worker and management observations, pre- and post-work review meetings, quality and safety issue resolution processes, issue tracking systems, performance indicators, lessons learned, internal and external assessments, operational and strategic planning, and a variety of other such activities. It is necessary for each of these mechanisms to use information from the others to derive maximum benefit from the feedback and improvement safety management function.

11.D. Identify and discuss existing Department programs and initiatives that lead to successful implementation of ISM, including:

- ***Standards/requirements identification documents (S/RIDS)***
- ***work smart standards (WSS) Contract reform and***
- ***performance-based contracting***

SRIDS

The concept of S/RIDs was developed by DOE's Offices of Defense Programs (DP) and Environmental Management (EM) in response to Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 90-2.

This recommendation, which was accepted by DOE, was that DOE should develop mechanisms for identifying which standards are applicable to the work, determining whether those standards are fully implemented, and determining whether the standards are appropriate and adequate to ensure protection of workers, the public, and the environment.

The original concept of S/RIDs as espoused by DP was a document that included all applicable Order requirements for which an exemption had not been granted, plus additional laws, regulations, and other standards necessary to ensure adequacy. EM's original concept was somewhat different. They believed from the beginning that many applicable Order requirements added little safety value for the types of work they did. In their concept, S/RIDs would result in selection of only those requirements that were important to a sound ES&H program.

By the time the S/RID Development and Approval Instruction was issued in September 1994, the S/RID concept had evolved considerably. An S/RID was defined as containing “the standards/requirements that are necessary and sufficient to provide an adequate level of protection of workers, the public, and the environment.”

The determination of selected standards was to be tailored to the work to be performed. “Judgments related to inclusion of requirements in S/RID will be based on the hazards present at the site, facility, or activity.” There was no longer any requirement to include all applicable DOE Order requirements. Justification for standards/requirements not chosen for inclusion was not required, although the instruction recommended that records of the rationale for not including Order requirements should be maintained until DP, EH, and EM could agree on a process for permitting them to be dropped without formal exemptions.

It is important to note that many of the S/RIDs prepared in the DOE complex were prepared before the final instruction was issued and followed earlier ground rules. In many cases, the completed S/RIDs included excessive requirements. Also, since the process was not specified in the instruction, some of the groups preparing S/RIDs used a formal and rigorous process, while others did not.

Similarities between S/RIDs and WSS Sets

S/RIDs and WSS sets are intended to achieve the same goals: to arrive at a mutually agreed upon set of ES&H and related standards that a contractor is contractually obligated to implement. The two concepts are really a single concept that represents maturing ideas and increased experience in standards management.

They include standards that are necessary and sufficient to protect the environment and the health and safety of workers and the public. They address hazards of the work performed.

Differences between S/RIDs and WSS Sets

S/RIDs are limited to activities conducted under DP and EM, while WSS are intended to apply to all departmental ES&H activities. However, Headquarters has stated that the WSS process cannot be applied to emergency management or occurrence reporting.

The S/RID instruction describes an end product, with little information on how to create that product. DOE M 450.3-1, Documentation for Work Smart Standards Applications: Characteristics and Considerations, which provides instructions for the development of WSS sets, does not describe the end product in any detail.

Instead, it provides assurance through a defined process that the set of standards is adequate for its intended use and has broad buy-in by the various groups performing, managing, overseeing, or otherwise involved in the work.

A WSS set for a specific scope of work replaces the S/RID for that scope of work. Any exceptions are identified in the WSS approval or in the contract modification incorporating the WSS set into the contract. Also, the WSS program is a refined and improved version of the S/RID program. New sets of standards for contractors developed after April 1996 will be developed using the WSS Closure Process.

Contract Reform and Performance-Based Contracting

In 1997, the Department published a final rule (Acquisition Regulations: Department of Energy Management and Operating Contracts, 62 FR 34842) that implemented a number of recommendations principally in areas relating to the acquisition processes of its management and operating contracts. One of these recommendations involved the adoption of performance-based contracting concepts. Since the beginning of its contract reform initiatives, the Department has tested a number of approaches to conform its use of fees to such concepts. A core consideration in the application of performance-based contracting concepts is the development of performance measures that are used to evaluate a contractor's accomplishments on either a subjective or objective basis, or both, and awarding a fee based on that performance.

11.E. Discuss the purpose, content, and application of DOE P 450.4, Safety Management System Policy.

Safety management systems provide a formal, organized process whereby people plan, perform, assess, and improve the safe conduct of work. The safety management system is institutionalized through DOE Directives and contracts to establish the Department-wide safety management objective, guiding principles, and functions.

The system encompasses all levels of activities and documentation related to safety management throughout the DOE complex. Throughout this policy statement, the term "safety" is used synonymously with ES&H to encompass protection of the public, the workers, and the environment.

The DOE safety management system establishes a hierarchy of components to facilitate the orderly development and implementation of safety management throughout the DOE complex. The safety management system consists of six components: objective, guiding principles, core functions, mechanisms, responsibilities, and implementation

The objective, guiding principles, and core functions of safety management shall be used consistently in implementing safety management throughout the DOE complex. The mechanisms, responsibilities, and implementation components are established for all work and will vary based on the nature and hazard of the work being performed.

11.F Discuss the relationship of DEAR Clause 970.5223-1, Integration of Environment, Safety, and Health into Work Planning and Execution, to the ISM process.

Sections (c) through (i) of this clause establish the foundation for ISMS. The following is an excerpt from the regulation.

The contractor shall manage and perform work according to a documented safety management system. Documentation of the system shall describe how the contractor will: define the scope of work, identify and analyze hazards associated with the work, develop and implement hazard controls, perform work within controls, provide feedback on adequacy of controls and continue to improve safety management.

The system shall describe how the contractor will establish, document, and implement safety performance objectives, performance measures, and commitments in response to DOE program and budget execution guidance while maintaining the integrity of the system. The system shall also describe how the contractor will measure system effectiveness.

The contractor shall comply with, and assist DOE in complying with, ES&H requirements of all applicable laws and regulations, and applicable directives identified in the clause of the contract entitled "Laws, Regulations, and DOE Directives." The contractor shall cooperate with federal and non-federal agencies having jurisdiction over ES&H matters under the contract. The contractor shall promptly evaluate and resolve any noncompliance with applicable ES&H requirements and the system.

If the contractor fails to provide resolution or if, at any time, the contractor's acts or failure to act causes substantial harm or an imminent danger to the environment or health and safety of employees or the public, the contracting officer may issue an order stopping work in whole or in part.

Any stop work order issued by a contracting officer under this clause shall be without prejudice to any other legal or contractual rights of the Government. In the event that the contracting officer issues a stop work order, an order authorizing the resumption of the work may be issued at the discretion of the contracting officer. The contractor shall not be entitled to an extension of time or additional fee or damages by reason of, or in connection with, any work stoppage ordered in accordance with this clause.

Regardless of the performer of the work, the contractor is responsible for compliance with the ES&H requirements applicable to the contract. The contractor is responsible for flowing down the ES&H requirements applicable to the contract to subcontracts at any tier to the extent necessary to ensure the contractor's compliance with the requirements. The contractor shall include a clause substantially the same as this clause in subcontracts involving complex or hazardous work on site at a DOE-owned or DOE-leased facility. Such subcontracts shall provide for the right to stop work under the conditions described in this clause. Depending on the

complexity and hazards associated with the work, the contractor may choose not to require the subcontractor to submit a safety management system for the contractor's review and approval.

Competency 11 - References/Additional Reading

DOE G 450, Integrated Safety Management System Guide

DEAR Clause 970.5223-1, Integration of Environment, Safety, and Health into Work Planning and Execution

Department of Energy Acquisition Regulations (DEAR) 970.5204-2,

DOE M 450.3-1, Documentation for Work Smart Standards Applications: Characteristics and Considerations

Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 90-2,

DOE P 450.4, Safety Management System Policy.

DOE P 411.1, Safety Management Functions, Responsibilities, and Authorities

Competency 12: Occupational Safety and Health Act

12. Describe DOE's responsibilities with respect to OSH Act, including the following:

- **hazard recognition and evaluation**
- **accident investigation**
- **hazard reduction/elimination**
- **job safety analysis**
- **accident/injury/illness prevention**
- **blood-borne pathogens**

Note: some of the above topics are not explicitly identified in the OSH Act nor in DOE Orders. This "supporting knowledge" will be corrected in the next revision of the General Technical Base Qualification Standard. This course provides instruction on these topics to the extent that they are relevant to DOE operations.

Background

Public Law 91-596, "Occupational Safety and Health Act of 1970" requires that the head of each Federal agency establish and maintain an effective and comprehensive occupational safety and health program including:

- providing safe and healthful places and conditions of employment
- acquiring, maintaining, and requiring the use of safety equipment, personal protective equipment, and devices reasonably necessary to protect employees;
- keeping adequate records of all occupational accidents and illnesses for proper evaluation and necessary corrective action;
- making an annual report to the Secretary with respect to occupational accidents and injuries and the agency's program

Section 4(b)(1) of the Occupational Safety and Health Act of 1970 (OSH Act) removes from OSHA's coverage working conditions for which another Federal agency (or State agency acting under the Atomic Energy Act) has prescribed or enforced safety and health regulations. This exemption is designed to prevent the duplication of Federal effort.

Most of the workers at DOE sites are employees of private-sector companies with which DOE contracts or subcontracts. Because DOE has chosen to prescribe its own safety and health requirements, the OSH Act would allow these private employers to be exempt from OSHA requirements. This was also the case with DOE's predecessor agencies, the Atomic Energy Commission and the Energy Research and Development Administration. However, DOE safety and health requirements invokes some OSHA regulations (although OSHA does not have enforcement authority over implementation of the regulations).

DOE's health and safety requirements are contained in DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees. In this Order DOE has specified that its contractors must meet two important OSHA regulations, i.e., 29 CFR 1910, and 29 CFR 1926. These are discussed in detail later in this course. Additional worker protection requirements, beyond those specified in 29 CFR 1910 and 1960 are also specified in DOE O 440.1A and other DOE policy and guidance documents (e.g., integrated safety management as specified in 48 CFR 970.5223 and DOE G 450.4-1B).

Hazard Recognition and Evaluation

OSHA has developed specific requirements to minimize hazards to workers. These requirements were developed based upon OSHA's assessment of common and important workplace hazards. However, OSHA does not include specific requirements for employers to perform hazard evaluations except in OSHA 29 CFR 1910.119, Process Safety Management for Highly Hazardous Chemicals. This requirement only applies to facilities which contain chemical types and quantities that are listed in the regulation. The quantities are typically very large in comparison to the amounts used at DOE facilities.

OSHA does have specific requirements in 29 CFR 1910.1200, Hazard Communication, for chemical manufactures and importers to assess the hazards of chemicals which they produce or import, and for all employers to provide information to their employees about the hazardous chemicals to which they are exposed, by means of a hazard communication program (these requirements are discussed in more detail later in this course)

DOE has developed its own hazards recognition and evaluation requirements that are more comprehensive than OSHA's and that contractors identify job hazards and perform hazard evaluations for all hazards as part of its integrated safety management system. The integrated safety management system is discussed in detail in Competency 11.

DOE has developed additional requirements (10 CFR 830) and guidance for evaluating hazards involved with the use of nuclear materials. These are discussed in Competency 19.

Accident Investigation

OSHA requires that accidents involving a fatality or the hospitalization of five or more employees be investigated to determine the causal factors involved. Typical accident investigation reports include the time, date, and location of the accident, along with a description of the operations at the workplace, a description of the accident itself, photographs, interview results, and additional information determined relevant by the investigator. Any information discovered during an accident investigation that would be of use in developing a new Occupational Safety and Health Administration (OSHA) standard or modifying/revoking an existing standard is transmitted to the Secretary of Labor.

DOE has an equivalent accident investigation process that is defined in DOE Order 225.1A, Accident Investigations.

Hazard Reduction and Elimination

OSHA does not provide specific requirements for hazard reduction and elimination. However good practices are to:

- Develop procedures to control the access to hazardous chemicals, materials, and activities by using engineering controls, work practices, and administrative controls that limit worker exposures.
- Implement interim protective measures, when required, based on risk assessments that indicate a danger to workers. In all cases the workers must be protected immediately from imminent dangerous conditions until final abatement of the hazard.
- Ensure potential hazards are addressed when selecting or purchasing equipment, products, and services to minimize the introduction of any new hazards and/or to prevent an increase in any existing hazardous condition.
- Track hazards to final abatement or disposition

Job Safety Analysis (JSA)

Neither OSHA nor DOE has requirements that specifically call out performing a “job safety analysis.”

However, OSHA has issued a booklet on performing job hazard analysis which provides guidelines for performing a step-by-step analysis.

Job hazard analysis includes:

- breaking down into its component parts any work method, process system, or work activity to determine the hazards therein and the requirements or qualifications for those who perform the work;
- identifying hazards associated with each step or task; and
- implementing adequate solutions to eliminate, nullify, or reduce the consequences of such hazards.

Furthermore, DOE has requirements for performing evaluating job hazards as part of its integrated management system. The ISM system includes the following core functions:

- Define scope of work
- Analyze the hazards
- Develop and implement controls
- Perform work within controls
- Provide feedback and improvement

Competency 11 discussed the ISM system in more detail.

Accident, Injury, and Illness Prevention

Accident/injury/illness prevention requires a proactive program to ensure that accidents, injuries, and illnesses do not occur or have an opportunity to occur. This includes the following components: Safety meetings and inspections, a lockout/tagout system, operational safety analysis, job safety analysis, protective equipment, hazard communication, occupational safety, industrial hygiene, electrical safety, radiation safety, explosives safety, environmental safety, construction safety, motor vehicle and pedestrian safety, and fire prevention.

OSHA regulates, with minimum standards, most of these safety topics using core sections within 29 CFR 1910.

DOE implements this OSHA requirement and provides additional requirements for each within its ISMS.

Blood-Borne Pathogens

Universal precautions are to be implemented to prevent contact with blood or other bodily fluids. This concept involves an approach to infection control in occupational settings to treat all human blood and certain bodily fluids as if they are known to be infectious for human immunodeficiency virus, hepatitis B virus, hepatitis C virus, and other blood-borne pathogens. Procedures should be developed that cover the following: engineering and work practice controls; contaminated equipment; PPE; Hepatitis B vaccination or exposure incident; and housekeeping, cleaning, and decontamination.

OSHA regulates blood borne pathogens in 29 CFR 1910.1030.

DOE regulates blood borne pathogens in DOE O 440.1A.

12.b. Using references, discuss the purpose of 29 CFR 1910, Occupational Safety and Health Standards, and 29 CFR 1960, Basic Program Elements for Federal Employee Occupational Safety and Health and Related Matters.

29 CFR 1910, Occupational Safety and Health Standards

Note: DOE O 440.1A requires DOE contractors to comply with 29 CFR 1910.

The purpose of 29 CFR 1910 is to provide standards for work place safety for the general industry. It contains several parts of particular applicability to DOE in oversight of contractor safety including:

Subpart D_Walking - Working Surfaces

- **1910.23** Guarding floor and wall openings and holes.
- **1910.27** Fixed ladders.

- **1910.28** Safety requirements for scaffolding.

Subpart E - Exit Routes, Emergency Action Plans, and Fire Prevention Plans

- **1910.38** Emergency action plans.
- **1910.39** Fire prevention plans.

1910 Subpart G - Occupational Health and Environment Control

- **1910.94** Ventilation.
- **1910.95** Occupational noise exposure.

1910 Subpart H - Hazardous Materials

- **1910.119** Process safety management of highly hazardous chemicals.
- **1910.120** Hazardous waste operations and emergency response.

1910 Subpart I - Personal Protective Equipment

1910 Subpart J - General Environmental Controls

- **1910.145** Specifications for accident prevention signs and tags.
- **1910.146** Permit-required confined spaces.
- **1910.147** The control of hazardous energy (lockout/tagout).

29 CFR 1960, Basic program elements for Federal employee occupational safety and health programs and related matters

This section contains special provisions to assure safe and healthful working conditions for federal employees. It is the responsibility of the head of each federal agency to establish and maintain an effective and comprehensive occupational safety and health program that is consistent with the standards promulgated under section 6 of the Act. The Secretary of Labor, under section 19 of the Act, is to report to the President certain evaluations and recommendations with respect to the programs of the various agencies.

Requirements include:

- **1960.9** Supervisory responsibilities.
- **1960.10** Employee responsibilities and rights.
- **1960.11** Evaluation of occupational safety and health performance.
- **1960.12** Dissemination of occupational safety and health program information.
- **1960.16** Compliance with OSHA standards.
- **1960.25** Qualifications of safety and health inspectors and agency inspections.
- **1960.26** Conduct of inspections.
- **1960.28** Employee reports of unsafe or unhealthful working conditions.

- **1960.29** Accident investigation.
- **1960.30** Abatement of unsafe or unhealthful working conditions.

Another important OSHA requirement identified in DOE O 440.1A that has wide applicability at DOE sites is 29 CFR, Part 1926, "Safety and Health Regulations for Construction."

12.c. Discuss the regulatory interfaces between the Occupational Safety and Health Administration and other regulatory agencies.

Occupational Safety and Health Administration standards must be incorporated into all federal agency health and safety programs. In addition to OSHA requirements, an agency may be required to comply with additional standards outside the OSHA realm. Although it is not anticipated that agency standards will conflict with OSHA standards, the Secretary of Labor must be notified when a conflict exists. Until the conflict is resolved, the affected agency is expected to comply with the most conservative of the standards.

12.c Discuss workplace inspection techniques.

OSHA inspections are guided by 29 CFR **1903, Inspections, Citations, and Proposed Penalties**. However OSHA does not perform inspections at DOE facilities. Rather assessments of worker health and safety programs and their implementation are primarily a responsibility of both the contractor and DOE management who are directing the work activity. Furthermore, DOE has an organization, the Office of Environment, Safety and Health Oversight within the Office of Independent Oversight and Performance Assurance that provides periodic assessment of worker safety programs.

The independent assessments (i.e., independent of line management) are typically performed every two years at higher hazard sites. The assessment occurs over about a two month period of time and includes scoping, planning, data collection and report writing.

The most intense part of the assessment is the data collection period where a team of about 10 inspectors evaluate the worker safety programs by evaluating the implementation of ISMS at the job task level. This involves evaluating workers as they perform work to determine whether work place hazards have been identified, as well as appropriate hazard controls and whether workers are effectively implementing the controls. In addition to evaluating ISMS at the job task level, assessment of management programs, feedback and improvement, and safety system functionality are typically performed during the independent assessments. The requirements for independent assessments are contained in DOE 470.2B, Independent Oversight and Performance Assurance Program.

12.d. Discuss the major components of the OSHA hazard communication protocol.

OSHA requirements for hazard communication are contained in 20 CFR 1910.1200. The purpose of this regulation is to ensure that the hazards of all chemicals produced or imported are evaluated, and that information concerning their hazards is transmitted to employers and employees. This transmittal of information is to be accomplished by means of comprehensive hazard communication programs, which are to include container labeling and other forms of warning, material safety data sheets and employee training.

Major components of hazard communication include:

- identifying and evaluating a hazardous chemical
- maintaining an inventory or list of hazardous chemicals and locations
- labeling of containers of chemicals with the following minimal information:
 - identifying the hazardous chemical
 - issuing appropriate hazard warnings
 - providing the name and address of the chemical manufacturer, importer, or other responsible party

- preparing and distributing material safety data sheets to employees and downstream employers
- developing and implementing employee training programs regarding hazards of chemicals and protective measures
- guiding the acquisition of hazardous chemicals
- guiding the transportation of hazardous materials
- guiding the handling, use, and storage of hazardous chemicals
- conducting surveillances

References/Additional Information

OSHA 29 CFR 1910.119. Process Safety Management for Highly Hazardous Chemicals

DOE Order 225.1A, Accident Investigations

29 CFR 1910.1030, Blood Borne pathogens

29 CFR 1910, Occupational Safety and Health Standards

29 CFR 1960, Basic Program Elements for Federal Employee Occupational Safety and Health and Related Matters.

29 CFR 1926, Safety and Health Regulations for Construction

DOE O 440.1A, Worker Protection Management for DOE Federal and Contractor Employees

DOE 470.2B, Independent Oversight and Performance Assurance Program.

DOE G 450.4-1B, Integrated Safety Management System Guide

48 CFR 970.5223, Integration of environment, safety, and health into work planning and execution

Competency 13: Fire Safety

13. Personnel shall demonstrate a familiarity level knowledge of Fire Safety for Department facilities necessary to identify safe/unsafe work practices.

Background

“Fire protection” is a broad term that encompasses all aspects of fire safety, including building construction and fixed building fire features, fire suppression and detection systems, fire water systems, emergency process safety control systems, emergency fire fighting organizations (fire departments, fire brigades, etc.), fire protection engineering, and fire prevention. Fire protection is concerned with preventing or minimizing the direct and indirect consequences of fire. It also includes aspects of the following perils as they relate to fire protection: explosion, natural phenomenon, and smoke and water damage from fire. Information from the fire protection program shall be incorporated in the emergency plan. The facility fire protection organization shall be involved in developing the emergency plan and in all related training and drills.



The objectives of DOE fire protection program are to:

- Minimize the potential for the occurrence of a fire or related event;
- Ensure that a fire does not cause an unacceptable on-site or off-site release of hazardous or radiological material that will threaten the health and safety of employees, the public, or the environment;
- Establish requirements that will provide an acceptable degree of life safety to DOE and contract employees
- Ensure vital DOE programs will not suffer unacceptable interruptions as a result of fire and related hazards
- Ensure property losses from a fire and related events will not exceed defined limits established by DOE; and

- Ensure critical process controls and safety class systems are not damaged as a result of a fire and related events.

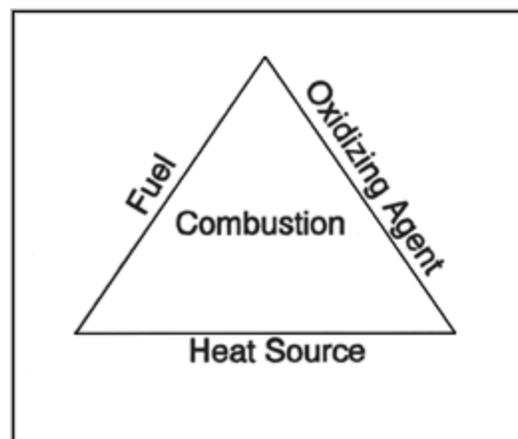
DOE Order 420.1A, Worker Safety, and 440.1A Worker Protection Management for DOE Federal and Contractor Employees, provide requirements for fire protection programs at DOE sites.

13.a Discuss the critical aspects of fire prevention, emergency planning, and control of fires.

Fire Prevention

Critical aspects of fire prevention include limiting combustibles, proper design and maintenance of system (e.g., electrical systems), ensuring proper hot work permits are obtained and followed, and establishing fire watches when needed for certain type of work activities.

Three factors are needed to support and continue fire: fuel, air (or oxidizing agent), and sufficient high temperature. This is known as the fire triangle. Removing any of these factors will prevent (or put out) the fire. Note: This is a simplified model of fires. The tetrahedron model of fire is a more recent and complex model that includes a fourth essential element of fire: the sustaining chemical reaction.



Fire Triangle

Emergency Planning

Critical aspects of emergency planning include determining fire response needs (response equipment, alarm and communication, personnel, and response times); establishing and maintaining the resources and equipment, and training and drilling response personnel as well as workers.

DOE requires that “pre-fire plans” be developed so that fire department and facility personnel can exchange critical information that can be used to mitigate an emergency situation including information on:

- Building occupancy, type of construction, and contents (e.g., hazardous materials)
- On-site fire protection features including water supply
- Access
- Interagency assistance

Control of Fires

Critical aspects of control of fires include fire suppression systems and training of employees and fire response personnel.

Fire suppression systems are categorized as water-based, gaseous, or dry-chemical systems

- Water based: Automatic sprinkler, fixed water spray, and foam-water systems
- Gaseous: Carbon Dioxide, Halon, or Halon replacement agents (“clean agents”)
- Dry Chemical: Variety of agents based upon material to be extinguished

13.b Describe fire hazards that could affect the safety of facility personnel

A fire hazard exists any time you have the combination of a heat energy source, combustible material (fuel), and available oxygen. Pyrophoric materials such as very finely divided uranium or plutonium may ignite upon exposure to air. Other combustible materials can be fire hazards in a facility and thus require controls such as maximum allowed quantities and proper storage locations. Electrical fires can occur due to excessive loading of circuits and poorly maintained electrical/electronic equipment.

In 1997 a fatality occurred at a DOE site when a worker’s anti-contamination clothing caught on fire when sparks from welding landing on the clothing.

13.c Discuss the key elements of the National Fire Protection Association (NFPA) Life Safety Code.

One of the fundamental principles of fire protection is that structures be designed so that the occupants of the building can safely escape during a fire event. NFPA 101 provides consensus “life safety” standards for fire protection that DOE has adopted for its buildings.

The NFPA Life Safety Code (NFPA 101):

- Addresses life safety from fire and similar emergencies.
- Addresses those construction, protection, and occupancy features necessary to minimize danger to life from fire, smoke, fumes, or panic.
- Identifies the minimum criteria for the design of egress facilities so as to permit prompt escape of occupants from buildings or, where desirable, into safe areas within the building.
- Recognizes that life safety is more than a matter of egress and, accordingly, deals with other considerations that are essential to life safety.

Fundamental Requirements

The fundamental requirements, quoted below, are the key elements that are further elaborated upon for specific building occupancy types later in the Code:

- Every building or structure, new or old, designed for human occupancy shall be provided with exits and other safeguards sufficient to permit the prompt escape of occupants or furnish other means to provide a reasonable degree of safety for occupants in case of fire or other emergency. The design of exits and other safeguards shall be such that reliance for safety to life in case of fire or other emergency will not depend solely on any single safeguard; additional safeguards shall be provided for life safety in case any single safeguard is ineffective due to some human or mechanical failure.
- Every building or structure shall be so constructed, arranged, equipped, maintained, and operated as to avoid undue danger to the lives and safety of its occupants from fire, smoke, fumes, or resulting panic during the period of time reasonably necessary for escape from the building or structure or for that period of time needed to defend in place in case of fire or other emergency.
- Every building or structure shall be provided with exits and other safeguards of kinds, numbers, locations, and capacities appropriate to the individual building or structure, with due regard to the character of the occupancy, the capabilities of the occupants, the number of persons exposed, the fire protection available, the height and type of construction of the building or structure, and other factors necessary to provide all occupants with a reasonable degree of safety.

- In every building or structure, exits shall be so arranged and maintained as to provide free and unobstructed egress from all parts of the building or structure at all times when it is occupied. No lock or fastening shall be installed to prevent free escape from the inside of any building. Exits shall be accessible to the extent necessary to assure reasonable safety for occupants having impaired mobility.
- Every exit shall be clearly visible, or the route to reach every exit shall be conspicuously indicated in such a manner that every occupant of every building or structure who is physically and mentally capable will readily know the direction of escape from any point. Each means of egress, in its entirety, shall be so arranged or marked that the way to a place of safety is indicated in a clear manner. Any doorway or passageway that is not an exit or a way to reach an exit, but is capable of being confused with an exit shall be so arranged or marked to prevent occupant confusion with acceptable exits. Every effort shall be taken to avoid occupants mistakenly traveling into dead-end spaces in a fire emergency.
- Where artificial illumination is required in a building or structure, exit facilities shall be included in the lighting design in an adequate and reliable manner.
- In every building or structure of such size, arrangement, or occupancy that a fire itself may not provide adequate occupant warning, fire alarm facilities shall be provided where necessary to warn occupants of the existence of fire. Fire alarms will alert occupants to initiate emergency procedures. Fire alarms facilitate the orderly conduct of fire exit drills.
- Two means of egress, as a minimum, shall be provided in every building or structure, section, and area where their size, occupancy, and arrangement endanger occupants attempting to use a single means of egress that is blocked by fire or smoke. The two means of egress shall be arranged to minimize the possibility that both may be rendered impassable by the same fire or emergency condition.
- Every vertical way of exit and other vertical opening between floors of a building shall be suitably enclosed or protected, as necessary, to afford reasonable safety to occupants while using exits and to prevent spread of fire, smoke, or fumes through vertical openings from floor to floor before occupants have entered exits.
- Compliance with the Code shall not be construed as eliminating or reducing the necessity for other provisions for safety of persons using a structure under normal occupancy conditions. Also, no provision of the Code shall be construed as requiring or permitting any condition that may be hazardous under normal occupancy conditions.

12.d. Discuss the purpose of fire hazard analysis.

The purpose of a fire hazards analysis (FHA) is to comprehensively assess the risk from fire within individual fire areas in a DOE facility in relation to existing or proposed fire protection to determine if the objectives of DOE Orders are met. The FHA is developed using a graded

approach, and is incorporated into the facility's safety analysis report (SAR), design-basis, and beyond-design-basis accident conditions.

A FHA includes an evaluation of:

The combustibles within a given fire area (e.g., combustible liquids, plastics, wood structures)

and

Potential ignition sources (e.g., electrical equipment, heat generated by friction, heated equipment)

Fire hazards are controlled by minimizing and segregating the hazards so that potential fires are limited to a manageable magnitude.

DOE requirements for a FHA are contained in DOE O 420.1A. An example FHA can be found at the DOE fire protection web site (<http://www.eh.doe.gov/fire/>)

13.e. Describe the characteristics and methods/agents used to extinguish the following classes of fires:

- 1. Class A**
- 2. Class B**
- 3. Class C**
- 4. Class D**

Background

Fires can be extinguished by four basic methods:

- Physically separating the combustible substance from the flame
- Removing or diluting the oxygen supply
- Reducing the temperature of the combustible or the flame
- Introducing chemicals that modify the combustion chemistry

Class A

These are fires involving combustibles such as wood, paper, cloth, etc. These fires are typically extinguished with water or a dry chemical fire extinguisher. Halon is also effective. Carbon dioxide may also be used but is only effective for small fires.



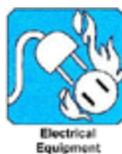
Class B

These are fires involving liquids (e.g., lubricating oil, fuel oil, diesel fuel, gasoline, kerosene, etc.). These fires are extinguished with a foaming agent, a chemical agent such as PKP, or a dry chemical fire extinguisher. A water fog is marginally effective if applied properly. Halon can be effective also.



Class C

These are fires involving electrical circuits. The circuit must be de-energized to remove the heat source. Carbon dioxide and halon are the principal extinguishing agents. Water is not used due to the associated shock hazard if the circuits are energized. Chemical agents are also not recommended due to their corrosive nature, although a dry chemical fire extinguisher would be effective against a class C fire.



Class D

These are fires involving burning metal (e.g., plutonium, magnesium, sodium, lithium, etc.). These fires are typically extinguished using an inert smothering agent such as magnesium oxide, sand, or a dry powder fire extinguisher. Metallic fires burn at the surface, are very hot, and are extremely hard to put out because of the extreme heats that are produced. Plutonium will continue burning in relatively low oxygen concentration environments once the process gets started.



13.f. Discuss the key components and use of building fire protection equipment, including detection, alarm, communication, and extinguishing systems (automatic and manual).

Key components of fire protection equipment include detection, alarm, communication, and manual/automatic extinguishing systems.

Fire protection consists of a comprehensive system of defense against the fire hazard for the benefit of personnel and the facility. It starts with good fire prevention practices (good housekeeping, proper storage of flammable materials, minimizing combustible loading, etc.) and facility design (use of fire walls, fire doors in glove box lines, sprinkler and other suppression systems, avoidance of layouts that promote updrafts, etc.). Next comes the use of fire detection systems as close to the potential sources as possible (e.g., storage trays equipped with heat detection in the glove boxes, temperature probes in the ventilation ducting before reaching the plenums, trained operators, etc.). Detection systems are used to drive alarms to warn personnel and alert fire department personnel, and to activate automatic fire suppression systems.

Communication systems enable operating personnel to quickly notify the fire department and other facility personnel of a fire condition through the use of pull-stations and/or sound-powered phones, with direct lines to the fire department, at or close to operating stations. Fire suppression (extinguishing) systems include sprinkler systems, plenum deluge systems, halon discharge systems, and carbon dioxide discharge systems that activate either automatically or manually. Portable extinguishers are installed throughout the facility to enable trained personnel to take immediate action to control a small fire before it spreads into a larger one, until the fire department can arrive. A supervisory alarm system is also used to detect faults in the system. Periodic surveillance testing ensures that fire panels and detectors are continuously operable.

Competency 13 - References/Additional Reading

DOE O 420.1A, Facility Safety

DOE Order 440.1A, Worker Protection Management for Federal and Contractor Employees

DOE-STD-1066-99, Fire Protection Design Criteria

DOE-STD-1088 Fire Protection for Relocatable Structures

DOE-HDBK-1062 DOE Fire Protection Handbook

DOE-HDBK-1081 Primer on Spontaneous Heating and Pyrophoricity

EH2TEC/04-97/01AI, Type A Accident Investigation Board Report of the February 13, 1997
Welding/Cutting Fatality at the K-33 Building, K-25 Site Oak Ridge, Tennessee

Competency 14: Industrial Hygiene

14. Personnel shall demonstrate a familiarity level knowledge of industrial hygiene principles.

Several additional supporting knowledge and skills useful in meeting this competency (beyond those identified in the qualification standard) were included in this course. The following is the complete list (the items in *italics* are the skills and knowledge from the 2001 qualification standard).

- Define industrial hygiene (IH)
- Discuss basic IH concepts and terminology
- Discuss key elements of an IH program
- Discuss IH requirements
- *Discuss the key elements of a hazards communication program and the use of material safety data sheets (MSDS).*
- *Discuss the importance and types of equipment used for personnel protection and safety.*
- *Define a carcinogen and provide examples of carcinogens.*
- *Discuss the key elements of a carcinogen control program, including specifically carcinogenic chemicals and asbestos control*
- *Discuss the importance of facility sanitation and housekeeping programs.*

Note: Only the skills and knowledge identified in the qualification standard are shown as numbered sections (e.g., “14.a” or “14.b”) below.

Define Industrial Hygiene

Industrial hygiene is the science of anticipating, recognizing, evaluating, and controlling workplace conditions that may cause workers' injury or illness. Industrial hygienists use environmental monitoring and analytical methods to detect the extent of worker exposure and employ engineering, work practice controls, and other methods to control potential health hazards.

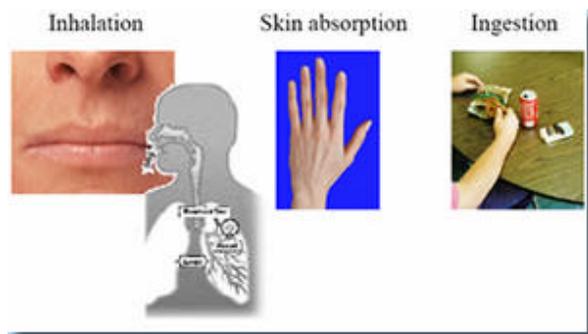




Discuss basic Industrial Hygiene concepts and terminology:

Routes of exposure

There are four basic routes of exposure; inhalation, ingestion, absorption through the skin, injection. The inhalation route is uptake through the pulmonary system and is usually the greatest concern regardless the form of the hazard. Ingestion is usually a minor route involving the gastrointestinal (GI) tract uptake by eating or swallowing contaminated food. Skin absorption is uptake through the skin. Some materials will readily penetrate the skin barrier or through cuts or abrasions. Injection can be via a needle or via a contaminate located on a broken piece of glass that penetrates the skin as examples.



Dose and toxicity

- Dose is determined by exposure to a given concentration of a substance for a given period of time.
- Toxicity of a substance is determined by the effect on the body.
- Hazard is determined by the toxicity, dose and susceptibility of the individual.
- Acute exposure is defined as short term, one time event.
- Chronic exposure is the continual, repeated, ongoing event.
- The degree of hazard is a function of chemical compound or type of energy and its toxicity or action on the body; the rate or intensity of exposure; duration of exposure; and the susceptibility of the person.

Exposure limits

- **Threshold Limit Value-TLV** American Conference of Governmental Industrial Hygienists version of occupational health exposure standard. The concentration to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.
- **Permissible Exposure Limit-PEL** An exposure limit that is published and enforced by the Occupational Safety and Health Administration (OSHA) as a legal standard.
- **Time Weighted Average-TWA** The average exposure measured over a given period of time (e.g., an entire working shift)
- **Short Term Exposure Limit-STEEL** The concentration to which workers can be exposed continuously for a short period of time.
- **Ceiling Limit-** The concentration that should not be exceeded during any part of the working exposure
- **Action Level-** An administrative control limit set below the PEL (usually one-half)
- **ppm-**parts per million
- **mg/m³-**milligram per cubic meter of air

Hierarchy of controls

The following is the hierarchy of controls (primary, secondary, etc)

- Engineering controls include eliminating toxic chemicals and replacing toxic materials with less hazardous, enclosing work processes or confining work operations, and installing general and local ventilation system.
- Work practice controls alter the manner in which a task is performed such as following proper procedures that minimize exposures, inspecting and maintaining equipment, good housekeeping procedures etc.
- Administrative controls include controlling employees' exposure by scheduling production and workers' tasks or both in ways that minimize exposure levels such as scheduling the highest exposure potential operations during periods when the fewest employees are present.

Personal Protective Equipment

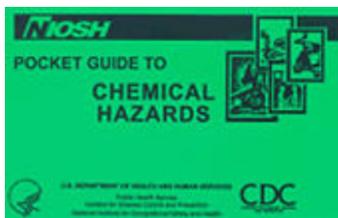
When effective work practices and/or engineering controls are not feasible to achieve the PEL, or while such controls are being instituted, and in emergencies, appropriate PPE (i.e. respiratory equipment) must be used.



Health hazards

Air contaminants are classified as either particulate, gas or vapor contaminants. Particulate contaminants include dusts, fumes, mists aerosols and fibers. Gases are formless fluids that expand to occupy the space or enclosure in which they are confined. Vapors are the volatile form of substances that are normally in a solid or liquid state at room temperature and pressure.

Harmful chemical compounds in the form of solids, liquids, gases, mists, dusts, fumes and vapors exert toxic effects by inhalation (breathing), absorption (through direct contact with the skin), or ingestion (eating or drinking).



- Biological hazards include bacteria, viruses, fungi, and other living organisms that can cause acute and chronic infections by entering the body either directly or through breaks in the skin.
- Physical hazards include non-ionizing and electromagnetic radiation (laser and microwave), noise, vibration, illumination, and temperature.
- Ergonomic hazards or conditions such as excessive vibration and noise, eye strain, repetitive motion and heavy lifting problems are caused by poorly designed job tasks.



Discuss the key elements of an Industrial Hygiene Program

Exposure Assessment and Monitoring

This element is used to identify air contaminants; estimate employee exposures; characterize an environment generally; identify and quantify emission sources; check the effectiveness of emission and exposure controls; and check for compliance with standards.



Housekeeping

Actions to be taken such as wet mopping or vacuuming to lower the exposure potential in an environment known to have exposure potential above federal limits as in asbestos and lead abatement operations.

Engineering Controls

These types of controls (process change, substitution, isolation, ventilation, source modification) depend on regulatory requirements (some operations require specific controls like local exhaust ventilation), the nature of the hazard and the way it effects the employee like the route of entry to the body for chemicals hazards.

Respiratory Protection

When environmental, administrative and engineering controls are not available, appropriate respirators may be used to provide employee protection. Respirators may be used in environments in which the atmospheric conditions (chemical concentrations) are immediately dangerous to life and health (IDLH) and those which are not. Respiratory protection programs

should be administered by a qualified individual and prescribe the type of respiratory protection (NISOH / MSHA certified) required for each assessed hazard.



Labeling

Signs which alert employees of the presence of a hazardous chemical or environment, precautions to be taken, and entry requirements posted at all entrances to regulated areas.

Training Requirements

Material, guidelines, and instructions that provide basic knowledge of the hazards of the material or process, potential health risks, available employee protection, and proper use of controls.

Medical Surveillance

The systematic collection, analysis, and evaluation of health data to identify disease cases, patterns, or trends suggesting adverse health effects and the need for further investigation, evaluation, and/or remedial action.

Recordkeeping

Establish and maintain accurate records of all hazards inventory information, hazard assessments, exposure measurements, exposure controls and medical surveillance.

Discuss Industrial Hygiene Requirements

DOE Order 440.1A, Worker Protection Management for Federal and Contractor Employees

This Order establishes the framework for an effective worker protection program that will reduce or prevent injuries, illnesses, and accidental losses by providing DOE Federal and contractor workers with a safe and healthful workplace. In addition, this includes implementing a comprehensive and effective industrial hygiene program to reduce the risk of work-related disease or illness.

DOE Notice 450.7, The Safe Handling, Transfer, and Receipt of Biological Etiologic Agents at Department of Energy Facilities

The purpose of this notice was to ensure that work involving etiologic or potentially biological etiologic agents, including biological select agents, occurs in a safe, secure, and effective manner that protects workers, the public, and the environment.

The Notice requires compliance with regulations such as 42 CFR 72 and 73, and 29 CFR 1910.1030, as well as adoption of best practices such as CDC Publication No. 93-8395, Biosafety in Microbiological and Biomedical Laboratories; and the NIH publication Guidelines for Research Involving Recombinant DNA Molecules; including Laboratory Registration/Select Agent Program registration application package requesting registration of a laboratory facility at Biosafety Level 2, 3, or 4, for the purpose of transferring, receiving, or handling biological select agent(s).

10 CFR 850, Chronic Beryllium Disease Prevention Program (CBDPP)

The CBDPP must specify the existing and planned operational tasks that are within the scope and include formal plans and measures for maintaining exposures to beryllium at or below the permissible exposure level and contain provisions for minimizing the opportunities for exposure and number of workers exposed and potentially exposed to beryllium.

10 CFR 851, Worker Safety and Health Program; Proposed Rule

Specifies safety and health requirements that a contractor responsible for a covered workplace must implement through a worker safety and health program and Procedures for investigating whether a violation of a requirement has occurred, for determining the nature and extent of any such violation, and for imposing an appropriate remedy. Note: this is a only a proposed rule as of October 2005.

OSHA 29 CFR 1910 & 1926

DOE Order 440.1A incorporates OSHA 29 CFR 1910 (which specifies General Industry operation standards) & 29 CFR 1926 (which specifies Construction Industry operation standards). Key Industrial Hygiene standards in 1910 are found in Subpart G—Occupational Health and Environmental Control and Subpart Z—Toxic and Hazardous Substances which includes the Hazard Communication standard.

ACGIH

The American Conference of Governmental Industrial Hygienists (ACGIH®) is a member-based organization and community of professionals that advances worker health and safety through education and the development and dissemination of scientific and technical knowledge. Examples of this include annual editions of the **TLVs® and BEIs®** and work practice guides in ACGIH®'s **Signature Publications**. DOE Order 440.1A incorporates the TLVs.

14.a. Discuss the key elements of a hazards communication program and the use of material safety data sheets (MSDS).

The purpose of a hazards communication program is to ensure that employees are properly informed about chemical hazards in the workplace. This is accomplished by maintaining lists of hazardous chemicals site-wide, by using MSDSs in the workplace, by properly labeling chemical containers, and by training.

MSDSs are required by the Occupational Safety and Health Administration's hazards communication standard. They provide information concerning chemical hazards and control measures necessary to ensure a safe work environment when working with specific materials. Copies of MSDSs are maintained in binders in each workplace. A master file of all MSDSs in use site wide is maintained by industrial hygiene personnel.

Each MSDS must be in English and contain at least the following information:

- Manufacturer's information - name, address, and telephone number of the chemical manufacturer, importer, or other responsible party who can provide additional information on the hazardous chemical
- Hazardous ingredients/identity information - the chemical and common name(s) of the ingredient(s) that contribute to the known hazards and the common name(s) of the mixture itself
- Physical/chemical characteristics of the material - such as liquid, solid, or gas; color; corrosivity; and reactivity
- Fire and explosion hazard information - such as vapor pressure and flash point
- The primary route(s) of entry into the body

- Health hazard data - the health hazards of the hazardous chemical, including signs and symptoms of exposure, and any medical conditions that are recognized as being aggravated by exposure to the chemical
- The OSHA permissible exposure limit, American Conference of Governmental Industrial Hygienist's threshold limit value, and any other exposure limit used or recommended by the chemical manufacturer, importer, or employer preparing the MSDS
- Whether the hazardous chemical is carcinogenic or potentially carcinogenic based on various reports
- Precautions for safe handling and use - any generally applicable precautions for safe handling and use that are known, including appropriate hygienic practices, protective measures during repair and maintenance of contaminated equipment, and procedures for clean-up of spills and leaks
- Emergency and first aid procedures

- Control measures - any generally applicable control measures that are known, such as appropriate engineering controls, work practices, or personal protective equipment
- Date of preparation of the MSDS

Some information from an MSDS is transcribed to a hazard-warning label. All containers with hazardous chemicals must be labeled. Typically, the label is provided by the manufacturer. If for some reason a container doesn't have a manufacturer's warning label, one will be affixed locally.

Example MSDS

XEROX	Material Safety Data Sheet	MSDS No: A-0057B
		Date: 9/22/86
		Revision: 11/13/00
Manufacturer: Xerox Corporation Rochester, NY 14644	Telephone # (s):	<i>Safety Information: (800) 828-0571</i> <i>Health Emergency: (710) 422-2177</i> <i>Transportation Emergency (Chemical): (800) 424-9300</i>
Section I - Product Identification		
Trade Names/Synonyms:	1065/4235/5046/5047/5065/5335/5365/ 5365 SE/Document Centre System 35/ Class III / Class IV Black Dry Ink	Part No.: WH: 6R135, 6R229, 6R271, 6R311*, 6R452, 6R804, 106R2 XCI: 6R517, 6R518*, 6R523* XL: 6R90098, 6R90147, 502862479 NVY: CL3P6R459, CL4P6R452, CL336R459, CL466R452, CL366R459, CL436R452 *Carotinal
Chemical Name:	None	
WHMIS Status:	This is not a WHMIS controlled product.	
	Ingredients (% by wt.)	CAS No.
	Styrene/butadiene copolymer (75-80%)	9003-55-8
	Iron oxide (15-20%)	1309-37-1
	Carbon black (<3%)	1333-86-4
	Quaternary ammonium salt (<2%)	3843-16-1
Section II - Emergency and First Aid		
Primary Route of Entry: Inhalation Eyes: Flush with water. Skin: Wash with soap and water. Inhalation: Remove from exposure. Ingestion: Dilute stomach contents with several glasses of water.	Symptoms of Overexposure: Minimal respiratory tract irritation may occur as with exposure to large amounts of any non-toxic dust. Medical Conditions Generally Aggravated by Exposure: None when used as described by product literature. Additional Information: None.	
Section III - Toxicology and Health Information		
<i>This material has been evaluated by Xerox Corporation. The toxicity data noted below is based on test results of similar xerographic materials.</i>		
Oral LD₅₀:	>10 g/kg (rats) practically non-toxic.	TLV: 10 mg/m ³ (total dust)
Dermal LD₅₀:	>2 g/kg (rabbits) practically non-toxic.	PEL: 15 mg/m ³ (total dust)
Inhalation LC₅₀:	>5 mg/l (rats, 4 hr exposure) practically non-toxic. >20 mg/l (calculated 1 hr exposure) non-poisonous, DOT.	5 mg/m ³ (respirable dust)
Eye Irritation:	Not an irritant.	STEL: N.E.
Skin Sensitization:	Not a sensitizer.	CEILING: N.E.
Skin Irritation:	Not an irritant.	XEL¹: 2.5 mg/m ³ (total dust) 0.4 mg/m ³ (respirable dust)
Human Patch:	Non-irritating, non-sensitizing.	
Mutagenicity:	No mutagenicity detected in Ames, Micronucleus, CHO/HGPRT, and Yeast Mating Recombination Assays.	
Cardiogens:	None present.	
Aquatic LC₅₀:	>1000 mg/l (fathead minnows) non-toxic.	
Additional Information: The results obtained from a Xerox sponsored Chronic Toner Inhalation Study, demonstrated no lung change in rats for the lowest (1mg/m ³) exposure level (i.e. the level most relevant to potential human exposure). A very slight degree of fibrosis was noted in 25% of the animals at the middle (4mg/m ³) exposure level, while a slight degree of fibrosis was noted in all the animals at the highest (16 mg/m ³) exposure level. These findings are attributed to "lung overloading", a generic response to excessive amounts of any dust retained in the lungs for a prolonged period. This study was conducted using a special test toner to comply with EPA testing protocol. The test toner was ten times more respirable than commercially available Xerox toner, and would not be functionally suitable for Xerox equipment.		
¹ N.E. - Not an Established Exposure Limit N.A. - Not Applicable N.E. - None Established N.D. - Not Determined		

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Xerox **Trade Name:** 1065/4235/5046/5047/5065/5335/5365/5365 SE/ Document Centre System 35/Class III/ Class IV Black Dry Ink **MSDS No.:** A-0057B

Section IV - Physical Data

Appearance/Odor:	Black powder / faint odor	Softening Range:	85°C to 100°C
Boiling Point:	N.A.	Melting Point:	N.A.
Solubility in Water:	Negligible	Specific Gravity (H₂O=1):	1
Evaporation Rate:	N.A.	Vapor Pressure (mm Hg):	N.A.
Vapor Density (Air=1):	N.A.	pH:	N.A.
Volatile:	N.A. % (Wt) N.A. % (Vol.)		

Section V - Fire and Explosion Data

Flash Point (Method Used): N.A.
Flammable Limits: LEL: N.A., UEL: N.A.
NFPA 704: Health - 0, Fire - 3, Reactivity - 0
Extinguishing Media: Water, dry chemical, carbon dioxide or foam.
Special Fire Fighting Procedures: Avoid inhalation of smoke. Wear protective clothing and self-contained breathing apparatus.
Fire and Explosion Hazards: Toner is a combustible powder. Like most organic materials in powder form, it can form explosive mixtures when dispersed in air.

Section VI - Reactivity Data

Stability: Stable
Hazardous Polymerization: Will Not Occur
Hazardous Decomposition Products: Products of combustion may be toxic. Avoid breathing smoke.
Incompatibility (Materials to Avoid): None known

Section VII - Special Protection Information

Respiratory Protection: None required when used as intended in Xerox equipment.
Eye Protection: None required when used as intended in Xerox equipment.
Protective Gloves: None required when used as intended in Xerox equipment.
Other: For use other than normal customer - operating procedures (such as in bulk toner processing facilities), goggles and respirators may be required. For more information, contact Xerox.

Section VIII - Special Precautions

Handling and Storage: None
Conditions to Avoid: Avoid prolonged inhalation of excessive dust.

Section IX - Spill, Leak, and Disposal Procedures

For Spills or Leakage: Sweep up or vacuum spilled toner and carefully transfer into sealable waste container. Sweep slowly to minimize generation of dust during clean-up. If a vacuum is used, the motor must be rated as dust tight. A conductive hose bonded to the machine should be used to reduce static buildup (See Section V). Residue can be removed with soap and cold water. Garments may be washed or dry cleaned, after removal of loose toner.
Waste Disposal Method: This material is not a hazardous waste according to Federal Regulation 40 CFR 261 when disposed. State and Local requirements however, may be more restrictive. Consult with the appropriate State and Local waste disposal authorities for additional information. Incinerate only in a closed container.

Section X - Transportation Information

DOT Proper Shipping Name: N.A. (Not Regulated) **ID Number:** N.A.
Hazard Classification: N.A. **Packing Group:** N.A.

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14.b. Define a carcinogen and provide examples of carcinogens.

A carcinogen is any material that, based on scientifically evaluated evidence, can cause cancer in man or animals. Epidemiological and toxicological studies, case histories from clinical records, and studies of chemical structure are used by government agencies to evaluate the carcinogenic potentials of materials. Examples of carcinogens are arsenic, asbestos, benzene, carbon tetrachloride, formaldehyde, and vinyl chloride.

14.c. Discuss the key elements of a carcinogen control program, including specifically carcinogenic chemicals and asbestos control.

The carcinogen/asbestos control program establishes the requirements to identify, evaluate, and control occupational exposures to chemical carcinogens. The program is designed to maintain occupational exposure as low as reasonably achievable. Key elements of the program include

- An occupational safety analysis must be written describing the use of a carcinogen, the procedures controlling its use, and emergency actions for all regulated areas.
- Regulated areas must be established where carcinogens are used.
- Records must be maintained for all personnel working in regulated areas. The records become part of the employee's medical file.
- Signs warning of the presence of carcinogens must be posted at all entrances to regulated areas.
- Inventories of carcinogens shall be maintained and reviewed periodically.
- Employees must be trained to work with carcinogens

14.d Discuss the importance of facility sanitation and housekeeping programs.

One of the purposes of a housekeeping program is to limit a facility's combustible loading to prevent the occurrence of a facility fire or at least mitigate the consequences of a fire. Good housekeeping practices are also important in reducing trip-and-fall hazards, reducing airborne dust and other potential respiratory irritants, and reducing the hazard from falling objects. Sanitation is important because it can affect the health of employees. In an unsanitary facility, the potential for the spread of disease is significantly increased.

14.e. Discuss the importance and types of equipment used for personnel protection and safety, including:

- **Eye protection**
- **Foot protection**
- **Ear protection**
- **Protective clothing**
- **Head protection**
- **Respiratory protection**

Eye Protection

Eye and face protection requirements for work activities are determined by the job supervisor with assistance from occupational safety and industrial hygiene personnel. All personnel are required to obey posted eye protection requirements.

- Class I. Safety glasses that meet the requirements of ANSI Standard Z87, American National Standard Practice for Occupational and Educational Eye and Face Protection, and provide basic protection against impact particles and innocuous sprays are class I. Glasses and frames with side shields are the most common eye protection.
- Class II. Class II provides additional eye and face protection from impact particles. Class II protection consists of safety glasses with side shields worn below a full-face shield.
- Class III. Class III provides eye and face protection against chemical dusts, liquids, and gases. Class III protection consists of chemical goggles worn below a full-face shield.
- Class IV. This final class of equipment provides eye and face protection against special hazards encountered with furnace operations, welding, glasswork, laser operations, etc.

Foot Protection

All occupational protective footwear must comply with the provisions of ANSI Z41.1, American National Standard for Personal Protection-Protective Footwear. There are three classes of footwear:

- Protective footwear worn in most industrial locations, construction sites, warehouses, and shop areas are fiberglass toe occupational protective footwear rated at 75, as a minimum, for compression and impact.
- For soil compacting (tamping) and jackhammer operations, employees must use metatarsal guarding over safety shoes.
- Finally, if any unique hazards are identified for an activity, the supervisor and occupational safety will determine the need for specialized protective footwear.

Ear Protection

The basic requirements for an ear protection program should include

- The need to maintain a hearing conservation program that consists of workplace monitoring for noise
 - audiometric testing for employees who work in high-noise areas
 - providing hearing protection equipment for employees
 - records keeping
 - training
- The need to post high-noise areas appropriately and control access to such areas. Personnel shall not be allowed to enter high-noise areas without
 - appropriate hearing protection;
 - training in hearing conservation procedures, and
 - a current (within 12 months) audiogram if entering a high-noise area is routine

Protective Clothing

Proper protective clothing is required whenever hazards of processes or environment, chemical hazards, radiological hazards, or mechanical irritants encountered are capable of causing injury or impairment in the function of any part of the body through absorption, inhalation, or physical contact. The type of protective clothing to be used is based on the type of environment and hazards associated with the hazard.

Factors that affect the choice of protective clothing are permeability, durability and breakthrough.

Head Protection

Head protection requirements for work activities are determined by the job supervisor with assistance from occupational safety and industrial hygiene personnel. All personnel are required to obey posted head protection requirements. The primary head protection device is a helmet. Helmets must comply with ANSI Z89.1-1986, National Standard for Personnel Protection-Protective Headwear for Industrial Workers-Requirements. The types and classes of helmets are described below:

- Type 1: helmets with brim.
- Type 2: no brim but may include a peak.
- Class A: intended to reduce the force of impact of falling objects and to reduce the danger of contact with exposed low-voltage conductors.
- Class B: intended to reduce the force of impact of falling objects and to reduce the danger of contact with exposed high-voltage conductors.
- Class C: intended to reduce the force of impact of falling objects. This class offers no electrical protection.

Respiratory Protection

When engineering and administrative controls have been applied and the potential for airborne exposure still exists, respiratory protection should be used to limit exposures. Respiratory requirements for specific jobs are determined by the nature of the hazard and the work place conditions. Workers must be trained and qualified to use the prescribed protection. Additionally, workers must be fitted for the equipment to ensure the equipment functions properly. The two basic types of respirators are those which supply safe, clean air (atmospheric supplying) and those which purify the air (air purifying). Air purifying respirators have a limited life depending on the concentration of the contaminant in air, the type of canister, the ambient temperature and the wearer's breathing rate. The assigned protection factor (APF) of a respirator reflects the level of protection that a properly functioning respirator would be expected to provide to a population of properly fitted and trained users. For example, an APF of 10 for a respirator means that a user could expect to inhale no more than one tenth of the airborne contaminant present. All respirators sold in the USA for industrial use are approved/certified by NIOSH/MSHA. OSHA requires that respirators used for employee protection must be certified or approved.

Competency 14 - References/Additional Reading

DOE Order 440.1A, Worker Protection Management for Federal and Contractor Employees

DOE Notice 450.7, The Safe Handling, Transfer, and Receipt of Biological Etiologic Agents at Department of Energy Facilities

42 CFR 72, Interstate Shipment of Etiologic Agents

42 CFR 73, Possession, Use, and Transfer of Select Agents and Toxins;

29 CFR 1910.1030, Bloodborne pathogens

CDC Publication, Biosafety in Microbiological and Biomedical Laboratories

NIH publication, Guidelines for Research Involving Recombinant DNA Molecules

10 CFR 850, Chronic Beryllium Disease Prevention Program (CBDPP)

10 CFR 851, Worker Safety and Health Program; Proposed Rule

29 CFR 1910, Subpart G—Occupational Health and Environmental Control

29 CFR 1910, Subpart Z—Toxic and Hazardous Substances which includes the Hazard Communication standard.

29 CFR 1926, Safety and Health Regulations for Construction

ANSI Standard Z87, American National Standard Practice for Occupational and Educational Eye and Face Protection

ANSI Z41.1, American National Standard for Personal Protection-Protective Footwear

ANSI Z89.1-1986, National Standard for Personnel Protection-Protective Headwear for Industrial Workers-Requirements

Competency 15: Conduct of Operations in Operational Environment

- 15. Personnel shall demonstrate a working* level knowledge of the principles of Conduct of Operations and relate these principles to an operational environment.**

Note: This courses only provides a familiarity level o f knowledge

- 15.a. Referring to a copy of DOE Order 5480.19, Conduct of Operations Requirements for DOE Facilities, locate applicable guidelines and requirements for specific activities.**

This is a site-specific competency. The qualifying official will evaluate the completion of this element.

- 15.b. For each of the eighteen chapters in attachment 1 of the DOE Order 5480.19, explain how each chapter contributes to an effective and safe operational environment.**

The purpose of DOE O 5480.19 is to provide requirements and guidelines to use in developing directives, plans, and/or procedures relating to the conduct of operations at DOE facilities.

Chapter 1 - Operations Organization and Administration

This chapter describes the administrative controls and practices that, when implemented fully, result in an effective and safe operational environment. This chapter includes DOE facility policies that describe the standards of excellence for facility operation and establish lines of responsibility for normal and emergency conditions. The following principles are suggested for the control of operations:

- Establishing written standards for operations
- Providing adequate resources to permit effective implementation
- Periodically monitoring and assessing performance
- Holding personnel accountable for their performance

Good practices for Operations organization and administration are contained in DOE-STD-1032-92, Guide to Good Practices for Operations Organization and Administration.

Chapter 2 - Shift Routines and Operating Practices

This chapter describes some important aspects of routine shift activities and watch-standing practices that promote the professional conduct of operations personnel and result in meeting

DOE and facility management expectations for operator performance. Professional conduct and good watch-standing practices result in appropriate attention to facility conditions, a necessary part of maintaining a safe and effective operational environment. Key elements are:

- effective equipment monitoring to detect abnormal conditions or adverse trends;
- notifying supervisors promptly of unusual or unexpected situations;
- understanding equipment status and operational authority, and following proper industrial safety, radiological protection (if applicable), and quality assurance practices.

The chapter specifically provides guidelines for status practices, safety practices, operator inspection tours, use of round/tour inspection sheets, personnel protection, response to indications, resetting protective devices, load changes, authority to operate equipment, shift operating bases, and potentially distractive written material and devices.

Good practices for shift routines and operating practices are contained in DOE-STD-1041-93, Guide to Good Practices for Shift Routines and Operating Practices.

Chapter 3 - Control Area Activities

This chapter recognizes the control area or control room as the most critical facility operating base and the coordination point for all important facility activities. It stresses principles involving limited control area access, professional behavior of personnel in the control area, monitoring of main control panels, control operator ancillary duties, and operation of control area equipment. The chapter also addresses errors and unnoticed equipment problems if formality and attention to detail are not practiced by operators in the control room.

Good practices for control area activities are contained in DOE-STD-1042-93, Guide to Good Practices for Control Area Activities.

Chapter 4 - Communications

This chapter describes the important aspects of a plant program for audible communications and emphasizes that accurate communications are essential for the safe and efficient operation of facilities. Audible communications are used to transmit operating and emergency information in the facility. Examples are oral, telephone, radio, and public address announcements; sound-powered phones; and special sounds. Guidance provided includes the practice of repeating back instructions to ensure accurate transmission and receipt of verbal instructions, use of standardized terminology, and use of a phonetic alphabet. Inadequate communication is a common root cause behind operator error.

Good practices for communications are contained in DOE-STD-1031-92, Guide to Good Practices for Communications.

Chapter 5 - Control of On-Shift Training

The guidelines of this chapter relate to control of training activities by operations personnel. On-shift training should be conducted so that the trainee completes all of the required training objectives satisfactorily and receives maximum learning benefit from this experience without unduly affecting normal operations. Facility operation by personnel under instruction should be carefully supervised and controlled to avoid mistakes in operations by unqualified personnel and to use trainees' time effectively. These controls are therefore necessary to maintain safe and efficient operation of the facility during the conduct of hands-on training. The following are important elements:

- Adherence to formal training programs
- Use of instructors that are qualified themselves on the subject equipment
- Supervision and control of trainees by qualified operators
- Operator qualification program approval
- Formal training documentation

Good practices for on-shift training are contained in DOE-STD-1040-93, Guide to Good Practices for Control of On-Shift Training.

Chapter 6 - Investigation of Abnormal Events

This chapter covers important aspects of the abnormal event investigation program. Abnormal events do occur and when they do, they often cause an impact on the safe and efficient operation of the affected facilities. Therefore, a program for the investigation of abnormal events should ensure that facility events are thoroughly investigated to assess the impact of the event, to determine the root cause of the event, to ascertain whether the event is reportable to DOE, and to identify corrective actions to prevent recurrence of the event. As future events are prevented through successful implementation of this program, the safe and efficient operation of the facility is improved.

Good practices for investigation of abnormal events is contained in DOE-STD-1045-93, Guide to Good Practices for Notifications and Investigation of Abnormal Events.

Chapter 7 - Notification

This chapter provides guidelines to ensure uniformity, efficiency, and thoroughness of notifications that support fulfillment of DOE requirements consistent with DOE O 232.1A, Occurrence Reporting and Processing of Operations Information. Proper notifications of abnormal or unusual events contribute to safe and efficient operation of the facility in a couple of ways. The first is that the notification results in the involvement of a larger pool of people whose knowledge can help stabilize and resolve the immediate situation at hand. The second is that being trained to follow a rigorous notification process ensures that vital information, needed to analyze and prevent future recurrence, is not overlooked.

Good practices for notifications is contained in DOE-STD-1045-93, Guide to Good Practices for Notifications and Investigation of Abnormal Events.

Chapter 8 - Control of Equipment and System Status

This chapter provides an overall perspective on control of equipment and system status. Control of equipment and system status contributes to safe and efficient facility operations by ensuring that an adequate safety envelope exists to authorize and perform work. A facility's safety envelope is defined by the proper operation and configuration of a set of equipment considered vital to a safe operating environment. This equipment is termed "vital safety equipment." If a piece of equipment fails or is shut down for maintenance, this fact needs to be recorded so that affected operations can be terminated or prevented until the equipment or system is restored. In the case where redundant equipment exists that could be operated to maintain the safety envelope for continued operations, its status must be known in order for it to be relied upon. Temporary modifications must also be tracked for the same reasons.

Good practices for control of equipment and system status are contained in DOE-STD-1039-93, Guide to Good Practices for Control of Equipment and System Status.

Chapter 9 - Lockouts and Tagouts

This chapter describes the important elements of a lockout/tagout program and is intended to meet the requirements of 29 CFR 1910, Occupational Safety and Health Standards. A safe and efficient operational environment is maintained by providing a method for equipment status control through component tagging or locking that should protect personnel from injury, protect equipment from damage, maintain operability of plant systems, and maintain the integrity of the physical boundaries of plant systems. Appropriate and proper use of tags and locks prevents inadvertent operation of equipment when there is a potential for equipment damage or personnel injury during equipment operation, servicing, maintenance, or modification activities.

Good practices are contained in DOE-STD-1030-96, Guide to Good Practices for Lockouts and Tagouts.

Chapter 10 - Independent Verification

This chapter describes the important aspects of an independent verification program that when implemented should provide a high degree of reliability in ensuring the correct facility operation (e.g., correct procedure steps are followed) and the correct position of components such as valves, switches, and circuit breakers. This is important to the safe and efficient operation of a facility because independent verification recognizes the human element of component operation; that is, any operator, no matter how proficient, can make a mistake. Thus, when mistakes are found and corrected before an operation takes place, safety and efficiency are improved.

Good practices are contained in DOE-STD-1036-93, Guide to Good Practices for Independent Verification.

Chapter 11 - Logkeeping

This chapter describes the features needed in the operation logs to ensure they are properly maintained. Operations logs should be established for all key shift positions and should contain a narrative of the facility's status and all events as required to provide an accurate history of facility operations. Proper log keeping is essential to the safe and efficient operation of a facility because it provides the data necessary for the reconstruction of abnormal or unusual events. When the data is properly analyzed and corrective actions are taken, subsequent recurrence of the event should be prevented. Logkeeping also promotes personal accountability and improved communication of information about the facility's status among operating personnel.

Good practices are contained in DOE-STD-1035-93, Guide to Good Practices for Logkeeping.

Chapter 12 - Operations Turnover

This chapter describes the important aspects of a good shift turnover. The comprehensive transfer of information pertinent to the operation of the facility is vital to safe and efficient operations, as evidenced by a historically high error rate associated with poor shift turnovers resulting from improper reviews of logs, unclear communications, and neglecting to discuss key operating parameters and status. Safe operations also depend on operating personnel being fit for duty. Therefore, it is also the responsibility of the off-going person to determine this by looking for evidence of sickness with corresponding degradation of mental or physical ability to do the job due to the sickness itself and/or the effects of medication the person might be taking. Other compromising conditions such as drug and alcohol abuse should also be considered.

Good practices are contained in DOE-STD-1038-93, Guide to Good Practices for Operations Turnover.

Chapter 13 - Operations Aspects of Facility Chemistry and Unique Processes

This chapter describes the important aspects of operations involving chemistry and unique processes and their relationship to safe and efficient facility operation. Operational monitoring of facility chemistry or unique process data and parameters should ensure that parameters are properly maintained. Proper monitoring will identify problems before components or safety is adversely affected. Operating personnel must be knowledgeable about the chemicals and processes they are working with and depending upon so that they can detect and correct off-normal parameters in a timely manner.

Good practices are contained in DOE-STD-1037-93 , Guide to Good Practices for Operations Aspects of Unique Processes.

Chapter 14 - Required Reading

This chapter describes an effective required-reading program. Such a program contributes to facility safety and efficiency by ensuring that appropriate individuals are made aware of important information that is related to job assignments. Procedure changes, equipment design

changes, related industry and in-house operating experience information, and other information necessary to keep operations department personnel aware of current facility activities are examples of the kind of useful information that should be made available to keep operating personnel current.

Good practices are contained in DOE-STD-1033-92, Guide to Good Practices for Operations and Administration Updates Through Required Reading.

Chapter 15 - Timely Orders to Operators

This chapter describes the key features of an effective operator orders program. This contributes to safe and efficient operation by providing a means for communicating current, short-term information and administrative instructions to operations personnel. This becomes necessary to accommodate the changing needs and requirements of DOE facility operations. For example, orders could include instructions on the need for and performance of specific evolutions or tests; orders could also include work priorities, announcements of policy information, and administrative information. Typical information includes special operations, administrative directions, special data-collection requirements, plotting process parameters, and other similar short-term matters.

Good practices are contained in DOE-STD-1034-93, Guide to Good Practices for Timely Orders to Operators.

Chapter 16 - Operations Procedures

This chapter describes the important aspects of operations procedure development and use. Operations procedures should provide appropriate direction to ensure that the facility is operated within its design basis and should be effectively used to support safe operation of the facility. When operations personnel adhere to the policy to follow approved, properly written procedures, their operational performance should always be consistent and safe.

Guidance for developing procedures is contained in DOE-STD-1029-92, Writer's Guide for Technical Procedures.

Chapter 17 - Operator Aid Postings

This chapter describes the important aspects of an operator aid program. Facility operator aids (information posted for personnel use) should provide information useful to operators in performing their duties and thus provide an important function in the safe operation of the facility, provided that they are kept current and do not conflict with any other controlled procedure or information. Examples are copies of procedures (portion or pages thereof), system drawings, handwritten notes, information tags, curves, and graphs.

Good practices are contained in DOE-STD-1043-93, Guide to Good Practices for Operator Aid Postings.

Chapter 18 - Equipment and Piping Labeling

This chapter describes the important aspects of a labeling program. A well-established and maintained equipment-labeling program should help ensure that facility personnel are able to positively identify equipment they operate. It will enhance training effectiveness, help reduce operator and maintenance errors resulting from incorrect identification of equipment, and reduce personnel radiation and other hazardous material exposure as operators spend less time identifying components.

Good practices are contained in DOE-STD-1044-93, Guide to Good Practices for Equipment and Piping Labeling.

15.c. Referring to a copy of DOE O 232.1A, Occurrence Reporting and Processing of Operations Information (formerly DOE Order 5000.3B, Occurrence Reporting), DOE O 433.1, Maintenance Management Program for DOE Nuclear Facilities (formerly DOE Order 4330.4B, Maintenance Management Program), and DOE O 414.1B Quality Assurance, explain how each contributes to a proper conduct of operations environment.

Note: Occurrence reporting now flows from DOE O 231.1A, *Environment, Safety, and Health Reporting*, to DOE M 231.1-2, *Occurrence Reporting and Processing Operations Information*. The current quality assurance order is DOE O 414.1C

DOE O 231.1-2, Environment, Safety, and Health Reporting

This Order provides guidance on what types of events should be reported, how they should be categorized, who should be notified and when for each event category, and what information about the event should be reported (date, time, category level, facility identification, responsible line manager, nature of occurrence, description of occurrence, direct and root causes, corrective actions, etc.).

The proper conduct of operations depends directly on the prompt identification, notification, analysis, and correction of errors and off-normal events. When this becomes a habit for employees, the resulting attention to detail, rigor, and formality of their operations is evidence of a healthy conduct of operations environment.

DOE O 433.1, Maintenance Management Program for DOE Nuclear Facilities

This Order defines the program for the management of cost-effective maintenance of DOE nuclear facilities.

Proper maintenance of facilities supports effective control of equipment and equipment status, which in turn supports maintaining the facility within its safety envelope.

DOE O 414.1B, Quality Assurance

The Order's purpose is to achieve quality assurance (QA) all work based upon the following principles:

- That quality is assured and maintained through a single, integrated, effective quality assurance program (i.e., management system).
- That management support for planning, organization, resources, direction, and control is essential to QA.
- That performance and quality improvement require thorough, rigorous assessment and corrective action.
- That workers are responsible for achieving and maintaining quality.
- That environmental, safety, and health risks and impacts associated with work processes can be minimized while maximizing reliability and performance of work products.

These principles are consistent with principles for conduct of operations. Furthermore the Order defines 10 criteria, several of which are consistent with Conduct of Operations including:

- Quality Improvement
- Documents and Records
- Work Processes

Further discussion of QA is provided in Competency 17.

15.d. Describe the purpose of safeguards and security and the role that it plays with regards to conduct of operations.

The purpose of safeguards and security (S&S) is to account for and protect special nuclear materials (SNM) and classified data from theft or loss.

S&S and conduct of operations are complementary programs. Conduct of operation aids S&S by providing a rigorous and formal operating environment that also facilitates the tracking and reporting of events that fall into the S&S arena. S&S contributes to conduct of operations by providing multiple levels of protection against terrorist attack or sabotage that often is aimed at compromising the safety systems of a facility and certainly endangers the health and safety of facility personnel.

15.e. Discuss proper critique principles and describe a proper critique process, including key elements.

The purpose of critiques is to assemble all of the facts about an event or operation. It is not to assign blame or to be used as a basis to administer disciplinary action against an involved employee. Employees must feel free to provide factual information without fear of retribution, and this must be communicated to them and practiced consistently by management for a cultural environment to exist that will support an effective critique process. Otherwise, information will be concealed that may be important to preventing recurrence of the event.

The principles and elements of a good critique process are as follows:

- Off-normal events and successes are critiqued. The critique of off-normal events provides the basis for understanding why something went wrong and how to prevent its recurrence. The critique of successes is to be able to repeat the success and to find ways of improving upon the success at the same time.
- The designation of who calls and conducts the critique meeting(s) is important to obtaining the facts in a complete and impartial manner. It may be necessary to assign a leader who was not involved in the event to prevent prejudice or inappropriate influence of the outcome.
- A critique is a formal meeting. It may consist of several meetings with a combination of personnel.
- All who can contribute factual information should attend the critique meeting(s).
- The DOE facility representative should be notified of each critique meeting and invited to attend.

- Critique meetings should, with few exceptions, be held as soon as the situation is stable. In any event, they are held before the involved people leave for the day, if possible. There are cases when an event is not discovered until sometime after those involved have gone home and they may get called back in, or those discovering the event may not know immediately everyone who might have factual knowledge.
- Initial categorization and notification for DOE O 232.1A, Occurrence Reporting and Processing of Operations Information, is made before or concurrently with the critique meeting. DOE O 232.1A, Occurrence Reporting and Processing of Operations Information, requires this to be done within 2 hours of discovery of the event's happening.
- A form is provided in the administrative procedure to be completed for the personal statements that are made by involved personnel.
- Before a critique convenes, the leader determines if personal statements are necessary. If they are, the leader will distribute forms to the appropriate people.

- When personal statements are required of key personnel involved with the event, they are encouraged to write what they did, saw, heard, etc.
- The statements are preferably prepared before the critique meeting starts and before the principal, involved people get together to discuss the event. Collaboration of the people involved greatly reduces the value of the statements.
- Personal statements are signed and dated.
- Completed personal statements are provided to the leader at the critique meeting. They are attached to the meeting minutes and become part of the official record.

- Formal meeting minutes are recorded. Facts shall be listed in chronological order. Tape recorders, stenographers, etc., are used to help document the minutes.
- The leader and all contributors sign critique minutes.

- A pre-designed form helps to guide the leader through the critique process. It provides the line of questioning and includes places for the pertinent information. The form is provided in the administrative procedure.
- Critique minutes serve as the record of what happened for simple events and the foundation for any subsequent investigation, if warranted, for more complex events. Categorization and/or notification may be changed when the critique is completed.
- Critique minutes facilitate the assigning of corrective action(s) and provide the basis from which the root cause and recurrence control can be determined.
- Critique reports are distributed within the facility, to other selected facilities, to DOE, and to a central organization for the purposes of further distribution and analysis.
- Persons designated as critique leaders are formally trained for the task and have passed a written test and an oral examination.
- The critique leader must endeavor to fully understand the details, corroborate the facts, challenge assumptions, and be aware of what hasn't been established (look for holes and missing information).

15.f Define root cause and explain its importance to operational safety.

The root cause is defined as the basic reason(s) for or the fundamental cause of an event, which if corrected, will prevent recurrence. Operational failures of all kinds (operator error, component failure, management system failure, procedural error, etc.) challenge the safety environment of a facility. Therefore, any reduction in the incident rate and/or the severity of off-normal events will result in an overall improvement of safety for the workers and the public at large.

Correctly identifying the root cause with corresponding corrective actions has the direct effect of achieving such a reduction.

15.g Define and describe what lessons learned are and explain their importance to operational safety.

Lessons learned are bulletins that contain related industry (e.g., NRC, commercial nuclear, etc.) and in-house (i.e., within DOE) operating experience information that may be of interest to operating personnel and management with respect to preventing off-normal events and/or improving operational efficiency. They come from a variety of sources, such as the occurrence reporting and processing system database, the weekly operating experience summary from the DOE Office of Nuclear Safety, and Government-Industry Data Exchange Program on-line information retrieval.

Lessons learned information contributes to operational safety by preventing future similar operational events from occurring, improving techniques for performing operations such that a risk reduction occurs, and improving management control systems that affect safety to make them more comprehensive or to correct deficiencies.

DOE maintains a Lessons Learned database on web page: <http://www.eh.doe.gov/doell>.

15.h Describe stop work authority and this position's role in its application.

All personnel whether they are contractor employees, subcontractors, visitors, or students have the authority and responsibility to stop work after identifying a hazardous condition or a condition that is adverse to quality in the work place.

Personnel who discover a condition that is believed to warrant a stop-work action may not be in a position to understand how to safely stop work. In some cases, abruptly stopping an activity could create a greater hazard. For this reason, personnel involved in an unsafe activity or a condition that is adverse to quality must involve their supervisor in the stop-work action. Since additional requirements may apply to situations involving stop-work actions, workers and supervisors shall determine the possible need for lockout/tagout processes, revisions of safety plans, formal readiness reviews, occurrence reporting, etc.

15.i Describe the key elements that determine the safety significance of a condition.

A condition is defined as any state, whether or not resulting from an event, that may have adverse safety, health, quality assurance, security, operational, or environmental implications. For example, an error in analysis or calculation, an anomaly associated with design or performance, and an item indicating a weakness in the management process are all conditions.

The operational conditions, referred to as limiting conditions for operation (LCOs), that are required to provide a safe facility environment are defined in the facility's final safety analysis report (FSAR). A condition that has safety significance has some degree of potential for challenging one or more of these LCOs. Also, any condition, besides those addressed by the FSAR, that could adversely affect the health and safety of workers in the facility would have safety significance.

The components of probable risk assessment, probability of occurrence and consequence, apply to determining the level of significance.

Examples of conditions that have safety significance are:

- degraded or failed vital safety system equipment (ventilation, fire suppression/detection, criticality detection and alarm, emergency power, etc.);
- improperly stored or leaking hazardous materials (radioactive and chemical);
- poor housekeeping (fire hazard, tripping hazard, etc.);
- improperly trained personnel;
- poorly written or maintained operational procedures;
- failure to perform surveillances required by the FSAR in a competent and/or timely manner.

15.j Describe the key elements of a lockout and tagout system.

A lockout/tagout program should be established that consists of policies and procedures to control potentially hazardous energy and materials, and of personnel training. This program should ensure that potentially hazardous energy or toxic material sources are isolated and rendered inoperative during servicing or maintenance or in any case where unexpected energizing, startup, or release of stored energy or toxic material can cause injury.

Procedure(s)

A procedure should be established that identifies what needs to be locked and/or tagged out and any necessary operating instructions for preparing the affected system or component for shutdown in a safe manner. The conduct of operations principle of independent verification should be applied to the written procedures and the performance of the procedures to ensure proper system alignment and safe system conditions.

Documentation

Lockout and tagout forms are used to record which components are being locked and/or tagged and the names and signatures of personnel who authorized, installed, and verified the locks and/or tags. The same form is used for documenting the removal of the locks and/or tags. These forms are kept together and indexed in a logbook that is maintained for the facility.

Locking and Tagging Devices

These are locks, tags, chains, wedges, key blocks, adapter pins, self-locking fasteners, or other hardware used for isolating, securing, or blocking machines or equipment from energy sources.

Periodic Inspections

Periodic inspections should be conducted and documented by authorized personnel, supervisors, or appropriate managers to determine whether procedures are being followed and to correct any deviations or inadequacies observed.

Training

Training should be provided and documented to ensure that the purpose and function of the lockout/tagout program is understood by all personnel and that they have the knowledge and skills required for safe application, use, and removal of lockouts and tagouts. Only qualified personnel should be authorized to accomplish a lockout and/or tagout.

Notification of Personnel

A supervisor or appropriate manager should notify affected personnel of the application and removal of lockout/tagout devices. Notification should be given before the devices are applied and after they are removed.

Competency 15 - References/Additional Reading

DOE G 231.1-2 Approved: 08-20-03 OCCURRENCE REPORTING CAUSAL ANALYSIS GUIDE

DOE Order 5480.19, Conduct of Operations Requirements for DOE Facilities

DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information

DOE Order 433.1, Maintenance Management Program for DOE Nuclear Facilities

DOE O 414.1A, Quality Assurance

DOE-STD-1032-92, Guide to Good Practices for Operations Organization and Administration

DOE-STD-1041-93, Guide to Good Practices for Shift Routines and Operating Practices.

DOE-STD-1042-93, Guide to Good Practices for Control Area Activities

DOE-STD-1031-92, Guide to Good Practices for Communications

DOE-STD-1045-93, Guide to Good Practices for Notifications and Investigation of Abnormal Events

DOE-STD-1030-96, Guide to Good Practices for Lockouts and Tagouts

DOE-STD-1036-93, Guide to Good Practices for Independent Verification

DOE-STD-1035-93, Guide to Good Practices for Logkeeping

DOE-STD-1033-92, Guide to Good Practices for Operations and Administration Updates Through Required Reading

DOE-STD-1034-93, Guide to Good Practices for Timely Orders to Operators

DOE-STD-1044-93, Guide to Good Practices for Equipment and Piping Labeling

DOE-STD-1029-92, Writer's Guide for Technical Procedures

DOE-STD-1039-93, Guide to Good Practices for Control of Equipment and System Status

DOE-STD-1040-93, Guide to Good Practices for Control of On-Shift Training

DOE-STD-1038-93, Guide to Good Practices for Operations Turnover

Competency 16: Occurrence Reporting and Processing of Operations Information

16. Personnel shall demonstrate a familiarity level knowledge of DOE Order 232.1, Occurrence Reporting and Processing of Operations Information.

Note: Order 232.1 was replaced by DOE O 231.1A (Environment, Safety, and Health reporting)

This course also briefly discusses the role of the facility representative in occurrence reporting.

16.a State the purpose of this Order (DOE O 231.1A)

Note: Order 232.1 was replaced by DOE O 231.1A (Environment, Safety, and Health reporting)

The purpose of DOE 231.1A is to ensure timely collection, reporting, analysis, and dissemination of information on environment, safety, and health issues as required by law or regulations or as needed to ensure that the Department of Energy (DOE) and National Nuclear Security Administration (NNSA) are kept fully informed on a timely basis about events that could adversely affect the health and safety of the public or the workers, the environment, the intended purpose of DOE facilities, or the credibility of the Department.

Several manuals and guides provide detailed requirements/guidance to supplement DOE Order 231.1A including:

- Manual 231.1-1A, Environment, Safety, and Health Reporting
- Manual 231.1-2, Occurrence Reporting and Processing Operations Information
- DOE G 231.1-1, Occurrence Reporting Performance Analysis and Reporting Guide
- DOE G 231.1-2, Occurrence Reporting Causal Analysis Guide

16.b Define the following terms:

- **Event**
- **Condition**
- **Notification report**
- **Occurrence report**
- **Reportable occurrence**

Event

Something significant and real-time that happens (e.g., pipe break, valve failure, loss of power, environmental spill, earthquake, tornado, flood).

Events involve, but are not limited to, facility conditions; environmental concerns; personnel safety; radiological protection; safeguards and security; transportation; loss or damage to DOE property; defective items, materials, or services (including counterfeit/suspect parts); nuclear explosive events; and cross-category items, including related occurrences, near-miss events, and potential concerns.

Condition

Any as-found state, whether or not resulting from an event, that may have adverse safety, health, quality assurance, operational or environmental implications. A condition is usually programmatic in nature; for example, errors in analysis or calculation; anomalies associated with design or performance; or items indicating a weakness in the management process are all conditions.

Facility

Any equipment, structure, system, process, or activity that fulfills a specific purpose. Examples include accelerators, storage areas, fusion research devices, nuclear reactors, production or processing plants, coal conversion plants, magnetohydrodynamic experiments, windmills, radioactive waste disposal systems and burial grounds, environmental restoration activities, testing laboratories, research laboratories, transportation activities, and accommodations for analytical examinations of irradiated and unirradiated components.

Notification Report

The initial documented report, to the Department, of an event or condition that meets the reporting criteria defined in DOE M 231.1-2.

The facility manager shall prepare the notification report (including all required fields and all other fields for which information is known) and distribute it to the facility representative and the program manager before the close of the next business day from the time of categorization (not to exceed 80 hours). When an unclassified, non-sensitive notification report is entered into the computerized occurrence reporting and processing system database, the distribution requirement is automatically satisfied.

Occurrence Report

A documented evaluation of an event or condition that is prepared in sufficient detail to enable the reader to assess its significance, consequences, or implications and to evaluate the actions being proposed or employed to correct the condition or to avoid recurrence.

Occurrence reports contain information about the facility operations and the occurrence to facilitate action by other personnel who are unfamiliar with details of the facility, equipment, process, or procedures.

Reportable Occurrence

Occurrence to be reported in accordance with the criteria defined in Manual 231.1-2.

A reportable occurrence is any event or situation that results in or has the potential to result in harm to an employee, visitor, student, the facility, or the environment.

16.c Discuss the Department's policy regarding the reporting of occurrences as outlined in the Order (manual).

It is DOE policy to ensure that the Office of the Secretary, DOE, and DOE contractor line management are kept fully informed on a timely basis of events that could adversely affect national security or the safeguards and security interests of DOE, the health and safety of the public or the workers, the environment, the intended purpose of DOE facilities, or the credibility of the Department. This information is analyzed for generic implications and for opportunities to improve operations.

The following objectives are established in support of this policy:

- To establish and maintain a system for reporting operations information related to DOE-owned and DOE-leased facilities and processing that information to identify the root causes of unusual, off-normal, and emergency occurrences and provide for appropriate corrective action
- To perform the following:
 - Timely identification, categorization, notification, and reporting to DOE management of reportable occurrences at DOE-owned and DOE-leased facilities
 - Review of reportable occurrences to assess the significance, root causes, generic implications, and the need for corrective actions
 - Timely evaluation and implementation of appropriate corrective actions
 - Dissemination of occurrence reports to DOE operations and facilities to prevent similar occurrences and facilitate analyses
 - Maintenance of a central DOE system for reporting, processing, retrieving and analyzing unclassified, non-sensitive occurrence reports

16.d. State the different categories of reportable occurrences and discuss each.

The Categories are:

- Operational Emergencies
- Significance Category 1
- Significance Category R
- Significance Category 2
- Significance Category 3
- Significance Category 4

Operational Emergencies (OEs)

Operational Emergency Occurrences are the most serious occurrences and require an increased alert status for onsite personnel and, in specified cases, for offsite authorities.

Significance Category 1

Occurrences that are not Operational Emergencies and that have a significant impact on safe

facility operations, worker or public safety and health, regulatory compliance, or public/business interests.

Significance Category R

Occurrences that are identified as recurring, as determined from the periodic performance analysis of occurrences across a site.

Significance Category 2

Occurrences that are not Operational Emergencies and that have a moderate impact on safe facility operations, worker or public safety and health, regulatory compliance, or public/business interests.

Significance Category 3

Occurrences that are not Operational Emergencies and that have a minor impact on safe facility operations, worker or public safety and health, regulatory compliance, or public/business interests.

Significance Category 4

Occurrences that are not Operational Emergencies and that have some impact on safe facility operations, worker or public safety and health, or public/business interests.

DOE maintains an ORPS data base on the password protected web page:

<https://orps.tis.eh.doe.gov/>

Groups of reportable occurrences

The Order also identifies 10 Groups of reportable occurrences, i.e.,

- Group 1 - Operational emergencies
- Group 2 - Personnel safety
- Group 3 - Nuclear safety basis
- Group 4 - Facility status
- Group 5 - Environmental
- Group 6 - Contamination/radiation control
- Group 7 - Nuclear explosive safety
- Group 8 - Transportation
- Group 9 - Noncompliance notifications
- Group 10 - Management concerns/issues

Group 1 - Operational emergencies

DOE O 151.1A, Emergency Management,” describes initiating events that are considered Operational Emergencies (OEs). More serious OEs are classified into three categories. From least significant to most significant these categories are

- Alert (local impact and potentially impacting co-located workers)
- Site Area Emergency (impact outside of facility)
- General Emergency (potential impact on the public)

Group 2 - Personnel safety

There are several subgroups for this group. Examples are shown below:

Occupational Illness/Injury

Examples:

- Any occurrence due to DOE operations resulting in a fatality or terminal injury/illness. For fatalities caused by overexposures, the intent of this criterion is to report those caused by acute rather than chronic effects.
- Any single occurrence requiring in-patient hospitalization of three or more personnel.
- Any single occurrence resulting in three or more personnel having Days Away, Restricted or Transferred (DART) cases per 29 CFR Part 1904.7.

Fires/Explosions

Examples:

- Any unplanned fire or explosion within primary confinement/containment boundaries for nuclear or hazardous material within a facility.
- Any unplanned fire or explosion in a non-nuclear facility that
 - Activates a fire suppression system,
 - Takes longer than 10 minutes to extinguish following the arrival of fire protection personnel, or
 - Disrupts normal operations in a high hazard facility.

Hazardous Energy Control

Failure to follow a prescribed hazardous energy control process (e.g., lockout/tagout) or disturbance of a previously unknown or mislocated hazardous energy source (e.g., live electrical power circuit, steam line, pressurized gas) resulting in a person contacting (burn, shock, etc.) hazardous energy

Group 3 - Nuclear safety basis

There are several subgroups for this group. Examples are shown below:

- Technical Safety Requirement Violations
- Violation of a safety limit or limiting condition for operation
- Exceeding surveillance period
- Documented Safety Analysis Inadequacies

- Potential or actual inadequate safety analysis
- Nuclear Criticality Safety
- Loss of criticality process control

Group 4 - Facility status

- Safety system/structure/component degradation
- Performance degradation that prevents performance of design function
- Operations
- A stop work order issued by DOE
- Actuation of a safety system due to an actual unsafe condition
- Facility evacuation
- Facility shutdown directed by management for safety reasons
- Suspect or counterfeit items
- Discovery of a suspect or counterfeit item in a safety class system

Group 5 - Environmental

Releases

Any release (onsite or offsite) of a hazardous substance, material, waste, or radionuclide from a DOE facility, that is above permitted levels and exceeds the reportable quantities specified in 40 CFR 302 or 40 CFR 355.

(Several other criteria are include in M 231.1-2)

Ecological and Cultural Resources

- Damage to a historical or archeological site
- Damage to wet lands

Group 6 - Contamination/radiation control

- Loss of control of radioactive material

Identification of radioactive material offsite due to DOE operations/activities that exceeds applicable DOE-approved authorized limits

- Spread of Radioactive Contamination

Identification of radioactive contamination offsite due to DOE operations/activities that exceeds applicable DOE-approved authorized limits

Identification of onsite radioactive contamination greater than 10 times the total contamination values in 10 CFR 835 Appendix D and that is found outside of the following locations:

Contamination Areas, High Contamination Areas, Airborne Radioactivity Areas, and Radiological Buffer Areas.

- Radiation Exposure
 - Determination of a dose that exceeds the limits specified in 10 CFR Part 835,
 - Any unmonitored exposure that exceeds the values for providing personnel dosimeters and bioassays as stated in 10 CFR 835.402(a) or 10 CFR 835.402(c).
- Personnel contamination
 - Any occurrence requiring offsite medical assistance for contaminated personnel, including transporting a person to an offsite medical facility or bringing offsite medical personnel onsite to perform treatment or decontamination.
 - Any onsite contamination of personnel or clothing (excluding site provided protective clothing) that exceeds 10 times the values for total contamination identified in 10 CFR Part 835.

Group 7 - Nuclear explosive safety

Damage to a nuclear explosive that results in a credible threat to nuclear explosive safety.

A violation of a nuclear explosive safety rule (NESR).

The unauthorized compromise of a nuclear explosive safety feature when installed on a nuclear explosive.

Group 8 - Transportation

Any offsite transportation incident involving hazardous materials that would require immediate notice pursuant to 49 CFR Part 171.15, e.g., when a person is killed or receives injuries requiring hospitalization:

Any offsite transport of hazardous material, including radioactive material, whose quantity or nature (e.g., physical or chemical composition) is different than intended,

Group 9 - Noncompliance notifications

Any enforcement action (other than associated with the Price Anderson Amendment Act) involving 10 or more cited violations, and/or an assessed fine of \$10,000 or more.

Any written notification from an outside regulatory agency that a site/facility is considered to be in noncompliance with a schedule or requirement

Group 10 - Management concerns/issues

Any event resulting in the initiation of a Type A or B accident investigation as categorized by DOE O 225.1A, Accident Investigation.

An event, condition, or series of events that does not meet any of the other reporting criteria, but is determined by the Facility Manager or line management to be of safety significance or of concern to other facilities or activities in the DOE complex.

A near miss, where no barrier or only one barrier prevented an event from having a reportable consequence.

The responsibilities of the Facility Representative as it relates to occurrence reporting are to:

- Evaluate facility implementation of the notification and reporting process to ensure it is compatible with and meets the requirements of DOE M 231.1-2
- Maintain day-to-day operational oversight of contractor activities
- Ensure that occurrences that may have generic or programmatic implications are identified and elevated to the Head of the Field Element for appropriate action,
- Ensure that facility personnel act to minimize and prevent recurrence of significant events
- Review and assess reportable occurrence information from facilities under their cognizance to determine acceptability of the Facility Manager's evaluation of the significance, causes, generic implications, and corrective action implementation and closeout, and to ensure that facility personnel involved in these operations perform the related functions

Competency 16- References/Additional Reading

DOE O 151.1A, Comprehensive Emergency Management System

DOE O 225.1A, Accident Investigation.

DOE O 231.1A, Chg 1, Environment, Safety, and Health Reporting

40 CFR 302, Designation, **Reportable Quantities, and Notification**

40 CFR 355, Emergency Planning and Notification

10 CFR 835, Occupational Radiation Protection

Manual 231.1-1A, Environment, Safety, and Health Reporting

Manual 231.1-2, Occurrence Reporting and Processing Operations Information

29 CFR Part 1904, Recording and Reporting Occupational Injuries and Illnesses

DOE G 231.1-1, Occurrence Reporting Performance Analysis and Reporting Guide

DOE G 231.1-2, Occurrence Reporting Causal Analysis Guide

Competency 17 Quality Assurance

17. Personnel shall demonstrate a familiarity level knowledge of DOE Order 414.1C, Quality Assurance.

17.a Discuss the objectives and applicability of the DOE O 414.1C, including its relationship to 10 CFR 830 Subpart A, Quality Assurance Requirements

Note: The current Quality Assurance (QA) Order is DOE O 414.1C

Objectives

1. To ensure that quality of DOE and NNSA products and services meet or exceed customers' expectations.
2. To achieve QA for all work based upon the following principles:
 - That quality is assured and maintained through a single, integrated, effective quality assurance program (i.e., management system).
 - That management support for planning, organization, resources, direction, and control is essential to QA.
 - That performance and quality improvement require thorough, rigorous assessment and corrective action.
 - That workers are responsible for achieving and maintaining quality.
 - That environmental, safety, and health risks and impacts associated with work processes can be minimized while maximizing reliability and performance of work products.
3. To establish quality process requirements to be implemented under a QA Program (QAP) for the control of suspect/counterfeit items and safety issue corrective actions.

Applicability

DOE/NNSA Elements

DOE elements, including NNSA (excepting the Naval Reactors Program and the Bonneville Power Administration) must follow this Order when performing their work.

Contractors

DOE Order 414.1C is implemented by contractors through their Contractor Requirements Documents (CRDs). The CRD must be included in contracts addressing work or operation at DOE sites, facilities, or for work accomplished outside of DOE physical boundaries, such as design, analytical, or other support-related services.

CRDs are incorporated into DOE contracts to ensure contractor compliance with the Order

Note: When DOE Orders are revised, they are not immediately incorporated into the contract. Rather there is some time period for incorporating the new Order requirements (and then a given time period for implementing the new requirements)

Relationship to 10 CFR 820

DOE Order 414.1C serves as an implementation Order for the QA Program requirements as identified in the 10 CFR 830 federal regulation.

17.b. Discuss the general requirements section of the Order, including the applicability to DOE and the contractors that operate DOE facilities.

Quality Assurance Program (QAP)

Each DOE organization must develop and implement a QAP that

- Implements quality assurance criteria as defined in the Order, using a graded approach.
- Uses voluntary national or international consensus standards where practicable and consistent with contractual or regulatory requirements.
- Applies additional standards, where practicable and consistent with contractual or regulatory requirements.
- Integrates quality management system requirements, Suspect/Counterfeit Items Prevention Process, and Corrective Action Management Program, as required by the Order.

Quality Assurance Criteria

The QAP must address the ten (10) QA criteria. The criteria are grouped into three sections that are discussed in the following.

17.c. Describe in general terms, the following sections of the quality assurance criteria:

- **Management**
- **Performance**
- **Assessment**

Section I: Management

Criterion 1–Program

- The QAP must describe the organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, performing, and assessing the work.
- The QAP must describe management processes, including planning, scheduling, and resource considerations.

The principal measure of an organization's performance is the quality of its products and services. The QA Order and Rule require that an organization develop, document, and maintain an effective QAP, also referred to as a quality management system. The goal of the quality management system is delivery of safe, reliable products and services that meet or exceed the customer's requirements, needs, and expectations.

Criterion 2–Personnel Training and Qualification

- Personnel must be trained and qualified to ensure they are capable of performing their assigned work.
- Personnel must be provided continuing training to ensure that job proficiency is maintained.

Policies and procedures that describe personnel selection, training, and qualification requirements should be established for each function.

Training assists personnel in acquiring knowledge of the correct and current processes and methods to accomplish assigned tasks. It enables personnel to understand the fundamentals of the work, the associated hazards, the context within which the work is performed, and the reasons for any special work requirements. Initial training should prepare personnel to perform the job. Continuing training should maintain and promote improved job performance.

Before personnel are allowed to work independently, management should ensure those personnel have the necessary experience, knowledge, skills, and abilities.

Criterion 3–Quality Improvement

- Processes to detect and prevent quality problems must be established and implemented.
- Items, services, and processes that do not meet established requirements must be identified, controlled, and corrected in accordance with established requirements.
- Corrective Action Plans must include identifying the causes of problems and working to prevent recurrence.

- Item characteristics, process implementation, and other quality-related information must be reviewed and the data analyzed to identify items, services, and processes needing improvement.

Quality improvement is a disciplined management process based on the premise that all work can be planned, performed, measured, and improved. Management should ensure that the focus is on improving the quality of products, processes, and services by establishing priorities, promulgating policy, promoting cultural aspects, allocating resources, communicating lessons learned, and resolving significant management issues and problems that hinder the organization from achieving its objectives. Management should balance safety and mission priorities (SMS Policy Principle 4) when considering improvement actions.

Criterion 4–Documents and Records

- Documents must be prepared, reviewed, approved, issued, used, and revised to prescribe processes, specify requirements, or establish design.
- Records must be specified, prepared, reviewed, approved, and maintained.

Key points

- A document system must be established and implemented
- Measures should be implanted to make sure that only correct documents are in use
- Records should accurately reflect completed work and be carefully maintained

Section II: Performance

Criterion 5–Work Processes

- Work must be performed consistent with technical standards, administrative controls, and hazard controls adopted to meet regulatory or contractual requirements using approved instructions, procedures, or other appropriate means.
- Items must be identified and controlled to ensure their proper use.
- Items must be maintained to prevent their damage, loss, or deterioration.
- Equipment used for process monitoring or data collection must be calibrated and maintained.

Work is defined as the process of performing a defined task or activity. Work processes consist of a series of actions planned and carried out by qualified personnel using approved procedures, instructions, and equipment under administrative, technical, and environmental controls to achieve an end result.

Criterion 6–Design

- Items and processes must be designed using sound engineering/scientific principles and appropriate standards.
- Applicable requirements and design bases must be incorporated into design work and changes.
- Design interfaces must be identified and controlled.
- The adequacy of design products must be verified or validated by individuals or groups other than those performing the work.
- Verification and validation of work must be completed before approval and implementation of the design.

A design process should be established that provides appropriate control of design inputs, outputs, verification, configuration and design changes, and technical and administrative interfaces. Design work should be based on sound engineering judgment, scientific principles, and applicable codes and standards. DOE O 420.1A, *Facility Safety*, identifies some of the design requirements.

Criterion 7–Procurement

- Procured items and services must meet established requirements and perform as specified.
- Prospective suppliers must be evaluated and selected on the basis of specified criteria.
- Processes must be established and implemented to ensure that approved suppliers continue to provide acceptable items and services must be established and implemented.

The procurement process should ensure that items and/or services provided by suppliers meet the requirements and expectations of the end user. The procurement process should be planned and controlled to ensure that:

- the end user's requirements are accurately, completely, and clearly communicated to the supplier;
- supplier, designer, and end-user requirements are met during the production phase; and
- the proper product is delivered on time and maintained until use.

Criterion 8–Inspection and Acceptance Testing

- Inspection and testing of specified items, services, and processes must be conducted using established acceptance and performance criteria.
- Equipment used for inspections and tests must be calibrated and maintained.

Inspections and tests are accomplished to verify that physical and functional aspects of items, services, and processes meet requirements and are fit for acceptance and use. Performance expectations, inspections and tests should be identified/considered early in the design process and/or specified in the design output and procurement documents.

Section III: Assessment

Criterion 9–Management Assessment

- Managers must assess their management processes to identify and correct problems that hinder the organization in achieving its objectives must be identified and corrected.

Managers at every level should periodically assess their organizations and functions to determine how well they meet customer and performance expectations and mission objectives, identify strengths or improvement opportunities, and correct problems. Assessments should address the effective use of resources to achieve the organization's goals and objectives. Management assessments should determine whether an integrated management system exists and whether it focuses on meeting both customer and performance requirements and strategic goals.

Criterion 10–Independent Assessment

- Independent assessments must be planned and conducted to measure item and service quality, to measure the adequacy of work performance, and to promote improvement.
- The group performing independent assessments must have sufficient authority and freedom from the line to carry out its responsibilities.
- Persons conducting independent assessments must be technically qualified and knowledgeable in the areas assessed.

Senior management should establish and implement a process to obtain an independent assessment of the organization's programs, projects, contractors, and suppliers. The purpose of this type of assessment is to evaluate compliance performance of work processes with regard to requirements, expectations of customers, and efforts required to achieve the mission and goals of the organization. The results of independent assessments provide an objective form of feedback to senior management that is useful in confirming acceptable performance and should be used for identifying improvement opportunities.

17.d. Discuss the safety issue corrective process as described in the Order.

(Note: the safety issue corrective process is called the Corrective Action Management Program)

The objective of the Corrective Action Management Program is to prescribe process requirements for DOE line managers to effectively perform corrective actions for safety issues arising from:

- Findings identified by the Offices of Independent Oversight and Performance Assurance; Environment, Safety, and Health (ES&H); and Emergency Management (DOE O 470.2B, Independent Oversight and Performance Assurance Program);
- Judgment of needs identified by Type A accident investigations (DOE O 225.1A, Accident Investigations);

- findings identified by the Office of Aviation Management (DOE O 440.2B): or
- Other sources as directed by the Secretary or Deputy Secretary, including crosscutting safety issues.

The Order provides requirements for

- Reporting Findings
- Corrective Action Plan Development, Approval, and Review
- Tracking and Reporting
- Corrective Action Effectiveness Review
- Identifying and Reporting Lessons Learned
- Chartering and maintenance of the Corrective Action Management (CAM) Team.

Competency 17 - References/Additional Reading

10 CFR 830, Subpart A, Quality Assurance Requirements

DOE O 414.1C, Quality Assurance

DOE O 470.2B, Independent Oversight and Performance Assurance Program

DOE O 225.1A, Accident Investigations

DOE O 440.2B, Aviation Management and Safety

DOE G 414.1-2A, Quality Assurance Management System Guide for Use with 10 CFR 830 Subpart A, Quality Assurance Requirements, and DOE O 414.1C, Quality Assurance

Competency 18: Unreviewed Safety Questions

18. Personnel shall demonstrate a familiarity level knowledge of DOE Order 5480.21, Unreviewed Safety Questions.

18.a. Describe the purpose of the Unreviewed Safety Question (USQ) Order

The purpose of 10 CFR 830.203, Unreviewed Safety Question (USQ) Order, is:

- To allow contractors to make physical and procedural changes and to conduct tests and experiments without prior DOE approval if the proposed change can be accommodated within the existing safety basis.
- To alert DOE of events, conditions, or actions that affect the DOE-approved safety basis of the facility or operation and ensure appropriate DOE line management action.

The USQ process provides contractors with the flexibility needed to conduct day-to-day operations by requiring only those changes and tests with a potential to impact the safety basis (and therefore the margin of safety of the nuclear facility) be approved by DOE.

The USQ process is required for Hazard Category 1, 2, and 3 nuclear facilities and is integrated with the facilities change control processes

10 CFR 830 defines the USQ process as “the mechanism for keeping the safety basis current by reviewing potential USQs, reporting USQs to DOE, and obtaining approval by DOE prior to taking any actions that involves an USQ.”

The USQ process involves several steps:

1. First proposed changes to the facility (including facility procedures) are documented.
2. Second, some strictly administrative (e.g., editorial) changes are screened out without going through the full USQ process.
3. Third a USQ “determination” is made. If the conclusion is that an USQ exists, then DOE must approve the change before it is implemented. If the conclusion is that an USQ does not exist, then the change may be made without prior DOE approval

Note: Some changes (e.g., changes to TSRs) must receive prior approval by DOE (whether they constitute an USQ or not), and therefore, do not need to go through the USQ process.

18.b. Discuss the reasons for performing a USQ determination.

The USQ determination is a formal-documented evaluation of a proposed plant change (or discrepant as found condition) against specific conditions identified in 10 CFR 830.203. The reason for performing a USQ determination is to determine whether the proposed change would result in the facility being outside its DOE approved safety basis.

The existence of a USQ does not mean that the proposed facility or operation is unsafe but only that proposed change is not within the current safety basis approved by DOE, and that DOE must approve the change prior to it being implemented.

If a change is proposed or a condition is discovered that could increase the risk of operating a facility beyond that established in the current safety basis, DOE line management, must review and determine the acceptability of that risk through the process of approving a revised safety basis that would be developed and submitted by the contractor.

18.c. Define and discuss the following terms as they related to USQ:

- Accident analyses
- Safety evaluation
- Technical safety requirements

Note: several additional terms (beyond those identified in the qualification standard) are discussed in this course including:

- USQ Determination
- USQ
- Documented Safety Analyses
- Safety evaluation reports
- Margin of safety
- Potential Inadequacy in the Safety Analysis

Accident Analyses

The accident analysis is the section of DSA that evaluates potential accidents and their consequences.

Safety Evaluation

The term “Safety evaluation” is used in different manners as related to USQs. It is sometime used to denote the contractor review of the safety of a proposed change. However, a more common term used by contractors processing proposed changes is a “USQ determination” which is the contractors documented review of whether a potential change is a USQ. As discussed previously, DOE utilizes the term Safety Evaluation Report to denote its record of review of contractor DSA and USQ submittals.

Technical Safety Requirements (TSRs)

TSRs are limits, controls, and related actions that establish the specific parameters for safe operation of a facility. The TSRs define the approved “safe operating envelope”. If a potential plant change results in a need to change a TSR, then prior DOE approval is needed and therefore, there is no need to make a USQ determination.

Other Key Terms:

USQ Determination

USQ Determination is the application of the USQ process to decide whether the observed discrepant condition(s) or proposed changes are “within” the safety basis. The “USQ evaluation (determination)” is the contractor record of whether a potential change is a USQ

USQ (or Positive USQ)

USQ is a condition that is not within the safety basis. DOE jargon is to call these Positive USQs to avoid confusion with the USQ as a process.

Documented Safety Analysis (DSA)

Documented safety analysis means a documented analysis of the extent to which a nuclear facility can be operated safely with respect to workers, the public, and the environment, including a description of the conditions, safe boundaries, and hazard controls that provide the basis for ensuring safety. [10 CFR 830]

The DSA contains the evaluation of potential accidents and their consequences and defines hazards controls necessary to protect the worker and public. The most important controls become part of the TSR. The DSA contains the analysis which forms the facility safety basis.

Safety Evaluation Report

Safety evaluation report means the report prepared by DOE to document (1) the sufficiency of the documented safety analysis; control settings and limiting conditions for operation are met, (2) the extent to which a contractor has satisfied the requirements of Subpart B of 10 CFR 830 and (3) the basis for approval by DOE of the safety basis for the facility, including any conditions for approval. [10 CFR 830]

A safety evaluation report is the DOE documented review of the facility DSA. The SER provides DOE approval and any conditions of approval for the DSA.

Margin of Safety

For purposes of performing the USQ determination, a margin of safety is defined by the range between two conditions. The first is the most adverse condition estimated or calculated in safety analyses to occur from an operational upset or family of related upsets. The second condition is the worst-case value known to be safe, from an engineering perspective. This value would be expected to be related to the condition at which some accident prevention or mitigation action must be taken in response to the upset or accident, as required by a DOE-approved TSR, not the actual predicted failure point of some component.

Potential Inadequacy in the Safety Analysis

Per 10 CFR 830 a potential inadequate safety analysis exists if the analysis potentially may not be bounding or may otherwise be inadequate.

18.d. Describe the situations that require a safety evaluation to be performed.

Note: as discussed previously a more common and appropriate term (than safety evaluation) is an "USQ determination"

A USQ determination is performed for:

1. temporary or permanent changes in the facility as described in the existing safety analyses;
2. temporary or permanent changes in the procedures as described in existing safety analyses;
3. test or experiments not described in existing safety analyses; or
4. Existing plant conditions that indicate that the documented safety analysis may not be bounding or may otherwise be inadequate.

The facility includes the equipment associated with the structure as well as the structure itself.

18.e. Define the conditions for a USQ.

The condition (i.e., proposed plant change or discrepancy) is a USQ if the condition results in:

1. the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the facility safety analyses could be increased;
2. the possibility for an accident or malfunction of a different type than any evaluated previously in the facility safety analyses could be created; or
3. a margin of safety, as defined in the bases of the TSRs, could be reduced.
4. the DSA may not be bounding or may be otherwise inadequate

The DOE implementing guide (DOE G 424.1-1) breaks these four criteria down into the following seven questions (if the answer to any of the questions is yes, then a USQ (positive USQ) exists).

- Could the proposed change increase the probability of an accident previously evaluated in the facility's existing safety analyses?
- Could the proposed change increase the consequences (to workers or the public) of an accident previously evaluated in the facility's existing safety analyses?
- Could the proposed change increase the probability of a malfunction of equipment important to safety previously described in the facility's existing safety analyses?

- Could the proposed change increase the consequences of a malfunction of equipment important to safety described in the facility's existing safety analyses?
- Could the proposed change create the possibility of an accident of a different type than any previously evaluated in the facility's existing safety analyses?
- Could the proposed change create the possibility of a malfunction of equipment important to safety of a different type than any previously evaluated in the facility's existing safety analyses?
- Does the proposed change reduce the margin of safety?

18.f. Describe the responsibilities of contractors authorized to operate defense nuclear facilities for the performance of safety evaluations.

Contractors for operating Hazard category 1, 2 and 3 nuclear facilities are responsible for implementing the USQ process.

For all USQ evaluations (safety evaluations) a contractor shall:

1. document the basis for the USQ determination;
2. maintain documentation required for the authorized operating period of the nuclear facility and ensure the complete transfer of all documentation to any contractor prior to termination of its contract;
3. incorporate in the existing DSA any changes that are needed as a result of the USQ evaluation or any action taken; and
4. submit to DOE, on a schedule corresponding to the periodic updates of the DSA, a report summarizing all situations for which a safety evaluation was required and indicating all changes considered in a safety evaluation and implemented six months or more before the submittal date of the report.

18.g. Describe the action(s) to be taken by a contractor upon identifying information that indicates a potential inadequacy of previous safety analyses or a possible reduction in the margin of safety as defined in the TSRs.

10 CFR 830.203 requires the following actions when a potential inadequacy in the safety analysis (PISA) is identified:

1. Place the facility in a safe condition
2. Notify DOE of the situation
3. Perform a USQ determination
4. Submit an evaluation of the safety of the situation before removing any operational restrictions

This is also a reportable occurrence in accordance with DOE O 231.1A.

DOE G 424.1 provides expectations for timeliness of processing PISAs. Specifically, the USQ determination should be prepared promptly and the results submitted promptly. The time frame after initial notification of DOE until submittal of the USQ determination results should be on the order of hours or days, not weeks or months.

Reasons a DSA may potentially be inadequate

The DSA may be inadequate for any number of reasons. In general, it is possible for a potentially inadequate analysis to arise from three entry conditions:

- a discrepant as-found condition,
- an operational event or incident, or
- new information, including discovery or an error, sometimes from an external source.

The main consideration is that the analysis does not match the current physical configuration of the facility, or the analysis is inappropriate or contains errors.

The analysis might not match the facility configuration because of a discrepant as-found condition.

Analytical errors might involve using incorrect input values, using invalid assumptions, using an improper model, or calculational errors.

The USQ process starts when the facility management has information that gives reason to believe that there is the *potential* that the facility DSA might be inadequate.

The USQ process does not apply to the process of upgrading DSAs in response to new requirements or to the use of new or different analytical tools during the upgrade process. However, the USQ process does apply when there is reason to believe that the current safety basis might be in error or otherwise inadequate.

18.h. Discuss the action(s) to be taken if it is determined that a USQ is involved.

If a USQ is involved (i.e., a proposed change is determined to be a USQ) then the impact on the safety basis must be defined and DOE must approve of the change (and changes to the safety basis) prior to the change being implemented. DOE might disapprove the change, in that case, the change can not be implemented.

18.i. Discuss the qualification and training requirements for personnel who perform safety evaluations.

Implementing procedures should establish the personnel training and qualifications needed to perform the USQ process. These include required educational background, years and/or types of work experience, knowledge of the facility, understanding of DOE requirements related to the

facility safety basis (including the USQ process), and familiarity with the facility-specific safety basis.

All personnel responsible for preparing, reviewing, or approving USQ documents should receive training on the application of Section 830.203, including any facility-specific procedures. The recommended interval for retraining in DOE 424.1-1 is every 2 years.

The contractor should maintain a list of those personnel who are currently qualified to perform the USQ process.

Competency 18 - References/Additional Reading

10 CFR 830.203, Unreviewed Safety Question Process

DOE G 424.1-1, Implementing Guide for Use in Addressing Unreviewed Safety Question Requirements

DOE O 231.1A Environment, Safety and Health Reporting

Competency 19: Safety Analysis Requirements

- 19. Personnel shall demonstrate a familiarity level knowledge of the technical safety requirements as described in Department of Energy (DOE) Order 5480.22, Technical Safety Requirements, and Department of Energy (DOE) Order 5480.23, Nuclear Safety Analysis Reports, and Code of Federal Regulations (CFR) 10 CFR 830 Subpart B, Nuclear Safety Management**

Note:

DOE Orders 5480.22 and 5480.23 have been canceled and replaced by DOE G 423.1-1, Implementation Guide for Use in Developing Technical Safety Requirements, and DOE G 421.1-2, Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830, respectively.

19.a. Define and compare the terms “risk” and “hazard”

Hazard

A source of danger (i.e., material, energy source, or operation) with the potential to cause illness, injury, or death to a person or damage to a facility or to the environment (without regard to the likelihood or credibility of accident scenarios or consequence mitigation). [DOE G 420.1-1]

Risk

The quantitative or qualitative expression of possible loss that considers both the probability that an event will occur and the consequence of that event. [DOE G420.1-1] Risk is the possibility that a hazard will lead to harm. It is a measure of the likelihood of a hazard to cause harm and the consequences of this harm. Example: Frequent exposures causing moderate consequences can have a comparable risk to infrequent exposures resulting in higher consequences.

Hazard/Risk Analysis

A hazard analysis is the determination of material, system, process, and plant characteristics that can produce undesirable consequences, followed by the assessment of hazardous situations associated with a process or activity. Largely qualitative techniques are used to pinpoint weaknesses in design or operation of the facility that could lead to accidents. The Safety Analysis Report hazard analysis examines the complete spectrum of potential accidents that could expose members of the public, onsite workers, facility workers, and the environment to hazardous materials. [DOE-STD-3009-94]

A risk analysis usually involves a combination of qualitative and quantitative analysis.

Qualitative analyses use engineering judgment supported by industry and DOE experience, consensus standards and guidance, and other estimates of event likelihood and potential

consequences to characterize risk.

Quantitative analyses provide a numerical risk evaluation through application of models or analysis processes that use numerical values to important likelihood and consequence factors. For example, radiological and chemical exposures leading to consequences can be more precisely estimated using models accounting for concentrations, exposure periods, weather, material form or many other factors.

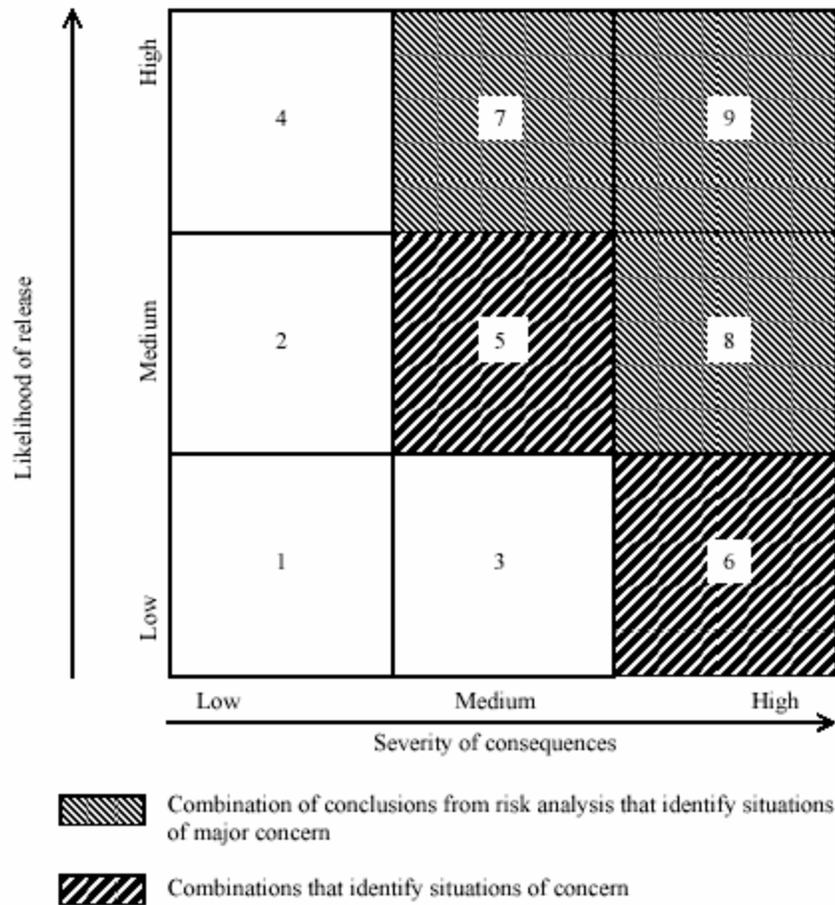
An example of hazard evaluation/risk ranking is shown below [from DOE STD 3009].

Qualitative severity classification table.

Descriptive word	Description
No	Negligible on-site and off-site impact on people or the environs.
Low	Minor on-site and negligible off-site impact on people or the environs.
Moderate	Considerable on-site impact on people or the environs; only minor off-site impact.
High	Considerable on-site and off-site impacts on people or the environs.

Qualitative likelihood classification table.

Descriptive word	Estimated annual likelihood of occurrence	Description
Anticipated	$10^{-1} > p > 10^{-2}$	Incidents that may occur several times during the lifetime of the facility. (Incidents that commonly occur)
Unlikely	$10^{-2} > p > 10^{-4}$	Accidents that are not anticipated to occur during the lifetime of the facility. Natural phenomena of this probability class include: Uniform Building Code-level earthquake, 100-year flood, maximum wind gust, etc.
Extremely Unlikely	$10^{-4} > p > 10^{-6}$	Accidents that will probably not occur during the life cycle of the facility. This class includes the design basis accidents.
Beyond Extremely Unlikely	$10^{-6} > p$	All other accidents.



Likelihood and Consequence Ranking Matrix [From DOE STD 3009]

Risk Factors

The factors that affect risk are:

- Likelihood or probability of event (that result in an adverse health or environmental impact)
- Consequence of event (magnitude of the impact)

Likelihood factors could include (not limiting):

- How often an activity is performed
- The level of control provided by the structures, systems and components (reliability, design, function, proximity)

Consequences factors could include (not limiting)

- Material form, quantity, dispersability,
- Material toxicity or equivalent, pathways
- Exposure mechanisms,
- Environmental conditions

DOE has defined 3 hazard categories in DOE-STD-1027-92

Hazard Category 1: The hazard analysis shows the potential for significant offsite consequences.

Hazard Category 2: The hazard analysis shows the potential for significant onsite consequences.

Hazard Category 3: The hazard analysis shows the potential for only significant localized consequences.

19.b Explain and compare the terms “design basis” and “authorization basis.”

Design Basis

Design basis means the set of requirements that bound the design of systems, structures, and components within the facility. These design requirements include consideration of safety, plant availability, efficiency, reliability, and maintainability. Some aspects of the design basis are important to safety, although others are not. [STD-3009]

Authorization Basis

The Authorization Basis is those aspects of the facility design basis and operational requirements relied upon by DOE to authorize operation. These aspects are considered to be important to the safety of the facility operations. The authorization basis includes the safety basis for the facility, which focuses on the protection of personnel, both offsite and onsite. DOE-STD-3009-94 defines "safety basis" as information relating to the control of hazards at a facility (including design, engineering analyses, and administrative controls) upon which DOE depends for its conclusion that activities at the facility can be conducted safely. The terms "authorization basis" and "safety basis" are sometimes used interchangeably. The authorization basis may also include information related to environmental protection. [DOE-STD-3024]. Note: 10 CFR 830 defines “safety basis” as the documented safety analysis and hazard controls that provide reasonable assurance that a DOE facility can be operated safely in a manner that adequately protects workers, the public, and the environment.

Documents that providing authorization basis information typically include, but are not necessarily limited to, the DSA, SAR, TSRs, EISs, hazard classification documents, DOE-issued Safety Evaluation Reports, and documents containing facility-specific commitments to comply with DOE Orders or policies.

In other words, authorization basis is the results of all analyses, decisions and agreements related to facility design basis and operational requirements that DOE relies upon to authorize a given facility for well defined set of operations. The focus of authorization basis is to assure the safety of the facility operations.

The design basis is a part of the authorization basis.

19.c. Discuss the purpose of TSRs and DSAs and the relationship between the two documents.

TSR

TSRs are the limits, controls, and related actions that establish the specific parameters and requisite actions for the safe operation of a nuclear facility and include, as appropriate for the work and the hazards identified in the documented safety analysis for the facility: Safety limits, operating limits, surveillance requirements, administrative and management controls, use and application provisions, and design features, as well as a bases appendix. [10 CFR 830]

TSRs are those requirements that define the conditions, safe boundaries, and the management or administrative controls necessary to ensure the safe operation of a nuclear facility and to reduce the potential risk to the public and facility workers from uncontrolled releases of radioactive materials or from radiation exposure due to inadvertent criticality.

The TSR defines the requirements necessary to ensure most important hazard controls are implemented. A TSR consists of operating limits, surveillance requirements, administrative controls, use and application instructions, design features and the bases thereof.

DSA

DSAs specifically examine those hazards inherent in processes and related operations that can result in uncontrolled release of hazardous material (i.e., chemical or radiological) or process-unique energy sources (e.g., high pressure autoclave). Standard industrial hazards do not require SAR DSA coverage. Standard industrial hazards such as burns from hot objects, electrocution, falling objects, etc., are of concern only to the degree that they can be a contributor to a significant uncontrolled release of hazardous material (e.g., 115-volt wiring as initiator of a fire) or major energy sources such as explosive energy.

A DSA documents the safety basis and provides detailed information for a determination that the facility can be operated, maintained, shut down, and decommissioned safely.

The TSRs are directly derived from the controls identified in the DSA.

The approved DSA, TSRs, and other supporting hazard analysis or control documents contain the principal safety basis for a DOE decision to authorize facility operation. Once facility operation is authorized, the final DSA, TSRs, and hazard controls will be the principal safety bases for sustaining authorization and safety oversight.

19.d. Describe the responsibilities of contractors authorized to operate defense nuclear facilities for TSRs and DSAs.

A contractor responsible for the operation of a DOE nuclear facility shall prepare DSAs and TSRs for the facility, submit the DSAs and TSRs to the Program Secretarial Officer (PSO) for approval, and operate the facility in accordance with the TSRs as approved by the PSO, including any modification by the PSO.

Development of a DSA or preliminary documented safety analysis (PDSA) is the process whereby facility hazards are identified, controls to prevent and mitigate potential accidents involving those hazards are proposed, and commitments are made for design, construction, operation, and disposition so as to assure adequate safety at DOE nuclear facilities. DOE, in its review and approval role, may require modification or addition to these commitments by the responsible contractor.

Throughout the life of the facility, from design and construction to mission-oriented operations, through deactivation, long-term surveillance and maintenance, to decontamination and decommissioning, there must be a safety basis in place that is appropriate to the activities (operations) occurring during each of those phases.

The TSR and its appendices constitute an agreement or contract between DOE and the facility operating management regarding the safe operation of the facility. As such, they cannot be changed without PSO approval.

TSRs should be written in a clear and concise manner, in language that is directed at and clearly understandable by those in the facility operating organization. The TSR should not contain excessive details that are more appropriate to the DSA.

19.e. Define the following terms and discuss the purpose of each:

- **Safety limit (SL)**
- **Limiting control settings**
- **Limiting conditions for operation (LCO)**
- **Surveillance requirements**

Safety Limit

SLs are limits on important process variables needed for the facility function that, if exceeded, could directly cause the failure of one or more of the passive barriers that prevent the uncontrolled release of radioactive materials, with the potential of consequences to the public above specified evaluation guidelines.[DOE G 423.1-1]

Safety Limit (continued)

If any SL is exceeded at any reactor or nonreactor nuclear facility, action shall begin immediately to place the facility in the most stable, safe condition attainable, including total shutdown of either reactor or nonreactor nuclear facilities. The appropriate time frame for the

completion of the action for each nuclear facility has to be developed and justified by the contractor, as appropriate, in the TSR document which requires PSO approval. The SLs shall describe the action to be taken when an SL is exceeded. If an SL is exceeded, the contractor shall notify DOE, review the matter, and record the results of the review. The review shall include the cause of the condition and the basis for any corrective actions taken to preclude reoccurrence. The safe, stable condition entered as corrective action shall be maintained until the cognizant program manager authorizes further operations.

Example

2.1 SAFETY LIMITS

2.1.1 REACTOR COOLANT SYSTEM (RCS) PRESSURE SAFETY LIMIT

SL: The RCS shall be maintained < 1000 psia

APPLICABILITY: Operation Mode

- ACTIONS:**
1. Go to SHUTDOWN mode IMMEDIATELY,
 2. Notify the DOE CSO within one hour of reaching SHUTDOWN mode, and
 3. Prohibit facility operation until authorized by DOE.

Limiting Control Settings

Limiting control settings (LCS) define the settings on safety systems that control process variables to prevent exceeding an SL [DOE G 423.1-1].

LCSs for reactors should include reactor trip system instrumentation set points. The reactor trip set-point limits are the nominal values at which the reactor trips are set and should be selected to provide sufficient allowances between the trip set point and the SL. This allowance will ensure the core and the reactor coolant system are prevented from exceeding SLs during normal operation and anticipated operational occurrences.

LCSs of instruments that monitor process variables at nonreactor nuclear facilities are the settings that either initiate protective devices themselves or sound an alarm to alert facility personnel to take action to protect barriers that prevent the uncontrolled release of radioactive materials. An LCS is only specified for a variable that also protects an SL. LCSs should be chosen so that there is adequate time after exceeding the setting to correct the abnormal situation, automatically or manually, before an SL is exceeded.

Example

3/4.2 LIMITING CONTROL SETTINGS

3.2 HEATING GLOVEBOX, HEATING TEMPERATURE LIMITING CONTROL SETTING

LCS: The temperature setting of the Temperature Control Heating Shutoff shall be no greater than the Safety Limit (SL 2.1) minus 36° C.

MODE APPLICABILITY: Operational and Maintenance when unstable materials and Plutonium are present in the heating glovebox

ACTIONS:

CONDITIONS	REQUIRED ACTION	COMPLETION TIME
A. The temperature setting in the temperature control heating shutoff exceeds the Safety Limit (SL 2.1) minus 36°C.	A.1 Shutoff power to the heaters in the affected heating glovebox.	IMMEDIATELY
	AND	
	A.2 Evacuate the facility of all personnel, except for those directly involved with corrective actions.	IMMEDIATELY
	AND	
	A.3 Repair and functionally test the affected heating glovebox and equipment.	Before returning power to the heaters in the affected heating glovebox

Limiting Conditions for Operation

LCOs define the limits that represent the lowest functional capability or performance level of safety systems, structures and components (SSCs) required to perform an activity safely. LCOs should include the initial conditions for those design basis accidents or transient analyses that involve the assumed failure of, or present a challenge to, the integrity of the primary radioactive material barrier.

Identification of these variables should come from a search of each transient and accident analysis documented in the DSA. The LCO should be established at a level that will ensure the process variable is not less conservative during actual operation than was assumed in the safety analyses. LCOs should also include those SSCs that are part of the primary success path of a safety sequence analysis, and those support and actuation systems necessary for them to function successfully. Support equipment for these SSCs would normally be considered to be part of the LCO if relied upon to support the SSCs function.

This subsection of the TSRs shall contain the limits on functional capability or performance level. Example of LCOs are “ventilation system must be operable” and “Fire Protection system must be operable.”

When an LCO is not met, the contractor shall take remedial actions defined by the TSRs until the condition can be met. The LCO shall describe the action to be taken in case the LCO is not met.

Example:

3/4.3 LIMITING CONDITIONS FOR OPERATION

3.2 HEATING GLOVEBOX TEMPERATURE SHUTOFF CONTROL SYSTEM

LCO: Each Heating Glovebox shall have two OPERABLE Heating Glovebox Temperature Control Shutoff systems and one OPERABLE temperature recorder.

MODE APPLICABILITY: Operation and Maintenance when unstable materials are present in the heating glovebox and plutonium is present

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One heating glovebox temperature control shutoff is not OPERABLE	A.1 Shutoff power to the heaters in the affected heating glovebox.	IMMEDIATELY
OR the temperature recorder is not OPERABLE.	AND A.2 Repair the affected heating glove box and equipment.	
		Before returning power to the heaters in the affected heating glovebox

Surveillance Requirements (SRs)

SRs are used to ensure operability or availability of the safety SSCs. SRs are most often used with LCOs to periodically validate the operability of active systems or components that are subject to a limiting condition.

SRs consist of short descriptions of the type of surveillance required and its frequency of performance.

SURVEILLANCE REQUIREMENTS

SURVEILLANCE REQUIREMENT	FREQUENCY
SR 4.3.1.1 Perform a TRIP ACTUATING DEVICE OPERATIONAL TEST on each fire detector instrument.	Semiannually
SR 4.3.1.2 Demonstrate that the NFPA Standard 72D supervised circuits supervision associated with the detector alarms of each fire detection instrument are OPERABLE.	Semiannually
SR 4.3.1.3 Demonstrate that the unsupervised circuits associated with detector alarms between the instrument and the control room are OPERABLE.	Monthly

Administrative Controls (ACs)

ACs are the provisions relating to organization and management, procedures, record keeping, reviews, and audits necessary to ensure safe operation of the facility. ACs may include reporting deviations from TSRs (i.e., exceeding LCOs, LCSs, or SRs, or violation of a TSR), staffing requirements for facility positions important to safe operation of the facility, ACs of the criticality safety program, and commitments to safety management programs important to worker safety.

DOE has defined a class of administrative controls as “Specific Administrative controls,” and issued guidance on their identification and implementation. Specific Administrative controls are administrative controls that provide preventive and/or mitigative functions for specific potential accident scenarios, and which, also have safety importance equivalent to engineered controls that would be classified as Safety Class (SC) or Safety Significant (SS) if the engineered controls were available and selected.

When ACs specifically state a limit or specific requirement rather than a generic programmatic reliance, failure to meet such statements can result in a TSR violation. In contrast, a TSR violation of a safety management program can only result from a gross program failure, significant enough to render the DSA assumptions invalid.

19.f Discuss the possible source documents that may be used in developing TSRs.

The DSA required by 10 CFR 830.204 furnishes the technical basis for TSRs. For some facilities, other documentation such as the SER may provide additional safety controls or operating restrictions that should be reflected in the TSRs. The TSR derivation section in the DSA is intended to provide a link between the safety analysis and the list of variables, systems,

components, equipment, and administrative procedures that must be controlled or limited in some way to ensure safety.

19.g. Discuss the conditions that constitute a violation of the TSRs and state the reporting requirements should a violation occur.

Violations of a TSR occur as a result of the following four circumstances.

- Exceeding an SL.
- Failure to complete an ACTION statement within the required time limit following exceeding an LCO or failing to comply with an LCO.
- Failure to perform a surveillance within the required time limit.
- Failure to comply with an AC statement.

Failure to comply with an AC statement is a TSR violation when either the AC is directly violated, as would be the case with not meeting minimum staffing requirements for example, or the intent of a referenced program is not fulfilled. To qualify as a TSR violation, the failure to meet the intent of the referenced program would need to be significant enough to render the DSA summary invalid.

TSR violations involving SLs require the facility to begin immediately to go to the most stable, safe condition attainable, including total shutdown. Reporting of all TSR violations should be made in accordance with the provisions of DOE O 232.1A, *Occurrence Reporting and Processing of Operations Information*.

The reporting of violations on ACs can involve judgment since the details of programs like, a program for criticality control do not appear directly as a TSR, and some program requirements are more important than others. Violations of controls identified in the accident or criticality scenarios in the DSA should be reported as if the were TSR violations.

Competency 19 - References/Additional Reading

DOE G 423.1-1, Implementation Guide for Use in Developing Technical Safety Requirements,

DOE G 421.1-2, Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830

DOE O 232.1A, Occurrence Reporting and Processing of Operations Information

DOE-STD-1027-92 Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports

DOE-STD-3009-94, Ch 2, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Documented Safety Analysis Reports

DOE-STD-3024-98, Content of System Design Descriptions

DOE-STD-1186-2004, Specific Administrative Controls

If you would like to take the End of Competency Exam, Click on the 'Begin Exam' button.
Otherwise, click on 'Competency Menu'.

Competency 20: Facility Safety

20. Personnel shall demonstrate a familiarity level knowledge of DOE Order 420.1A, Facility Safety.

20.a. Discuss the purpose and applicability of the Order (O 420.1A).

The purpose of this Order is to establish safety requirements for DOE/NNSA for:

- nuclear safety design
- criticality safety
- fire protection
- natural phenomena hazards mitigation
- a system engineer program

Note: The system engineer program requirements were added in the 2003 revision of DOE O 420.1A

This Order applies to all DOE-owned or DOE-leased facilities. However, while some sections (e.g., sections 4.2 and 4.4) apply to all facilities, others only apply to certain types of facilities. For example:

- All DOE nonreactor nuclear facilities that are classified as hazard category 1, 2, or 3; and explosives facilities must also meet sections 4.1 and 4.3 of the Order
- All DOE hazard category 1, 2, and 3 nuclear facilities must also meet section 4.5 of the Order

These requirements apply to the activities of design and construction of new DOE nuclear facilities and of modifications to existing DOE hazard category 1, 2, and 3 non-reactor nuclear facilities when the proposed modifications significantly degrade the approved Facility Safety for the facility.

Modifications to facility design and construction during the design and construction phase shall conform to the requirements for new facilities. Activities associated with facility deactivation at end of life are exempt if justified by safety analysis.

The contractor shall apply the mandatory standards for the design and construction of DOE explosives facilities or modifications thereof. Explosives facilities are those facilities or locations used for storage of or operations with explosives or ammunition. When these facilities are also nuclear facilities, the requirements for nuclear safety design also apply.

20.c Discuss in general terms the focus and content of the following sections of the Order:

- **Nuclear safety**
- **Fire protection**
- **Nuclear criticality safety**
- **Natural phenomena hazards mitigation**

Nuclear and Explosive Safety

The objectives of Section 4.1, Nuclear and Explosives Safety Design Criteria, are:

- to ensure that Department of Energy (DOE) nonreactor nuclear facilities are designed and constructed so as to assure adequate protection for the public, workers, and the environment from nuclear hazards.
- to establish mandatory standards for explosives safety in the design and construction of DOE explosives facilities or modifications thereof.

Associated requirements include:

- Non-reactor nuclear facilities shall be designed with the objective of providing multiple layers of protection to prevent or mitigate the unintended release of radioactive materials to the environment.
- All nuclear facilities with uncontained radioactive materials (as opposed to material contained within drums, grout, and vitrified materials) shall have means to confine them.
- Facilities shall be designed to facilitate safe deactivation, decommissioning, and decontamination at end of life.
- Facilities shall be designed to facilitate inspections, testing, maintenance, and repair and replacement of safety SSCs as part of an overall reliability, availability, and maintainability program.
- Explosive operations will implement safety requirements in the DOE Explosives Safety Manual.

Multiple layers of protection or “Defense in depth” is an important element of DOE safety design.

Defense in depth shall include:

- Siting, minimization of material at risk, the use of conservative design margins, and quality assurance
- The use of successive physical barriers for protection against the release of radioactivity (e.g., confinement, gloveboxes, HEPA ventilation);
- The provision of multiple means to ensure critical safety functions are available during off normal operations and accidents.
- Engineered systems to reduce human error and allow safe recovering from off normal operations or excursions.

Fire Protection

The objectives of Section 4.2, Fire Protection are to establish requirements for a comprehensive fire and related hazards protection program for facilities sufficient to minimize the potential for:

- (1) the occurrence of a fire or related event;
- (2) a fire that causes an unacceptable on-site or off-site release of hazardous or radiological material that will threaten the health and safety of employees, the public, or the environment;
- (3) vital DOE programs suffering unacceptable interruptions as a result of fire and related hazards;
- (4) property losses from a fire and related events exceeding defined limits established by DOE; and
- (5) critical process controls and safety class systems being damaged as a result of a fire and related events.

Fire protection requirements include:

DOE facilities, sites, and activities shall be characterized by a level of fire protection that is sufficient to fulfill the requirements of the best protected class of industrial risks and shall be provided protection to achieve defense in depth. This includes meeting the applicable building code and National Fire Protection Association codes and standards, or exceeding them, unless explicit written relief has been granted by DOE.

A fire protection program shall:

- Establish requirements for a comprehensive fire and related hazards protection program for facilities sufficient to minimize the likelihood and magnitude of fires and for protecting against loss
- Implement Emergency response and management plans
- Provide and protect engineered fire protections systems (sprinklers, alarms, life safety code egress, adequate water, control contaminated fire water runoff)

- Develop and use results of Fire Hazards Analysis to support Safety Bases and facility design and operations (e.g., noncombustible construction, flammable loading limits)
- Design fire protection systems so that their inadvertent operation, inactivation, or failure of structural stability will not result in the loss of vital safety functions

Nuclear Criticality Safety

The objective of Section 4.3, Nuclear Criticality Safety, is to establish nuclear criticality safety program requirements to ensure that:

1. Criticality safety is comprehensively addressed and receives an objective review, with all identified risks reduced to acceptably low levels and management authorization of the operation documented.
2. The public, workers, property, both government and private, the environment, and essential operations are protected from the effects of a criticality accident.

Requirements include.

Operations with fissionable materials which pose a criticality accident hazard shall be evaluated and documented to demonstrate that the operation will be sub-critical under both normal and credible abnormal conditions. Fissionable material operations shall be conducted in such a manner that consequences to personnel and property that result from a criticality accident will be mitigated. No single credible event or failure shall result in a criticality accident having unmitigated consequences.

The nuclear criticality safety program shall be evaluated and documented and shall include

- nuclear criticality safety evaluations for normal and credible abnormal conditions that document the parameters, limits, and controls required to ensure that the analyzed conditions are sub-critical;
- implementation of limits and controls identified by the nuclear criticality safety evaluations;
- reviews of operations to ascertain that limits and controls are being followed and that process conditions have not been altered such that the applicability of the nuclear criticality safety evaluation has been compromised;
- assessment of the need for criticality accident detection devices and alarm systems, and installation of such equipment where total risk to personnel will be reduced.

An important concept in criticality safety is the “Double Contingency” which specifies that process designs shall incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible.

Protection shall be provided by either (i) the control of two independent process parameters (which is the preferred approach, when practical, to prevent common-mode failure), or (ii) a system of multiple controls on a single process parameter. The number of controls required upon a single controlled process parameter shall be based upon control reliability and any features that mitigate the consequences of control failure. In all cases, no single credible event or failure shall result in the potential for a criticality accident, except as referenced in the paragraph that follows.

Natural Phenomena Hazards Mitigation

The objective of Section 4.4, Natural Phenomena Hazards Mitigation, is to ensure that all DOE facilities are designed, constructed, and operated so that the general public, workers, and the environment are protected from the impact of natural phenomena hazards (NPHs) such as seismic, wind, flood, and lightning.

This Order defines the design criteria that ensure SSCs (safety and critical process equipment inside structures) shall be designed, constructed, and operated to withstand the effects of natural phenomena as necessary to ensure the confinement of hazardous material, the operation of essential facilities, the protection of government property, and the protection of life safety for occupants of DOE buildings

Design criteria are based on frequency and magnitude of credible NPH events and applied using a graded approach depending on the facility hazards and potential for loss. More robust design criteria for more energetic NPH events.

System Engineer Program

The objective of the Section 4.5, System Engineer Program, is to ensure continued operational readiness of the systems within its scope. A System Engineer Program shall be established for DOE Category 1, 2, and 3 nuclear facilities.

Requirements

This Program applies to active safety class and safety significant SSCs, as defined in the nuclear facility's DOE-approved safety basis and other active systems that perform an important defense-in-depth function for the protection of the public, workers, or the environment within the context of the safety basis, as designated by the facility line management (hereafter collectively referred to as systems).

A cognizant system engineer (CSE) shall be designated for each system. The CSE shall provide technical assistance in support of line management responsibility to ensure continued operational readiness of the system. The CSE shall ensure that the configuration of assigned system(s) is being effectively managed

PURPOSE

The purpose of this reference guide is to provide a single document that contains the information required for a DOE technical employee to successfully complete the General Technical Base (GTB) Qualification Standard. In addition to providing information essential to meeting the qualification requirements some references and additional background material is provided.

SCOPE

This reference guide has been developed to address the competency statements in the October 2001 edition of DOE-STD-1146-2001, General Technical Base Qualification Standard. Competency statements and supporting knowledge and/or skill statements from the qualification standard are shown in contrasting bold italics, while the corresponding information associated with each statement is provided below it. The qualification standard for the GTB contains 20 competency statements. This reference guide addresses all 20 statements.

Every effort has been made to provide the most current information and references available as of September 2005. However, the candidate is advised to verify the applicability of the information provided.

Please direct your questions or comments related to this document to James Szenzi, NTC Safety Training Manager at 845-5170.

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