National Nuclear Security Administration

General Technical Base

Qualification Standard

Reference Guide

MARCH 2012

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Acronyms	
AC	administrative control
ACGIH	American Conference of Governmental Industrial Hygienists
AEA	Atomic Energy Act
AHJ	authority having jurisdiction
AIB	accident investigation board
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
CAA	Clean Air Act
CAS	central alarm station
CBDPP	Chronic Beryllium Disease Prevention Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CM	centimeter
CO	certifying official
CRAD	criteria review and approach document
CRD	contractor requirements document
CS	competency statement
CSO	cognizant secretarial officer
CSP	criticality safety program
CTA	central technical authority
CWA	Clean Water Act
DEAR	Department of Energy Acquisition Regulation
DHS	Department of Homeland Security
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DOT	Department of Transportation
DSA	documented safety analysis
EA	environmental assessments
EIS	environmental impact statement
EMS	environmental management system
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-To-Know Act
EPHA	emergency planning hazards assessment
EPZ	emergency planning zone
ERO	emergency response organization
ES&H	environment, safety, and health
FAQS	functional area qualification standard
FEM	field element manager
FEMA	Federal Emergency Management Agency
FFCA	Federal Facility Compliance Act
FHA	fire hazards analysis
FR	facility representative

GOCO	government-owned, contractor-operated
Gy	gray
HCO	headquarters certifying official
HCS	hazard communication standard
He	helium
HLW	high level waste
HQ	DOE headquarters
HSS	Office of Health, Safety and Security
ICS	incident command system
IDLH	immediately dangerous to life or health
IEEE	Institute of Electrical and Electronic Engineers
IH	industrial hygiene
ISM	integrated safety management
ISMS	integrated safety management system
KSA	knowledge, skill, and ability
LCO	limiting condition for operation
LCS	limiting control setting
LLMW	low-level mixed waste
LLW	low level waste
LO/TO	lockout/tagout
MAA	material access area
MC&A	material control and accountability
MeV	million electron volts
MOU	memorandum of understanding
MSDS	material safety data sheet
MTRU	mixed transuranic
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NIMS	National Incident Management System
NIOSH	National Institute for Occupational Safety and Health
NNSA	National Nuclear Security Administration
NPDES	National Pollutant Discharge Elimination System
NPH	natural phenomena hazards
NRC	Nuclear Regulatory Commission
OE	operational emergencies
OSH Act	Occupational Safety and Health Act
OSHA	Occupational Safety and Health Administration
OST	Office of Secure Transportation
PA	protected area
PCB	polychlorinated biphenyl
PDSA	preliminary documented safety analysis
PEL	permissible exposure limit
PIDAS	perimeter intrusion detection and assessment system
PNOV	preliminary notice of violation
PPA	Pollution Prevention Act
PPE	personal protective equipment

PSO	program secretarial officer
Pu	plutonium
QA	quality assurance
QAP	quality assurance program
rad	radiation absorbed dose
RCRA	Resource Conservation and Recovery Act
RCT	radiological control technician
rem	roentgen equivalent man
RF	radio frequency
RFP	request for proposal
S/CI	suspect/counterfeit item
S&S	safeguards and security
SAR	safety analysis report
SARA	Superfund Amendment and Reauthorization Act
SAS	secondary alarm station
SDWA	Safe Drinking Water Act
SER	safety evaluation report
SI	international system of units
SL	safety limit
SMS	safety management system
SNM	special nuclear material
SO	secretarial officer
SR	surveillance requirement
S/RIDs	standards/requirements identification documents
SSC	structures, systems, and components
SSP	site sustainability plan
STEL	short term exposure limit
Sv	sievert
SWDA	Solid Waste Disposal Act
TED	total effective dose
TLV	threshold limit value
TQP	Technical Qualification Program
TRU	transuranic
TSCA	Toxic Substances Control Act
TSR	technical safety requirement
TWA	time-weighted average
U	uranium
USQ	unreviewed safety question
W_R	radiation weighting factor
WSHP	worker safety and health program
WSS	work smart standards

PURPOSE

The purpose of this reference guide is to provide a document that contains the information required for a Department of Energy (DOE)/National Nuclear Security Administration (NNSA) technical employee to successfully complete the General Technical Base Functional Area Qualification Standard (FAQS). Information essential to meeting the qualification requirements is provided; however, some competency statements (CS) require extensive knowledge or skill development. Reproducing all the required information for those statements in this document is not practical. In those instances, references are included to guide the candidate to additional resources.

SCOPE

This reference guide addresses the competency statements in the December 2007 edition of DOE-STD-1146-2007, *General Technical Base Functional Area Qualification Standard*. The qualification standard for General Technical Base contains 28 competency statements.

Please direct your questions or comments related to this document to the NNSA Office of Leadership and Career Management, Technical Qualification Program (TQP).

PREFACE

Competency statements and supporting knowledge and/or skill statements from the qualification standard are shown in contrasting bold type, while the corresponding information associated with each statement is provided below it.

A comprehensive list of acronyms is provided at the beginning of this document. It is recommended that the candidate review the list prior to proceeding with the competencies, as the acronyms, abbreviations, and symbols may not be further defined within the text unless special emphasis is required.

The competencies and supporting knowledge, skill, and ability (KSA) statements are taken directly from the FAQS. Most corrections to spelling, punctuation, and grammar have been made without remark. Only significant corrections to errors in the technical content of the discussion text source material are identified. Editorial changes that do not affect the technical content (e.g., grammatical or spelling corrections, and changes to style) appear without remark. When they are needed for clarification, explanations are enclosed in brackets.

Every effort has been made to provide the most current information and references available as of March 2012. However, the candidate is advised to verify the applicability of the information provided. It is recognized that some personnel may oversee facilities that utilize predecessor documents to those identified. In those cases, such documents should be included in local qualification standards via the TQP.

In the cases where information about an FAQS topic in a competency or KSA statement is not available in the newest edition of a standard (consensus or industry), an older version is referenced. These references are noted in the text and in the bibliography.

TECHNICAL COMPETENCIES

NUCLEAR FUNDAMENTALS

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

The information for all of the KSAs in this CS is taken from DOE-HDBK-1019-93.

a. Identify and describe the three forces that are found within a nucleus.

Table 1. Forces acting in the nucleus

Force	Interaction	Range
Gravitational	Very weak attractive force between all nucleons	Relatively long
Electrostatic	Strong repulsive force between like charged particles (protons)	Relatively long
Nuclear	Strong attractive force between all nucleons	Extremely short

Source: DOE-HDBK-1019-93, vol 1

Gravitational Force

The gravitational force between two bodies is directly proportional to the masses of the two bodies and inversely proportional to the square of the distance between the bodies. The larger the masses of the objects or the smaller the distance between the objects, the greater the gravitational force. So even though the masses of nucleons (a nucleon is a particle that exists in the nucleus of an atom, such as a proton or neutron) are very small, the fact that the distance between nucleons is extremely short may make the gravitational force significant.

Electrostatic Force

The electrostatic force is directly proportional to the electrical charges of the two particles (in the nucleus of an atom, these particles would be protons) and inversely proportional to the square of the distance between the particles.

Nuclear Force

If only the electrostatic and gravitational forces existed in the nucleus, then it would be impossible to have stable nuclei composed of protons and neutrons. The gravitational forces are much too small to hold the nucleons together compared to the electrostatic forces repelling the protons. Since stable atoms of neutrons and protons do exist, there must be another attractive force acting within the nucleus. This force is called the nuclear force.

The nuclear force is a strong attractive force that is independent of charge. It acts equally only between pairs of neutrons, pairs of protons, or a neutron and a proton. The nuclear force has a very short range; it acts only over distances approximately equal to the diameter of the nucleus. The nuclear force between all nucleons drops off with distance much faster than the repulsive electrostatic force between protons. In stable atoms, the attractive and repulsive forces in the nucleus balance. If the forces do not balance, the atom cannot be stable, and the nucleus will emit radiation in an attempt to achieve a more stable configuration.

b. Define the terms "mass defect" and "binding energy" and discuss how they are related.

Mass Defect

Careful measurements have shown that the mass of a particular atom is always slightly less than the sum of the masses of the individual neutrons, protons, and electrons of which the atom consists. The difference between the mass of the atom and the sum of the masses of its parts is called the mass defect. Mass defect is due to the conversion of mass to binding energy when the nucleus is formed.

Binding Energy

Binding energy is the amount of energy that must be supplied to a nucleus to completely separate its nuclear particles (nucleons). It can also be understood as the amount of energy that would be released if the nucleus was formed from the separate particles. Binding energy is the energy equivalent of the mass defect.

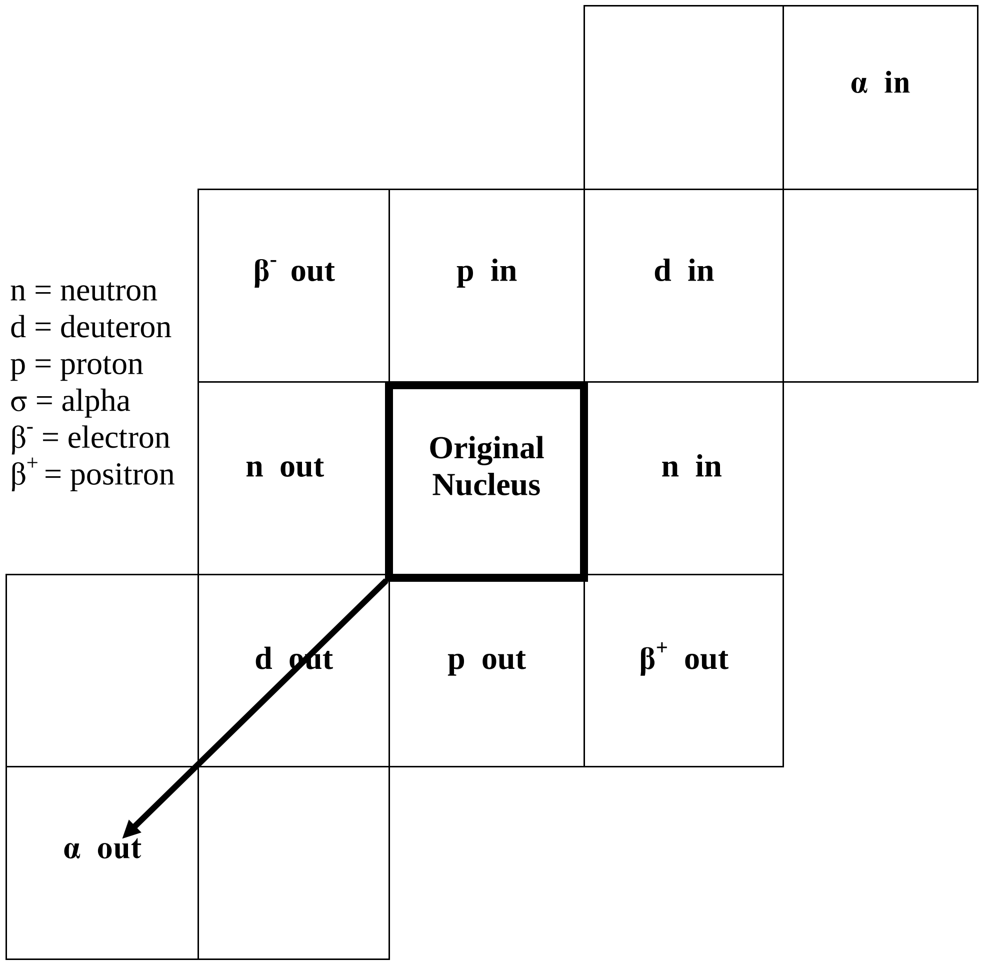
c. Describe the following processes, and trace the decay chain for a specified nuclide on the chart of the nuclides:
- **Alpha decay**
- **Beta-minus decay**
- **Beta-plus decay**
- **Electron capture**

Alpha (α) Decay

Alpha decay is the emission of alpha particles (helium [He] nuclei) which may be represented as either ${}_2He^4$ or ${}_2\alpha^4$. When an unstable nucleus ejects an alpha particle, the atomic number is reduced by two and the mass number decreased by four. An example is uranium (U)-234, which decays by the ejection of an alpha particle accompanied by the emission of a 0.068 million electron volt (MeV) gamma.

$$^{234}_{92}\mathrm{U} \rightarrow {}^{230}_{90}\mathrm{Th} + {}^{4}_{2}\alpha + \gamma + \mathrm{KE}$$

The combined kinetic energy of the daughter nucleus (thorium-230) and the α particle is designated as KE. The sum of the KE and the gamma energy is equal to the difference in mass between the original nucleus (U-234) and the final particles (equivalent to the binding energy released, since $\triangle$mass = BE). The alpha particle will carry off as much as 98 percent of the kinetic energy and, in most cases, can be considered to carry off all the kinetic energy. 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, as shown in figure 1.



Source: DOE-HDBK-1122-2009, part 6

Figure 1. Alpha decay illustration

Beta Decay

Beta decay is the emission of electrons of nuclear rather than orbital origin. These particles are electrons that have been expelled by excited nuclei and may have a charge of either sign.

If both energy and momentum are to be conserved, a third type of particle, the neutrino (ν) must be involved. The neutrino is associated with positive electron emission, and its antiparticle, the antineutrino ( ), is emitted with a negative electron. β^- decay effectively converts a neutron to a proton, thus increasing the atomic number by one and leaving the mass number unchanged. This is a common mode of decay for nuclei with an excess of neutrons, such as fission fragments. An example of a typical β^- decay reaction is shown below.

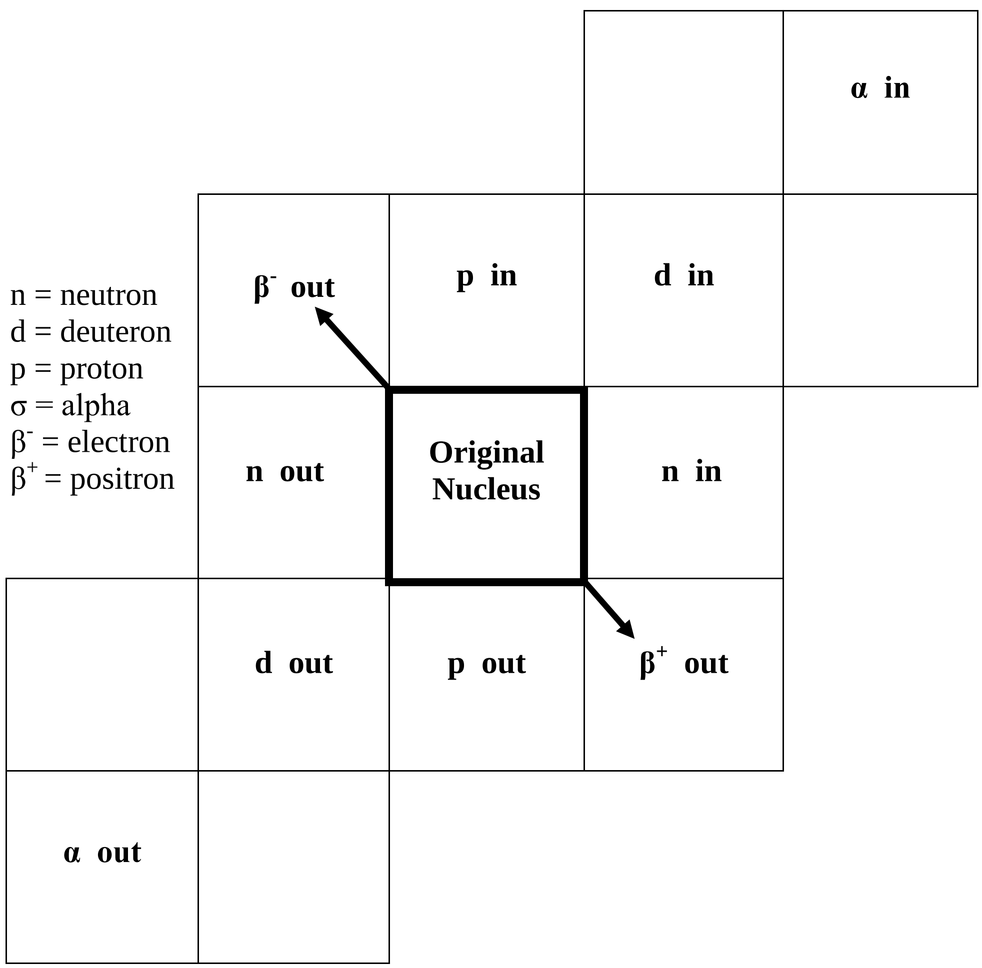
$$^{239}_{93}Np \rightarrow {}^{239}_{94}Pu + {}^{0}_{-1}\beta + {}^{0}_{0}\bar{\nu}$$

Positively charged electrons (β^+) are known as positrons. Except for sign, they are nearly identical to their negatively charged cousins. When a positron, represented as β^+, is ejected from the nucleus, the atomic number is decreased by one and the mass number remains unchanged. A proton has been converted to a neutron. An example of a typical β^+ decay is shown below.

$$^{13}_{7}N \rightarrow {}^{13}_{6}C + {}^{0}_{+1}\beta + {}^{0}_{0}\nu$$

Beta minus decay results in a change in position one up and one to the left in the chart of the 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 the 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]). Both of these processes are illustrated in figure 2.



Source: DOE-HDBK-1122-2009, part 6

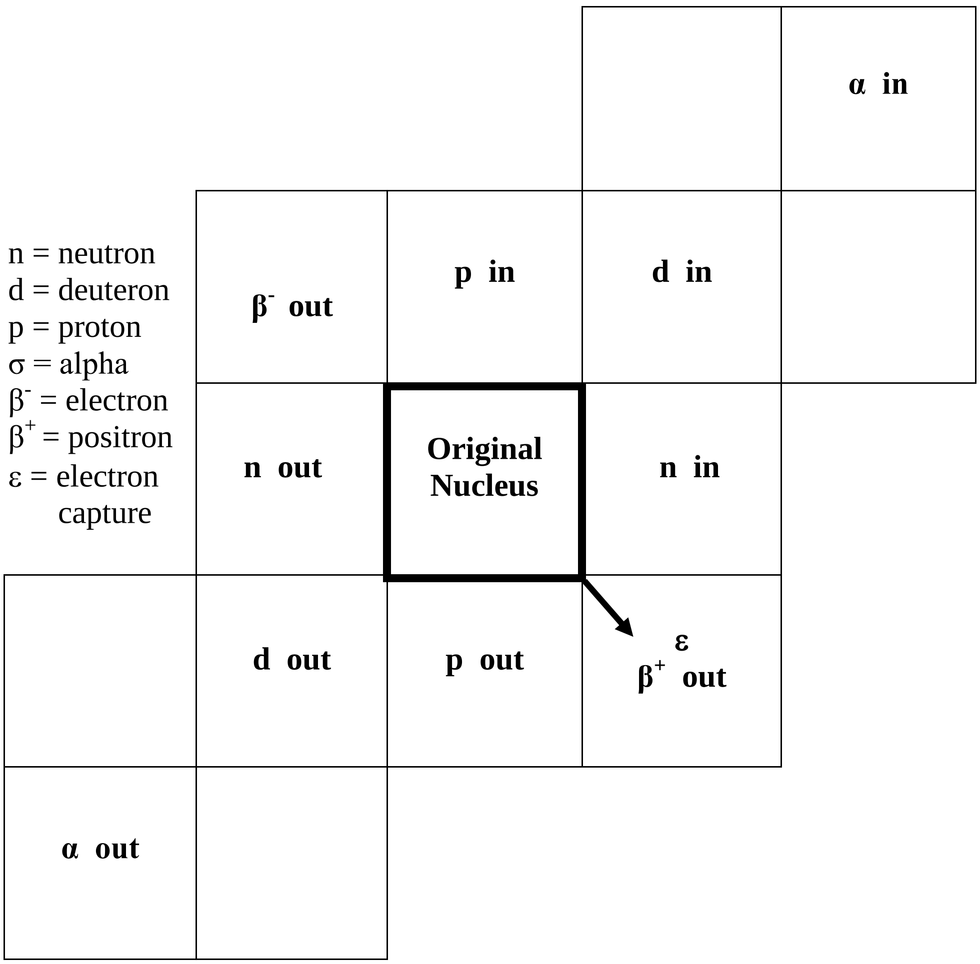
Figure 2. Beta-plus and beta-minus decay illustrations

Electron Capture

Nuclei having an excess of protons may capture an electron from one of the inner orbits which immediately combines with a proton in the nucleus to form a neutron. This process is called electron capture and is represented by the symbol ε. The electron is normally captured from the innermost orbit (the K-shell), and, consequently, this process is sometimes called K-capture. A neutrino is formed at the same time that the neutron is formed, and energy carried off by it serves to conserve momentum. The following equation depicts electron capture.

$$^{7}_{4}\mathrm{Be} + ^{0}_{-1}\mathrm{e} \rightarrow ^{7}_{3}\mathrm{Li} + ^{0}_{0}\nu$$

Electron capture results in a change in position one down and one to the right in the chart of the nuclides (similar to a beta plus decay). This process is shown in figure 3.



Source: DOE-HDBK-1122-2009, part 6

Figure 3. Electron capture decay illustration

d. Define the following terms:

- **Radioactivity**
- **Radioactive decay constant**
- **Activity**
- **Radioactive half-life**
- **Radioactive equilibrium**

Radioactivity

Radioactivity is the property of certain nuclides of spontaneously emitting particles or gamma radiation. The decay of radioactive nuclides occurs in a random manner, and the precise time at which a single nucleus will decay cannot be determined. However, the average behavior of a very large sample can be predicted accurately by using statistical methods.

Radioactive Decay Constant

The probability per unit time that an atom of a nuclide will decay is known as the radioactive decay constant lambda, and represented by the symbol λ. The units for the decay constant are inverse time such as 1/second, 1/minute, 1/hour, or 1/year. These decay constant units can also be expressed as $second^{-1}$, $minute^{-1}$, $hour^{-1}$, and $year^{-1}$.

Activity

The activity (A) of a sample is the rate of decay of that sample. This rate of decay is usually measured in the number of disintegrations that occur per second. For a sample containing millions of atoms, the activity is the product of the decay constant and the number of atoms present in the sample.

The relationship between the activity, number of atoms, and decay constant is shown in the following equation.

$$A = \lambda N$$

where:

A = activity of the nuclide (disintegrations/second)
λ = decay constant of the nuclide ($second^{-1}$)
N = number of atoms of the nuclide in the sample

Since λ is a constant, the activity and the number of atoms are always proportional.

Radioactive Half-Life

One of the most useful terms for estimating how quickly a nuclide will decay is the radioactive half-life. The radioactive half-life is defined as the amount of time required for the activity to decrease to one-half of its original value. The half-life can be calculated by solving the following equation for the time, t, when the current activity, A, equals one-half the initial activity, A_o.

$$A = A_o e^{-\lambda t}$$

where:

A = activity present at time t
A_o = activity initially present
λ = decay constant ($time^{-1}$)
t = time

First, solve the equation for t.

$$A = A_o e^{-\lambda t}$$

$$\frac{A}{A_o} = e^{-\lambda t}$$

$$\ln\left(\frac{A}{A_o}\right) = -\lambda t$$

$$t = \frac{-\ln\left(\frac{A}{A_o}\right)}{\lambda}$$

If A is equal to one-half of A_o, then A/ A_o is equal to one-half. Substituting this in the equation above yields an expression for $t_{1/2}$.

$$t_{1/2} = \frac{-\ln\left(\frac{1}{2}\right)}{\lambda}$$

$$t_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}$$

Radioactive Equilibrium

Radioactive equilibrium exists when a radioactive nuclide is decaying at the same rate at which it is being produced. Since the production rate and decay rate are equal, the number of atoms present remains constant over time.

For example, as U-238 begins to decay to Th-234, 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 Pa-234, the concentration of Pa-234 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.

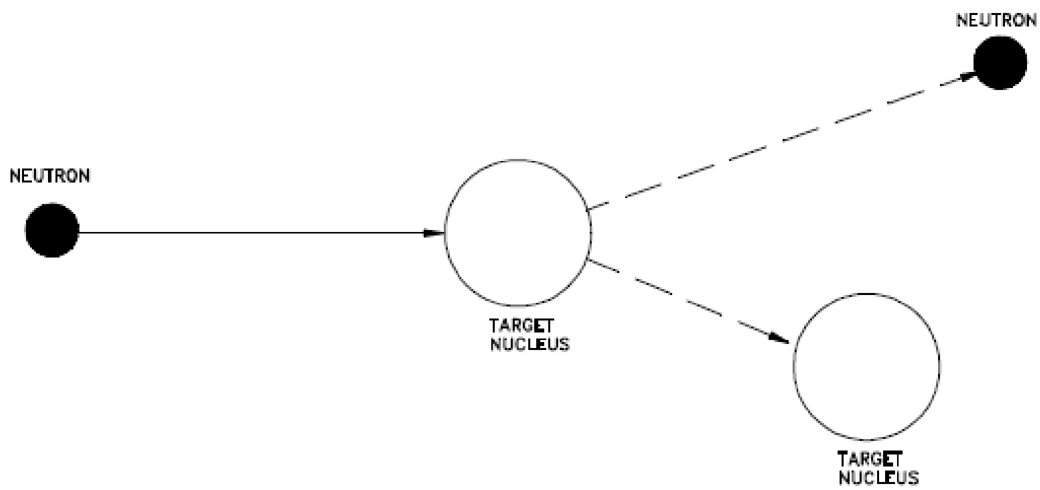
e. Describe the following neutron–nucleus interactions:

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

A neutron scattering reaction occurs when a nucleus, after having been struck by a neutron, emits a single neutron. Despite the fact that the initial and final neutrons do not need to be (and often are not) the same, the net effect of the reaction is as if the projectile neutron had merely “bounced off,” or scattered from, the nucleus. The two categories of scattering reactions, elastic and inelastic, are described in the following paragraphs.

Elastic Scattering

In an elastic scattering reaction between a neutron and a target nucleus, there is no energy transferred into nuclear excitation. Momentum and kinetic energy of the system are conserved although there is usually some transfer of kinetic energy from the neutron to the target nucleus. The target nucleus gains the amount of kinetic energy that the neutron loses. Figure 4 illustrates the process of elastic scattering of a neutron off a target nucleus.

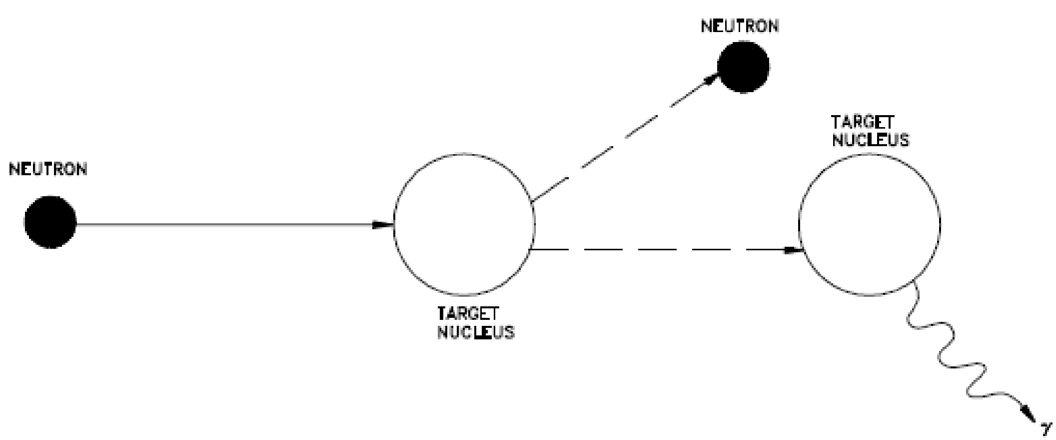


Source: DOE-HDBK-1019-93, vol 1

Figure 4. Elastic scattering

Inelastic Scattering

In inelastic scattering, the incident neutron is absorbed by the target nucleus, forming a compound nucleus. The compound nucleus will then emit a neutron of lower kinetic energy which leaves the original nucleus in an excited state. The nucleus will usually, by one or more gamma emissions, emit this excess energy to reach its ground state. Figure 5 shows the process of inelastic scattering.



Source: DOE-HDBK-1019-93, vol 1

Figure 5. Inelastic scattering

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 and are briefly described below.

Radiative Capture

In radiative capture the incident neutron enters the target nucleus forming a compound nucleus. The compound nucleus then decays to its ground state by gamma emission. An example of a radiative capture reaction is shown below.

$$^{1}_{0}n + ^{238}_{92}U \rightarrow \left(^{239}_{92}U\right)^{*} \rightarrow ^{239}_{92}U + ^{0}_{0}\gamma$$

Particle Ejection

In a particle ejection reaction the incident particle enters the target nucleus forming a compound nucleus. The newly formed compound nucleus has been excited to a high enough energy level to cause it to eject a new particle while the incident neutron remains in the nucleus. After the new particle is ejected, the remaining nucleus may or may not exist in an excited state depending upon the mass-energy balance of the reaction. An example of a particle ejection reaction is shown below.

$$^{1}_{0}n + ^{10}_{5}B \rightarrow \left(^{11}_{5}B\right)^{*} \rightarrow ^{7}_{3}Li + ^{4}_{2}\alpha$$

Nuclear Fission

One of the most important interactions that neutrons can cause is fission, in which the nucleus that absorbs the neutron actually splits into two similarly sized parts. This is described in greater detail under CS-2.

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

The information for KSAs a through c is taken from volume 1 of DOE-HDBK-1019-93.

a. Using the liquid drop model, explain the fission process.

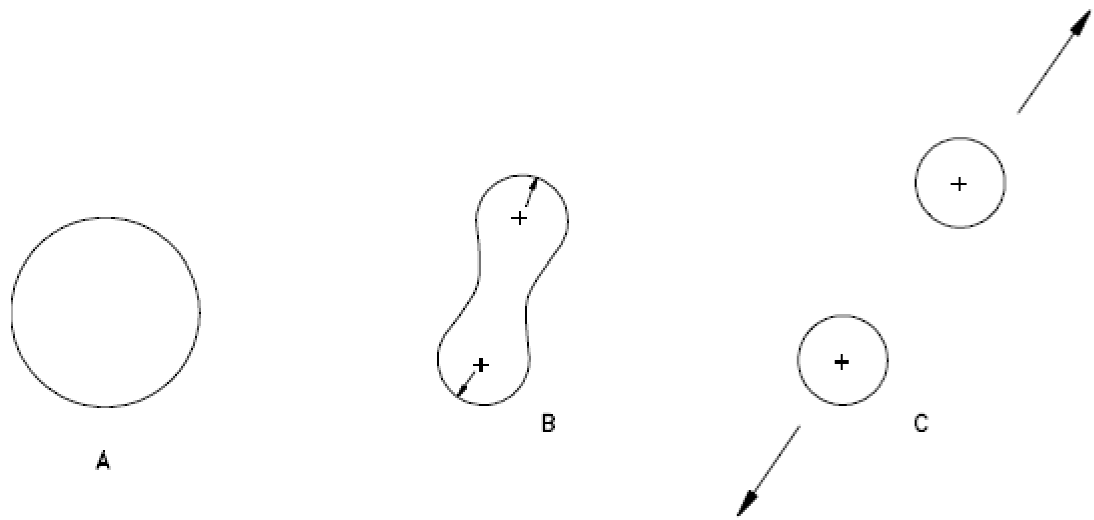
The nucleus is held together by the attractive nuclear force between nucleons. The characteristics of the nuclear force are:

- Very short range, with essentially no effect beyond nuclear dimensions (10^{-13} centimeters [cm])
- Stronger than the repulsive electrostatic forces within the nucleus

- Independent of nucleon pairing, in that the attractive forces between pairs of neutrons are no different than those between pairs of protons or a neutron and a proton
- Saturable, that is, a nucleon can attract only a few of its nearest neighbors

One theory of fission considers the fissioning of a nucleus similar in some respects to the splitting of a liquid drop. This analogy is justifiable to some extent by the fact that a liquid drop is held together by molecular forces that tend to make the drop spherical in shape and that try to resist any deformation in the same manner as nuclear forces are assumed to hold the nucleus together. By considering the nucleus as a liquid drop, the fission process can be described.

Referring to element A in figure 6, the nucleus in the ground state is undistorted, and its attractive nuclear forces are greater than the repulsive electrostatic forces between the protons within the nucleus.



Source: DOE-HDBK-1019-93, vol 1

Figure 6. Liquid drop model of fission

When an incident particle (in this instance a neutron) is absorbed by the target nucleus, a compound nucleus is formed. The compound nucleus temporarily contains all the charge and mass involved in the reaction and exists in an excited state. The excitation energy added to the compound nucleus is equal to the binding energy contributed by the incident particle plus the kinetic energy possessed by that particle. Element B in the figure illustrates the excitation energy thus imparted to the compound nucleus, which may cause it to oscillate and become distorted. If the excitation energy is greater than a certain critical energy, the oscillations may cause the compound nucleus to become dumbbell-shaped. When this happens, the attractive nuclear forces (short-range) in the neck area are small due to saturation, while the repulsive electrostatic forces (long-range) are only slightly less than before. When the repulsive electrostatic forces exceed the attractive nuclear forces, nuclear fission occurs, as illustrated in element C of figure 6.

The measure of how far the energy level of a nucleus is above its ground state is called the excitation energy (E_{exc}). 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.

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

Fissile material

A fissile material is composed of nuclides for which fission is possible with neutrons of any energy level. What is especially significant about these nuclides is their ability to be fissioned with zero kinetic energy neutrons (thermal neutrons). Thermal neutrons have very low kinetic energy levels (essentially zero) because they are roughly in equilibrium with the thermal motion of surrounding materials. Therefore, in order to be classified as fissile, a material must be capable of fissioning after absorbing a thermal neutron. Consequently, they impart essentially no kinetic energy to the reaction. Fission is possible in these materials with thermal neutrons, since the change in binding energy supplied by the neutron addition alone is high enough to exceed the critical energy. Some examples of fissile nuclides are U-235, U-233, and plutonium (Pu)-239.

Fissionable material

A 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. The change in binding energy that occurs as the result of neutron absorption results in a nuclear excitation energy level that is less than the required critical energy. Therefore, the additional excitation energy must be supplied by the kinetic energy of the incident neutron. The reason for this difference between fissile and fissionable materials is the so-called odd-even effect for nuclei. It has been observed that nuclei with even numbers of neutrons and/or protons are more stable than those with odd numbers. Therefore, adding a neutron to change a nucleus with an odd number of neutrons to a nucleus with an even number of neutrons produces an appreciably higher binding energy than adding a neutron to a nucleus already possessing an even number of neutrons. Some examples of nuclides requiring high energy neutrons to cause fission are thorium-232, U-238, and Pu-240.

Uranium-235 fissions with thermal neutrons because the binding energy released by the absorption of a neutron is greater than the critical energy for fission; therefore U-235 is a fissile material. The binding energy released by U-238 absorbing a thermal neutron is less than the critical energy, so additional energy must be possessed by the neutron for fission to be possible. Consequently, U-238 is a fissionable material.

Fertile material

All of the neutron absorption reactions that do not result in fission lead to the production of new nuclides through the process known as transmutation. These nuclides can, in turn, be transmuted again or may undergo radioactive decay to produce still different nuclides. The nuclides that are produced by this process are referred to as transmutation products. Because several of the fissile nuclides do not exist in nature, they can only be produced by nuclear reactions (transmutation). The target nuclei for such reactions are said to be fertile. Fertile materials are materials that can undergo transmutation to become fissile materials.

If a reactor contains fertile material in addition to its fissile fuel, some new fuel will be produced as the original fuel is burned up. This is called conversion. Reactors that are specifically designed to produce fissionable fuel are called breeder reactors. In such reactors, the amount of fissionable fuel produced is greater than the amount of fuel burnup. If less fuel is produced than used, the process is called conversion, and the reactor is termed a converter.

c. Discuss the various energy releases that result from the fission process.

The total energy released per fission will vary from the fission to the next depending on what fission products are formed, but the average total energy released per fission of U-235 with a thermal neutron is 200 MeV.

The majority of the energy liberated in the fission process is released immediately after the fission occurs and appears as the kinetic energy of the fission fragments, kinetic energy of the fission neutrons, and instantaneous gamma rays. The remaining energy is released over a period of time after the fission occurs and appears as kinetic energy of the beta, neutrino, and decay gamma rays.

In addition to this instantaneous energy release during the actual fission reaction, there is additional energy released when the fission fragments decay by β^- emission. This additional energy is called decay energy.

Total energy released in the fission of a U-235 nucleus is shown in table 2. Because the ten MeV of neutrino energy shown in table 2 is not absorbed in the reactor, the average value of 200 MeV per fission is still accurate.

Table 2. Total energy from U-235 fission

Kinetic energy of fission fragments	167 MeV
Kinetic energy of fission neutrons	5 MeV
Instantaneous gamma ray energy	5 MeV
Capture gamma ray energy	10 MeV
Beta particles from fission fragments	7 MeV
Gamma rays from fission fragments	6 MeV
Neutrinos	10 MeV
TOTAL	**210 MeV**

Source: DOE-HDBK-1019-93, vol 1

d. Define the term “criticality” and explain how criticality is detected.

The following is taken from DOE-HDBK-1122-2009, part 6.

Criticality is the condition in which the neutrons produced by fission are equal to the number of neutrons in the previous generation. This means that the neutrons in one generation go on to produce an equal number of fission events, which events in turn produce neutrons that produce another generation of fissions, and so forth. This continuation results in a self-sustaining chain reaction.

If the population of neutrons remains constant, the chain reaction will be sustained. The system is thus said to be critical. However, if too many neutrons escape from the system or are absorbed but do not produce a fission, then the system is said to be subcritical and the chain reaction will eventually stop.

On the other hand, if the two or three neutrons produced in one fission each go on to produce another fission, the number of fissions and the production of neutrons will increase exponentially. In this case the chain reaction is said to be supercritical.

In nuclear reactors this concept is expressed as the effective multiplication factor (K_{eff}). K_{eff} is defined as the ratio of the number of neutrons in the reactor in one generation to the number of neutrons in the previous generation. On the average, 2.5 neutrons are emitted per U fission. If K_{eff} has a value of greater than one, the neutron flux is increasing and the reactor is supercritical. Conversely, if K_{eff} has a value of less than one, the flux is decreasing with time and the reactor is subcritical. Finally, it follows that if K_{eff} is equal to one, the neutron flux is constant and the reactor is critical. Criticality can therefore be detected by measuring K_{eff}.

e. List five factors that affect criticality.

The following is taken from nuclear criticality safety engineer training (NCSET) modules located on the DOE/Nuclear Criticality Safety Program website. Although this KSA asks for five factors, nine commonly identified factors are listed below.

Concentration

The proportion of fissile material in the matrix greatly influences the critical mass or critical volume of matrix material. Concentration directly relates to the number of non-fissile atoms between a neutron and a fissionable atom, and thus the probability of the neutron being lost before interacting with a fissile atom. Concentration also influences the probability of the neutron slowing to a more probable fission energy.

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 U-235 or Pu-239 nuclei. There is an optimum degree of moderation because if the ratio of hydrogen nuclei to U nuclei becomes too large, neutron capture in the hydrogen becomes competitive with fission in the U.

Reflection

Reflection is the return of neutrons back into a region containing fissile material by collisions with atoms in surrounding materials. Reflector materials are frequently also moderators, and neutron poisons are better reflectors than they are poisons. Reflection decreases the loss term of the neutron balance equation.

Neutron Absorption

At the atomic level, neutron absorption is usually accompanied by the release of a photon to stabilize the nucleus. Many materials function as absorbers, including water and steel (due to hydrogen and largely iron, respectively). The absorption by hydrogen is most of the reason that there is a lower critical concentration limit. If the fissionable atoms only are included in a computation, (that is, no absorber materials), the neutron production-to-loss ratio in an infinite system is the average neutron production per fission.

Interaction

Interaction is a shorthand term for the number of neutrons leaving one fissile mass to cause fission in a nearby fissile mass. The sizes, distances, and intervening materials all influence interaction.

Mass

As an extensive property, mass is the most commonly used measure of how much fissile material is available to contribute to a potentially critical system. Mass is frequently one of the easiest items to control.

Volume

Volume is also an extensive property, and frequently easier to control than mass. For any fissile material, there is a minimum critical volume such that any smaller volume of that material (in isolation) is subcritical. However, small changes in the composition of the fissile material can result in large changes in the minimum critical volume.

Geometry

Geometry normally refers to the defined geometric form of a vessel (in the case of liquids) or solid shape. The geometry of a vessel has an effect on neutron leakage. When the shape of container provides enough leakage that a credible accumulation or concentration of fissile material cannot achieve criticality, it is commonly referred to as geometrically favorable.

Enrichment

Enrichment is the amount of fissile isotopes relative to the total amount of the element. Highly enriched U has more U-235 atoms than U 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. Enrichment, especially in low enriched materials (typically U), has a large effect on the critical mass of the fissile isotope.

f. Identify the hazards that result from an unwanted criticality.

LA-13638, *A Review of Criticality Accidents*, defines a criticality accident as the release of energy as a result of accidentally producing a self-sustaining or divergent fission chain reaction. PNNL-12199, *A Brief History of Nuclear Criticality Accidents in Russia—1953–1997*, states that nuclear criticality accidents are significant because of the loss of control of special nuclear material (SNM) and the resultant radiation doses to personnel, potential damage to equipment, and the release of radioactive material to the workplace and to the environment.

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

The following is taken from 10 CFR 70.4.

The double contingency principle means 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.

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

A brief discussion of this item is provided in CS-2f.

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

The information for KSAs a and b is taken from DOE-HDBK-1131-2007.

a. Define the term "ionizing radiation."

Radiation is energy emitted through space and matter. This energy release is in the form of rays or particles and is emitted from unstable atoms or various radiation-producing devices, such as televisions and X-ray machines. There are two basic types of radiation: ionizing and non-ionizing.

- Ionizing radiation is radiation that has enough energy to remove electrons from electrically neutral atoms. There are four basic types of ionizing radiation: alpha particles, beta particles, neutrons, and gamma rays.
- Non-ionizing radiation does not have enough energy to remove an electron from an atom. Types of non-ionizing radiation include microwaves, radio waves, visible light, heat, and infrared radiation.

b. Describe how nuclear radiation is generated.

People have always been exposed to radiation. Exposure to radiation originates from naturally occurring sources in the environment, man-made sources, and materials inside the body.

The average annual radiation dose to a member of the general population is about 620 millirem/year. This amount is a combination of both natural background and man-made sources of radiation.

Natural Background Sources of Radiation

Natural background radiation is by far the largest contributor (about 310 millirem/year) to radiation doses. The main sources of natural background radiation are:

- Cosmic radiation—radiation from the sun and outer space, varies with altitude (e.g., Denver would be higher than Miami)
- Radon (the principal source of background radiation exposure)—a gas from naturally-occurring U in the soil

- Terrestrial radiation from naturally occurring radioactive material found in the earth's crust, such as U found in rocks and soil
- Materials present in our bodies from naturally occurring radioactive material present in our food, such as potassium-40

Man-Made Sources of Radiation

Man-made sources of radiation, where the radiation is either produced or enhanced by human activities, contribute to the remainder of the annual average radiation dose (approximately 310 millirem). Man-made sources include the following:

- Medical uses such as X-rays and nuclear medicine tests or treatments
- Tobacco products
- Building materials

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)**

The following is taken from volume 1 of DOE-HDBK-1019-93.

Alpha Radiation

Alpha radiation is normally produced from the radioactive decay of heavy nuclides and from certain nuclear reactions. The alpha particle consists of two neutrons and two protons, so it is essentially the same as the nucleus of a He atom. Because it has no electrons, the alpha particle has a charge of plus two (+2). This positive charge causes the alpha particle to strip electrons from the orbits of atoms in its vicinity. As the alpha particle passes through material, it removes electrons from the orbits of atoms it passes near. Energy is required to remove electrons and the energy of the alpha particle is reduced by each reaction. Eventually the particle will expend its kinetic energy, gain two electrons in orbit, and become a He atom. Because of its strong positive charge and large mass, the alpha particle deposits a large amount of energy in a short distance of travel. This rapid, large deposition of energy limits the penetration of alpha particles.

Beta Radiation

A beta-minus particle is an electron that has been ejected at a high velocity from an unstable nucleus. An electron has a small mass and an electrical charge of minus one (-1). Beta particles cause ionization by displacing electrons from atom orbits. The ionization occurs from collisions with orbiting electrons. Each collision removes kinetic energy from the beta particle, causing it to slow down. Eventually the beta particle will be slowed enough to allow it to be captured as an orbiting electron in an atom. Although more penetrating than the alpha, the beta is relatively easy to stop and has a low power of penetration.

Positively charged electrons are called positrons. Except for the positive charge, they are identical to beta-minus particles and interact with matter in a similar manner. Positrons are very short-lived, however, and quickly are annihilated by interaction with a negatively charged electron, producing two gammas with a combined energy equal to the rest mass of the positive and negative electrons.

Gamma Radiation

Gamma radiation is electromagnetic radiation. It is commonly referred to as a gamma ray and is very similar to an x-ray. The difference is that gamma rays are emitted from the nucleus of an atom, and x-rays are produced by orbiting electrons. The gamma ray is produced by the decay of excited nuclei and by nuclear reactions. Because the gamma ray has no mass and no charge, it is difficult to stop and has a very high penetrating power.

There are three methods of attenuating gamma rays. The first method is referred to as the photo-electric effect. When a low energy gamma strikes an atom, the total energy of the gamma is expended in ejecting an electron from orbit. The result is ionization of the atom and expulsion of a high energy electron. This reaction is most predominant with low energy gammas interacting in materials with high atomic weight and rarely occurs with gammas having an energy above 1.0 MeV. Annihilation of the gamma results, with any gamma energy in excess of the binding energy of the electron carried off by the electron in the form of kinetic energy.

The second method of attenuation of gammas is called Compton scattering. The gamma interacts with an orbital or free electron; however, in this case, the photon loses only a fraction of its energy. The actual energy loss depends on the scattering angle of the gamma. The gamma continues on at lower energy, and the energy difference is absorbed by the electron. This reaction becomes important for gamma energies of about 0.1 MeV and higher.

At higher energy levels, a third method of attenuation is predominant. This method is pair-production. When a high energy gamma passes close enough to a heavy nucleus, the gamma completely disappears, and an electron and a positron are formed. For this reaction to take place, the original gamma must have an energy of at least 1.02 MeV. Any energy greater than 1.02 MeV becomes kinetic energy shared between the electron and positron. The probability of pair production increases significantly for higher energy gammas.

Neutron Radiation

Neutrons have no electrical charge. They have nearly the same mass as a proton (a hydrogen atom nucleus). A neutron has hundreds of times more mass than an electron, but 1/4 the mass of an alpha particle. The source of neutrons is primarily nuclear reactions, such as fission, but they may also be produced from the decay of radioactive nuclides. Because of its lack of charge, the neutron is difficult to stop and has a high penetrating power.

Neutrons are attenuated (reduced in energy and numbers) by three major interactions, elastic scatter, inelastic scatter, and absorption. See CS-1e and CS-1f for descriptions of these interactions.

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

The following is taken from DOE-HDBK-1122-2009.

Table 3. Radiation shielding material

Radiation Type	Typical Shielding Characteristics
Alpha	Thin amounts of most any material (paper, unbroken dead cell layer of skin, few cm of air)
Beta	Low Z and low density material (rubber, aluminum, plastic)
Gamma	High Z and high density material (lead, depleted U)
Neutron	Hydrogenous material for moderation (oil, plastic, water) and capture material for absorption (boron, cadmium)

Source: DOE-HDBK-1122-2009

e. Describe the biological effects of ionizing radiation (acute and chronic).

The information for KSAs e through g is taken from DOE-HDBK-1130-2008 except where noted otherwise.

Potential biological effects depend on how much and how fast a radiation dose is received. Radiation doses can be grouped into two categories: acute and chronic dose.

Acute Exposure

High doses of radiation received in a short period of time are called acute doses. The body's cell repair mechanisms are not as effective for damage caused by an acute dose.

- The prompt effects of large acute doses are, in order of increasing severity: blood changes; nausea and anorexia; and diarrhea, hemorrhage, and possible death.
- Delayed effects, which may result from either a single large acute overexposure or from continuing low-level chronic exposure, include cancer in its various forms; cataracts; life shortening; and for individuals exposed in the womb, lower IQ test scores.

Chronic Exposure

A chronic radiation dose is typically a small amount of radiation received over a long period of time. An example of a chronic dose is the dose received from natural background radiation over a lifetime. The body's cell repair mechanisms are better able to repair a chronic dose than an acute dose. The biological effects from chronic exposure are delayed, and are discussed above under acute exposure, delayed effects.

f. Describe the primary hazards to the human body (the whole body or the skin or that are internal) of each type of radiation.

Table 4. Biological hazard associated with types of ionizing radiation

Type of Radiation	Biological Hazard
Alpha	No external hazard (stopped by the dead layer of skin; internally, the alpha radiation is in close contact with body tissue, so it can deposit large amounts of energy in a small amount of body tissue
Beta	Internal hazard due to short range; externally, may be hazardous to skin and eyes
Gamma	Whole body exposure; the hazard may be external and/or internal depending on whether the source is inside or outside the body
Neutron	Whole body exposure; the hazard is generally external

Source: DOE-HDBK-1130-2008

g. Discuss radiation dose, including the terms rad, rem, roentgen, and international standard units (SI), and how it is measured.

CGS (centimeter/gram/second [SI]) Units

Table 5. CGS radiation dose units

Roentgen (R)	Rad (radiation absorbed dose)	Rem (roentgen equivalent man)
Unit for measuring exposure	Unit for measuring absorbed dose in any material	Unit for measuring dose equivalence (most commonly used unit)
Defined only for effect on air	Defined for any material	Pertains to human body
Applies only to gamma and X-ray radiation	Applies to all types of radiation	Applies to all types of radiation
Does not relate biological effects of radiation to the human body	Does not take into account the potential effect that different types of radiation have on the body	Takes into account the energy absorbed (dose) and the biological effect on the body due to the different types of radiation Equal doses of different types of radiation (as measured in rad) can cause different levels of damage to the body (measured in rem)

Source: DOE-HDBK-1130-2008

The following is taken from DOE-HDBK-1122-2009.

SI Units

In the SI system, there are taken units for quantities used for radiological control. For radiation dose, these are the gray (Gy) and the sievert (Sv).

- A Gy is the unit of absorbed dose, comparable to rad: 100 rad equal one Gy.
- A Sv is the unit for dose equivalence, comparable to rem: 100 rem equal one Sv.

The information for KSAs h and i is taken DOE-HDBK-1122-2009.

h. Define the term "quality factor" and discuss its application to radiation.

[Note: Prior to 2007, when DOE updated its dosimetric models and terminology, DOE used a quality factor. The quality factor was applied to the absorbed dose at a point in order to take into account the differences in the effects of different types of radiation. Now, for radiological protection purposes, the absorbed dose is averaged over an organ or tissue and this absorbed average dose is weighted for the radiation quality in terms of the radiation weighting factor (W_R).]

The W_R is used as a multiplier to reflect the relative amount of biological damage caused by the same amount of energy deposited in cells by the different types of ionizing radiation. Alpha radiation ionizes a lot of atoms in a very short distance and, for the same amount of energy deposited as beta or gamma radiation, is more damaging. Thus, rem = rad x W_R, or for SI units, Sv = Gy x W_R. Table 6 shows W_R values for various radiation types and energies.

Table 6. W_R values for various types of radiation

Radiation Type	W_R
X-rays, gamma rays, positrons, electrons (including beta particles)	1
Neutrons < 10 keV	5
Neutrons 10 keV to 100 keV	10
Neutrons > 100 keV to 2 MeV	20
Neutrons > 2 MeV to 20 MeV	10
Neutrons > 20 MeV	5
Protons, other than recoil protons, energy > 2 MeV	5
Alpha particles, fission fragments, heavy nuclei	20

Source: DOE-HDBK-1122-2009

i. Discuss the meaning of ALARA and describe the basic methods for achieving ALARA.

As Low as Reasonably Achievable (ALARA)

The ALARA concept is based on the belief that exposure to certain agents could cause undesirable effects. The concept also implies that there is a relationship between the amount of exposure and the possibility of an effect; there is a risk involved in receiving the exposure. The basis for the ALARA philosophy is quite simple: if you reduce your exposure to certain agents, you reduce the potential risk of an unwanted effect. This basic philosophy is used for a number of agents. Radiation is only one of these agents.

Methods for Achieving ALARA

The DOE and other regulating agencies have through their Orders and the Code of Federal Regulations (CFR) mandated that there should not be any occupational exposure of workers to ionizing radiation without the expectation of an overall benefit from the activity causing the exposure. All personal radiation exposure shall be maintained ALARA.

ALARA Programs

Every facility and the DOE complex as a whole, will strive to keep radiation exposure to the work force and public well below regulatory limits and ensure that there is no radiation exposure without commensurate benefit. For a facility to meet its ALARA objectives it should first establish a program to maintain exposures ALARA. This program should be updated throughout the evolution of the facility. The program should consider the following:

- Design and modification of the facility and selected equipment and components to integrate the ALARA concepts
- Updating the ALARA procedures and plans to reflect the current need of the facility
- The availability of equipment, instrumentation, and facilities necessary for the ALARA program
- Training facility workers and management as well as radiological control personnel in ALARA programs and reduction techniques
- Overall cost or job completion benefit versus the risk involved in receiving the exposure

ALARA Concepts

- Engineering features
  - Discharge of radioactive liquid to the environment
  - Control of contamination
  - Efficiency of maintenance, decontamination, and operations should be maximized
  - Components should be selected to minimize the buildup of radioactivity
  - Support facilities should be provided for donning and removal of protective clothing and for personnel monitoring
  - Shielding requirements
  - Ergonomics consideration
  - Access control designed for hazard level
  - Surfaces that can be decontaminated or removed
  - Equipment that can be decontaminated

- Area arrangement
  - Traffic patterns to allow access yet prevent unnecessary exposure
  - Equipment separation
  - Valve locations
  - Component laydown/storage areas

- Operations
  - Inspection tour—access, mirrors, visibility
  - In-service inspections—use of remote control equipment, TV, snap-on insulation, platforms, etc.
  - Remote readout instrumentation
  - Remote valve/equipment operators
  - Sampling stations, piping, valving, hoods, sinks

- Maintenance needs
  - Adequate lighting, electric outlets, other utilities
  - Removal and storage areas for insulation/shrouding
  - Relocation of components to low dose areas
  - Workspace for maintenance personnel
  - Lifting equipment
  - Conditions that could cause or promote the spread of contamination, such as a leaking roof or piping need to be identified and corrected on a priority basis

- Radiological control needs
  - Access control
  - Shielding adequacy and access plugs
  - Temporary shielding and support structures
  - Adequate ventilation
  - Breathing air
  - Contamination control—drip pans, curbs, drains, and routing
  - Decontamination facilities
  - Radiation monitoring equipment
  - Communications

j. Discuss the hazards, safe handling, storage requirements, and operational practices for each of the following nuclides in their various forms:
- Plutonium
- Uranium
- Tritium

The following is taken from DOE-STD-1128-2008**.**

Plutonium

Hazards

The major industrial hazard in Pu facilities is the potential for loss of control of a highly toxic substance, resulting in either the inhalation or ingestion of Pu or one of its compounds by personnel, or the exposure to excessive radiation from a criticality accident. The possibility of a fire or explosion in a Pu facility is probably the most serious threat because the consequences of a fire could lead to loss of containment and subsequent disbursement of highly mobile Pu particulates. In addition, fighting the fire with water to maintain containment could create the potential for a criticality accident and/or loss of containment in the immediate vicinity.

The day-to-day hazards for personnel in Pu facilities involve exposure to gamma rays, x-rays, and neutrons, as well as possible accumulation of Pu in the body.

The following is taken from DOE-HDBK-1145-2008**.**

Safe Handling/Operational Practices

A hierarchy of controls should be established to minimize exposure to Pu hazards as follows:

- Engineered controls are built into the system, and include shielding, ventilation, and containment systems.
- Administrative controls (ACs) for Pu facilities are the same as any other radiation source.
- Personnel protective equipment (PPE), including clothing and respiratory protection.

Methods to minimize exposure to external hazards:

- Time—plan ahead to avoid spending any more time near radiation sources than necessary.
- Distance—the further from the radiation source, the lower the dose.
- Shielding—in a Pu facility, shielding for neutrons must be addressed as well as shielding for X-ray and gamma radiation.
    - Plutonium emits low-energy x-ray and gamma radiation that is easily shielded with small amounts of steel or lead.
    - The most effective shielding for neutrons employs materials that contain hydrogen atoms, such as water, oil, polyethylene, or paraffin.

- Source reduction—the source of the radiation can be reduced by decontamination, better storage methods, or elimination of the source altogether.

Methods to minimize exposure to internal hazards:

- Respiratory protection is the primary method of preventing internal dose from inhalation.
- Placing leather gloves over glovebox gloves or ensuring there are no sharp objects inside containments are methods used to prevent injection wounds.
- Gloveboxes are almost always used when handling Pu in a dispersible form. However, properly vented hoods are acceptable for handling the very small quantities used in a research laboratory.
- Ventilation systems maintain proper airflow by ensuring that air flows from areas of low contamination to areas of greater contamination.
- Decontaminate to low or non-detectable levels after a loss of containment.

Methods to minimize/prevent unplanned criticalities:

- Engineered criticality controls (e.g., specific piping, container shape, and neutron poisons).
- Administrative criticality controls (e.g., procedures on container spacing and the amount of material in the container).
- Properly trained workers.
- Criticality safety approved containers that could hold Pu-bearing liquids.

Storage Requirements

Long-term storage of Pu-239 is accomplished by placing the metal in a sealed can, which is usually placed inside one or more cans. As the Pu decays, the can may build up pressure due to accumulation of He from the alpha particles and from radiolysis of impurities. The cans are monitored for “bulging” so they can be repacked before the pressure builds up and the cans burst.

Pu-238 can generate enough heat to require handling with insulated gloves (or another insulator) and packaging in special containers that dissipate heat. If Pu-238 is stored next to flammable material, a fire may result. If it is stored near material that degrades by heat, flammable or explosive gases may be formed.

The following is taken from DOE-STD-1136-2009.

Uranium

Hazards

The principal industrial hazards associated with U are fires, hydrogen generation, generation of oxides of nitrogen, and associated mechanical hazards characteristic of heavy objects (e.g., back injuries from lifting, dropping heavy parts on feet, etc.). Hydrogen fluoride and oxides of nitrogen are by-products or reactants of common chemical processes. Hydrogen can be generated by reaction of water with U metal, and finely divided U or U chips with a large surface-area-to-volume ratio can ignite spontaneously.

Both the chemical and radiological hazards of U are moderate compared to those of other industrial materials and radionuclides.

The chemical toxicity of U is a primary concern in establishing control limits. A heavy metal, U is chemically toxic to kidneys and exposure to soluble (transportable) compounds can result in renal injury. The factors to be considered in determining whether the chemical or radiological hazard is controlling are the enrichment, mode of entry, and the solubility/transportability of the material. Chemical toxicity is a higher risk with soluble material of ten percent or less enrichment.

The predominant hazard associated with U exposure depends upon its degree of enrichment, its chemical form, and its physical form. The degree of enrichment determines the gamma radiation intensity and the overall specific activity. Chemical form determines solubility and consequent transportability in body fluids. International Commission on Radiological Protection, *ICRP Publication 60,* classifies all materials into three material types: F, M, and S. Type F is most transportable (pulmonary removal half-time of days), type S the least transportable (removal half-time of years), and type M an intermediate category (removal half-time of weeks). The transportability of an inhaled or ingested material determines its fate within the body and, therefore, the resulting radiation dose or chemical effect.

The following is taken from DOE-HDBK-1113-2008.

Safe Handling/Operational Practices

A hierarchy of controls should be established to minimize exposure to U hazards as follows:

- Engineered controls are built into the system, and include shielding, ventilation, and containment systems.
- Administrative controls for U facilities are the same as any other radiation source.
- Personnel protective equipment, including clothing and respiratory protection.

Methods to minimize exposure to external hazards include:
- Time—plan ahead to avoid spending any more time near radiation sources than necessary.
- Distance—the further from the radiation source, the lower the dose.
- Shielding—in a U facility, shielding for beta radiation is used as follows:
  - Use low-Z elements to minimize bremsstrahlung (heavy rubber or plastic over objects)
  - Safety glasses for the lens of the eye
  - Heavy work gloves for the hands
- Source reduction—the source of the radiation can be reduced by decontamination, better storage methods, or elimination of the source altogether.

Methods to minimize exposure to internal hazards include the following:
- Respiratory protection is the primary method of preventing internal dose from inhalation.
- Placing leather gloves over glovebox gloves or ensuring there are no sharp objects inside containments are methods used to prevent injection wounds.
- Gloveboxes are almost always used when handling Pu in a dispersible form. However, properly vented hoods are acceptable for handling the very small quantities used in a research laboratory.
- Ventilation systems maintain proper airflow by ensuring that air flows from areas of low contamination to areas of greater contamination.
- Decontaminate to low or non-detectable levels after a loss of containment.

Methods to minimize/prevent unplanned criticalities include the following:
- Engineered criticality controls (e.g., specific piping, container shape, neutron poisons, material that surrounds containers or systems containing U, and U inventories).
- Administrative criticality controls (e.g., procedures on container spacing and the amount of material in the container).
- Properly trained workers.
- Analyzing work environments to assess the risk of criticality and eliminate likely criticality concerns.

Storage Requirements

Uranium should be in oil for long-term storage.

The use of water or oil baths for collecting and storing U chips needs to be evaluated for criticality safety concerns before put into practice.

Materials such as water, graphite (a form of carbon), and beryllium are good at reflecting neutrons. If the U material is surrounded by these reflector materials, criticality is easier to obtain. Accordingly, it is undesirable to store fissile material where there is potential for these materials to be present.

Tritium

The following is taken from U.S. Department of Defense, Directive 5100.52-M.

Hazards

Tritium constitutes a health hazard when personnel are engaged in specific weapon render-safe procedures, when responding to an accident that has occurred in an enclosed space, and during accidents that have occurred in rain, snow, or in a body of water. In its gaseous state, tritium is not absorbed by the skin to any significant degree. The hazardous nature of tritium is due to its ability to combine with other materials. Tritium water vapor is readily absorbed by the body through inhalation and absorption through the skin. The radioactive water that enters the body is chemically identical to ordinary water and is distributed throughout the body tissue. Although it takes a relatively large amount of tritium to be a significant radiation hazard, caution should be taken. Tritium that has plated-out on a surface or combined chemically with solid materials is a contact hazard. The human body normally eliminates and renews 50 percent of its water in about eight to twelve days.

The following is taken from DOE-HDBK-1129-2008.

Safe Handling/Operational Practices

The preferred hierarchy of controls to minimize exposure to tritium hazards begins with engineered controls and continues through ACs to PPE, as follows.

Engineered controls include:

- Containment and confinement
  - Containment or confinement is a series of physical barriers that minimizes exposure of workers.
  - Confinements such as gloveboxes are almost always used when handling large quantities of tritium. However, hoods are acceptable for handling small quantities, such as in a laboratory.
- Airflow
  - Maintaining negative ventilation is essential for the safe operation of a tritium facility.
  - Airflow should be from areas of least to most contamination.
- Local exhaust ventilation
  - The primary advantage of local exhaust ventilation techniques is the removal of airborne tritium, regardless of its release rate or chemical or physical form.
  - In addition, these techniques use relatively low volume rates compared to normal ventilation requirements.
- Dilution ventilation—the once-through flow technique of exchanging outside air for inside air for comfort and the reduction of airborne sources.
- Storage—Tritium can be stored in storage beds. Metal tritide and U hydride are the most common for these storage systems. Tritium is generally released by heating the metal tritide.

Administrative controls: There are many ACs to reduce doses. The following are just a few that should apply to all sites:

- Limitation of access time
- Procedures/radiation work permits
- Postings

For tritium and tritium compounds, 10 CFR 835, appendix D requires posting contamination areas based on removable contamination values of 10,000 disintegrations per minute/100cm2.

Personnel protective equipment includes:

- Air supplied suits—because of the absorption through the skin associated with the use of respirators and other breathing apparatus, air supplied plastic suits that completely enclose the body are widely used by facilities that handle large quantities of tritium.
- Protective clothing.
  - Protective clothing, or anti-contamination clothing (anti-Cs), is used to minimize the spread of contamination from contaminated to clean areas.
  - In many operations, the hands and forearms of workers are vulnerable to contact with tritium surface contamination. The proper selection of gloves and glove materials is important. In many instances a plastic/waterproof suit is required.

Storage Requirements

Storage systems must consider the total cost of the storage cycle and the purpose for the storage. Storage techniques that increase the complexity of the handling process without adding beneficial features should not be used.

- Short term storage—tritium used to support the day-to-day activities in a facility must be readily available to the facility customers. If the facility uses tritium in gaseous form and its decay to He does not impact the process, then, to simplify the operation and the equipment, the tritium can be stored in gaseous form. The storage container should be fabricated of all metal, hydrogen-compatible materials including valves, valve seats, and seals.
- Medium term storage—if tritium is only used in periods of two years or less, the requirements do not change significantly from those of short-term storage. Experience has shown that tritium can be stored safely at near atmospheric pressure for long periods of time. If the buildup of He in the supply does not impact the use, then storage as a gas is an acceptable alternative.
- Long term storage—due to its short half-life, storing tritium for several years implies that it is not readily needed. It should be placed in a safe and stable condition while it decays.

4. Personnel must demonstrate a familiarity level knowledge of contamination control and theory.

The following is taken from DOE-HDBK-1130-2008 unless specified otherwise.

a. Define the term “contamination” and list three types of contamination.

Radioactive contamination is radioactive material that is uncontained and in an unwanted place. Table 7 lists and describes the three types of radioactive contamination.

Table 7. Types of radioactive contamination

Type of Contamination	Description
Fixed	▪ Cannot be removed by casual contact ▪ May be released when the surface is disturbed (buffing, grinding, using volatile liquids for cleaning, cutting piping internally contaminated, etc.) ▪ Over time, may become loose or removable
Removable	▪ May be transferred by casual contact ▪ Any object that makes contact with it may in turn become contaminated ▪ Air movement across removable contamination may cause the contamination to become airborne
Airborne radioactivity	▪ Airborne radioactivity is radioactive contamination suspended in the air

Reference: DOE-HDBK-1130-2008

b. Describe three ways to control contamination.

The three ways to control contamination are listed below, followed by a brief description of each.

1. Prevention
2. Engineering controls
3. 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.
- Establish adequate work controls before starting jobs.
- During pre-job briefings, discuss measures that will help reduce or prevent contamination spread. The agreed upon measures should be implemented by workers at the job site.
- Change protective gear (e.g., gloves) as necessary (typically as directed by radiological control personnel) to prevent cross-contamination.
- Stage areas to prevent contamination spread from work activities.
- Prepare tools and equipment to prevent contamination.
- 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.
- Use standard contamination control procedures as established by the radiological control organization.
- Ensure ventilation systems are operating as designed (i.e., no unauthorized modifications).

- Radiological workers should always 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 filters) are designed to maintain airflow from areas of least contamination to areas of most contamination (e.g., clean from contaminated to highly contaminated areas).
- A slight negative pressure is maintained on buildings/rooms/enclosures where potential contamination exists.
- High efficiency particulate air 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, gloveboxes, tents, huts, and plastic coverings.

Personal Protective Equipment

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

c. Describe how contamination is detected.

The following is taken from DOE-HDBK-1122-2009, part 6.

Fixed Contamination

Direct instrument surveys are used to measure the presence of radioactive contamination on a floor or surface. This is the only method available to detect “fixed” surface contamination. It must be remembered, however, that this method will detect removable as well as fixed surface contamination activity. As a result, a direct survey must be combined with a “smear” survey to determine if the surface contamination present is removable or fixed.

Removable Contamination

Floors and Equipment

In a smear survey, a disk smear is wiped over a specified area and counted with proper instrumentation to determine how much removable contamination is present.

Personnel

Personnel surveys are either performed by the individual (self-monitoring) using hand-held or automated instruments or by a radiological control technician (RCT). Self-monitoring is typically performed upon exiting a contaminated area at established boundary points. Personnel monitoring by an RCT is usually conducted whenever contamination of the body or clothing is suspected, or as required by exit monitoring when self-monitoring is not feasible (remote location) or not allowed.

The following is taken from DOE-HDBK-1130-2008.

Appropriate actions to take if contamination is detected during self-monitoring are as follows:

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

The information for KSAs d through g is taken from DOE-HDBK-1122-2009, part 6.

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

[Note: Although CS-4d implies that there are three ways, there are actually four ways.]

Modes of Entry

Radioactive material can enter the body through one or more of the following pathways:

- Inhalation: Materials enter the body in the air that is breathed.
- Ingestion: Materials enter the body through the mouth.
- Absorption: Material enters the body through intact skin.
- Entry through wounds:
  - Penetration: Materials enter (passively) through existing wounds which were not adequately covered.
  - Injection: Materials enter (forcefully) through wounds incurred on the job.

Knowledge of the ways in which radioactive materials enter the body is essential for two reasons:

1. How radioactive material gets into the body must be known in order to design and implement measures to prevent entry.
2. The mode of entry by which particular materials get into the body can influence the behavior of the materials.

Preventative Measures

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

Note that the preventive measures are designed to do one of two things:

1. Minimize the amount of radioactive materials present which are available to enter the body
2. Block the pathway from the source of radioactive materials into the body

e. Describe the methods used for internal dose determination.

The method that is used to determine internal dose contributions relies on calculation of dose to affected portions of the body based on the quantities of radioactive materials in the body.

Thus, the real problem becomes one of quantifying the amount of material present. The estimation of internal dose should be based on bioassay data rather than air concentration values unless bioassay data are unavailable, inadequate, or internal dose estimates based on air concentration values are demonstrated to be as or more accurate.

Bioassay is the term that is used to describe the assessment of the quantity of radioactive material present in the body. There are currently two types of bioassay measurements employed in nuclear industries: in vivo and in vitro. In vivo bioassay involves counting the living tissue, as described below. In vitro involves counting an excreted sample, such as urine.

In Vivo Measurements

In vivo techniques consist of direct measurements of gamma or X-radiation emanating from the body. This method is very useful for any radionuclide that emits photons of sufficient energy to escape the body.

Advantages

- No sample required
- Results obtained quickly
- Some equipment design allows field use
- Time and manpower requirements minimized

Disadvantages

- Limited to detection and measurement of gamma emitters
- Individual must be free of external contamination
- Long count times for identification
- Effects of background
- Complex calibration procedure and calibration equipment
- Expense
- Quantification error due to differences in tissue structure from one person to another as compared to calibration phantom

In Vitro Measurements

The amount of material present in the body is estimated using the amount of materials present in excretions or secretions from the body. Samples could include urine, feces, blood, sputum, saliva, hair, and nasal discharges.

Advantages

- Can be used for estimation of neutron doses using activation product concentration in hair and blood
- Can be used to quantify presence of materials which decay by alpha and beta emission to allow detection and measurement with external detector systems

Disadvantages

- Requires sample submission and analysis
- Time and manpower requirements

f. Describe the types of personnel protective equipment (PPE).

In order to prevent radioactive contamination from getting on or into the body, protective clothing requirements must be established where the potential exists. Following is a discussion of the controls/clothing types for specific areas of the body.

Whole Body Protection

- A lab coat provides protection from low levels of contamination and is only applicable when the potential for upper body contact with contaminated surfaces is very low. In general, lab coats are worn for hands-off tours and inspections in areas with removable contamination at levels one to ten times the values in DOE-STD-1098-2008, *Radiological Control*, table 2-2, or during benchtop, laboratory fume hood, sample station, and glovebox operations.
- Coveralls provide protection from low to moderate levels of dry contamination protection. Protection is low when body contact with contaminated surfaces is prolonged (since contamination can be ground into or through the cloth) and when the surface is wet. The degree of protection can be increased by use of more than one pair at a time to protect the body. Cloth coveralls are permeable, and so are not effective against radionuclides with high permeability properties (gases, tritium, etc.).
- Plastic coveralls provide protection from high levels of dry contamination and wet contamination. They provide limited protection from tritium and other highly permeating radionuclides (which may be transported through coveralls to the skin surface).
- Disposable coveralls (e.g., tyvek suits) provide moderate protection from radioactive contamination and are used for work involving mixed hazards, (e.g., asbestos, polychlorinated biphenyl, [PCBs] etc.), where reuse is not desirable. Disposable coveralls can be fairly easily torn.

Hand Protection

- Surgical gloves are a minimal requirement normally used in only light contamination work areas, which require a high degree of dexterity. Surgical gloves are fairly easily torn or punctured.
- Rubber gloves are lightweight and provide a good gripping surface. They are normally used in moderate to heavy contamination locations. Rubber gloves have greater puncture, abrasion and solvent resistance, but afford a lower degree of dexterity than surgical gloves.
- Neoprene gloves are synthetic rubber gloves mounted to various containment devices to allow access by the wearer into the device. They are used to provide protection for the wearer when working inside a containment device in which highly contaminated materials are present. They are usually of arm length attached to dry boxes, gloveboxes and bags, or other cabinets and provide a gas tight seal to the structure.
- Cotton glove liners may be worn inside standard gloves for comfort, but should not be worn alone or considered as a layer of protection.
- Leather or canvas work gloves should be worn in lieu of or in addition to standard gloves for work activities requiring additional strength or abrasion resistance.

Foot Protection

- Booties are used to protect the lower leg area below the coveralls from contamination. Different constructions used are plastic and cloth (sometimes called cloth shoe covers).
- Shoe covers are worn over booties to provide a second layer of protection and provide traction to wearer. They are normally constructed of plastic or rubber, and may be taped to the pant legs of the coveralls or plastic suit depending on the level of contamination and type of job.

Respiratory Protection

- Full face masks are used to filter particulate radionuclides and/or radioactive iodine from the breathing air of the wearer when the surrounding atmosphere is not immediately dangerous to the life and health of the wearer.
- Supplied air systems may prevent inhalation of particulate and gaseous nuclides by the wearer in a non-life threatening atmosphere.
- A self contained breathing apparatus is used to provide a portable source of breathing air to the user when entering an atmosphere which may be immediately dangerous to life or health (IDLH).

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

The following is taken from Weitz and Luxenberg PC, Learn More about the Harmful Effects of Radiation Contamination.

The hazards to people and the environment from radioactive contamination depend on the nature of the radioactive contaminant, the level of contamination, and the extent of the spread of contamination.

Low levels of radioactive contamination pose no risk at all, but can still be detected by radiation instrumentation, thereby being more of an annoyance than a threat. In the case of low-level contamination by isotopes with a short half-life, the best course of action may be to simply allow the material to naturally decay. Longer-lived isotopes should be cleaned up and disposed of properly.

High levels of contamination may pose major risks to people and the environment. People can be exposed to potentially lethal radiation levels, both externally and internally, from the spread of contamination following an accident (or a deliberate detonation) involving large quantities of radioactive material. The biological effects of external exposure to radioactive contamination are generally the same as those from an external radiation source not involving radioactive materials, such as x-ray machines, and are dependent on the absorbed dose.

The biological effects of internally deposited radionuclides depend greatly on the activity and the biodistribution and removal rates of the radioisotope, which in turn depends on its chemical form. The biological effects may also depend on the chemical toxicity of the deposited material, independent of its radioactivity. Radioactive iodine is a common fission product; it was a major component of the radioactivity released from the Chernobyl disaster, leading to many cases of pediatric thyroid cancer and hypothyroidism.

Radioactive contamination can enter the body through ingestion, inhalation, absorption, or injection. Radioactive contamination may also be ingested as the result of eating contaminated plants and animals or drinking contaminated water or milk from exposed animals.

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

a. Describe the proper use and function of, and radiation detected by, different types of thermoluminescent dosimeters and self-reading dosimetry.

The following is taken from DOE-HDBK-1122-2009, part 6.

Thermoluminescent Dosimeters

Thermoluminescent dosimeters are used to measure the external radiation dose received by radiation workers (personnel with the potential to receive greater than 100 mrem per year whole body effective dose equivalent from occupational exposures). Thermoluminescent dosimeters can be configured to detect beta, gamma, and neutron radiation.

Self-reading Dosimetry

- Pocket and electronic dosimeters are supplemental dosimeters that provide real-time indication of exposure to (primarily gamma and X) radiation and assist in maintaining personnel doses less than AC levels.
- Supplemental dosimeters shall be issued to personnel prior to entry into a high or very high radiation area [10 CFR 835.502(a)(2)], or when required by a radiation work permit. Pocket dosimeters should be selected with the lowest range applicable (typically 0-200 mR) for anticipated personnel exposures.
- Supplemental dosimeters should be read periodically while in use and should not be allowed to exceed 75 percent of full scale.
- The energy dependence of supplemental dosimeters, particularly to low-energy beta radiation, should be considered in determining their applicability.
- Use of electronic dosimeters is encouraged for entry into high radiation areas.

The following is taken from DOE-HDBK-1130-2008.

Worker Responsibilities for External Dosimetry

- Wear dosimeters when required.
- Wear dosimeters properly.
    - Primary dosimeters should be worn on the chest area. This area is on or between the neck and the waist. Radiological control procedures or work authorizations may also identify proper placement.
    - Supplemental dosimeters are worn in accordance with site policy. This includes pocket, electronic dosimeters, extremity dosimetry, or multiple dosimeter sets.

- Take proper actions if dosimeter is lost, damaged, contaminated, or off-scale. If in an area controlled for radiological purposes, take the following actions:
  - Place work activities in a safe condition.
  - Alert others.
  - Immediately exit the area.
  - Notify radiological control personnel.

- Store the dosimeter in the proper storage location.
- Return dosimeters for processing as directed. Personnel that fail to return dosimeters may be restricted from continued radiological work.
- Dosimeters issued from the permanent work site cannot be worn at another site.

b. State the purpose and function of the following radiation-monitoring systems:
- **Criticality**
- **Area**
- **Process**
- **Airborne**

Criticality Alarm System

The following is taken from DOE-STD-1128-2008.

If the fissionable material mass exceeds American National Standards Institute (ANSI)/American Nuclear Society-8.3 limits and the probability of criticality is greater than 10^{-6} per year, a criticality alarm system (DOE O 420.1B, section 4.3.3) shall be provided to cover occupied areas in which the expected dose exceeds twelve rad in free air. The criticality alarm system should include a criticality detection device and a personnel evacuation alarm.

The alarm signal shall be for immediate evacuation purposes only and of sufficient volume and coverage to be heard in all areas that are to be evacuated. The alarm trip point shall be set low enough to detect the minimum accident of concern. The minimum accident of concern may be assumed to deliver the equivalent of an absorbed dose in free air of 20 rad at a distance of two meters from the reacting material within 60 seconds.

Area Radiation Monitors

The following is taken from DOE-STD-1098-2008.

In addition to the requirements and recommendations of DOE-STD-1098-2008, article 551, area radiation monitors should be installed in frequently occupied locations with the potential for unexpected increases in dose rates and in remote locations where there is a need for local indication of dose rates prior to personnel entry.

The need for and placement of area radiation monitors should be documented and assessed when changes to facilities, systems, or equipment occur.

Process Radiation Monitoring Systems

The following is taken from U.S. Nuclear Regulatory Commission, Westinghouse Systems Course R-304P, part 7.

Process radiation monitoring systems monitor the radiation level of various process liquid and gas streams that may serve as discharge routes for radioactive materials. These monitors are provided to indicate the radioactivity of the process stream and to alert operating personnel when operational limits are approached for the normal release of radioactive material to the environment.

On process streams that do not discharge to the environs, process monitors are provided to indicate process stream malfunctions. In addition to providing continuous indication and alarms, the process radiation monitor may provide various automatic functions, such as the closing of vent valves, discharge valves, etc.

If the activity level in the process stream reaches a predetermined setpoint, the system will perform its automatic function, which ensures that the discharge of radioactive material to the environs is limited.

Continuous Air Monitors

The following is taken from DOE-HDBK-1122-2009.

Installed continuous air monitors provide an estimate of airborne radioactivity concentrations averaged over time at a fixed, designated location, and provide immediate local and remote readout and alarm capabilities for preset concentrations. They provide preset audible and visual alarms/warning levels.

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

The following is taken from 10 CFR 835.

a. Discuss the purpose and general requirements of 10 CFR 835, "Occupational Radiation Protection," to include the following:
- **Access training**
- **Dose limits**
- **Posting types and use**
- **Access requirements**
- **Differences in radiological terminology between the 1998 and 2007 revisions of 10 CFR 835.**

Purpose

The purpose of 10 CFR 835 is to establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities.

Access Training

Each individual shall demonstrate knowledge of the radiation safety training topics established at 10 CFR 835.901(c), commensurate with the hazards in the area and required controls, by successful completion of an examination and performance demonstrations before
- being permitted unescorted access to radiological areas
- performing unescorted assignments as a radiological worker

Radiation safety training shall include the following topics, to the extent appropriate to each individual's prior training, work assignments, and degree of exposure to potential radiological hazards:

- Risks of exposure to radiation and radioactive materials, including prenatal radiation exposure
- Basic radiological fundamentals and radiation protection concepts
- Physical design features, ACs, limits, policies, procedures, alarms, and other measures implemented at the facility to manage doses and maintain doses ALARA, including routine and emergency actions
- Individual rights and responsibilities as related to implementation of the facility radiation protection program
- Individual responsibilities for implementing ALARA measures required by 10 CFR 835.101
- Individual exposure reports that may be requested in accordance with 10 CFR 835.801

Dose Limits

Except for planned special exposures conducted consistent with 10 CFR 835.204 and emergency exposures authorized in accordance with 10 CFR 835.1302, the occupational dose received by general employees shall be controlled such that the following limits are not exceeded in a year:

- A total effective dose (TED) of 5 rems (0.05 Sv)
- The sum of the equivalent dose to the whole body for external exposures and the committed equivalent dose to any organ or tissue other than the skin or the lens of the eye of 50 rems (0.5 Sv)
- An equivalent dose to the lens of the eye of 15 rems (0.15 Sv)
- The sum of the equivalent dose to the skin or to any extremity for external exposures and the committed equivalent dose to the skin or to any extremity of 50 rems (0.5 Sv)

All occupational doses received during the current year, except doses resulting from planned special exposures conducted in compliance with 10 CFR 835.204 and emergency exposures authorized in accordance with 10 CFR 835.1302, shall be included when demonstrating compliance with 10 CFR 835.202(a) and 10 CFR 835.207.

Doses from background, therapeutic and diagnostic medical radiation, and participation as a subject in medical research programs shall not be included in dose records or in the assessment of compliance with the occupational dose limits.

Posting Types and Use

Each access point to a controlled area shall be posted whenever radiological areas or radioactive material areas exist in the area. Individuals who enter only controlled areas without entering radiological areas or radioactive material areas are not expected to receive a TED of more than 0.1 rem (0.001 Sv) in a year. Signs used for this purpose may be selected by the contractor to avoid conflict with local security requirements.

Each access point to radiological areas and radioactive material areas shall be posted with conspicuous signs bearing the wording provided in 10 CFR 835.603, as follows:

- Radiation area—the words “Caution, Radiation Area” shall be posted at each radiation area.
- High radiation area—the words “Caution, High Radiation Area” or “Danger, High Radiation Area” shall be posted at each high radiation area.
- Very high radiation area—the words “Grave Danger, Very High Radiation Area” shall be posted at each very high radiation area.
- Airborne radioactivity area—the words “Caution, Airborne Radioactivity Area” or “Danger, Airborne Radioactivity Area” shall be posted at each airborne radioactivity area.
- Contamination area—the words “Caution, Contamination Area” shall be posted at each contamination area.
- High contamination area—the words “Caution, High Contamination Area” or “Danger, High Contamination Area” shall be posted at each high contamination area.
- Radioactive material area—the words “Caution, Radioactive Material(s)” shall be posted at each radioactive material area.

Access Requirements

Radiological areas:

- Personnel entry control shall be maintained for each radiological area.
- The degree of control shall be commensurate with existing and potential radiological hazards within the area.
- One or more of the following methods shall be used to ensure control:
  - Signs and barricades
  - Control devices on entrances
  - Conspicuous visual and/or audible alarms
  - Locked entrance ways
  - Administrative controls
- Individuals exiting contamination, high contamination, or airborne radioactivity areas shall be monitored, as appropriate, for the presence of surface contamination.
- Protective clothing shall be required for entry to areas in which removable contamination exists at levels exceeding the removable surface contamination values specified in appendix D of 10 CFR 835.
- Written authorizations shall be required to control entry into and perform work within radiological areas. These authorizations shall specify radiation protection measures commensurate with the existing and potential hazards.
- No control(s) shall be installed at any radiological area exit that would prevent rapid evacuation of personnel under emergency conditions.

High and very high radiation areas:

- The following measures shall be implemented for each entry into a high radiation area:
  - The area shall be monitored as necessary during access to determine the exposure rates to which the individuals are exposed.
  - Each individual shall be monitored by a supplemental dosimetry device or other means capable of providing an immediate estimate of the individual’s integrated equivalent dose to the whole body during the entry.

- Physical controls—one or more of the following features shall be used for each entrance or access point to a high radiation area where radiation levels exist such that an individual could exceed an equivalent dose to the whole body of 1 rem (0.01 Sv) in any one hour at 30 centimeters from the source or from any surface that the radiation penetrates:
  - A control device prevents entry to the area when high radiation levels exist or upon entry causes the radiation level to be reduced below that level defining a high radiation area.
  - A device functions automatically to prevent use or operation of the radiation source or field while individuals are in the area.
  - A control device energizes a conspicuous visible or audible alarm signal so that the individual entering the high radiation area and the supervisor of the activity are made aware of the entry.
  - Entryways that are locked. During periods when access to the area is required, positive control over each entry is maintained.
  - Continuous direct or electronic surveillance is capable of preventing unauthorized entry.
  - A control device will automatically generate audible and visual alarm signals to alert personnel in the area before use or operation of the radiation source and in sufficient time to permit evacuation of the area or activation of a secondary control device that will prevent use or operation of the source.
- Very high radiation areas—in addition to the above requirements, additional measures shall be implemented to ensure individuals are not able to gain unauthorized or inadvertent access to very high radiation areas.
- No control(s) shall be established in a high or very high radiation area that would prevent rapid evacuation of personnel.

The following is taken from the Federal Register.

Differences in Radiological Terminology

Table 8. Changes to 10 CFR 835 dosimetric terms

1998 Dosimetric Terms	2007 Dosimetric Terms
Committed effective dose equivalent	Committed effective dose
Committed dose equivalent	Committed equivalent dose
Cumulative total effective dose equivalent	Cumulative total effective dose
Deep dose equivalent	Deep equivalent dose
Dose equivalent	Equivalent dose
Effective dose equivalent	Effective dose
Lens of the eye dose equivalent	Lens of the eye equivalent dose
Quality factor	Radiation weighting factor
Shallow dose equivalent	Shallow equivalent dose
Weighting factor	Tissue weighting factor
Total effective dose equivalent	Total effective dose

Source: Federal Register—10 CFR 820 and 835, “Procedural Rules for DOE Nuclear Activities and Occupational Radiation Protection”; Final Rule.

b. Discuss the purpose of, and general guidance provided under, DOE-STD-1098-99, *Radiological Control*.

[Note: DOE-STD-1098-99 has been cancelled by DOE-STD-1098-2008, from which the following is taken.]

The DOE has developed this standard to assist line managers in meeting their responsibilities for implementing occupational radiological control programs. While this standard does not establish requirements, it does restate, paraphrase, or cite many (but not all) of the requirements of 10 CFR 835 and related documents (e.g., occupational safety and health, hazardous materials transportation, and environmental protection standards).

To assist its operating entities in achieving and maintaining compliance with the requirements of 10 CFR 835, DOE has established its primary regulatory guidance in DOE G 441.1C, *Radiation Protection Programs Guide for use with Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection*. DOE G 441.1C is structured to assist radiation protection professionals in developing the documented radiation protection program required by 10 CFR 835.101 and the supporting site- and facility-specific policies, programs, and procedures that are necessary to ensure compliance with the related regulatory requirements.

This standard supplements DOE G 441.1-1C and serves as a secondary source of guidance for achieving compliance with 10 CFR 835. In contrast to the macroscopic view adopted by DOE G 441.1-1C, this standard discusses specific measures that should be implemented by affected line managers, workers, and support staff to ensure proper fulfillment of their radiological control responsibilities. DOE expects that each site will identify the provisions of this standard that support its efforts to implement an effective radiological control program and incorporate these provisions, as appropriate, into the site-specific radiological control manual, site procedures, training, or other administrative instruments that are used to guide employee activities.

ENVIRONMENTAL MANAGEMENT

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

The following is taken from DOE M 435.1-1 chg. 2, unless specified otherwise.

a. Discuss the following terms and the differences among them:

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

Low-Level Radioactive Waste (LLW)

Low-level radioactive waste is radioactive waste that is not high level radioactive waste, spent nuclear fuel, transuranic (TRU) waste, byproduct material (i.e., U and thorium mill tailings or waste from processed ore), or naturally occurring radioactive material.

Hazardous Waste

The following is taken from DOE G 430.1-1, appendix A.

Hazardous waste is a solid waste, or combination of solid wastes, that because of its quantity, concentration, or physical, chemical, or infectious characteristics, may cause or significantly contribute to an increase in mortality or an increase in serious, irreversible, or incapacitating reversible illness or pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed.

Transuranic Waste

Transuranic waste is radioactive waste containing more than 100 nanocuries (3700 becquerels) of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years, except for the following:

- High-level radioactive waste
- Waste that the Secretary of Energy has determined, with the concurrence of the Administrator of the Environmental Protection Agency (EPA), does not need the degree of isolation required by the 40 CFR 191 disposal regulations
- Waste that the Nuclear Regulatory Commission (NRC) has approved for disposal on a case-by-case basis in accordance with 10 CFR 61

High-level Radioactive 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 taken 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.

Mixed (Hazardous) Waste

Mixed waste is radioactive waste that contains both source, special nuclear, or by-product material subject to the Atomic Energy Act (AEA) of 1954, as amended, and a hazardous component that is subject to the Resource Conservation and Recovery Act (RCRA).

b. Describe potential sources of each of 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

The following is taken from the U.S. Environmental Protection Agency website, *Low-level Radioactive Waste*.

Low-level radioactive waste is radioactively contaminated industrial or research waste such as paper, rags, plastic bags, protective clothing, cardboard, packaging material, organic fluids, and water-treatment residues. It is waste that does not fall into any of the other waste categories.

Low-level radioactive waste is generated by government facilities, utilities, industries, and institutional facilities. In addition to 35 major DOE facilities, over 20,000 commercial users of radioactive materials generate some amount of LLW. LLW generators include approximately 100 operating nuclear power reactors, associated fuel fabrication facilities, and U fuel conversion plants, which together are known as nuclear fuel-cycle facilities. Hospitals, medical schools, universities, radiochemical and radiopharmaceutical manufacturers and research laboratories are other users of radioactive materials which produce LLW. The clean-up of contaminated buildings and sites will generate more LLW in the future.

Hazardous Waste

The following is taken from the U.S. Environmental Protection Agency website, *Hazardous Waste.*

Hazardous wastes are divided into listed wastes, characteristic wastes, universal wastes, and mixed wastes. Mixed wastes are discussed separately later in this KSA.

- Listed wastes are wastes that EPA has determined are hazardous. The lists include the F-list (wastes from common manufacturing and industrial processes), K-list (wastes from specific industries), and P- and U-lists (wastes from commercial chemical products).
- Characteristic wastes are wastes that do not meet any of the listings above but that exhibit ignitability, corrosivity, reactivity, or toxicity.
- Universal wastes include batteries, pesticides, mercury-containing equipment (e.g., thermostats) and lamps (e.g., fluorescent bulbs).

Transuranic Waste

The following is taken from the U.S. Environmental Protection Agency website, *Transuranic Radioactive Waste.*

Transuranic waste materials have been generated in the U.S. since the 1940's. Most of this waste originates from nuclear weapons production facilities for defense programs. "Transuranic" refers to atoms of man-made elements that are heavier (higher in atomic number) than U. The most prominent element in most TRU waste is Pu. Some TRU waste consists of items such as rags, tools, and laboratory equipment contaminated with radioactive materials. Other forms of TRU waste include organic and inorganic residues or even entire enclosed contaminated cases in which radioactive materials were handled.

The following is taken from the U.S. Environmental Protection Agency website, *About Mixed Waste.*

High-Level Radioactive Waste

DOE's HLW is radioactive waste which is liquid prior to treatment and comes from reprocessing spent nuclear fuel and irradiated targets from reactors. Some of its elements will remain radioactive for thousands of years. Because it contains highly corrosive, organic, or heavy metal components that are regulated under RCRA, this HLW is considered a mixed waste.

Mixed Hazardous Waste

DOE's 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 m^3 of LLMW over the next 20 years.

DOE's mixed TRU (MTRU) waste is waste that has a hazardous component and radioactive elements heavier than U. The radioactivity in the MTRU must be greater than 100 nanocuries per gram (nCi/g) and contaminated with RCRA hazardous constituents.

Mixed TRU waste is primarily generated from nuclear weapons fabrication, Pu-bearing reactor fuel fabrication, and spent fuel reprocessing. The amount of MTRU waste generated by entities other than DOE is negligible. Approximately 55 percent of DOE's TRU waste is MTRU waste. Approximately 1,500 m^3 of MTRU waste from Rocky Flats, Colorado has been retrieved for disposal and the site is closed. Mixed TRU waste is currently being retrieved for disposal at five DOE sites.

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**

The following is taken from DOE M 435.1-1 chg. 2, from which a large amount of additional information is available.

Low-Level Radioactive Waste

Storage

- Low-level waste in storage shall not be readily capable of detonation, explosive decomposition, reaction at anticipated pressures and temperatures, or explosive reaction with water. Prior to storage, pyrophoric materials shall be treated, prepared, and packaged to be nonflammable.
- Low-level waste that has an identified path to disposal shall not be stored longer than one year prior to disposal, except for storage for decay, or as otherwise authorized by the field element manager (FEM).
- Low-level waste that does not have an identified path to disposal shall be characterized as necessary to meet the data quality objectives and minimum characterization requirements of chapter I of DOE M 435.1-1, *Radioactive Waste Management Manual*, to ensure safe storage, and to facilitate disposal. Characterization information for all LLW in storage shall be maintained as a record in accordance with the requirements for records management in chapter I of DOE M 435.1-1.

- Low-level waste shall be stored in a location and manner that protects the integrity of waste for the expected time of storage and minimizes worker exposure.
- A process shall be developed and implemented for inspecting and maintaining containers of LLW to ensure container integrity is not compromised.
- Low-level waste storage shall be managed to identify and segregate LLW from LLMW.
- Staging of LLW shall be for the purpose of the accumulation of such quantities of waste as necessary to facilitate transportation, treatment, and disposal. Staging longer than 90 days shall meet the requirements for storage above and in chapter I of DOE M 435.1-1.

Treatment

Low-level waste treatment to provide more stable waste forms and to improve the long-term performance of an LLW disposal facility shall be implemented as necessary to meet the performance objectives of the disposal facility.

Disposal

- Dose to representative members of the public shall not exceed 25 mrem (0.25 mSv) in a year TED from all exposure pathways, excluding the dose from radon and its progeny in air.
- Dose to representative members of the public via the air pathway shall not exceed 10 mrem (0.10 mSv) in a year TED, excluding the dose from radon and its progeny.
- Release of radon shall be less than an average flux of 20 pCi/m^2/s (0.74 Bq/m^2/s) at the surface of the disposal facility. Alternatively, a limit of 0.5 pCi/liter (0.0185 Bq/liter) of air may be applied at the boundary of the facility.

Hazardous Waste

Hazardous wastes are divided into listed wastes, characteristic wastes, universal wastes, and mixed wastes, and will be discussed under mixed hazardous waste later in this KSA.

Transuranic Waste

Storage

- Transuranic waste in storage shall not be readily capable of detonation, explosive decomposition, reaction at anticipated pressures and temperatures, or explosive reaction with water. Prior to storage, pyrophoric materials shall be treated, prepared, and packaged to be nonflammable.
- Transuranic waste shall be stored in a location and manner that protects the integrity of waste for the expected time of storage and minimizes worker exposure.
- A process shall be developed and implemented for inspecting and maintaining containers of TRU waste to ensure container integrity is not compromised.
- Plans for the removal of TRU waste from retrievable earthen-covered storage facilities shall be established and maintained. Prior to commencing waste retrieval activities, each waste storage site shall be evaluated to determine relevant information on types, quantities, and location of radioactive and hazardous chemicals as necessary to protect workers during the retrieval process.

Treatment

Transuranic waste shall be treated as necessary to meet the waste acceptance requirements of the facility receiving the waste for storage or disposal.

Disposal

Transuranic waste shall be disposed in accordance with the requirements of 40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes."

High-level Radioactive Waste

Storage

- Confinement systems shall be operated and maintained so as to preserve the design basis.
- Secondary confinement systems, where provided, shall be operated to prevent any migration of wastes or accumulated liquid out of the waste confinement systems.
- Leak-tight tanks in-service—a structural integrity program shall be developed for each HLW storage tank site to verify the structural integrity and service life of each tank to meet operational requirements for storage capacity. The program shall be capable of identifying the additional controls necessary to maintain an acceptable operating envelope.
- In-service tanks that have leaked or are suspect—for each HLW storage tank in-service that is known to have leaked, or is suspect, a modified structural integrity program shall be developed and implemented to identify the safe operational envelope.
- Other storage components—the structural integrity of other storage components shall be verified to assure leak tightness and structural strength.
- Canisters of immobilized HLW awaiting shipment to a repository shall be
  - stored in a suitable facility;
  - segregated and clearly identified to avoid commingling with LLW, LLMW, or TRU wastes; and
  - monitored to ensure that storage conditions are consistent with DOE/EM–0093, *Waste Acceptance Product Specifications for Vitrified High-level Waste Forms*, or DOE/RW-0351, *Waste Acceptance System Requirements Document*, for non-vitrified immobilized HLW. Facilities and operating procedures for storage of vitrified HLW shall maintain the integrity of the canistered waste form.

Treatment

Treatment shall be designed and implemented in a manner that will ultimately comply with DOE/EM–0093 or DOE/RW-0351, for non-vitrified immobilized HLW.

Disposal

Disposal of HLW must be in accordance with the provisions of the AEA of 1954, as amended, the Nuclear Waste Policy Act of 1982, as amended, or any other applicable statutes.

Mixed Hazardous Wastes

Mixed waste is radioactive waste that contains both source, special nuclear, or by-product material subject to the AEA of 1954, as amended, and a hazardous component that is subject to RCRA.

- Mixed LLW shall be managed in accordance with the requirements of RCRA, DOE O 435.1, *Radioactive Waste Management*, and DOE M 435.1-1.
- Mixed TRU waste shall be managed in accordance with the requirements of RCRA, DOE O 435.1, and DOE M 435.1-1.
- Mixed HLW—unless demonstrated otherwise, all HLW shall be considered mixed waste and is subject to the requirements of the AEA, as amended, RCRA, as amended, DOE O 435.1, and DOE M 435.1-1.

8. Personnel must demonstrate a familiarity level knowledge of DOE Orders, standards, regulations, and laws related to environmental protection, pollution prevention, environmental restoration, and waste management issues.

a. Discuss the purpose of the following environmental laws as they apply to the Department and the contractors that operate its facilities:
- **National Environmental Policy Act (NEPA)**
- **Resource Conservation and Recovery Act (RCRA)**
- **Comprehensive Environmental Response, Compensation, and Liability Act—Superfund Act (CERCLA)**

National Environmental Policy Act

The following is taken from Energy.gov, Office of NEPA Policy and Compliance, *DOE, NEPA and You*.

The NEPA is a Federal law that serves as the nation’s basic charter for environmental protection. It requires that all Federal agencies consider the potential environmental impacts of their proposed actions. The NEPA promotes better agency decision-making by ensuring that high quality environmental information is available to agency officials and the public before the agency decides whether and how to undertake a major Federal action.

Early in its planning process for a proposed action, DOE considers how to comply with NEPA. The appropriate level of review depends on the significance, that is, consideration of the context and intensity of the potential environmental impacts associated with the proposed action. There are three levels of NEPA review:

- Environmental impact statement (EIS): For major Federal actions that may significantly affect the quality of the human environment, NEPA requires preparation of an EIS. An EIS is a detailed analysis of the potential environmental impacts of a proposed action and the range of reasonable alternatives.
- Environmental assessment (EA): When the need for an EIS is unclear, an agency may prepare an EA to determine whether to prepare an EIS or to issue a finding of no significant impact. An EA is a brief analysis. DOE’s procedures provide notification and comment opportunities for host states and tribes. DOE then considers any comments received, makes revisions as appropriate, and issues the EA.
- Categorical exclusion: DOE’s NEPA regulations list classes of actions that normally do not require an EIS or an EA because, individually or cumulatively, they do not

have the potential for significant environmental impacts. Examples are information gathering activities and property transfers when the use is unchanged.

The following is taken from the U.S. DOE website, Office of Health, Safety and Security (HSS), *Environmental Policy*.

Resource Conservation and Recovery Act

The RCRA, (Pub. L. 94-580) established a system for managing non-hazardous and hazardous solid wastes in an environmentally sound manner. Specifically, it provides for the management of hazardous wastes from the point of origin to the point of final disposal (i.e., "cradle to grave"). The RCRA also promotes resource recovery and waste minimization.

Source: U.S. EPA RCRA Orientation Manual

Figure 7. RCRAs cradle-to-grave hazardous waste management system

Comprehensive Environmental Response, Compensation, and Liability Act—Superfund Act

Under CERCLA, Congress gave the Federal government broad authority to regulate hazardous substances, to respond to hazardous substance emergencies, and to develop long-term solutions for the nation's most serious hazardous waste problems. The CERCLA also created a $1.6 billion hazardous substance response trust fund. This fund, supported by an excise tax on feedstock chemicals and petroleum, was used to pay for cleanup activities at abandoned waste sites.

The CERCLA requires the parties responsible for the contamination to conduct or pay for the cleanup. If the EPA's efforts to take an enforcement action for the cleanup are not successful, the Federal government can clean up a site using the CERCLA trust fund. If the superfund program conducts the cleanup, the government can take court action against responsible parties to recover up to three times the cleanup costs.

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

- **Clean Water Act (CWA), including the National Pollutant Discharge Elimination System (NPDES)**
- **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)**
- **Solid Waste Disposal Act (SWDA)**

All of the information for this KSA is taken from the U.S. DOE website, Office of Health, Safety, and Security, *Environmental Policy*, unless specified otherwise.

Clean Water Act

The purpose of the CWA is to attain a level of water quality that "provides for the protection and propagation of fish, shellfish, and wildlife, and provides for recreation in and on the water" by 1983 and to eliminate the discharge of pollutants into navigable waters by 1985.

All DOE facilities that discharge wastewaters to either a surface water body or a publically owned treatment work must comply with the CWA. Facilities that directly discharge wastewaters must obtain an NPDES permit. This permit specifies the discharge standards and monitoring and reporting requirements that the facility must achieve for each point source or outfall.

Clean Air Act

On November 15, 1990, revisions of the CAA were signed into law. These revisions

- strengthen measures for attaining air quality standards
- set forth provisions relating to mobile sources
- expand the regulation of hazardous air pollutants
- require substantial reductions in power plant emissions for control of acid rain
- establish operating permits for all major sources of air pollution
- establish provisions for stratospheric ozone protection
- expand enforcement powers and penalties

The CAA amendments will have far-reaching effects not only on environmental activities at DOE facilities, but also on procurement, maintenance, and motor vehicle operation activities.

Emergency Planning and Community Right-To-Know Act

The EPCRA was enacted by Congress as a stand-alone provision of the SARA of 1986. The EPCRA was passed in response to concerns regarding the environmental and safety hazards posed by the storage and handling of toxic chemicals, and imposed requirements on both states and regulated facilities. Facilities must notify the local emergency planning districts regarding materials stored at and released from sites.

40 CFR 355, "Emergency Planning and Notification," Appendix A, defines extremely hazardous substances. Any DOE facility that manages substances in quantities exceeding the threshold planning quantities noted in appendix A of 40 CFR 355 must comply with EPCRA.

Federal Facility Compliance Act

Under section 102, the FFCA amended section 6001 of RCRA to specify that Federal facilities are subject to "all civil and administrative penalties and fines, regardless of whether such penalties or fines are punitive or coercive in nature." These penalties and fines can be levied by EPA or by authorized states. In addition, the FFCA states that "the United States hereby expressly waives any immunity otherwise applicable to the United States."

Many DOE facilities are now subject to Federal facility compliance agreements and other binding administrative cleanup orders. The FFCA will allow regulators to impose fines or penalties on Federal entities that fail to meet milestones or deadlines contained in such agreements or orders. Penalties specified in the agreements will now be enforceable and may result in substantial financial penalties to noncompliant facilities.

Section 105 of the FFCA further amends RCRA by adding the new section 3021. This section, *Mixed Waste Inventory Reports and Plan[s]*, provides the mechanism for fulfilling the requirements cited above by imposing several new reporting requirements on DOE related to mixed waste

Pollution Prevention Act of 1990

Executive Order (EO) 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements," directs Federal agencies and their facilities to comply with the provisions of EPCRA and the PPA. Thus, all DOE facilities, including national laboratories, research facilities, power administrations, and petroleum reserves are potential reporters under EPCRA. Also, if they meet any reporting thresholds, they would be required to comply with section 13106 of PPA.

Safe Drinking Water Act

In 1974 Congress enacted the SDWA to manage potential contamination threats to groundwater. The act instructed EPA to establish a national program to prevent underground injections of contaminated fluids that would endanger drinking water sources. Primary drinking water standards promulgated under the SDWA apply to drinking water "at the tap" as delivered by public water supply systems. As such, the standards apply directly to those DOE facilities that meet the definition of a public water supply system (e.g., the DOE Oak Ridge Reservation is a public water supply system because it provides water to the City of Oak Ridge).

Of equal significance to DOE is that the drinking water standards are used to determine groundwater protection regulations under a number of other statutes (e.g., RCRA). Therefore, many of the SDWA requirements apply to DOE activities, especially cleanup of contaminated sites and storage and disposal of materials containing radionuclides, inorganic chemicals, organic chemicals, and hazardous wastes.

Superfund Amendments and Reauthorization Act

The following is taken from the U.S. Environmental Protection Agency website, Laws and Regulations, *Summary of CERCLA.*

The SARA of 1986 reauthorized CERCLA to continue cleanup activities around the country. Several site-specific amendments, definitions, clarifications, and technical requirements were added to the legislation, including additional enforcement authorities. Also, title III of SARA authorized EPCRA.

Toxic Substances Control Act

The TSCA (Public Law [Pub. L.] 94-469) authorizes EPA to secure information on all new and existing chemical substances and to control any of these substances that could cause an unreasonable risk to public health or the environment. The TSCA closed the gap in the earlier laws by requiring that the health and environmental effects of all new chemicals be reviewed before they are manufactured for commercial purposes.

The TSCA's major impact on DOE occurs through its regulation of PCBs. Determinations regarding compliance with TSCA must be made on a case-by-case basis if a DOE activity involves the manufacture, processing, distribution in commerce, use, and /or disposal of a new or existing chemical substance or mixture that may present an unreasonable risk of injury to human health or the environment. Although TSCA excludes nuclear material, the TSCA-regulated portion of a mixed nuclear and regulated waste must comply with TSCA requirements.

Solid Waste Disposal Act

The following is taken from the U.S. Environmental Protection Agency website, Laws and Regulations, *What is the Solid Waste Disposal Act of 1965?*

Congress passed the SWDA in 1965 as part of the amendments to the CAA. This was the first Federal law that required environmentally sound methods for disposal of household, municipal, commercial, and industrial waste. Subsequent amendments to the SWDA, such as RCRA, have substantially increased the Federal government's involvement in solid waste management.

c. Using the following documents as references, discuss their purpose and general requirements:

- **DOE O 450.1, Admin. Chg. 1, *Environmental Protection Program***

  [Note: DOE O 450.1, Chg. 1 was cancelled by DOE O 450.1A, which was cancelled by DOE O 436.1, *Departmental Sustainability*.]
- **DOE O 451.1B, Chg. 1 (formerly DOE Order 5440.1), *National Environmental Policy Act Compliance Program***

  [Note: DOE O 451.1B, Chg. 1 was cancelled by DOE O 451.1B, Chg. 2, same title.]
- **DOE O 435.1, Chg. 1, *Radioactive Waste Management***
- **DOE Order 5400.5, Chg. 2, *Radiation Protection of the Public and the Environment***

  [Note: DOE Order 5400.5, Chg. 2 was cancelled by DOE O 458.1, Chg. 2, same title.]

DOE O 436.1, Departmental Sustainability

The purpose of DOE O 436.1 is to provide requirements and responsibilities for managing sustainability within DOE to

- ensure the Department carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges, and advances sustainable, efficient and reliable energy for the future;
- institute wholesale cultural change to factor sustainability and greenhouse gas reductions into all DOE corporate management decisions; and
- ensure DOE achieves the sustainability goals established in its strategic sustainability performance plan pursuant to applicable laws, regulations and EOs, related performance scorecards, and sustainability initiatives.

Requirements

- Comply with the sustainability requirements contained in EO 13423 "Strengthening Federal Environmental, Energy, and Transportation Management," EO 13514 "Federal Leadership in Environmental, Energy, and Economic Performance," the National Energy Conservation Policy Act, the Energy Policy Acts (EP Act) of 1992 and 2005, the Energy Independence and Security Act of 2007, and continue to adhere to the inventory and reporting requirements of section 301 through 313 of the EPCRA, the PPA of 1990 at DOE facilities, related statutory and administrative requirements.
- Prepare and submit any other required reports supporting and related data as requested pursuant to the EOs and laws listed above, including Federal agency scorecards.
- Site sustainability plans (SSPs): Each site must develop and commit to implementing an annual SSP that identifies its respective contribution toward meeting the Department's sustainability goals.
- Financing: Use, to the maximum extent practicable, alternative financing for energy saving projects, which includes renewable energy, energy efficiency, water efficiency, high performance sustainable building, pollution prevention, and other sustainability projects.

DOE O 451.1B Chg. 2, National Environmental Policy Act Compliance Program

The purpose of DOE O 451.1B is to establish DOE internal requirements and responsibilities for implementing the NEPA of 1969, the Council on Environmental Quality regulations implementing the procedural provisions of NEPA (40 CFR 1500-1508), and the DOE NEPA implementing procedures (10 CFR 1021). The goal of establishing the requirements and responsibilities presented here 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.

Requirements

In addition to requirements established in NEPA and the regulations, DOE's NEPA compliance program shall include the following:

- A system of DOE NEPA compliance officers.
- Internal scoping procedures for EAs and EISs that include development of a schedule. For an EIS, the schedule, absent extraordinary circumstances, will provide for completion of a final EIS within 15 months of the issuance of the Notice of Intent.
- NEPA quality assurance (QA) plans and public participation plans.
- Annual NEPA planning summaries.
- A DOE NEPA document manager for each EIS and EA.
- A system for reporting lessons learned and encouraging continuous improvement.
- Tracking and annually reporting progress in implementing a commitment for environmental impact mitigation that is essential to render the impacts of a proposed action not significant, or that is made in a record of decision.

DOE O 435.1, Chg. 1, Radioactive Waste Management

The objective of DOE O 435.1 is to ensure that all DOE radioactive waste is managed in a manner that is protective of worker and public health and safety, and the environment.

Requirements

- DOE radioactive waste management activities shall be systematically planned, documented, executed, and evaluated.
- Radioactive waste shall be managed to
  - protect the public from exposure to radiation from radioactive materials;
  - protect the environment;
  - protect workers;
  - comply with applicable Federal, state, and local laws and regulations. These activities shall also comply with applicable EOs and other DOE directives.
- All radioactive waste shall be managed in accordance with the requirements in DOE M 435.1-1.
- DOE, within its authority, may impose such requirements, in addition to those established in DOE O 435.1, as it deems appropriate and necessary to protect the public, workers, and the environment, or to minimize threats to property.

DOE Order 458.1, Chg. 2, Radiation Protection of the Public and the Environment

The purpose of DOE O 458.1 is to establish requirements to protect the public and the environment against undue risk from radiation associated with radiological activities conducted under the control of the DOE pursuant to the AEA of 1954, as amended.

The objectives of DOE O 458.1 are to

- conduct DOE radiological activities so that exposure to members of the public is maintained within the dose limits established in DOE O 458.1;
- control the radiological clearance of DOE real and personal property;
- ensure that potential radiation exposures to members of the public are ALARA;
- ensure that DOE sites have the capabilities, consistent with the types of radiological activities conducted, to monitor routine and non-routine radiological releases and to assess the radiation dose to members of the public; and
- provide protection of the environment from the effects of radiation and radioactive material.

Requirements

[Note: Only the titles of the requirements are listed here. Section 4 of DOE O 458.1 should be consulted for a detailed description of each requirement.]

- Environmental radiological protection program
- Public dose limit
- Temporary dose limits
- As low as reasonably achievable
- Demonstrating compliance with the public dose limit
- Airborne radiological effluents
- Control and management of radionuclides from DOE activities in liquid discharges
- Radioactive waste and spent nuclear fuel
- Protection of drinking water and groundwater
- Protection of biota
- Release and clearance of property
- Records, retention, and reporting requirements
- Implementation

d. Using DOE O 450.1 as a reference, discuss the concept of an Environmental Management System.

[Note: DOE O 450.1 was cancelled by DOE O 450.1A, which was cancelled by DOE O 436.1, from which the following is taken.]

DOE O 436.1 defines an environmental management system (EMS) as a management tool enabling an organization of any size or type to accomplish the following:

- Identify and control the environmental impact of its activities, products or services
- Improve its environmental performance continually
- Implement a systematic approach to setting environmental objectives and targets, to achieving these and to demonstrating that they have been achieved

One of the requirements of DOE O 436.1 is SSPs. Each site must develop and commit to implementing an annual SSP that identifies its respective contribution toward meeting the Department's sustainability goals. SSPs must

- be completed and submitted to the sustainability performance office through the appropriate line management per annual guidance; and
- account for each individual site's contribution to meeting the sustainability goals and commit appropriate personnel resources, an appropriate financing plan, and establish a timeline for execution coupled with specific performance measures and deliverables.
- DOE sites must use EMSs as a platform for SSP implementation and programs with objectives and measurable targets that contribute to the Department meeting its sustainability goals. Sites must maintain their EMSs as being certified to or conforming to ISO 14001:2004 in accordance with the accredited registrar provisions of the international standard or the self-declaration instructions specified in DOE O 436.1.

One of the responsibilities of DOE FEMs is to ensure that EMSs covering all site activities are certified to, or conform with, ISO 14001:2004 (E) in accordance with the accredited registrar provisions of the international standard or the self-declaration instructions specified in DOE O 436.1.

e. Using DOE Order 5400.5 as a reference, discuss the concept of maintaining doses to the public and to the environment as far below dose limits and constraints as is reasonably achievable (i.e., ALARA).

[Note: DOE Order 5400.5, Chg. 2 was cancelled by DOE O 458.1, Chg. 2, from which the following is taken.]

As Low as Reasonably Achievable

- A documented ALARA process must be implemented to optimize control and management of radiological activities so that doses to members of the public (both individual and collective) and releases to the environment are kept ALARA. The process must be applied to the design or modification of facilities and conduct of activities that expose the public or the environment to radiation or radioactive material.

- The ALARA process must: consider DOE sources, modes of exposure, and all pathways which potentially could result in the release of radioactive materials into the environment, or exposure to the public; use a graded approach; and to the extent practical and when appropriate, be coordinated with the 10 CFR 835 ALARA process.
- The ALARA process must be applied to all routine radiological activities. Though not applicable to non-routine radiological events (for example, accidental, unplanned, or inadvertent releases or exposures), the ALARA process is applicable during recovery and remediation activities associated with a non-routine event.

DOE O 458.1 defines the ALARA process as a graded process for evaluating alternative operations, processes, and other measures, for optimizing releases of radioactive material to the environment, and exposure to the work force and to members of the public taking into account societal, environmental, technical, economic, and public policy considerations to make a decision concerning the optimum level of public health and environmental protection. A graded approach provides the flexibility to perform qualitative or quantitative ALARA analyses. For low doses, qualitative evaluations normally will suffice.

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

a. 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 the following:
- **Cleanup operations**
- **Corrective actions**
- **Voluntary clean-up operations**
- **Operations involving hazardous wastes**
- **Emergency response operations**

DOE O 440.1B, *Work Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*, requires DOE and its contractors to comply with the applicable worker protection requirements of 29 CFR 1910, "Occupational Safety and Health Standards," including 1910.120.

The following is taken from 29 CFR 1910,120, which provides a large amount of additional information on these topics.

Cleanup Operations (Voluntary and Mandated) and Corrective Actions

29 CFR 1910.120 requires that employers with employees involved in cleanup operations and corrective actions shall develop and implement a written safety and health program for those employees. 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 elements. Details of these elements are provided in 29 CFR 1910.120.
- An organization structure
- A comprehensive work plan
- A site-specific safety and health plan

- A safety and health training program
- Medical surveillance of employees
- The employer's standard operating procedures for safety and health
- Any necessary interface between general program and site-specific activities

Operations under RCRA Involving Hazardous Wastes

29 CFR 1910.120 requires that employers with employees involved in certain operations conducted under RCRA shall provide and implement the following programs. Details of these elements are provided in paragraph (p) of 29 CFR 1910.120.

- A safety and health program
- A hazard communication program
- A medical surveillance program
- A decontamination program
- A new technology program
- A material handling program
- A training program
- An emergency response plan that addresses the following areas:
  - Pre-emergency planning and coordination with outside parties
  - Personnel roles, lines of authority, and communication
  - Emergency recognition and prevention
  - Safe distances and places of refuge
  - Site security and control
  - Evacuation routes and procedures
  - Decontamination procedures
  - Emergency medical treatment and first aid
  - Emergency alerting and response procedures
  - Critique of response and follow-up
  - PPE and emergency equipment
  - Site topography, layout, and prevailing weather conditions
  - Procedures for reporting incidents to local, state, and Federal governmental agencies

Emergency Response Operations

The following requirements apply to employers whose employees are engaged in emergency response no matter where it occurs, except as discussed previously in this KSA. Details of these elements are provided in paragraph (q) of 29 CFR 1910.120.

The employer shall develop an emergency response plan for emergencies which shall address, as a minimum, the following to the extent that they are not addressed elsewhere:

- Pre-emergency planning and coordination with outside parties
- 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
- Emergency medical treatment and first aid
- Emergency alerting and response procedures

- Critique of response and follow-up
- PPE and emergency equipment

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

The following is taken from 29 CFR 1910.120.

All suspected conditions that may pose inhalation or skin absorption hazards that are IDLH, or other conditions that may cause death or serious harm, shall be identified during a preliminary survey and evaluated 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.

Any information concerning the chemical, physical, and toxicologic properties of each substance known or expected to be present onsite that is available to the employer and relevant to the duties an employee is expected to perform shall be made available to the affected employees prior to the commencement of their work activities. The employer may utilize information developed for the hazard communication standard for this purpose.

c. Describe the linkage between 10 CFR 851, "Worker Safety and Health Program," and 29 CFR 1910.120.

10 CFR 851.23, "Safety and Health Standards," states, "Contractors must comply with the following safety and health standards that are applicable to the hazards at their covered workplace." Among the standards cited is 29 CFR 1910, excluding 29 CFR 1910.1096, "Ionizing Radiation."

10. Personnel must demonstrate a familiarity level knowledge of potential personal and organizational liability associated with environmental laws.

a. Using NEPA as a reference, discuss the Department's responsibilities associated with NEPA and the potential consequences of noncompliance with NEPA.

Federal Agency (e.g., DOE) Responsibilities

The following is taken from the U.S. Environmental Protection Agency website, NEPA, *Basic Information*.

Title I of NEPA contains a declaration of national environmental policy that requires the Federal government to use all practicable means to create and maintain conditions under which man and nature can exist in productive harmony. 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 EISs.

Potential Consequences of Noncompliance

The following is taken from the U.S. Environmental Protection Agency website, Compliance and Enforcement, *Federal Facilities Enforcement*.

EPA has explicit authority to assess fines at Federal facilities violating environmental statutes. EPA's Federal facilities civil enforcement program helps protect public health and the environment by ensuring that Federal facilities comply with Federal environmental laws.

EPA also enforces environmental cleanup requirements at Federal facilities. Cleanup enforcement authority is taken from several statutes: CERCLA or Superfund, the RCRA, including the Underground Storage Act program, and the Oil Pollution Act, a part of the CWA. These statutes, as well as presidential EOs, require Federal facilities to clean up environmental contamination at their facilities.

The following is taken from the U.S. Environmental Protection Agency website, Tribal Enterprises Topics, *Regulatory Requirements*.

EPA's criminal enforcement program uses stringent sanctions, including jail sentences, to promote deterrence and help ensure compliance in order to protect human health and the environment. Criminal enforcement is often used against the most serious environmental violations as well as those which involve egregious negligence or conduct involving intentional, willful, or knowing disregard of the law.

b. Using RCRA as a reference, discuss the Department's responsibilities associated with RCRA and the potential consequences of noncompliance with RCRA.

Federal Agency (e.g., DOE) Responsibilities

The following is taken from the HSS website, Environmental Policy, *RCRA*.

RCRA established a system for managing non-hazardous and hazardous solid wastes in an environmentally sound manner. Specifically, it provides for the management of hazardous wastes from the point of origin to the point of final disposal (i.e., "cradle to grave"). RCRA also promotes resource recovery and waste minimization.

Potential Consequences of Noncompliance

The following is taken from the U.S. Environmental Protection Agency RCRA Orientation Manual.

EPA (or an authorized state) has a broad range of enforcement options under RCRA, including the following:

- Administrative actions—an enforcement action taken by EPA or a state under its own authority.
- Civil judicial actions—a formal lawsuit, filed in court, against a person who has either failed to comply with a statutory or regulatory requirement or administrative order, or against a person who has contributed to a release of hazardous waste or hazardous constituents.
- Criminal actions—usually reserved for only the most serious violations; can result in the imposition of fines or imprisonment.

A decision to pursue one of these options is based on the nature and severity of the problem.

SAFETY MANAGEMENT

11. Personnel must demonstrate a familiarity level knowledge of the Department's philosophy and approach to implementing Integrated Safety Management (ISM).

a. Explain the objective of ISM.

The following is taken from DOE G 450.4-1C.

The objective of ISM is to integrate safety into management and work practices at all levels, addressing all types of work and all types of hazards to ensure safety for workers, the public, and the environment.

b. Describe how the seven guiding principles in the ISM policy are used to implement an integrated safety management philosophy.

The following is taken from DOE G 450.4-1C.

The ISM guiding principles describe the environment or context for work activities. Most ISM principles apply to each and every ISM function. Experience and research with safety cultures and high-reliability organizations over the past ten or more years have provided new insights and deeper understanding of the relevant guiding principles and associated attributes for attaining the desired work environment for effective safety management.

The following is taken from DOE P 450.4A.

The seven guiding principles of ISM (and a brief explanation of each) are as follows:

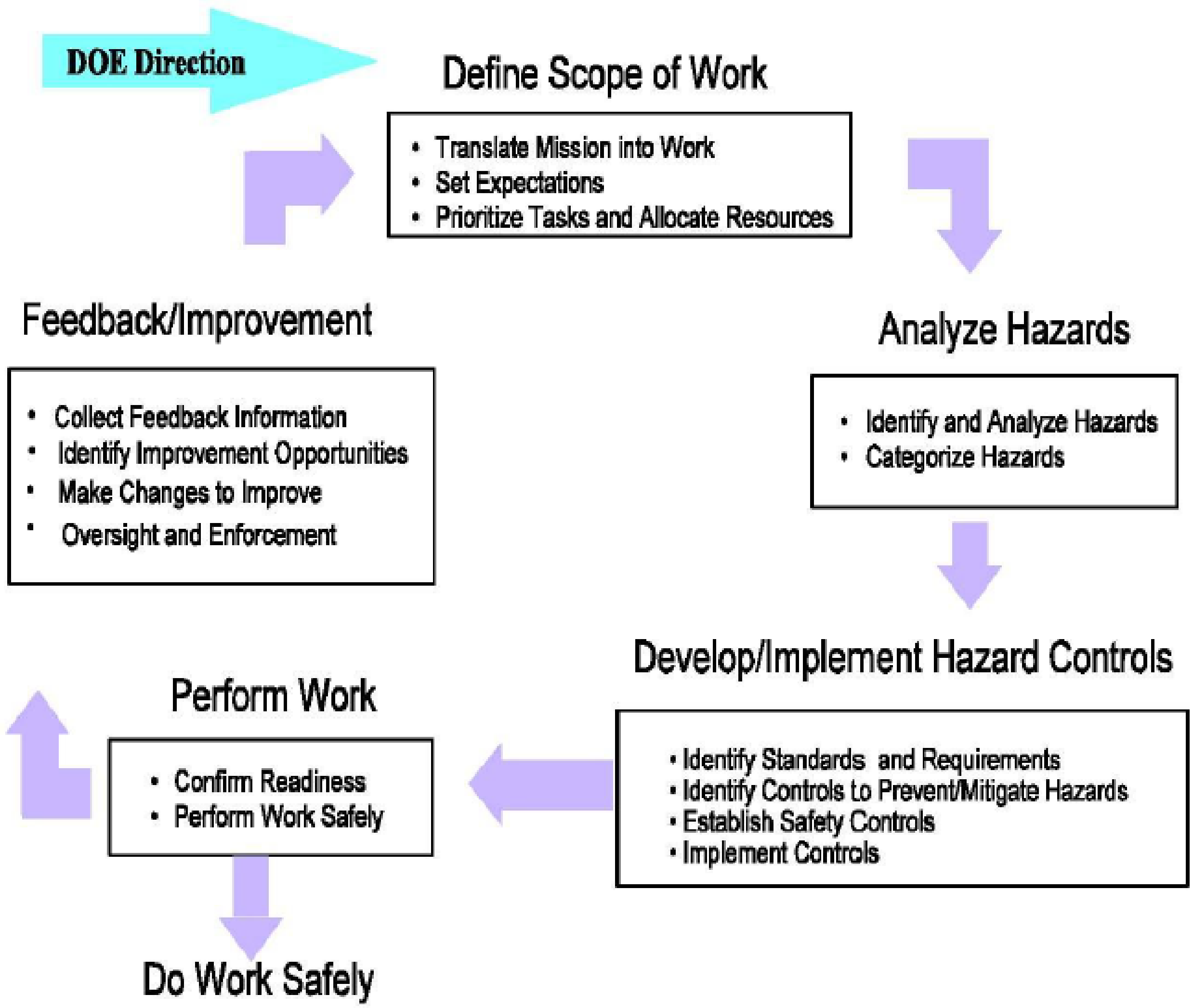
1. Line management responsibility for safety. Line management is directly responsible for the protection of the workers, the public, and the environment.
2. Clear roles and responsibilities. Clear and unambiguous lines of authority and responsibility for ensuring safety are established and maintained at all organizational levels within the Department and its contractors.
3. Competence commensurate with responsibilities. Personnel possess the experience, knowledge, skills, and abilities that are necessary to discharge their responsibilities.
4. Balanced priorities. Resources are effectively allocated to address safety, programmatic, and operational considerations. Protecting the workers, the public, and the environment is a priority whenever activities are planned and performed.
5. Identification of safety standards and requirements. Before work is performed, the associated hazards are evaluated and an agreed-upon set of safety standards and requirements is established which, if properly implemented, will provide adequate assurance that the workers, the public, and the environment are protected from adverse consequences.
6. Hazard controls tailored to work being performed. Administrative and engineering controls to prevent and mitigate hazards are tailored to the work being performed and associated hazards.
7. Operations authorization. The conditions and requirements to be satisfied for operations to be initiated and conducted are clearly established and agreed upon.

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

The following is taken from DOE G 450.4-1C.

The five core functions provide the necessary structure for any work activity that could potentially affect the public, workers, or the environment. The core functions are applied as a continuous cycle. These functions are identified and described below.

Figure 8 illustrates the conceptual relationship among the core safety functions. These functions are not independent, sequential functions but instead, a linked, interdependent collection of functions that often occur concurrently. The output of each function can affect the results of each of the other functions and, potentially, the whole system. Work planning processes, for example, affect multiple functions on an iterative basis before a plan is approved and work is performed.



Source: DOE G 450.4-1C

Figure 8. Relationship of the ISM core functions

Core Function 1, Define the Scope of Work

Missions are translated into work, expectations are set, tasks are identified and prioritized, and resources are allocated.

An ISM system (ISMS) should include a process to identify the activities necessary to accomplish the assigned mission and a process to develop these activities into discrete tasks. DOE uses strategic plans, goals, objectives, and mission statements to define the contractor's broad work assignments; the contractor in turn uses these assignments to prepare its work proposals.

Core Function 2, Analyze Hazards

Hazards associated with the work are identified, analyzed, and categorized.

Sites identify and categorize the hazards, then develop an understanding of the potential for each hazard to affect the health and safety of workers, the public, and the environment. The level of line management involvement in reviewing and approving hazard analyses should be commensurate with the complexity of the work and the hazards involved. Regulatory and contractual requirements applicable to the work and the complexity and hazards of the work dictate the methods used to identify and analyze hazards. These standards also establish the expectations for the contractor's conduct of hazard analyses, how hazard analysis is to be integrated into work processes, and how activity-specific hazard analyses are to be integrated with site-wide and facility hazard analyses.

Core Function 3, Develop and Implement Hazard Controls

Applicable safety standards and requirements are identified and agreed-upon, controls to prevent/mitigate hazards are identified, the safety envelope is established, and controls are implemented.

Hazard controls include engineered controls (e.g., buildings, enclosures, safety systems, controls, and instrumentation), administrative measures (limits, safety requirements embedded in procedures, warning signs, environmental monitoring, and associated training), and PPE (e.g., protective clothing, respirators). The established level of controls protects workers, the public, and the environment from all hazards associated with work activities. A strong linkage is needed between project, facility, and activity-level hazard analyses and the established controls as part of a defined ISM work planning process.

Core Function 4, Perform Work within Controls

Readiness is confirmed and work is performed safely.

There is a process to confirm adequate preparation and readiness to begin work prior to authorizing the performance of work at the facility, project, or activity level. The formality and rigor of the process and the extent of documentation and level of approval is based on the hazards and complexity of work. Agreed-upon safety control measures are a discernible part of the work plan and integrated into the work. Personnel are responsible and accountable for working in accordance with the controls. These controls are adequate to ensure safe work performance and to prevent accidents, uncontrolled releases, or unacceptable exposures to hazardous materials. Safety support functions and required interfaces (e.g., training, maintenance, radiological protection) are established and effectively maintained. There is a process to ensure that the safety envelope is continually maintained.

Core Function 5, Perform Feedback and Continuous Improvement

Feedback information on the adequacy of controls is gathered; opportunities for improving the definition and planning of work are identified and implemented.

The concept of continuous improvement implies that line management establishes formalized mechanisms and processes for identifying and capturing environment, safety, and health (ES&H)-related deficiencies, as well as for tracking the implementation and effectiveness of associated corrective actions. The process of ensuring that corrective actions are timely, complete, and effective is founded on a firm technical basis and clearly identified responsibility for timely implementation. To avoid recurrence of events having ES&H

implications, line management establishes a process for disseminating lessons learned to affected personnel, both internally and across the DOE complex.

d. Identify and discuss existing Department manuals, guides, standards and other documents and practices supporting implementation of ISM, including the following:

- **DOE M 450.4-1, *Integrated Safety Management System Manual***

  [Note: DOE M 450.4-1 was cancelled by DOE O 450.2, *Integrated Safety Management*]
- **DOE G 450.4-1B, *Integrated Safety Management System Guides***

  [Note: DOE G 450.4-1B was cancelled by DOE G 450.4-1C, *Integrated Safety Management System Guide*]
- **Standards/Requirements Identification Documents (S/RIDs) and Work Smart Standards**
- **Contract reform and performance-based contracting**

DOE O 450.2, Integrated Safety Management

The purpose of DOE O 450.2 is to ensure that DOE, including NNSA, systematically integrates safety into management and work practices at all levels, so that missions are accomplished efficiently while protecting the workers, the public, and the environment.

To help achieve this purpose, requirement 4.a. of DOE O 450.2 states that DOE line management organizations must document their approach for ensuring that both their DOE offices and their contractors establish ISMSs, including the implementing mechanisms, processes, and methods to be used in an ISMS description document. The ISMS description document must be consistent with the hazards and complexity of the facilities and work performed. Furthermore, this document must clearly describe how ISM guiding principles and core functions have been applied and how relevant safety goals and objectives are established, documented, and implemented.

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

DOE G 450.4-1C has two purposes:

1. To provide DOE line management with information that may be useful to them in effectively and efficiently implementing the provisions of DOE P 450.4A, *Integrated Safety Management Policy*, and the requirements and responsibilities of DOE O 450.2
2. To provide DOE contractor management with information that may be useful to them in effectively and efficiently implementing the ISM contract requirements specified by the Department of Energy Acquisition Regulation (DEAR) clause at 48 CFR 970.5223-1, *Integration of Environment, Safety, and Health into Work Planning and Execution*

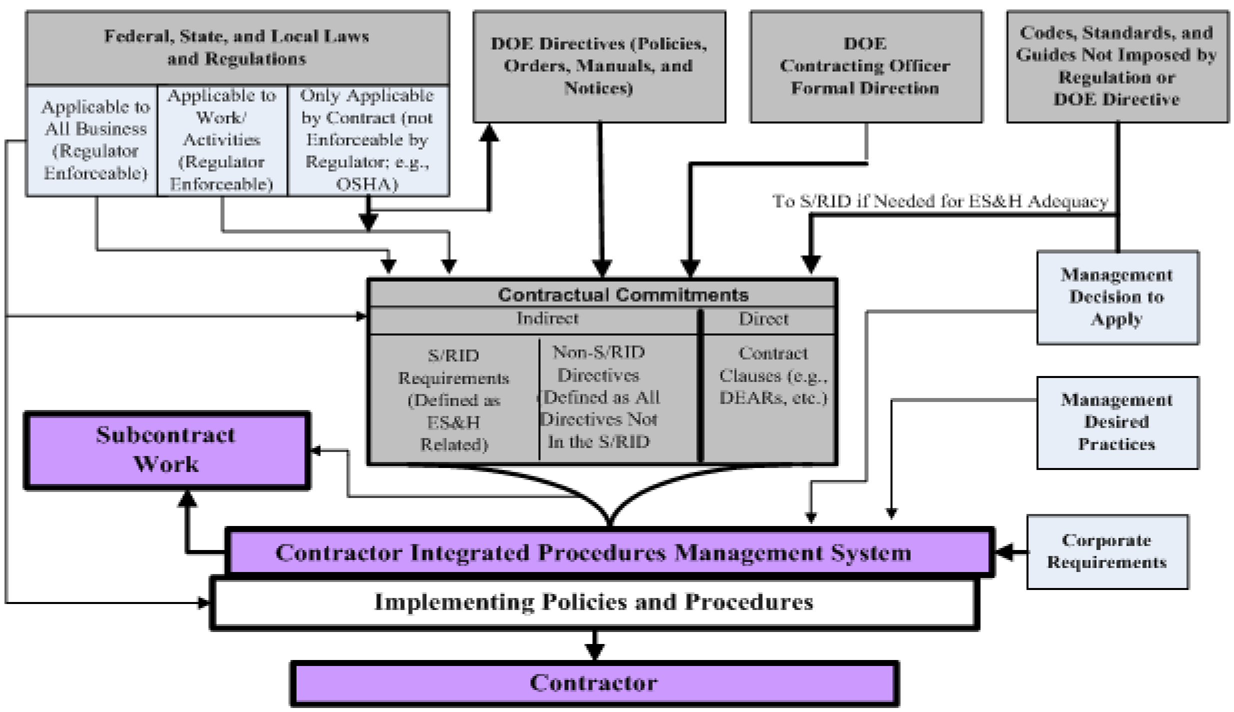
The guidance provided by DOE G 450.4-1C focuses on information related to development, implementation, approval, monitoring, evaluation, and improvement of ISMS; and is organized around the key topic areas identified in DOE O 450.2 and/or the DEAR ISM clause. These include: general ISM information (including discussion of the guiding principles and core functions of ISM); developing ISMS descriptions; monitoring, evaluating, and improving ISM implementation; safety culture; safety goals, objectives, and measures; safety management functions, responsibilities, and authorities; and the ISM champions council.

Standards/Requirements Identification Documents and Work Smart Standards (WSS)

S/RIDs

The following is taken from DOE G 440.1-8 (archived).

Environment, safety and health requirements in the form of laws, regulations, DOE directives, consensus standards, and others flow down from their source into the contractor's S/RID listing requirements that DOE agrees are applicable to the work and conditions at the site. The S/RID defines the applicability of requirements on a facility basis according to the work and hazards conducted at each facility. The contract directs that all work be conducted according to the applicable requirements in the S/RID. From the S/RID, the applicable requirements flow down to policies and procedures established and maintained by the integrated procedures management system. These policies and procedures include controls tailored to the work/activity and the type and level of hazards present. An example of the site flow down process is shown in figure 9.



Source: DOE G 440.1-8

Figure 9. Site system for flowing down ES&H and other requirements to the work

Work Smart Standards

The following is taken from the Oak Ridge National Laboratory Frequently Asked Questions website.

Work smart standards are sets of ES&H laws, regulations, and other standards that have been specifically chosen for applicability and appropriateness for a particular scope of work. They are selected to provide adequate protection (when properly implemented) against the hazards associated with that work. Work smart standard sets were previously known as necessary and sufficient sets of standards prior to the name change directed by the Secretary of Energy in April 1996.

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 represent maturating ideas and increased experience in standards management.

Contract Reform and Performance-Based Contracting

The following is taken from the U.S. DOE Acquisition Guide, chapter 70.8.

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.

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

[Note: DOE P 450.4 was cancelled by DOE P 450.4A.]

The purpose of DOE P 450.4A is to establish the DOE's expectation for safety, including ISM that will enable the Department's mission goals to be accomplished efficiently while ensuring safe operations at all departmental facilities and activities.

The Department will implement ISMSs to systematically integrate safety into management and work practices at all levels in the planning and execution of work. All organizations will develop, maintain, and implement ISMSs for their operations and work practices, based upon the ISM guiding principles and core functions. **[Note: The ISM guiding principles and core functions are discussed in CS-11b and 11c respectively.]** To improve effectiveness and efficiency, organizations are expected to tailor their safety management system (SMS) to the hazards and risks associated with the work activities supporting the mission; including using established mechanisms to tailor requirements. Further, decisions impacting safety are made by technically qualified managers with knowledge of the operations and after consideration of hazards, risks, and performance history. To complement these systems and mechanisms, the Department expects all organizations to embrace a strong safety culture where safe performance of work and involvement of workers in all aspects of work performance are core values that are deeply, strongly, and consistently held by managers and workers. The Department encourages a questioning attitude by all employees and a work environment that fosters such an attitude.

The ultimate responsibility and accountability for ensuring adequate protection of the workers, the public, and the environment from the operation of DOE facilities rests with DOE line management. The Department will meet this responsibility by

- establishing functions and clear lines of responsibilities, authorities, and appropriate accountabilities;
- measuring safety management performance, with special emphasis on work related to high consequence activities by evaluating incident reports; using ES&H performance measures; and assessing performance; and
- holding itself and its contractors accountable at all organizational levels for safety performance through codified safety regulations, contract clauses, DOE directives, and the use of contractual and regulatory enforcement tools.

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.

The following is taken from the DOE Action Plan, *Lessons Learned from the Columbia Space Shuttle Accident and Davis-Besse Reactor Pressure-Vessel Head Corrosion Event*.

The language in the contract clause, 48 CFR 970.5223-1, establishes the contractual requirement for ISM and the governing requirements for contractor programs. In addition, the DEAR clause, 48 CFR 970.5215-3, provides DOE contracting officers with a tool to avoid complacency. The clause requires the DOE contracting officer to reduce a contractor's fee payment should the contractor not meet their agreed-upon annual ES&H program requirements, established as a result of the annual update process of 48 CFR 970.5223-1 (e), or if the contractor experiences significant adverse events.

g. Describe the requirements in 10 CFR 830 Subpart A and DOE O 414.1C to integrate the ISM system description with the quality assurance program.

[Note: DOE O 414.1C, *Quality Assurance*, was cancelled by DOE O 414.1D, Quality Assurance.]

The following is taken from 10 CFR 830, subpart A.

10 CFR 830, "Nuclear Safety Management," defines an SMS as an ISMS, and requires contractors to integrate the QA criteria with the SMS, or describe how the QA criteria apply to the SMS.

Because DOE O 414.1D does not directly address ISMSs, the following is taken from DOE G 414.1-2B, *Quality Assurance Program Guide*.

The quality assurance program (QAP) should be integrated with the ISMS, as described in DOE P 450.4A and DEAR 48 CFR 970.5204-2, "Laws, Regulations, and DOE Directives." The QAP provides processes and tools for ensuring that ISMS objectives are achieved. DOE P 450.4A expresses a fundamental expectation that work will be performed safely.

The ten criteria of DOE O 414.1D and 10 CFR 830, appendix A, define the generic elements of a management system applicable to DOE work. They are implemented using a graded approach based on an evaluation of the risks associated with the work to be performed. The

SMS defined in DOE O 450.2 selectively applies and amplifies the generic management system requirements defined by the ten criteria to ensure that DOE work is performed safely.

12. Personnel must demonstrate a familiarity level knowledge of 10 CFR 851, "Worker Safety and Health Program," and DOE O 440.1B, *Worker Protection Program for DOE (including National Nuclear Security Administration) Federal Employees*.

[Note: 10 CFR 851 establishes a worker safety and health program (WSHP) for DOE contractors; while DOE O 440.1B provides this function for DOE Federal employees. Both programs are addressed by DOE G 440.1-1B, *Worker Safety and Health Program for DOE (Including the National Nuclear Security Administration) Federal and Contractor Employees*. For this reason, DOE G 440.1-1B is the source of information for KSAs a through e.]

a. Discuss the requirements for development and approval of worker safety and health programs.

Program Development

It is the Department's policy to provide a safe and healthful workplace for its Federal and contractor employees. This provision closely parallels the Occupational Safety and Health Administration's (OSHA's) general duty clause established in section 5(a)(1) of the Occupational Safety and Health Act (OSH Act). Accordingly, in implementing this provision, DOE and its contractors should consider criteria similar to those established by OSHA for the implementation of the general duty clause.

Fundamental elements of the WSHP include the following:

- Establishing a written program with policy, goals, objectives, and performance measures
- Using qualified staff
- Assigning responsibility and holding personnel accountable
- Encouraging involvement of workers
- Ensuring workers' rights and informing workers of their rights and responsibilities
- Identifying workplace hazards and evaluating risk of injury and illness
- Preventing or abating workplace hazards
- Providing worker protection training
- Complying with DOE-prescribed worker protection standards

The Department recognizes that the requirements contained in DOE Orders and rules provide the basic foundation for a WSHP and some managers may need or decide to go beyond the minimum requirements in establishing programs to protect workers from hazards associated with their activities. Decisions concerning implementation of worker protection measures should be based on the use of a graded approach to ensure that available resources are used most efficiently. The Department also recognizes that the WSHPs will be integrated into other related site-specific worker protection activities and with the ISMS. The graded approach, or tailoring, refers to developing safety controls fitted to the hazards and the work.

The written program provides the methods for implementing the requirements. The program should describe an integrated management organization and support systems that fully satisfy DOE worker protection requirements of all technical disciplines. It should clearly convey the framework for the program and describe how the program works. All elements of the safety and health program should be included in, or explicitly referenced by, the written program. This description should be a high level description of the program that gives the overall structure of the program and identifies the lower tiered and complementary policies, programs, and procedures that, combined with the high level description, constitute the full program.

All contractors and subcontractors at any tier must be included in some fashion in an approved written WSHP. The components of the written program addressing subcontractors and small DOE contractors may be tailored to the hazards and complexity of the work and the capabilities of the subcontractor or small DOE contractor.

DOE G 440.1-1B, section 8 provides additional guidance on the integration of functional area requirements into the written program. The contractor should explain the relationship of other documentation that is not directly part of its WSHP but is relevant for integration of the program, and interfaces with other functions.

Program Review and Approval

The heads of DOE field elements should review and approve contractors' WSHPs. A standard review plan developed by a cognizant secretarial officer (CSO) for field office use in reviewing contractor submitted WSHPs may be used by other DOE elements as a model to develop their own review plans.

Intuitively, the contractors should apply the review standard when preparing and evaluating their program. Equally important is the need for a coordinated review and approval required by 10 CFR 851.11(a)(2)(ii) for contractors. The approval document should include all associated heads of field elements. Federal worker protection programs should use this or a similar approach for developing its programs and coordinating Federal worker safety programs.

b. Describe management responsibilities and worker rights and responsibilities.

Management Responsibilities

Management responsibilities include the following:

- Establishing a written worker protection policy that includes specific goals and objectives
- Requesting the necessary funding for operation of the facility and properly planning for effective use of the personnel, material, and resources to support the worker protection program
- Hiring and retaining qualified worker safety and health professionals needed for the hazards at the site
- Clearly communicating roles, responsibilities, and authorities and insisting on accountability of workers at all levels
- Assigning and communicating worker protection responsibilities to workers, providing adequate authority and resources to permit them to meet these responsibilities, and holding them accountable for proper performance
- Promptly responding to reports depending on the impact of the meaning

- Establishing a system for communicating with employees about matters relating to worker protection, including provisions designed to encourage employees to inform the employer of hazards at the worksite without reprisal
- Informing workers of their rights and responsibilities

Worker Rights and Responsibilities

Workers should actively take advantage of their rights in a responsible manner and should be free of any form of job discrimination as a result of exercising these rights. These rights include the following:

- Notification when monitoring results indicate the worker was overexposed to hazardous materials
- Allowing an affected worker or authorized representative of workers to observe the actual monitoring
- The opportunity to participate in briefings and in the walk-around phase of DOE conducted enforcement inspections
- Notification of the results of inspections and investigations
- Expressing concerns if they believe they are being denied their rights or are being subjected to reprisals for attempting to exercise those rights
- Exercising a stop work authority in a justifiable and responsible manner

Along with their rights, workers also have several responsibilities (e.g., complying with safety and health rules and directives). In addition, they should

- read the worker protection poster;
- wear or use prescribed protective clothing and equipment while working;
- report hazardous conditions to the supervisor;
- report any job-related injury or illness to the employer, and seek treatment promptly;
- cooperate with worker protection professionals conducting inspections; and
- exercise their rights in a responsible manner.

For Federal employees additional details about requirements for informing workers through training are contained in DOE O 360.1C, *Federal Employee Training*.

c. Describe hazard identification, assessment, prevention, and abatement.

Hazard Identification and Assessment

- Identify and assess risks.
  - Assess worker exposures.
  - Document hazard assessment.
  - Record results—observations, testing and monitoring results must be recorded.
  - Analyze designs for potential hazards—incorporating worker protection features and requirements in the design and construction of facilities and equipment is the most cost-effective way to control hazards.
  - Evaluate operations, procedures, and facilities—ongoing hazard identification is accomplished most effectively by workers and their supervisors during the course of daily activities, with technical assistance from worker protection professionals and functional area technical experts, as necessary.
  - Job activity-level hazard analysis—routine job activity-level hazard analyses must be performed.

- Review safety and health experience—reporting and investigating accidents, injuries, and illnesses and analysis of related data for trends and lessons learned are key components of this review.
- Workplace hazards and radiological hazards—interaction between workplace hazards (e.g., chemical, physical, biological, or safety hazards) and other hazards such as radiological hazards must be considered.

- Closure facilities hazard identification—closure facility hazards should be submitted when the hazards discovered are beyond the range of hazards for which controls have previously been identified and utilized with success.
- Hazard identification baseline and schedule—hazard identification tasks must be performed initially to obtain a baseline and then as often as necessary to ensure compliance.

Hazard Prevention and Abatement

An effective hazard abatement program is essential to ensure that workers are protected from exposure to current and future workplace hazards. The focus of this program must be the control of identified workplace hazards. Where immediate control is not possible, the program must ensure the protection of workers while awaiting final abatement of the hazard. For significant hazards, this should include interim compensatory measures (e.g., limiting activities in the area, installing barriers and signs, providing hazard-specific training, and use of fire watches). It must provide an efficient mechanism to ensure that all identified hazards are abated in a timely manner.

Hazard Prevention and Abatement Process

- During design or procedure development—for hazards identified either in the facility design or during the development of procedures, controls must be incorporated in the appropriate facility design or procedure.
- Existing hazards—for existing hazards identified in the workplace, abatement actions, which are prioritized according to risk to the worker, should be promptly implemented and interim protective measures must be implemented pending final abatement of the hazards.

Hierarchy of Controls

- Elimination or substitution—elimination or substitution of hazards must be the first choice for controlling hazards.
- Engineering controls—engineering controls must be the second choice for controlling hazards after elimination or substitution of the hazard has been implemented to the extent feasible and appropriate.
- Work practices and ACs—work practices and ACs must be the third choice for controlling hazards after elimination or substitution of the hazard and engineering controls have been implemented to the extent feasible and appropriate.
- Personal protective equipment—when elimination or substitution, engineering, and work practices and ACs have been considered and implemented and are not sufficient to fully protect the worker from a recognized hazard, PPE must be used to supplement these other controls as appropriate.
- Purchasing equipment, products, and services—hazards must be addressed when selecting or purchasing equipment, products, and services. Provisions should be made

for worker protection professional and employee evaluation of pre-engineered or "off-the-shelf" equipment prior to selection and purchase.

d. Discuss applicable safety and health standards.

DOE managers should determine which standards are applicable to the site hazards and whether additional standards are needed for their workplaces and activities to control recognized hazards. If necessary to protect the safety and health of workers, managers must include such additional standards in their written WSHP.

Some of the standards reference additional (i.e., secondary) standards. Contractors are required to comply with secondary standards that are applicable to identified hazards. The primary standards that reference secondary standards usually state how these secondary standards are to be used. Similarly, mandatory provisions of secondary standards are incorporated by reference in the WSHP and have the same force and effect as primary cited standards.

Equivalencies that were granted prior to the promulgation of 10 CFR 851, and in accordance with an authority having jurisdiction (AHJ) and equivalency provisions of a code or standard that is included in a DOE-approved WSHP should continue to be acceptable to DOE and not require a variance. Those equivalencies should be identified in the DOE-approved WSHP. The equivalency process is separate from the variance process.

Consult 10 CFR 851 and DOE O 440.1B for lists of safety and health standards that may be applicable.

e. Discuss the process for obtaining a variance from a safety and health standard.

Consideration of Variance

Contractors should discuss the possibility of filing a variance application with representatives of the head of the DOE field element and the CSO prior to filing the request in order to gain a preliminary view of the sufficiency of the supporting material and likelihood of the request being granted. The head of the DOE field element also should provide the CSO with its recommendation for the approval and terms and conditions of variance applications that it supports.

Relief from technical compliance with certain codes and standards may be available within the code or standard in which case a variance may not be needed. Certain codes and standards provide implementation flexibility in the form of

- an AHJ that can permit the use of alternate methods where such methods provide equivalent protection (referred to as equivalencies). The AHJ is authorized to approve equivalencies; and
- acceptability of the code that was in effect at the time a facility or item of equipment was designed and constructed (referred to as the code of record) rather than the current code.

Equivalencies approved by the AHJ and code of record accepted for facilities should be documented and retrievable for as long as the documents are in effect.

Approval Criteria

Circumstances that could warrant granting of a variance include the following:

- Application of the requirement in the particular circumstances conflicts with other requirements.
- Application of the requirement in the particular circumstances would not serve, or is not necessary to achieve, its underlying purpose; or would result in resource impacts which are not justified by the safety improvements.
- Application of the requirement would result in a situation significantly different than that contemplated when the requirement was adopted, or that is significantly different from that encountered by others similarly situated.
- The variance would result in benefit to human health and safety that compensates for any detriment that may result from the granting of the variance.
- Circumstances exist which would justify temporary relief from application of the requirement while taking good faith action to achieve compliance.
- There is present any other material circumstance not considered when the requirement was adopted for which it would be in the public interest to grant a variance.
- A schedule is established for full or partial compliance with the standard.

f. Discuss the 10 CFR 851 enforcement process.

The following is taken from 10 CFR 851, subpart E.

Investigations and Inspections

- The director may initiate and conduct investigations and inspections relating to the scope, nature, and extent of compliance by a contractor with the requirements of this part and take such action as the director deems necessary and appropriate to the conduct of the investigation or inspection. DOE enforcement officers have the right to enter work areas without delay to the extent practicable, to conduct inspections.
- Contractors must fully cooperate with the director during all phases of the enforcement process and provide complete and accurate records and documentation as requested by the director during investigation or inspection activities.
- Any worker or worker representative may request that the director initiate an investigation or inspection.
- The director must inform any contractor that is the subject of an investigation or inspection in writing at the initiation of the investigation or inspection and must inform the contractor of the general purpose of the investigation or inspection.
- The director may issue enforcement letters that communicate DOE’s expectations with respect to any aspect of the requirements of this part, and may also sign, issue, and serve subpoenas.

Settlement

- DOE encourages settlement of a proceeding under this subpart at any time if the settlement is consistent with this part. The director and a contractor may confer at any time concerning settlement. The director may resolve any issues in an outstanding proceeding with a consent order. A consent order must set forth the relevant facts that form the basis for the order and what remedy, if any, is imposed.

- Notwithstanding any other provision of this part, the director may resolve any issues in an outstanding proceeding under this subpart with a consent order.

Preliminary Notice of Violation (PNOV)

- Based on a determination by the director that there is a reasonable basis to believe a contractor has violated or is continuing to violate a requirement of this part, the director may issue a PNOV to the contractor.
- A reply to a PNOV must contain a statement of all relevant facts pertaining to an alleged violation.
- If a contractor fails to submit a written reply within 30 calendar days of receipt of a PNOV
    - the contractor relinquishes any right to appeal any matter in the preliminary notice; and
    - the preliminary notice, including any proposed remedies therein, constitutes a final order.

Final Notice of Violation

- If a contractor submits a written reply within 30 calendar days of receipt of a PNOV, that presents a disagreement with any aspect of the PNOV and civil penalty, the director must review the submitted reply and make a final determination whether the contractor violated or is continuing to violate a requirement.
- Based on a determination by the director that a contractor has violated or is continuing to violate a requirement, the director may issue to the contractor a final notice of violation that states concisely the determined violation and any remedy, including the amount of any civil penalty imposed on the contractor.
- If a contractor fails to submit a petition for review to the Office of Hearings and Appeals within 30 calendar days of receipt of a final notice of violation
    - the contractor relinquishes any right to appeal any matter in the final notice; and
    - the final notice, including any remedies therein, constitutes a final order.

13. Personnel must demonstrate a familiarity level knowledge of the Occupational Safety and Health Act.

a. Using the following documents as references, discuss the purpose of 29 CFR 1910, "Occupational Safety and Health Standards"; 29 CFR 1926, "Safety and Health Regulations for Construction Industry"; 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

The purpose of 29 CFR 1910 is to establish, as rapidly as possible, standards with which industries are generally familiar, and on whose adoption interested and affected persons have already had an opportunity to express their views. Such standards are either national consensus standards on whose adoption affected persons have reached substantial agreement, or Federal standards already established by Federal statutes or regulations.

29 CFR 1926, Safety and Health Requirements for Construction

The purpose of 29 CFR 1926 is to set forth the safety and health standards promulgated by the Secretary of Labor under section 107 of the Contract Work Hours and Safety Standards Act. These standards are published in subpart C of this regulation.

Subpart B of regulation contains statements of general policy and interpretations of section 107 of the Contract Work Hours and Safety Standards Act having general applicability.

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

29 CFR 1960 contains special provisions to ensure 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 OSH Act. The Secretary of Labor, under section 19 of the OSH Act, is to report to the President certain evaluations and recommendations with respect to the programs of the various agencies.

b. Discuss the regulatory interfaces between the Occupational Safety and Health Administration (OSHA) and other regulatory agencies.

The following is taken from a memorandum of understanding between the U.S. Department of Labor, Occupational Safety and Health Administration and the U.S. Environmental Protection Agency, Office of Enforcement.

The purpose of this interagency memorandum of understanding (MOU) is to establish and improve the working relationship between the Office of Enforcement of the EPA and the OSHA of the Department of Labor. The goals of the agencies are to improve the combined efforts of the agencies to achieve protection of workers, the public, and the environment at facilities subject to EPA and OSHA jurisdiction; to delineate the general areas of responsibility of each agency; to provide guidelines for coordination of interface activities between the two agencies with the overall goal of identifying and minimizing environmental or workplace hazards.

This MOU establishes a process and framework for notification, consultation, and coordination between EPA and OSHA to aid both agencies in identifying environmental and workplace health and safety problems and to more effectively implement enforcement of our national workplace and environmental statutes.

This MOU is intended to improve the information exchange relating to job-site safety and health, and protection of the public health and environment thereby reducing the potential for workplace related injury, death, and environmental contamination. This MOU implements OSHA's authority under the OSH Act and EPA's general and statute-specific authorities to enter into agreements with other Federal agencies to further the legislative objectives of Congress and the President.

c. Describe DOE's responsibilities with respect to the Occupational Safety and Health Act.

The following is taken from U.S. Department of Labor, OSHA, DOE Transition, *Background*.

In 1993, Secretary of Energy Hazel O'Leary announced that DOE would seek external regulation of its government-owned, contractor-operated (GOCO) sites for occupational safety and health, replacing the current system of self-regulation. A DOE advisory committee subsequently recommended that OSHA assume jurisdiction for all worker safety and health enforcement issues at DOE sites. A report prepared by the National Academy of Public Administration reiterated and expanded on these issues [section 4(b)(1) of the OSH Act currently preempts OSHA enforcement at DOE GOCO sites]. Since Secretary O'Leary's initial announcement OSHA has continued to work with DOE to prepare for an orderly transition to OSHA external regulation of worker safety and health at GOCO sites.

OSHA and DOE have developed a mutually acceptable policy to transfer occupational safety and health enforcement responsibility at privatized facilities and operations located on DOE sites. Privatized facilities and operations are located on DOE sites, but they are leased to private sector enterprises that are not conducting activities for or on behalf of DOE. In July 2000, the agencies entered into an MOU on this subject.

In addition, OSHA and DOE also reached final agreement on a list of non-AEA sites, such as fossil fuel and power administration sites. OSHA acknowledges DOE's opinion that DOE does not have AEA enforcement authority at these sites and OSHA, therefore, has safety and health enforcement jurisdiction. In July 2000, OSHA published a Federal Register notice on this subject.

d. Discuss workplace inspection techniques.

The following is taken from HSS criteria review and approach document (CRAD) 64-10, rev 2.

Within the DOE Office of Independent Oversight, the Office of ES&H Evaluations' mission is to assess the performance of ES&H systems (ISM); programs (WSHPs); and practices in protecting our workers, the public, and the environment from the hazards associated with DOE activities and sites.

The focus of this CRAD is on observing work activities to determine if implementation of systems, programs, and practices result in application of adequate controls to protect against the associated hazards. Where deficiencies are identified, systems, programs, and practices are reviewed to identify if systemic weaknesses are present.

This CRAD also includes engagement of workers and their site union representatives with regard to involvement in work planning and safety rights. A key to success is the rigor and comprehensiveness of our process; and, as with any process, we continually strive to improve and provide additional value and insight to field operations. Integral to this is our commitment to enhance our program. Therefore, we have revised our inspection criteria, approach, and lines of inquiry for internal use to include additional focus on 10 CFR 851 requirements.

e. Discuss the major components of the OSHA hazard communication protocol.

The following is taken from the U.S. Department of Labor, Occupational Safety and Health Administration, Draft Model Training Program for Hazard Communication.

The Five Main Sections of the Hazard Communication Standard (HCS)

1. Identification of Hazardous Chemicals
   - Manufacturers/importers evaluate their products.
   - If hazardous, a material safety data sheet (MSDS) is prepared and sent to customers/purchasers.
   - If nonhazardous, chemicals are not covered by the HCS.
   - Hazardous chemicals can be found as
     - liquids in containers
     - substances in pipes
     - chemicals generated in work operations
     - solids, gases, vapors
   - Where employees are potentially exposed.

2. Elements of the Written Program

A “blueprint” for compliance, the written program contains descriptions of
   - staff responsibilities
   - labeling procedures
   - MSDS procedures (obtaining/maintenance)
   - information and training program
   - location/accessibility of all HCS elements

3. Labels and Other Forms of Warning
   - Manufacturer must send labels with
     - identity of chemical
     - appropriate hazard warning
     - name/address of manufacturer
   - Identity of the chemical on the in-plant label must be linked to the name on the MSDS and the inventory list of chemicals.
   - Labels, tags, placards, process sheets, and markings on workplace containers must show
     - identity of chemical
     - appropriate hazard warning

4. Material Safety Data Sheets
   - A detailed document sent by the manufacturer/importer. Designed to communicate hazard information to
     - employers
     - employees
     - health professionals

    - emergency personnel
  - Always available/accessible to employees.

5. Information and Training
   - Employees must be informed of
     - requirements of the HCS
     - operations in work area where there are hazardous chemicals
     - location/availability of written program
   - Employees must be trained in
     - methods/observations to detect presence/release of hazardous chemicals
     - physical and health hazards of chemicals in the work area
     - how to protect themselves
     - details of the hazard communication program

f. Discuss how the OSHA Rule is invoked on DOE Federal and contractor staff by 10 CFR 851 and DOE Order 440.1, respectively.

[Note: DOE O 440.1 was cancelled by DOE O 440.1B.]

10 CFR 851

The following is taken the Federal Register, 10 CFR 850 and 851, "Chronic Beryllium Disease Prevention Program; Worker Safety and Health Program"; Final Rule.

10 CFR 851.10(a)(1) provides that, with respect to a covered workplace for which a contractor is responsible, the contractor must provide a place of employment that is free from recognized hazards that are causing or have the potential to cause death or serious physical harm to workers. A similar provision established in section 5(a)(1) of the OSH Act is commonly referred to as the general duty clause and states that each employer shall furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees. DOE believes that the language used in final rule section 851.10(a)(1) for the general duty clause is consistent with the language established in the OSH Act.

DOE O 440.1B

The following is taken from U.S. DOE HSS, Federal employee occupational safety and health program overview.

Congress established the OSH Act "to ensure so far as possible every working man and woman in the nation safe and healthful working conditions and to preserve our human resources." Section 19 of the OSH Act contains broad responsibilities and requirements for Federal agency safety and health programs to ensure safe and healthful working conditions for Federal employees.

EO 12196, "Occupational Safety and Health Programs for Federal Employees," contains, among other items, additional responsibilities for the heads of Federal agencies and a requirement for the Secretary of Labor to issue basic program elements for Federal agency safety and health programs in conformance with the OSH Act.

The basic program elements in EO 12196 are issued in the Department of Labor's implementing regulations in 29 CFR 1960. This OSHA standard establishes and communicates the requirements under which Federal agencies, including the DOE, must develop and implement their Federal employee occupational safety and health program.

DOE O 440.1B requires that DOE elements implement a written worker protection program that provides a place of employment free from recognized hazards which are causing or likely to cause death or serious physical harm to their employees and integrates all DOE Orders and 29 CFR 1960 requirements.

14. Personnel must demonstrate a familiarity level knowledge of fire safety for Department facilities necessary to identify safe and unsafe work practices.

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

Fire Prevention

The following is taken from 29 CFR 1910, appendix to subpart E.

Important considerations of fire prevention include the following:

- Training—the employees selected or who volunteer to serve as wardens should be trained in the complete workplace layout and the various alternative escape routes from the workplace.
- Fire prevention housekeeping—employers and employees must ensure that hazardous accumulations of combustible waste materials are controlled so that a fast developing fire, rapid spread of toxic smoke, or an explosion will not occur.
- Maintenance of equipment under the fire prevention plan—employees and supervisors should be aware of the specific type of control devices on equipment involved with combustible materials in the workplace and should make sure, through periodic inspection or testing, that these controls are operable.

Fire Prevention Plan

The following is taken from 29 CFR 1910.39.

An employer must have a fire prevention plan when an OSHA standard in this part requires one. The requirements in this section apply to each such fire prevention plan.

A fire prevention plan must be in writing, be kept in the workplace, and be made available to employees for review. However, an employer with ten or fewer employees may communicate the plan orally to employees.

The minimum elements of a fire prevention plan must include the following:

- A list of all major fire hazards, proper handling and storage procedures for hazardous materials, potential ignition sources and their control, and the type of fire protection equipment necessary to control each major hazard
- Procedures to control accumulations of flammable and combustible waste materials
- Procedures for regular maintenance of safeguards installed on heat-producing equipment to prevent the accidental ignition of combustible materials

- The name or job title of employees responsible for maintaining equipment to prevent or control sources of ignition or fires
- The name or job title of employees responsible for the control of fuel source hazards

An employer must inform employees upon initial assignment to a job of the fire hazards to which they are exposed. An employer must also review with each employee those parts of the fire prevention plan necessary for self-protection.

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

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

The following is taken from the Federal Emergency Management Agency (FEMA), *Introduction to Fire Inspection Principles and Practices.*

Fire hazards are any actions, materials, or conditions that might increase the size or severity of a fire or that might cause a fire to start. Common fire hazards are found in most occupancies and are not associated with any special occupancy. Smoking, trash, electrical appliances, storage, and heating are common to most occupancy types. Special fire hazards are linked to some specific process or activity in particular occupancies. Chemicals, spray painting, welding, combustible dusts, and flammable liquids are examples of special fire hazards.

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

The following is taken from National Fire Protection Association, *Life Safety Code,* NFPA 101.

Fundamental Requirements

- Multiple Safeguards. The design of every building or structure intended for human occupancy shall be such that reliance for safety to life does not depend solely on any single safeguard. An additional safeguard(s) shall be provided for life safety in case any single safeguard is ineffective due to inappropriate human actions or system failure.
- Appropriateness of Safeguards. Every building or structure shall be provided with means of egress and other fire and life safety safeguards of kinds, numbers, locations, and capacities appropriate to the individual building or structure, with due regard to the following:
    - Character of the occupancy, including fire load
    - Capabilities of the occupants
    - Number of persons exposed

    - Fire protection available
    - Capabilities of response personnel
    - Height and construction type of the building or structure
    - Other factors necessary to provide occupants with a reasonable degree of safety.

- Means of Egress
    - Number and Means of Egress. 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.
    - Unobstructed Egress. In every occupied building or structure, means of egress from all parts of the building shall be maintained free and unobstructed. Means of egress shall be accessible to the extent necessary to ensure reasonable safety for occupants having impaired mobility.
    - Awareness of Egress System. Every exit shall be clearly visible, or the route to reach every exit shall be conspicuously indicated. 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.
    - Lighting. Where artificial illumination is needed in a building or structure, egress facilities shall be included in the lighting design.

- Occupant Notification. 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.
- Situation Awareness. Systems used to achieve the goals of section 4.1 of NFPA 101 shall be effective in facilitating and enhancing situation awareness, as appropriate, by building management, other occupants, and emergency responders of the functionality or state of critical building systems, the conditions that might warrant emergency response, and the appropriate nature and timing of such responses.
- Vertical Openings. Every vertical opening between floors of a building shall be suitably enclosed or protected, as necessary, to afford reasonable safety to occupants while using the means of egress and to prevent spread of fire, smoke, or fumes through vertical openings from floor to floor before occupants have entered exits.
- Compliance with NFPA 101 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 NFPA 101 shall be construed as requiring or permitting any condition that may be hazardous under normal occupancy conditions.
- System Design/Installation. Any fire protection system, building service equipment, feature of protection, or safeguard provided to achieve the goals of NFPA 101 shall be designed, installed, and approved in accordance with applicable NFPA standards.
- Maintenance. Whenever or wherever any device, equipment, system, condition, arrangement, level of protection, or any other feature is required for compliance with provisions of NFPA 101, such device, equipment, system, condition, arrangement, level of protection, or other feature shall thereafter be maintained, unless NFPA 101 exempts such maintenance.

d. Discuss the purpose of fire hazard analysis.

The following is taken from DOE G 420.1-3.

The purpose of a fire hazards analysis (FHA) is to conduct a comprehensive, qualitative assessment of the risk from fire within individual fire areas in a DOE facility to ascertain whether the DOE fire safety objectives of DOE O 420.1B are met. This should include an assessment of the risk from fire and related hazards (wildland fire exposure, direct flame impingement, hot gases, smoke migration, fire-fighting water damage, etc.) in relation to existing or proposed fire safety features to ensure that the facility can be safely controlled and stabilized during and after a fire. In accordance with the "graded approach" concept, the level of detail necessary for an acceptable FHA is directly related to the complexity of the facility and the potential risk to the public and facility operators. The scope and content of an FHA should be limited to only those issues that are significant and relevant to the facility.

e. Describe the characteristics of, and methods/agents used to extinguish, the following classes of fires:
- **Class A**
- **Class B**
- **Class C**
- **Class D**

The following is taken from Federal Emergency Management Agency, The Life Safety Group.

Class A fires are fires in ordinary combustibles such as wood, paper, cloth, trash, and plastics. Today's most widely used type of fire extinguisher is the multipurpose dry chemical that is effective on class A, B and C fires. Water extinguishers are for class A fires only. Halocarbon and halon 1211 extinguishers are effective on class A, B, and C type fires. Halocarbon agents replaced halon 1211 within the last eight years and are much more environmentally acceptable. Water mist extinguishers are primarily for class A fires, although they are safe for use on class C fires as well. Although wet chemical or class K extinguishers were developed for modern, high efficiency deep-fat fryers in commercial cooking operations, some may also be used on class A fires in commercial kitchens.

Class B fires are fires in flammable liquids such as gasoline, petroleum oil, and paint. Also included are flammable gases such as propane and butane. Class B fires do not include fires involving cooking oils and grease. Today's most widely used type of fire extinguisher is the multipurpose dry chemical that is effective on class A, B and C fires. Halocarbon and halon 1211 extinguishers are effective on class A, B, and C type fires.

Class C fires are fires involving energized electrical equipment such as motors, transformers, and appliances. Remove the power and the class C fire becomes one of the other classes of fire. Today's most widely used type of fire extinguisher is the multipurpose dry chemical that is effective on class A, B and C fires. Halocarbon and halon 1211 extinguishers are effective on class A, B, and C type fires. Water mist extinguishers are primarily for class A fires, although they are safe for use on class C fires as well.

Class D fires are fires in combustible metals such as potassium, sodium, aluminum, and magnesium. Dry powder extinguishers are for class D or combustible metal fires, only. They are ineffective on all other classes of fires.

Class K fires are fires in cooking oils and greases such as animal fats and vegetable fats. Wet chemical or class K extinguishers were developed for modern, high efficiency deep-fat fryers in commercial cooking operations.

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

The following is taken from 29 CFR 1910, subpart L.

Detection Systems

The employer shall do the following:

- Restore all fire detection systems and components to normal operating condition as promptly as possible after each test or alarm
- Maintain all systems in an operable condition except during repairs or maintenance
- Ensure that fire detection equipment installed outdoors or in the presence of corrosive atmospheres is protected from corrosion
- Ensure that fire detection systems installed for the purpose of actuating fire extinguishment or suppression systems shall be designed to operate in time to control or extinguish a fire
- Ensure that fire detection systems installed for the purpose of employee alarm and evacuation are designed and installed to provide a warning for emergency action and safe escape of employees
- Not delay alarms or devices initiated by fire detector actuation for more than 30 seconds unless such delay is necessary for the immediate safety of employees
- Ensure that the number, spacing and location of fire detectors is based upon design data obtained from field experience, or tests, engineering surveys, the manufacturer’s recommendations, or a recognized testing laboratory listing

Alarm and Communication Systems

Radio may be used to transmit alarms from remote workplaces where telephone service is not available, provided that radio messages will be monitored by emergency services, such as fire, police or others, to ensure alarms are transmitted and received.

In recognition of physically impaired individuals, OSHA is accepting various methods of giving alarm signals. For example, visual, tactile or audible alarm signals are acceptable methods for giving alarms to employees. Flashing lights or vibrating devices can be used in areas where the employer has hired employees with hearing or vision impairments. Vibrating devices, air fans, or other tactile devices can be used where visually and hearing-impaired employees work. Two-way radio communications would be most appropriate for transmitting emergency alarms in such workplaces which may be remote or where telephones may not be available.

Reporting (Communicating) Alarms

- Employee alarms may require different means of reporting, depending on the workplace involved. For example, in small workplaces, a simple shout throughout the workplace may be sufficient to warn employees of a fire or other emergency. In larger workplaces, more sophisticated equipment is necessary so that entire plants or high-rise buildings are not evacuated for one small emergency. In remote areas, such as pumping plants, radio communication with a central base station may be necessary. The method of transmitting the alarm should reflect the situation found at the workplace.
- Personal radio transmitters, worn by an individual, can be used where the individual may be working such as in a remote location. Such personal radio transmitters shall send a distinct signal and should clearly indicate who is having an emergency, the location, and the nature of the emergency. All radio transmitters need a feedback system to ensure that the emergency alarm is sent to the people who can provide assistance.
- For multi-story buildings or single story buildings with interior walls for subdivisions, the more traditional alarm systems are recommended for these types of workplaces. Supervised telephone or manual fire alarm or pull-box stations with paging systems to transmit messages throughout the building is the recommended alarm system. The alarm-box stations should be available within a travel distance of 200 feet. Water flow detection on a sprinkler system, fire detection systems (guard's supervisory station) or tour signal (watchman's service), or other related systems may be part of the overall system. The paging system may be used for nonemergency operations provided the emergency messages and uses will have precedence over all other uses of the system.

The requirements for supervising the employee alarm system circuitry and power supply may be accomplished in a variety of ways. Typically, electrically operated sensors for air pressure, fluid pressure, steam pressure, or electrical continuity of circuitry may be used to continuously monitor the system to ensure it is operational and to identify trouble in the system and give a warning signal.

Manual Extinguishing Systems

Portable Fire Extinguishers

Portable fire extinguishers may be mounted in any location that is accessible to employees without the use of portable devices such as a ladder.

The employer is responsible for the proper selection and distribution of fire extinguishers and the determination of the necessary degree of protection. The selection and distribution of fire extinguishers must reflect the type and class of fire hazards associated with a particular workplace.

The employer is permitted to substitute acceptable standpipe systems for portable fire extinguishers under certain circumstances. It is necessary to ensure that any substitution will provide the same coverage that portable units provide. This means that fire hoses, because of their limited portability, must be spaced throughout the protected area (PA) so that they can reach around obstructions such as columns, machinery, etc. and so that they can reach into closets and other enclosed areas.

Standpipe and Hose Systems

- Employers must make sure that standpipes are protected from mechanical and physical damage so that they can be relied upon during a fire emergency.
- The employer should keep fire protection hose equipment in cabinets or inside protective covers which will protect it from the weather elements, dirt or other damaging sources.
- When the employer elects to provide small hose in lieu of portable fire extinguishers, those hose stations being used for the substitution must have hose attached and ready for service.
- Variable stream nozzles can provide useful variations in water flow and spray patterns during fire fighting operations and they are recommended for employee use.

Automatic Extinguishing Systems

Sprinkler Systems

There are two basic types of sprinkler system design as follows. Either design can be used to comply with this standard.

- Pipe schedule designed systems are based on pipe schedule tables developed to protect hazards with standard sized pipe, number of sprinklers, and pipe lengths.
- Hydraulic designed systems are based on an engineered design of pipe size which will produce a given water density or flow rate at any particular point in the system.

Before new sprinkler systems are placed into service, an acceptance test is to be conducted. The employer should invite the installer, designer, insurance representative, and a local fire official to witness the test. Problems found during the test are to be corrected before the system is placed into service.

Dry Chemical Systems

In conjunction with the requirements of 29 CFR 1910.160, “Fixed Extinguishing Systems, General,” one test that must be conducted during the maintenance check is to determine if the chemical agent has remained free of moisture. If an agent absorbs any moisture, it may tend to cake and thereby clog the system.

Gaseous Systems

Total flooding gaseous systems are based on the volume of gas which must be discharged in order to produce a certain designed concentration of gas in an enclosed area. Employers must ensure that the flooded area has been ventilated before employees are permitted to reenter the work area without protective clothing and respirators.

Certain halogenated hydrocarbons will break down or decompose when they are combined with high temperatures found in the fire environment. The products of the decomposition can include toxic elements or compounds. The employer must find out from the manufacturer which toxic products may result from decomposition of a particular agent, and take the necessary precautions to prevent employee exposure to the hazard.

Water Spray and Foam Systems

When selecting the type of foam for a specific hazard, the employer should consider the following limitations of some foams:

- Some foams are not acceptable for use on fires involving flammable gases and liquefied gases with boiling points below ambient workplace temperatures. Other foams are not effective when used on fires involving polar solvent liquids.
- Any agent using water as part of the mixture should not be used on fire involving combustible metals unless it is applied under proper conditions to reduce the temperature of burning metal below the ignition temperature. The employer should use only those foams that have been tested and accepted for this application by a recognized independent testing laboratory.
- Certain types of foams may be incompatible and break down when they are mixed together.
- For fires involving water-miscible solvents, employers should use only those foams tested and approved for such use. Regular protein foams may not be effective on such solvents.

Whenever employers provide a foam or water spray system, drainage facilities must be provided to carry contaminated water or foam overflow away from the employee work areas and egress routes. This drainage system should drain to a central impounding area where it can be collected and disposed of properly.

15. Personnel must demonstrate a familiarity level knowledge of electrical safety for Department facilities necessary to identify safe/unsafe work practices.

a. Discuss general safety precautions for working near low voltage electrical equipment and high voltage electrical equipment.

The following is taken from DOE-HDBK-1092-2004.

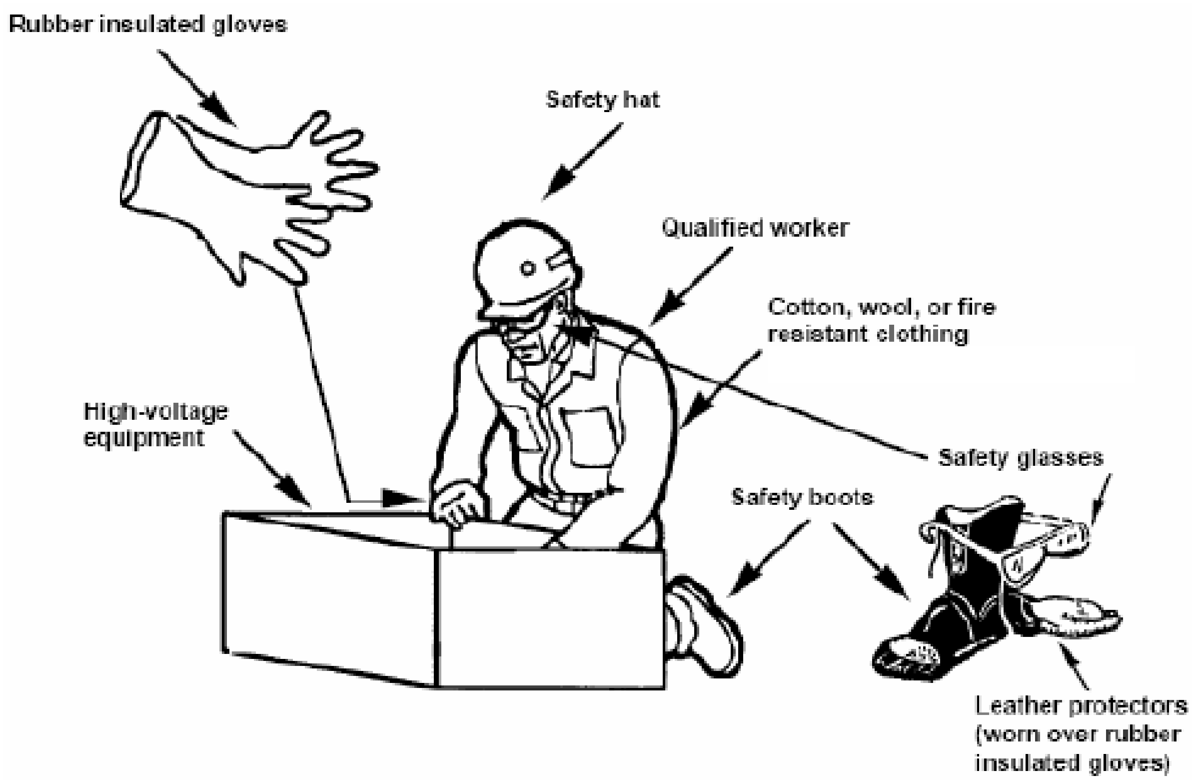
General Safety Precautions

The following, where used, will improve the safety of the workplace:

- Maintain good housekeeping and cleanliness.
- Identify and control potential hazards.
- Anticipate problems.
- Resist pressure to "hurry up."
- Plan and analyze for safety in each step of a project.
- Document work.
- Use properly rated test equipment and verify its condition and operation before and after use.
- Know and practice applicable emergency procedures.
- Become qualified in CPR and first aid and maintain current certifications.
- Wear appropriate PPE.
- Refer to system drawings and perform system walkdowns.
- Electrical equipment should be maintained in accordance with the manufacturer's instructions.
- Ensure that work is adequately planned through an approved work control process.

Precautions When Working Around High Voltage

In addition to the general safety precautions listed above, employees shall wear appropriate PPE to protect them from hazards of high-voltage apparatus. Employees authorized or required to work on high-voltage systems shall be completely familiar with the PPE they need for adequate protection while working on such systems. Figure 10 illustrates this PPE, which is discussed below.



Source: DOE-HDBK-1092-2004

Figure 10. Appropriate PPE and protective clothing

Shoes

Employees should wear shoes or boots that comply with the requirements of American National Standards Institute, (ANSI) Z41. No metal parts shall be present in the sole or heel of the shoes where nonconductive shoes are required.

Hardhats

Workers should wear approved hardhats when working above ground on poles, structures, or buildings, or in trees. Workers shall wear hardhats when working on the ground near poles, structures, buildings, or trees in which work is being done. Workers shall wear hardhats when visiting or observing in areas where overhead work is being done.

Eye Protectors

Whenever eyes are in danger of being injured, workers shall wear safety goggles or other eye protectors meeting ANSI standards. When the work being performed dictates, workers should wear nonmetallic and nonconductive eye protection. Appropriate PPE is needed to protect workers from arc flash hazards.

Metal Fasteners

Workers shall not wear articles such as loose chains, keys, watches, or rings if such articles increase the hazards associated with inadvertent contact with energized parts or can become caught under or snagged while climbing off or on structures, equipment, or vehicles.

Work Gloves

When insulated gloves suitable for high voltage are not required, otherwise suitable work gloves should be worn while handling materials and equipment to prevent the possibility of slivers, cuts, and skin irritation.

Work Clothes

Work clothes should be made of natural materials, such as cotton or wool, or fire resistant materials and should have full-length sleeves. Sleeves should be rolled down for greatest protection.

Fire-Resistant Clothing

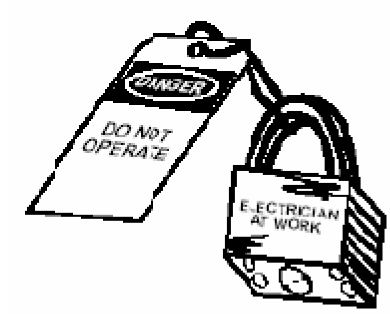
Fire-resistant materials, such as flame-retardant treated cotton, meta-aramid, para-aramid, and polybenzimidazole fibers provide thermal protection. These materials can ignite but will not continue to burn after the ignition source is removed. Fire-resistant fabrics can reduce burn injuries during an arc flash blends, para-aramid adds strength to a fabric to prevent the fabric from breaking open due to the blast shock wave and high thermal energy of the arc.

b. Describe basic electrical isolation devices and methods.

The following is taken from the Institute of Electrical and Electronic Engineers, IEEE Std 384-2008.

Energy isolating device—A physical device that prevents the transmission or release of energy, including, but not limited to, the following: a manually operated electric circuit breaker, a disconnect switch, a manually operated switch, a slide gate, a slip blind, a line valve, blocks, and any similar device with a visible indication of the position of the device. (Push buttons, selector switches, and other control-circuit-type devices are not energy isolating devices.)

Each employer shall document and implement lockout/tagout (LO/TO) procedures to safeguard employees from injury while they are working on or near de-energized electric circuits and equipment. The LO/TO procedures shall meet the requirement of NFPA 70E 120.2, 29 CFR 1910.147(c) to (f), 1910.269(d) and (m), 1910.333, and 1926.417. Figure 11 illustrates LO/TO devices.



Source: DOE-HDBK-1092-2004

Figure 11. LO/TO devices

c. Describe how safety considerations differ for alternating and direct current.

The following is taken from the National Institute for Occupational Safety and Health (NIOSH), Electrical Safety, section 7, *Safety Model Stage 3-Controlling Hazards: Safe Work Environment*.

Personal protective equipment and work practices are established for alternating current voltages above 50 volts. For direct current voltages the focus is on shock effect for currents above 100 milliamperes. Alternating current safe work practices would target voltage (for shocks and arc flash events), whereas direct current safe work practices would target current values above the 100 milliamperes threshold. In summary, the concern with alternating current safety is related to voltage, while the focus is on current when addressing direct current safety.

d. Describe basic office electrical safety precautions.

The following is taken from the Texas State Office of Risk Management, Office Safety, *Office Electrical Safety*.

Electricity is essential to the operations of a modern automated office as a source of power. Electrical equipment used in an office is potentially hazardous and can cause serious shock and burn injuries if improperly used or maintained. Electrical accidents usually occur as a result of faulty or defective equipment, unsafe installation, or misuse of equipment on the part of office workers.

General Electrical Safety Tips

- Replace or repair loose or frayed cords on all electrical devices.
- Avoid running extension cords across doorways or under carpets.
- In areas with small children, electrical outlets should have plastic safety covers.
- Follow the manufacturer's instructions for plugging an appliance into a receptacle outlet.
- Avoid overloading outlets. Consider plugging only one high-wattage appliance into each receptacle outlet at a time.
- If outlets or switches feel warm, shut off the circuit and have them checked by an electrician.

- When possible, avoid the use of “cube taps” and other devices that allow the connection of multiple appliances into a single receptacle.
- Place lamps on level surfaces, away from things that can burn, and use bulbs that match the lamp’s recommended wattage.

Outlet Safety

The outlet, or receptacle, is perhaps the most commonly used and least thought of device in the office. Every electrical appliance, tool, computer, and entertainment center component is powered through one. Here are some simple but important safety principles:

- Check outlets regularly for problems, including over-heating, loose connections, reversed polarity, and corrosion. An electrical inspection should be performed by a qualified, licensed electrician to help determine the integrity of the outlets and the entire electrical system.
- Check for outlets that have loose-fitting plugs, which can lead to arcing and fire.
- Avoid overloading outlets with too many appliances. Never plug more than one high-wattage appliance in at a time in each.
- Check for any hot or discolored outlet wall plates. From across the room a darkened area in a teardrop shape around and above the outlet may indicate dangerous heat buildup at the connections.
- Warm to the touch is OK, hot is not. If an outlet or switch wall plate is hot to the touch, immediately shut off the circuit and have it professionally checked.
- Replace any missing or broken wall plates.

Power Cords

An appliance can look like it’s in good operating order and yet still represent a hazard if its cord is damaged. Safety principles that relate to power cords include the following:

- Don’t use power cords if they are frayed, cracked, or cut.
- Make sure all power cords and extension cords are in good condition, not frayed, cracked, or cut. If the power cord to a lamp or appliance is damaged, take the item to an authorized service center, or cut the power cord and dispose of the item safely. Cutting the cord helps ensure that no one else will pick up the item and take the hazard home with them.
- Never attempt to repair or splice a cut cord yourself. “Electrical” tape, as commonly referred to—usually black vinyl tape—is not rated for the heat generated by electricity running through wires. The tape will melt and burn.
- Make sure all electrical items, including appliances, extension cords, and surge suppressors, are certified by a nationally recognized independent testing lab, such as Underwriters Laboratories, Canadian Standards Association, ETL Testing Laboratories, or MET Laboratories.
- Do not coil power cords when in use.
- Do not place power cords in high traffic areas or under carpets, rugs, or furniture.
- Power cords should never be nailed or stapled to the wall, baseboard, or another object.
- Make sure appliances are turned off before connecting cords to outlets.
- Never remove the ground pin (the third prong) to make a three-prong plug fit into a two-prong outlet; this could lead to an electrical shock.

- Never force a plug into an outlet. Plugs should fit securely into outlets, but should not require much force to fit.
- Make sure to fully insert the plug into the outlet.
- Unplug appliances when not in use to conserve energy but also to minimize the opportunities for electric shock or fire.

Extension Cords

Extension cords are temporary solutions only, and yet the majority of homes have at least one extension cord plugged in and left in place. Continual use can cause the insulation to rapidly deteriorate, creating a dangerous shock and fire hazard. In addition to the same safety tips that apply to power cords, keep the following principles in mind when using extension cords:

- Extension cords should only be used on a temporary basis; they are not intended as permanent household wiring.
- A heavy reliance on extension cords is an indication there are too few outlets to address electrical needs; have additional outlets installed.
- Make sure extension cords are properly rated for their intended use, indoor or outdoor, and meet or exceed the power needs of the appliance or tool being plugged into it.
- Assume 125 watts per amp when converting to determine if the extension cord is properly rated for the appliance being connected to it. For example, if the appliance indicates that it uses 5 amps at 125 volts, then its wattage rating is 625 watts (5 amps X 125 watts).

Power Strips and Surge Suppressors

Power strips provide the ability to plug more products into the same outlet, which can be a help but also a hindrance to safety if used inappropriately. Power strips and surge suppressors don't provide more power to a location, just more access to the same limited capacity of the circuit into which it is connected. The circuit likely also still serves a variety of other outlets and fixtures in addition to the multiple electrical items. In addition to the tips above, keep these safety principles in mind when using power strips and surge suppressors:

- Do not overload the circuit. Know the capacity of the circuit and the power requirements of all the electrical items plugged into the power strip and into all the other outlets on the circuit, as well as the light fixtures on the circuit.
- A heavy reliance on power strips is an indication that there are too few outlets. Have additional outlets installed where needed.
- Understand that a surge suppressor only protects the items plugged into it, not back along the circuit into which it is connected.
- Surge suppressors can manage the small surges and spikes sometimes generated by the turning on and off of appliances. They may even protect against a large surge generated from outside sources like lightning or problems along the power lines to the office or house. In the event of a large surge or spike, the surge suppressor is a one-time-use protector and will likely have to be replaced.
- Consider purchasing surge suppressors with cable and phone jacks to provide the same protection to your phone, fax, computer modem, and television.
- Not all power strips are surge suppressors; not all surge suppressors can handle the same load and events. Be sure the equipment matches the need.

e. Discuss NFPA 70E, *Standard for Electrical Safety in the Workplace*.

The following is taken from National Fire Protection Association, NFPA 70E, *Standard for Electrical Safety in the Workplace*.

NFPA 70E addresses electrical safety-related work practices for employee workplaces that are necessary for the practical safeguarding of employees relative to the hazards associated with electrical energy during activities such as the installation, inspection, operation, maintenance, and demolition of electric conductors, electric equipment, signaling and communications conductors and equipment, and raceways. NFPA 70E also includes safe work practices for employees performing other work activities that can expose them to electrical hazards as well as safe work practices for the following:

- Installation of conductors and equipment that connect to the supply of electricity
- Installations used by the electric utility, such as office buildings, warehouses, garages, machine shops, and recreational buildings that are not an integral part of a generating plant, substation, or control center

NFPA 70E does not cover safety-related work practices for the following:

- Installations in ships, watercraft other than floating buildings, railway rolling stock, aircraft, or automotive vehicles other than mobile homes and recreational vehicles
- Installations underground in mines and self-propelled mobile surface mining machinery and its attendant electrical trailing cable
- Installations of railways for generation, transformation, transmission, or distribution of power used exclusively for operation of rolling stock or installations used exclusively for signaling and communications purposes
- Installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations
- Installations under the exclusive control of an electric utility

16. Personnel must demonstrate a familiarity level knowledge of industrial hygiene principles.

a. Define the term “industrial hygiene,” including the elements of anticipation, recognition, evaluation, and control of health hazards in the workplace.

The following is taken from the American Industrial Hygiene Association, *What is an Industrial Hygienist?*

Industrial hygiene (IH) is the science and art devoted to the anticipation, recognition, evaluation, prevention, and control of those environmental factors or stresses arising in or from the workplace which may cause sickness, impaired health and well being, or significant discomfort among workers or among citizens of the community.

b. Discuss basic industrial hygiene concepts and terminology, including the following:

- **Routes of exposure (inhalation, ingestion, dermal injection)**
- **Dose and toxicity (acute, chronic, concentration)**

- **Exposure limits [permissible exposure limits (PEL), time-weighted average (TWA), threshold limit values (TLV), short term exposure limit (STEL), ceiling, action level, parts per million (PPM), milligrams per cubic meter (mg/m^3)]**
- **Hierarchy of controls (engineering, substitution, administrative, PPE)**
- **Health hazards (chemical, physical, biological)**
- **Key elements of a carcinogen control program, including carcinogenic chemicals and asbestos control**

Routes of Exposure

The following is taken from National Safety Council, *Fundamentals of Industrial Hygiene*.

To exert its toxic effect, a harmful agent must come into contact with a body cell and must enter the body via inhalation, skin absorption, or ingestion.

Inhalation

Inhalation involves airborne contaminations that can be inhaled directly into the lungs and can be physically classified as gases, vapors, and particulate matter, including dusts, fumes, smokes, aerosols, and mists.

Inhalation, as a route of entry, is particularly important because of the rapidity with which a toxic material can be absorbed in the lungs, pass into the bloodstream, and reach the brain. Inhalation is the major route of entry for hazardous chemicals in the work environment.

Ingestion

In the workplace, people can unknowingly eat or drink harmful chemicals. Toxic compounds can be absorbed from the gastrointestinal tract into the blood.

Inhaled toxic dusts can also be ingested in hazardous amounts. If the toxic dust swallowed with food or saliva is not soluble in digestive fluids, it is eliminated directly through the intestinal tract. Toxic materials that are readily soluble in digestive fluids can be absorbed into the blood from the digestive system.

It is important to study all routes of entry when evaluating the work environment—candy bars or lunches in the work area, solvents being used to clean work clothing and hands, in addition to airborne contaminants in working areas.

Dermal Injection

Absorption through the skin can occur quite rapidly if the skin is cut or abraded. Intact skin, however, offers a reasonably good barrier to chemicals. Unfortunately, there are many compounds that can be absorbed through intact skin.

Some substances are absorbed by way of the openings for hair follicles and others dissolve in the fats and oils of the skin, such as organic lead compounds, many nitro compounds, and organic phosphate pesticides. Compounds that are good solvents for fats also can be absorbed through the skin.

Many organic compounds can produce systemic poisoning by direct contact with the skin.

Dose and Toxicity

The following is taken from the Extension Toxicology Network (EXTOXNET), *Dose-Response Relationships in Toxicology*.

The science of toxicology is based on the principle that there is a relationship between a toxic reaction (the response) and the amount of poison received (the dose). An important assumption in this relationship is that there is almost always a dose below which no response occurs or can be measured. A second assumption is that once a maximum response is reached, any further increases in the dose will not result in any increased effect.

One particular instance in which this dose-response relationship does not hold true is in regard to true allergic reactions. For all other types of toxicity, knowing the dose-response relationship is a necessary part of understanding the cause and effect relationship between chemical exposure and illness. The toxicity of a chemical is an inherent quality of the chemical and cannot be changed without changing the chemical to another form. The toxic effects on an organism are related to the amount of exposure.

The following is taken from the Extension Toxicology Network (EXTOXNET), *Glossary*.

Acute exposure is a single or short-term exposure; used to describe brief exposures and effects which appear promptly after exposure.

Chronic exposure occurs over a long period of time, either continuously or intermittently; used to describe ongoing exposures and effects that develop only after a long exposure.

Concentration is the amount of active ingredient or pesticide equivalent in a quantity of diluent, expressed as lb/gal, ml/liter, etc.

Exposure Limits

The following is taken from National Institute for Occupational Safety and Health, *Preventing Occupational Hearing Loss—A Practical Guide*.

Permissible Exposure Limit

A PEL is a TWA exposure that must not be exceeded during any 8-hour work shift of a 40-hour work week.

Time-weighted Average

A TWA is a value that is computed so that the resulting average would be equivalent to an exposure resulting from a constant noise level over an 8-hour period.

The following is taken from Interactive Learning Paradigms, Inc., MSDS HyperGlossary.

Threshold Limit Value

Threshold limit values are guidelines (not standards) prepared by the American Conference of Governmental Industrial Hygienists (ACGIH) to assist industrial hygienists in making decisions regarding safe levels of exposure to various hazards found in the workplace.

A TLV reflects the level of exposure that the typical worker can experience without an unreasonable risk of disease or injury. Threshold limit values are not quantitative estimates of risk at different exposure levels or by different routes of exposure.

Short Term Exposure Limit

A STEL is defined by ACGIH as the concentration to which workers can be exposed continuously for a short period of time without suffering from

- irritation;
- chronic or irreversible tissue damage;
- narcosis of sufficient degree to increase the likelihood of accidental injury, impair self-rescue, or materially reduce work efficiency.

Short term exposure limits are generally used only when toxic effects have been reported from high acute (short-term) exposures in either humans or animals. A STEL is not a separate independent exposure limit, but supplements TWA limits where there are recognized acute effects from a substance whose toxic effects are generally chronic (long-term) in nature.

Ceiling Value

According to the MSDS HyperGlossary, PEL ceiling values are exposure limits that should not be exceeded at any time. They are sometimes denoted with the letter C.

Action Level

Action levels are used by OSHA and NIOSH to express a health or physical hazard. They indicate the level of a harmful or toxic substance/activity that requires medical surveillance, increased IH monitoring, or biological monitoring.

Action levels are generally set at one half of the PEL, but the actual level may vary from standard to standard. The intent is to identify a level at which the vast majority of randomly sampled exposures will be below the PEL.

Parts per Million

The term parts per million is defined as the mass of the component in solution divided by the total mass of the solution multiplied by 10^6.

Milligrams per Cubic Meter

Density is the amount of something per unit volume (mass per unit volume is typically used for a solid or liquid). Therefore, milligrams per cubic meter is a measure of density.

Hierarchy of Controls

The following is taken from DOE G 440.1-1B.

Elimination or Substitution

Elimination or substitution of hazards must be the first choice for controlling hazards. The contractor should verify that potential hazards of the substitution are identified and addressed before deciding to proceed.

Engineering Controls

Engineering controls must be the second choice for controlling hazards after elimination or substitution of the hazard has been implemented to the extent feasible and appropriate. Feasibility analysis should consider characteristics of the technology available for the task; worker acceptance; level of protection provided; hazards, operations and maintenance burdens introduced; and cost. Principal engineering controls include the following:

- Enclosing the hazard
- Locating hazardous operations or equipment in remote or unoccupied areas
- Establishing physical barriers and guards
- Using local and general exhaust ventilation

Work Practices and Administrative Controls

Work practices and ACs must be the third choice for controlling hazards after elimination or substitution of the hazard and engineering controls have been implemented to the extent feasible and appropriate. The effectiveness of work practices and ACs depends on the ability of line management to make employees aware of established work practices and procedures, to reinforce the practices and procedures, and to provide consistent and reasonable enforcement. Administrative controls include the following:

- Written operating procedures, safe work practices, and work permits
- Exposure time limitations
- Limits on the use of hazardous materials and monitoring of such operations
- Health and safety plans
- Altered work schedules, such as working in the early morning or evening to reduce the potential for heat stress
- Training employees in methods of reducing exposure

Personal Protective Equipment

When elimination or substitution, engineering, and work practices and ACs have been considered and implemented and are not sufficient to fully protect the worker from a recognized hazard, PPE must be used to supplement these other controls as appropriate. PPE is acceptable as a control method as follows:

- To supplement elimination or substitution, engineering, and work practices and ACs when such controls are not feasible or do not adequately reduce the hazard
- As an interim measure while engineering controls are being developed and implemented
- During emergencies when elimination or substitution, engineering, and work practices and ACs may not be feasible
- During maintenance and other non-routine activities where other controls are not feasible

The use of PPE can itself create significant worker hazards, such as heat stress; physical and psychological stress; and impaired vision, mobility, and communication. An example would be a worker wearing several layers of protective clothing (for contamination control), a respirator, gloves, and a helmet while welding or cutting. This arrangement of PPE could prevent the worker from being aware of the environment in the event of a fire or other emergency.

In these situations, engineering and/or ACs (e.g., a fire watch to ensure the safety of the worker as well as the property) should be implemented to supplement PPE.

Health Hazards

Chemical

The following is taken from the National Safety Council, *Fundamentals of Industrial Hygiene*.

The majority of occupational health hazards arise from inhaling chemical agents in the form of vapors, gases, dusts, fumes, and mists, or by skin contact with these materials. The degree of risk of handling a given substance depends on the magnitude and duration of exposure.

To recognize occupational factors or stresses, a health and safety professional must first know about the chemicals used as raw materials and the nature of the products and byproducts manufactured. The required information can be obtained from the MSDS that must be supplied by the chemical manufacturer or importer for all hazardous materials under the OSHA hazard communication standard.

Many industrial materials such as resins and polymers are relatively inert and nontoxic under normal conditions of use, but when heated or machined, they may decompose to form highly toxic byproducts.

Breathing of some materials can irritate the upper respiratory tract or the terminal passages of the lungs and the air sacs, depending on the solubility of the material. Contact of irritants with the skin surface can produce various kinds of dermatitis.

The presence of excessive amount of biologically inert gases can dilute the atmospheric oxygen below the level required to maintain the normal blood saturation value for oxygen and disturb cellular processes. Other gases and vapors can prevent the blood from carrying oxygen to the tissues or interfere with its transfer from the blood to the tissue, thus producing chemical asphyxia or suffocation.

Some substances may affect the central nervous system and brain to produce narcosis or anesthesia. In varying degrees, many solvents have these effects. Substances are often classified according to the major reaction they produce, as asphyxiants, systemic toxins, pneumoconiosis-producing agents, carcinogens, and irritant gases.

Biological

Biological stressors represent a distinct category of hazards. Unlike chemical or physical hazards, biological stressors 1) grow, reproduce, and die; 2) disperse both actively and passively; 3) interact with other biological populations in the ecosystem; and 4) evolve. Therefore, biological stressors as diverse as human pathogens (e.g., Salmonella and Bacillus anthracis), plant and animal pathogens (e.g., Asian soybean rust and avian influenza virus), and invasive species (e.g., Mediterranean fruit fly and kudzu) share many common features. The distinction between risk assessment for biological stressors and chemical risk assessment may be overstated, however, and a number of parallels can be drawn. For example, pathogen inactivation is analogous to chemical sequestration, and a population of invasive cells in the body is analogous to a population of invasive species in the environment. To date, however, the practice of risk assessment for biological stressors has not adopted conventions as simplifying assumptions to the extent that they are generally applied in the more mature field of chemical risk assessment. As with risk assessment in other fields, managing the tension between complexity and utility is likely to remain an ongoing challenge for the emerging field of risk assessment for biological stressors.

29 CFR 1910.1030, "Bloodborne Pathogens," defines bloodborne pathogens as pathogenic microorganisms that are present in human blood and can cause disease in humans. These pathogens include, but are not limited to, hepatitis B virus and human immunodeficiency virus.

Each employer having an employee(s) with occupational exposure shall establish a written exposure control plan designed to eliminate or minimize employee exposure. Occupational exposure means reasonably anticipated skin, eye, mucous membrane, or parenteral contact with blood or other potentially infectious materials that may result from the performance of an employee's duties. Each employer who has an employee(s) with occupational exposure shall prepare an exposure determination. Engineering and work practice controls shall be used to eliminate or minimize employee exposure. Where occupational exposure remains after institution of these controls, PPE shall also be used.

When there is occupational exposure, the employer shall provide, at no cost to the employee, appropriate PPE such as, but not limited to, gloves, gowns, and laboratory coats; face shields/ masks and eye protection; and mouthpieces, resuscitation bags, pocket masks, or other ventilation devices. PPE will be considered appropriate only if it does not permit blood or other potentially infectious materials to pass through or to reach the employee's work clothes, street clothes, undergarments, skin, eyes, mouth, or other mucous membranes under normal conditions of use and for the duration of time the protective equipment will be used.

Physical

29 CFR 1910.95, "Occupational Noise Exposure," states that when employees are subjected to sound levels exceeding those listed in table 9, below, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels to permissible limits as specified in table 9, PPE shall be provided and used to reduce sound levels so that they fall within the levels of the table.

Table 9. Permissible noise exposures

Duration per day (hours)	Sound level, dBA Slow Response
8	90
6	92
4	95
3	97
2	100
1.5	102
1	105
0.5	110
0.25 or less	115

Source: 29 CFR 1910.95

The employer shall administer a continuing, effective hearing conservation program whenever employee noise exposures equal or exceed an eight-hour TWA sound level of 85 decibels measured on the A scale (slow response) or, equivalently, a dose of 50 percent.

According to 29 CFR 1926.54, “Nonionizing Radiation,” employees working in areas where there exists a potential exposure to direct or reflected laser light greater than 0.005 watts (5 milliwatts) shall be provided with anti-laser eye protection devices. Areas in which lasers are used shall be posted with standard laser warning placards. Employees whose occupation or assignment requires exposure to laser beams shall be furnished suitable laser safety goggles which will protect for the specific wavelength of the laser and be of optical density adequate for the energy involved.

Lasers are classified in categories 1 (safe) to 4 (dangerous). Most precautions apply to class 3b and 4 lasers. The ACGIH provides TLVs for lasers, while ANSI Z136.1, *American National Standard for the Safe Use of Lasers*, provides more detailed guidance on acceptable practices to provide safety. DOE G 420.2-1, *Accelerator Facility Safety Implementation Guide for DOE O 420.2B, Safety of Accelerator Facilities,* states that although eye injury from nonionizing radiation is generally the primary hazard, laser systems can present electrical and chemical hazards as well. In addition to the nonionizing radiation hazard, electrical hazards are associated with the high-voltage power supplies used in many laser systems. In particular, class 4 lasers often use large power supplies that carry an appreciable risk of electrocution, especially in maintenance and adjustment procedures. Chemical hazards can be associated with halogen and dye lasers, as well as with radiation decomposition.

Electromagnetic radiation is restricted to that portion of the spectrum commonly defined as the radio frequency (RF) region, which includes the microwave frequency region. DOE G 420.2-1, states that to avoid exposure of persons to unacceptable levels of RF fields, engineered control measures, such as shielding, prevention of wave-guide leakage, enclosures, interlocks preventing accidental energizing of circuits, and dummy load terminations, should be given first consideration over any use of PPE. Where exposure in excess of the limits is possible, RF leakage tests should be conducted when the system is first operated and after modifications that might result in changes to the leakage. Area RF monitors are appropriate when RF energy can be expected in occupied areas. The ACGIH specifies guidelines for personnel protection in the form of TLVs. Use of the ACGIH guidelines in their most current form for RF and microwave fields is required as part of worker protection management for DOE contractor employees.

Key Elements of a Carcinogen Control Program, Including Carcinogenic Chemicals and Asbestos Control

Carcinogen Control Program

The following is taken from DOE-STD-6005-2001.

A policy and procedures should be established and implemented to control occupational exposure to chemical carcinogens. For OSHA-regulated carcinogens, control procedures shall be implemented that, at a minimum, conform to the requirements of respective OSHA standards. For other carcinogens, control procedures shall be implemented that are consistent with the current ACGIH *Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*. Controls will depend on the physical and chemical properties of the material, how it will be handled (specifically if the material will be handled in a way where it could be dispersed into the air or spread on surfaces), the quantity involved, and the duration and number of potential exposures. Generally, the following controls should be applied to the use and handling of chemical carcinogens:

- Written safety plans, standard operating procedures, and/or experimental protocols should be prepared to describe the use of chemical carcinogens and the methods used to control employee exposure. These documents should be reviewed and approved by the senior industrial hygienist prior to the initiation of an operation.
- Regulated areas should be established where chemical carcinogens are used (consistent with OSHA requirements, where applicable). The design and characteristics of these regulated areas should be appropriate to ensure that access is controlled and all carcinogenic materials are confined. A record should be maintained of all personnel working in regulated areas. Provisions should be made to ensure that contaminated air is not released into adjacent, non-regulated work areas or to the outside environment.
- Engineering control should be the primary method used to control employee exposure to carcinogens and to prevent the release of carcinogens into the workroom environment. All contaminated wastes and materials should be stored and disposed of using approved methods.
- Signs warning of the presence of chemical carcinogens should be posted at all entrances to regulated work areas. Appropriate labeling should be used on all chemical carcinogen containers and contaminated wastes to identify and warn of the carcinogenic hazard.
- Appropriate personal hygiene and work practices should be implemented, including use of protective clothing, shower facilities, change rooms, prohibition on eating, drinking, and smoking in regulated areas, and the use of non-permeable work surfaces, as feasible.
- Procedures should be established for emergency actions involving chemical carcinogens (e.g., cleanup of spills or accidental releases). Occurrences that could result in exposure of personnel or release to the environment should be investigated and, if appropriate, reported.

Asbestos Control Program

The following is taken from 29 CFR 1910.1001.

The employer shall ensure that no employee is exposed to an airborne concentration of asbestos in excess of 1.0 fiber per cubic centimeter of air (1 f/cc) as averaged over a sampling period of 30 minutes.

Exposure monitoring—Determinations of employee exposure shall be made from breathing zone air samples that are representative of the 8-hour TWA and 30-minute short-term exposures of each employee.

Representative 8-hour TWA employee exposures shall be determined on the basis of one or more samples representing full-shift exposures for each shift for each employee in each job classification in each work area. Representative 30-minute short-term employee exposures shall be determined on the basis of one or more samples representing 30-minute exposures associated with operations that are most likely to produce exposures above the excursion limit for each shift for each job classification in each work area.

Initial monitoring—Each employer who has a workplace or work operation covered by 29 CFR 1910.1001 "Asbestos," shall perform initial monitoring of employees who are, or may reasonably be expected to be exposed to airborne concentrations at or above the TWA PEL and/or excursion limit.

Where the employer has monitored after March 31, 1992, for the TWA PEL and/or the excursion limit, and the monitoring satisfies all other requirements, the employer may rely on such earlier monitoring results to satisfy the requirements.

Where the employer has relied on objective data that demonstrate that asbestos is not capable of being released in airborne concentrations at or above the TWA PEL and/or excursion limit under the expected conditions of processing, use, or handling, then no initial monitoring is required.

c. Discuss the key elements (exposure assessment and monitoring, engineering controls, respiratory protection, PPE and clothing, housekeeping, labeling, training, medical surveillance, record keeping) of an industrial hygiene program.

Exposure Assessment and Monitoring

The following is taken from DOE G 440.1-3 (archived).

Exposure assessment is the systematic collection and analysis of occupational hazards and exposure determinants such as work tasks; magnitude, frequency, variability, duration, and route of exposure; and the linkage of the resulting exposure profiles of individuals and similarly exposed groups for the purposes of risk management and health surveillance.

Specific applicable requirements for exposure assessment contained in DOE O 440.1B include the following:

- Identify existing and potential workplace hazards and evaluate the potential risk of associated worker injury or illness. Assess worker exposure to chemical, physical, biological, or ergonomic hazards through appropriate workplace monitoring (including personal, area, wipe, and bulk sampling), biological monitoring, and observation. Monitoring results need to be recorded. Documentation shall describe the tasks and locations where monitoring occurred, identify workers monitored or represented by the monitoring, and identify the sampling methods and durations, control measures in place during monitoring (including the use of PPE), and any other factors that may have affected sampling results.
- Implement a comprehensive and effective IH program to reduce the risk of work-related disease or illness at affected facilities.
- Evaluate workplace and activities 1) routinely by workers, supervisors, and managers and 2) periodically by qualified worker protection professionals.
- Comply with the worker protection requirements.

Engineering Controls

The following is taken from DOE G 440.1-1B.

Engineering controls must be the second choice for controlling hazards after elimination or substitution of the hazard has been implemented to the extent feasible and appropriate. Principal engineering controls include

- enclosing the hazard
- locating hazardous operations or equipment in remote or unoccupied areas
- establishing physical barriers and guards
- using local and general exhaust ventilation

The following is taken from DOE-STD-6005-2001.

Respiratory Protection

When respiratory protection is required, DOE and contractor line management must ensure that NIOSH-approved respirators are used. However, for certain specific DOE activities/situations, NIOSH-approved respirators may not exist. In such cases, DOE and contractor line management may request from the Office of Environment, Safety, and Health, approval to use respiratory protection that has been tested and accepted for specific applications by the Los Alamos National Laboratory Respirator Studies Program.

Personal Protective Equipment and Clothing

Use of PPE is generally considered the last line of defense because it places the burden of hazard control directly on the worker. Its use should be limited to

- the period necessary to install, evaluate or repair engineering controls;
- work situations such as maintenance and repair activities and hazardous waste and emergency response operations in which engineering controls are not feasible;
- work situations in which engineering controls and supplemental work practice controls are not sufficient to reduce exposures to or below occupational exposure limits; and
- emergency or escape situations.

Housekeeping

The following is taken from DOE-STD-1072-94 (archived).

Housekeeping is the cleaning and preservation of the facility, its systems and components. It is also used to refer to the condition of facility cleanliness, orderliness, and preservation. Examples of housekeeping deficiencies include to following:

- Cluttered areas, dirt accumulation
- Undisposed packaging material
- Cigarette butts on floors, equipment, or structures
- Improper waste disposal
- Tool cribs in disarray
- Tools or parts left unattended for prolonged periods of time
- Caked dirt on equipment and bed plates
- Signs and labeling in disarray
- Storage areas disorderly

- Shop areas cluttered; old parts lying about

Labeling

The following is taken from DOE-STD-1044-93.

Facilities should establish written guidelines for labeling components, systems, and hazards that personnel may be expected to encounter in the course of their work.

A label should provide a concise and meaningful verbal description of the function (noun name) of an item being identified, and a unique alphanumeric code identifying the system and component. Noun names and alphanumeric codes used on labels should be consistent with those used in all facility procedures, round sheets, alignment checklists, engineering drawings, and piping and instrument diagrams. Information on control panel labels should be consistent with the information on labels attached to the equipment being controlled. Alphanumeric codes should be developed in a manner that will aid personnel in consistently identifying the correct component and prevent misidentification. For example, two parallel motor control centers may be identified as MCC-1A and MCC-1B, but identifying them as MCC-1A and MCC-1-1A may lead to confusion.

Abbreviations and acronyms used on labels should come from the facility's approved list of abbreviations and acronyms, and should be commonly understood.

The following additional guidelines should be considered when developing labels for specific components:

- Labels installed on electrical cabinets, panels, and equipment should indicate the maximum voltage present.
- Labels placed outside doors to rooms should identify the major equipment items contained within.
- Labels for electric motors and other electrical equipment should identify the power supply.
- Labels for pneumatic actuators should identify the respective isolation valves.
- Labels on piping should indicate the contents (or hazard) and the normal flow direction. Piping containing radioactive fluids, toxic materials, or explosive gases should be uniquely marked.

Training Requirements

The following is taken from DOE-STD-6005-2001.

DOE and contractor line management are required to provide worker hazard training and to encourage employee involvement. Line workers are the individuals most in contact with the hazards and, therefore, have a vested interest in the worker protection program. As such, they can serve as valuable resources and problem solvers. Workers who are properly trained and allowed to contribute and implement ideas are more likely to support them since they now have a personal stake in ensuring that rules and procedures are followed. Therefore, line workers should be directly involved with, and should participate in, activities such as inspecting work sites, identifying hazards, selecting work practice controls, and serving on worker protection committees.

Medical Surveillance

The following is taken from the National Safety Council, *Fundamentals of Industrial Hygiene*.

Health surveillance, although not an occupational exposure control, can be used to prevent health impairments by means of periodic evaluations. A health surveillance program includes pre-placement, periodic, special purpose, and hazard-oriented examinations.

Medical surveillance is mandated by specific OSHA, Mine Safety and Health Administration, and EPA regulations. Over 30 OSHA standards and proposed standards contain medical surveillance requirements (SRs). Among these are the asbestos, lead, formaldehyde, and hazardous waste operation standards.

Hazard-oriented medical surveillance monitors biological indicators of absorption of chemical agents based on analysis of the agent or its metabolite in blood, urine, or expired air. Inorganic lead absorption is measured by blood lead levels, and carbon monoxide absorption is indicated by carboxyhemoglobin levels in blood or carbon monoxide in exhaled air.

Recordkeeping

The following is taken from DOE-STD-6005-2001.

DOE and contractor line management must ensure written hazard assessment and control records are developed and maintained for all potentially hazardous work operations and activities. This includes assessments where no significant worker exposures are expected or determined. This latter case is important since new exposure effects may be identified and retrospective health concerns can only be addressed by documented assessment records. Consequently, assessments for operations determined to have no significant exposure potential (i.e., negative exposure) should be appropriately documented for historical purposes following the standard protocol for all surveys. Because of the significance of the information contained in these records, it is crucial that the persons assigned this task be appropriately trained. Critical records should be reviewed and approved by the senior industrial hygienist or designee. All such recordkeeping must comply with the requirements of 29 CFR 1910.1020, “Access to Employee Exposure and Medical Records,” any applicable DOE directives, and/or applicable OSHA hazard-specific or expanded health standards, or any other applicable law.

d. Discuss industrial hygiene requirements as found in the following regulations:
- **10 CFR 850, “Chronic Beryllium Disease Prevention Program”**
- **10 CFR 851, “Worker Safety and Health Program”**

10 CFR 850, “Chronic Beryllium Disease Prevention Program”

The chronic beryllium disease prevention program (CBDPP) must specify the existing and planned operational tasks that are within the scope of the CBDPP. The CBDPP must augment and, to the extent feasible, be integrated into the existing worker protection programs that cover activities at the facility.

The detail, scope, and content of the CBDPP must be commensurate with the hazard of the activities performed, but in all cases the CBDPP must

- include formal plans and measures for maintaining exposures to beryllium at or below the permissible exposure level prescribed in 10 CFR 850.22;
- satisfy each requirement in subpart C of 10 CFR 850; and
- contain provisions for
  - minimizing the number of workers exposed and potentially exposed to beryllium;
  - minimizing the number of opportunities for workers to be exposed to beryllium;
  - minimizing the disability and lost work time of workers due to chronic beryllium disease, beryllium sensitization and associated medical care; and
  - setting specific exposure reduction and minimization goals that are appropriate for the beryllium activities covered by the CBDPP to further reduce exposure below the PEL prescribed in 10 CFR.22.

10 CFR 851.10, "Worker Safety and Health Program"

With respect to a covered workplace for which a contractor is responsible, the contractor must

- provide a place of employment that is free from recognized hazards that are causing or have the potential to cause death or serious physical harm to workers
- ensure that work is performed in accordance with
  - all applicable requirements of 10 CFR 851
  - the WSHP for that workplace

The written WSHP must describe how the contractor complies with

- the requirements set forth in subpart C of 10 CFR 851 that are applicable to the hazards associated with the contractor's scope of work
- any compliance order issued by the Secretary pursuant to 10 CFR 851.4

e. Discuss the key elements of a hazard communication program and the use of material safety data sheets.

The following is taken from 29 CFR 1910.1200 unless otherwise stated.

Hazard Communication Program Elements

Employers shall develop, implement, and maintain at each workplace, a written hazard communication program which at least describes how the criteria specified in paragraphs (f) "Labels and Other Forms of Warning," (g) "Material Safety Data Sheets," and (h) "Employee Information And Training," of 29 CFR 1910.1200 "Hazard Communication," will be met, and which also includes the following:

- A list of the hazardous chemicals known to be present using an identity that is referenced on the appropriate MSDS (the list may be compiled for the workplace as a whole or for individual work areas)
- The methods the employer will use to inform employees of the hazards of non-routine tasks (for example, the cleaning of reactor vessels), and the hazards associated with chemicals contained in unlabeled pipes in their work areas

For multi-employer workplaces, employers who produce, use, or store hazardous chemicals at a workplace in such a way that the employees of other employer(s) may be exposed (e.g., employees of a construction contractor working onsite) shall additionally ensure that the hazard communication programs developed and implemented under 29 CFR 1910.1200(e) include the following:

- The methods the employer will use to provide the other employer(s) onsite access to MSDSs for each hazardous chemical the other employer(s)' employees may be exposed to while working
- The methods the employer will use to inform the other employer(s) of any precautionary measures that need to be taken to protect employees during the workplace's normal operating conditions and in foreseeable emergencies
- The methods the employer will use to inform the other employer(s) of the labeling system used in the workplace

Where employees must travel between workplaces during a work shift (i.e., their work is carried out at more than one geographical location), the written hazard communication program may be kept at the primary workplace facility.

Material Safety Data Sheets

The following is taken from MSDSonline.com.

An MSDS is a required document that contains information for the safe handling, use, storage and disposal of potentially hazardous chemicals. Global agencies like the United Nations, OSHA, EPA, the European Union and Health Canada require that all potentially hazardous chemicals carry an MSDS to ensure the safety of all personnel that are involved in manufacturing, distributing, transporting and using these materials in their day-to-day operations.

Material safety data sheets may be kept in any form, including operating procedures, and may be designed to cover groups of hazardous chemicals in a work area where it may be more appropriate to address the hazards of a process rather than individual hazardous chemicals. However, the employer shall ensure that in all cases the required information is provided for each hazardous chemical, and is readily accessible during each work shift to employees when they are in their work area(s).

Material safety data sheets shall also be made readily available, upon request, to designated representatives and to the Assistant Secretary, according to the requirements of 29 CFR 1910.120(e). The Director shall also be given access to MSDSs in the same manner.

f. Discuss the importance of the following types of equipment used for personnel protection and safety:

- **Eye protection**
- **Ear protection**
- **Protective clothing/gloves**
- **Respiratory protection**

Eye Protection

The following is taken from American National Standards Institute Z87.1-2003.

Lenses

ANSI Z87.1-2003, *Industrial Eyewear Impact Statement*, designates that lenses will be divided into two protection levels, basic impact and high impact as dictated by test criteria. Basic impact lenses must pass the "drop ball" test; a 1-inch-diameter steel ball is dropped on the lens from 50 inches. High-impact lenses must pass "high velocity" testing where ¼-inch steel balls are "shot" at different velocities.

- Spectacles: 150 ft/sec
- Goggles: 250 ft/sec
- Faceshields: 300 ft/sec

Frames

All eyewear/goggle frames, faceshields or crowns must comply with the high-impact requirement. (This revision helps eliminate the use of "test lenses," and ensures all protectors are tested as complete—lenses in frame—devices). After making an eye hazard assessment, employers (safety personnel) should decide on appropriate eyewear to be worn, although high impact would always be recommended.

Impact Protection Level

To identify a device's level of impact protection, the following marking requirements apply to all new production spectacles, goggles, and faceshields. Basic impact spectacle lenses will have the manufacturer's mark (i.e., an AO safety product will have "AOS" and a Pyramex product will have a "P," etc.). Goggles and faceshields will have AOS and Z87 (AOS Z87). High-impact spectacle lenses will also have a plus + sign (AOS+ or "P+" etc.). All goggle lenses and faceshield windows are to be marked with the manufacturer's mark, Z87, and a + sign.

Note: Lenses/windows may have additional markings. Shaded lenses may have markings denoting a shade number such as 3.0, 5.0 etc. Special purpose lenses may be marked with "S." A variable tint lens may have a "V" marking.

Side shield coverage, as part of the lens, part of the spectacle, or as an individual component, has been increased rearward by 10 millimeters via a revised impact test procedure. While side protection in the form of wraparound lens, integral or attached component side shield devices is not mandated in this standard, it is highly recommended. Further, OSHA does require lateral protection on eye protection devices wherever a flying particle hazard may exist, and flying particle hazards are virtually always present in any occupational environment.

Thickness Requirement

High-impact Lenses. The standard does not have a "minimum lens thickness" requirement for high impact spectacle lenses. The previous standard required a 2-millimeter minimum. However, the protective advantages of wraparound lenses and the many other advancements in eyewear design have eliminated this need.

Ear Protection

According to 29 CFR 1926.101, "Hearing Protection," wherever it is not feasible to reduce the noise levels or duration of exposures to those specified in table D-2, Permissible Noise Exposures, in 29 CFR 1926.52, "Occupational Noise Exposure," ear protective devices shall be provided and used. Ear protective devices inserted in the ear shall be fitted or determined individually by competent persons. Plain cotton is not an acceptable protective device.

Protective Clothing

The following is taken from DOE-HDBK-1122-2009.

The basic factors that determine the type and extent of protective clothing required are:

- Type and form of contamination
- Levels of contamination
- Type of work being performed
- Potential for increased levels of contamination
- Area of the body at risk
- Competing hazards (i.e., asbestos, heat stress, etc.)

Once the types of protection needed are established, the most efficient protective clothing must be selected from the different articles of protective clothing available for use.

Whole Body Protection

- Laboratory coat
  - Provides protection from low levels of contamination.
  - Only applicable when the potential for body contact with contaminated surfaces is very low.
  - Lab coats are generally worn for hands-off tours and inspections in areas with removable contamination at levels 1 to 10 times the values in table 2-2 of the radiological control standard.
  - Lab coats may also be worn during benchtop, laboratory fume hood, sample station, and glovebox operations.
- Coveralls
  - Provide protection from low to moderate levels of dry contamination.
  - Protection is low when body contact with contaminated surfaces is prolonged (since contamination can be ground into the cloth).
  - Protection is low when the surface is wet.
  - Degree of protection can be increased by use of more than one pair at a time to protect the body.
  - Not effective against radionuclides with high permeation properties (gases, tritium, etc.).
- Plastic coveralls
  - Provide protection from high levels of dry contamination.
  - Provide protection from wet forms of contamination.
  - Provide limited protection from tritium and other highly permeating radionuclides being transported through the coveralls to the skin surface.
- Disposable coveralls

- Used for work involving mixed hazards (e.g., asbestos, etc.) where reuse is not desirable.
- Types of suits are Tyvek, Gore-Tex, etc. which provide moderate protection from radioactive contamination.
- Can be easily torn.

Gloves

The following is taken from 29 CFR 1910, subpart I, appendix B.

Gloves are often relied upon to prevent cuts, abrasions, burns, and skin contact with chemicals that are capable of causing local or systemic effects following dermal exposure. OSHA is unaware of any gloves that provide protection against all potential hand hazards, and commonly available glove materials provide only limited protection against many chemicals. Therefore, it is important to select the most appropriate glove for a particular application and to determine how long it can be worn, and whether it can be reused.

It is also important to know the performance characteristics of gloves relative to the specific hazard anticipated (e.g., chemical hazards, cut hazards, flame hazards, etc.). These performance characteristics should be assessed by using standard test procedures. Before purchasing gloves, the employer should request documentation from the manufacturer that the gloves meet the appropriate test standard(s) for the hazard(s) anticipated.

Other factors to be considered for glove selection in general include:

- As long as the performance characteristics are acceptable, in certain circumstances, it may be more cost effective to regularly change cheaper gloves than to reuse more expensive types.
- The work activities of the employee should be studied to determine the degree of dexterity required, the duration, frequency, and degree of exposure of the hazard, and the physical stresses that will be applied.

With respect to selection of gloves for protection against chemical hazards:

- The toxic properties of the chemical(s) must be determined; in particular, the ability of the chemical to cause local effects on the skin and/or to pass through the skin and cause systemic effects.
- Generally, any chemical resistant glove can be used for dry powders.
- For mixtures and formulated products (unless specific test data are available), a glove should be selected on the basis of the chemical component with the shortest breakthrough time, since it is possible for solvents to carry active ingredients through polymeric materials.
- Employees must be able to remove the gloves in such a manner as to prevent skin contamination.

Respiratory Protection

The following is taken from DOE G 441.1-1C.

Respiratory protective equipment is used to reduce an individual's intake of airborne radioactive materials. Each respiratory protective device is assigned a protection factor that indicates the degree of protection afforded by the respirator. Respiratory protective devices should be chosen based on the protection factor and actual or potential airborne radioactivity levels, taking into account ALARA considerations, other industrial hazards, and worker safety. DOE requires its respiratory protection programs to be conducted, for DOE contractors in accordance with 10 CFR 851, and for DOE Federal employees in accordance with DOE O 440.1B.

An important step in selecting the proper respiratory protective equipment is determining the actual or potential concentration of airborne radioactivity in the area the individual is to enter. Air sampling shall be performed as necessary to characterize the airborne radioactivity hazard where respiratory protection against airborne radionuclides has been prescribed. Typically, grab sampling is used to determine the airborne radioactivity concentration. Real-time air monitoring may be useful in areas where substantial work is being performed and airborne radioactivity concentrations fluctuate. If the individual is entering an area where the airborne radioactivity concentration is routinely sampled and is not likely to have changed since air monitoring was last performed, previously obtained samples may be used to characterize the airborne radioactivity hazard.

When the need for air monitoring is not clear, historical data from fixed-location air sampling and real-time air monitoring should be analyzed to determine whether respiratory protection is appropriate.

CONDUCT OF OPERATIONS

17. Personnel must demonstrate a familiarity level knowledge of DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*, and the principles of conduct of operations, and relate these principles to an operational environment.

[Note: DOE Order 5480.19 was cancelled by DOE O 422.1, *Conduct of Operations,* from which the information for KSAs a, b, and h is taken.]

a. Discuss the purpose of DOE Order 5480.19, *Conduct of Operations Requirements for DOE Facilities*.

The purpose of DOE O 422.1 is to ensure that management systems are designed to anticipate and mitigate the consequences of human fallibility or potential latent conditions and to provide a vital barrier to prevent injury, environmental insult or asset damage, and to promote mission success.

b. State the eighteen chapters in attachment 1 of DOE Order 5480.19, and discuss how each chapter contributes to an effective and safe operational environment.

[Note: Attachment 2 of DOE O 422.1 lists the 18 chapters of DOE Order 5480.19 as “specific requirements” a through r. In section 2, attachment 2, “specific requirements,” of DOE O 422.1, each section references the related DOE technical standard to provide further explanatory material and examples.]

Specific requirement a—Organization and Administration (DOE-STD-1032-92 chg. 1, *Guide to Good Practices for Operations Organization and Administration*)

The operator must establish policies, programs, and procedures that define an effective operations organization, including the following elements:

- Organizational roles, responsibilities, authority, and accountability
- Adequate material and personnel resources to accomplish operations
- Monitoring and self-assessment of operations
- Management and worker accountability for the safe performance of work
- Management training, qualification, succession, and, when appropriate, certification
- Methods for the analysis of hazards and implementation of hazard controls in the work planning and execution process
- Methods for approving, posting, maintaining, and controlling access to electronic operations documents (procedures, drawings, schedules, maintenance actions, etc.) if electronic documents are used

Specific requirement b—Shift Routines and Operating Practices (DOE-STD-1041-93 chg. 1, *Guide to Good Practices for Shift Routines and Operating Practices*)

The operator must establish and implement operations practices to ensure that shift operators are alert, informed of conditions, and operate equipment properly, addressing the following elements:

- The facility status, abnormalities, or difficulties encountered in performing assigned tasks
- Adherence by operating personnel and other workers to established safety requirements
- Awareness by operating personnel of the status of equipment through inspection, conducting checks, and tours of equipment and work areas
- Procedures for completing round sheets or inspection logs, responding to abnormal conditions, and periodic supervisory reviews of round sheets or inspection logs
- Procedures for protecting operators from personnel hazards (e.g., chemical, radiological, laser, noise, electromagnetic, toxic or nano-scale materials)
- Prompt response to instrument indications, including the use of multiple indications to obtain parameters
- Procedures for resetting protective devices
- Authorization to operate facility equipment
- Designating shift operating bases and providing equipment for them
- Professional and disciplined operator performance of duties

Specific requirement c—Control Area Activities (DOE-STD-1042-93 chg. 1, *Guide to Good Practices for Control Area Activities*)

The operator must establish and implement operations practices that promote orderly, business-like control area operations and address the following elements:

- Control-area access
- Formality and discipline in the control and at-the-controls areas
- Surveillance of control panels and timely response to determine and correct the cause of abnormalities/out-of-specification conditions
- Limitation of the number of concurrent evolutions and duties
- Authorization to operate control area equipment

Specific requirement d—Communications (DOE-STD-1031-92 chg. 1, *Guide to Good Practices for Communications*)

The operator must establish and implement operations practices that ensure accurate, unambiguous communications among operations personnel and address the following elements:

- Provision of communications systems for emergency and normal operations
- Administrative control of communications equipment, including authorization to use the public address system and allowable locations and purposes for radio use
- Methods for control areas to contact operators and supervisors
- Use of abbreviations and acronyms
- Use of oral instructions and communications, including use of repeat-backs and sender/receiver identifications

Specific requirement e—On-shift Training (DOE-STD-1040-93 chg. 1, *Guide to Good Practices for Control of On-Shift Training*)

The operator must establish and implement operations practices that control on-shift training of facility operators, prevent inadvertent or incorrect trainee manipulation of equipment, and address the following elements:

- On-shift training program
- Authorization and documentation of training activities
- Supervision and control of personnel under instruction by qualified personnel
- Facility conditions and controls for conducting training during operational activities, including suspension of training during unanticipated or abnormal events

Specific requirement f—Investigation of Abnormal Events, Conditions, and Trends (DOE-STD-1045-93 CN 1, *Guide to Good Practices for Notifications and Investigation of Abnormal Events*)

The operator must establish and implement operations practices for investigating events to determine their impact and prevent recurrence, addressing the following elements:

- Specific events requiring investigation, and criteria for identifying other events or conditions to be investigated
- Designation of investigators and their training and qualification
- Investigation process and techniques
- Causal analysis and corrective action determination
- Event investigation reporting, training, and trending
- Response to known or suspected sabotage

Specific requirement g—Notifications (DOE-STD-1045-93 CN 1, *Guide to Good Practices for Notifications and Investigation of Abnormal Events*)

The operator must establish and implement operations practices to ensure appropriate event notification for timely response, addressing the following elements:

- Procedures for internal, DOE, and external notifications, including events, persons to be notified, persons responsible to make notifications, contact information, and recordkeeping

- Communications equipment for notifications

Specific requirement h—Control of Equipment and System Status (DOE-STD-1039-93 chg. 1, *Guide to Good Practices for Control of Equipment and System Status*)

The operator must establish and implement operations practices for initial equipment lineups and subsequent changes to ensure facilities operate with known, proper configuration as designed, addressing the following elements:

- Authorization for, and awareness of, equipment and system status changes
- Initial system alignment, and maintaining control of equipment and system status through startup, operation, and shutdown, and documentation of status
- Use and approval of lockouts and tagouts for AC of equipment status (see also paragraph 2.i)
- Operational limits compliance and documentation
- Management of equipment deficiencies, maintenance activities, post maintenance testing, and return to service
- Awareness and documentation of control panel and local alarm issues
- Control of temporary equipment modifications and temporary systems
- Configuration control and distribution of engineering documents

Specific requirement i—Lockout and Tagouts (DOE-STD-1030-96, *Guide to Good Practices for Lockouts and Tagouts*)

The operator must establish and implement operations practices that address the following elements for the installation and removal of LO/TO for the protection of personnel:

- Procedures, roles and responsibilities associated with the development, documentation, review, installation, and removal of a LO/TO
- Compliance with OSHA rules, 29 CFR 1910 and/or 29 CFR 1926, requirements for the protection of workers using LO/TO
- Compliance with NFPA standard 70E electrical safety requirements using LO/TO
- Description and control of the tags, locks, lockboxes, chains, and other components utilized for the LO/TO program
- Training and qualification in LO/TO and special considerations for DOE facilities (e.g., operational limitations, or seismic issues from the mass of locks or chains)

The operator must establish and implement operations practices that address the following elements for the installation and removal of caution tags for equipment protection or operational control:

- Roles and responsibilities associated with the development, documentation, review, installation, and removal of caution tags to convey operational information or equipment alignments for protection of equipment
- Description and control of the tags
- Measures to prevent relying on caution tags for personnel protection

Specific requirement j—Independent Verification (DOE-STD-1036-93 chg. 1, *Guide to Good Practices for Independent Verification*)

The operator must establish and implement operations practices to verify that critical equipment configuration is in accordance with controlling documents, addressing the following elements:

- Structures, systems, components, operations, and programs requiring independent verification
- Situations requiring independent verification
- Methods for performing and documenting independent verification
- Situations, if any, allowing concurrent dual verification
- Methods for performing concurrent dual verification, if used

Specific requirement k—Logkeeping (DOE-STD-1035-93 chg. 1, *Guide to Good Practices for Logkeeping*)

The operator must establish and implement operations practices to ensure thorough, accurate, and timely recording of equipment information for performance analysis and trend detection, addressing the following elements:

- Narrative logs at all key positions, as defined by management, for the recording of pertinent information
- Prompt and accurate recording of information
- Type, scope, and format for log entries
- Method for recording late entries and correcting erroneous entries without obscuring the original entry
- Periodic supervisory reviews for accuracy, adequacy, and trends
- Document retention requirements

Specific requirement l—Turnover and Assumption of Responsibilities (DOE-STD-1038-93 chg. 1, *Guide to Good Practices for Operations Turnover*)

The operator must establish and implement operations practices for thorough, accurate transfer of information and responsibilities at shift or operator relief to ensure continued safe operation, addressing the following elements:

- Definitions for all key positions requiring a formal turnover process
- Turnover of equipment/facility status, duties, and responsibilities that results in the safe and effective transfer of equipment status and in-progress or planned activities from one shift or workgroup to the next
- Process for reliefs during a shift

Specific requirement m—Control of Interrelated Processes (DOE-STD-1037-93 chg. 1, *Guide to Good Practices for Operations Aspects of Unique Processes*)

The operator must establish and implement operations practices to ensure that interrelated processes do not adversely affect facility safety or operations, addressing the following elements:

- Defined responsibilities with respect to the control of interrelated processes (processes or activities that can affect operations, but are under the control of persons other than the affected operators, such as shared support systems or special testing)
- Operator training and qualification to understand interrelated processes, to interpret instrument readings, and provide timely corrective action for process-related problems
- Established lines of communication between operating personnel, process support personnel, and other interrelated process operators for coordination of activities

Specific requirement n—Required Reading (DOE-STD-1033-92 chg. 1, *Guide to Good Practices for Operations and Administration Updates Through Required Reading*)

The operator must establish and implement operations practices for an effective required reading program to keep operators updated on equipment or document changes, lessons learned, or other important information, addressing the following elements:

- Identification of material to be distributed via required reading
- Identification of which personnel are required to read specific required reading items
- Distribution of required reading to appropriate personnel and documentation of their timely completion

Specific requirement o—Timely Instructions/Orders (DOE-STD-1034-93 chg. 1, *Guide to Good Practices for Timely Orders to Operators*)

The operator must establish and implement operations practices for timely written direction and guidance from management to operators, addressing the following elements:

- Appropriate circumstances for the use of timely instructions/orders
- Designated levels of review and approval prior to issuance
- Configuration control of timely instructions/orders
- Distribution of timely instructions/orders to appropriate personnel and documentation of their receipt and understanding

Specific requirement p—Technical Procedures (DOE-STD-1029-92 chg. 1, *Writer's Guide for Technical Procedures*)

The operator must establish and implement operations practices for developing and maintaining accurate, understandable written technical procedures that ensure safe and effective facility and equipment operation, addressing the following elements:

- Expectations for the use of procedures to perform operations
- A process for procedure development
- Procedure content, including consistent format and use of terms (e.g., prerequisites, warnings, cautions, notes, hold points, etc.), sufficient for accomplishing the operation; technically accurate procedures capable of performance as written; and procedure conformance with the facility design and manufacturer documentation
- A process for procedure changes (pen and ink or page changes) and revisions (complete reissues)
- A process for training personnel on new, revised, or changed procedures
- A process for approval of new, revised, or changed procedures
- Initial-issue and periodic review and testing of procedures

- Availability and use of the latest revisions of procedures
- Specified and defined procedure use requirements (i.e., reader-worker method, reference use only, use-each-time, and emergency response)

Specific requirement q—Operator Aids (DOE-STD-1043-93 chg. 1, *Guide to Good Practices for Operator Aid Postings*)

The operator must establish and implement operations practices to provide accurate, current, and approved operator aids, addressing the following elements:

- Technical evaluation and management approval of operator aids
- Operator aids serving as conveniences, not operational requirements
- Operator aids not obscuring equipment
- Administrative control of installed operational aids
- Periodic review for adequacy and correctness

Specific requirement r—Component Labeling (DOE-STD-1044-93 chg. 1, *Guide to Good Practices for Equipment and Piping Labeling*)

The operator must establish and implement operations practices for clear, accurate equipment labeling, addressing the following elements:

- Components that require a label
- Label information that uniquely identifies components and is consistent with regulations, standards, and facility documents
- Durable and securely attached labels that do not interfere with controls or equipment
- Administrative control of labels, including a process for promptly identifying and replacing lost or damaged labels, preventing unauthorized or incorrect labels, and control of temporary labels

c. Discuss how each of the following Orders contributes to a proper conduct of operations environment:

- **DOE O 231.1A, *Environment, Safety, and Health Reporting***

  [Note: DOE O 231.1A was cancelled by DOE O 231.1B.]
- **DOE O 433.1A, *Maintenance Management Program for DOE Nuclear Facilities***

  [Note: DOE O 433.1A was canceled by DOE O 433.1B.]
- **DOE O 414.1C, *Quality Assurance***

  [Note: DOE O 414.1C was canceled by DOE O 414.1D.]

DOE O 231.1B, Environment, Safety, and Health Reporting

The purpose of DOE O 231.1B is to ensure DOE, including NNSA, receives timely and accurate information about events that have affected or could adversely affect the health, safety and security of the public or workers, the environment, the operations of DOE facilities, or the credibility of the Department.

Paragraph two of the Purpose section of DOE O 422.1 states that the purpose of the Order is to ensure that management systems are designed to anticipate and mitigate the consequences of human fallibility or potential latent conditions and to provide a vital barrier to prevent injury, environmental insult or asset damage, and to promote mission success.

DOE O 433.1B, Maintenance Management Program for DOE Nuclear Facilities

The purpose of DOE O 433.1B is to define the safety management program required by 10 CFR 830.204(b)(5) for maintenance and the reliable performance of structures, systems, and components (SSCs) that are part of the safety basis required by 10 CFR 830.202 at hazard category 1, 2 and 3 DOE nuclear facilities.

Specific requirement h of DOE O 422.1 states that the operator must establish and implement operations practices for initial equipment lineups and subsequent changes to ensure facilities operate with known, proper configuration as designed, addressing…management of equipment deficiencies, maintenance activities, post-maintenance testing, and return to service… Specific requirement h also requires

- restoration of safety-related systems following maintenance includes functional testing of their capability;
- designated managers authorize in writing the work control documents for all activities, including maintenance on equipment important to safety, on equipment that affects operations, or that changes control indications or alarms;
- work control documents specify re-test requirements to ensure, prior to restoration to service, proper functioning, effectiveness of the maintenance, and that no new problems were introduced; and
- supervisors ensure themselves of proper equipment operation before authorizing its return to service after maintenance, testing, or emergency/abnormal event.

DOE O 414.1D, Quality Assurance

The purpose of DOE O 414.1 is to

- ensure that DOE, including NNSA, products and services meet or exceed customers' requirements and expectations;
- achieve quality for all work; and
- establish additional process-specific quality requirements to be implemented under a QAP for the control of suspect/counterfeit items (S/CI), and nuclear safety software as defined in DOE O 422.1.

Specific requirement a(3) of DOE O 422.1 requires that appropriate outside organizations such as QA or other oversight organizations observe operations and provide feedback.

The information for KSAs d through f is taken from Oak Ridge Associated Universities Conduct of Operations Training Course.

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

The purpose of a critique is to assemble all of the facts about an event or operation. It is not to assign blame or be used as a basis to administer disciplinary action against an involved employee. The principles and elements of a good critique process are summarized as follows:

- Initial categorization and notification using DOE O 232.2 *Occurrence Reporting and Processing of Operations Information*, is made before or concurrently with the critique meeting. Critique meetings, with few exceptions, should be held as soon as the situation is stable.

- A leader, who is trained in proper critique methods, is assigned. It may be necessary to assign a leader who was not involved in the event to prevent prejudice or inappropriate influence of the outcome.
- Before a critique convenes, the leader determines if personal statements are necessary. If so, statements will be obtained. The statements are preferably prepared before the critique meeting starts and before personnel can discuss the event (collaboration can greatly reduce the value of statements).
- Both 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 important to be able to repeat the success and to find ways of improving upon the success at the same time.
- Formal critique minutes are prepared and serve as the record of what happened for simple events, and the foundation for any subsequent investigation, if warranted, for more complex events. Critique minutes facilitate the assignment of corrective action responsibility and provide the basis from which root cause and recurrence control can be determined. Completed personal statements are attached to the meeting minutes.

e. Define the term "root cause" and explain its importance in operational safety.

Root cause is defined as those causal factors that, if corrected, would preclude recurrence of the event.

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 both 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.

f. Define the term "lessons learned" and explain their importance in operational safety.

The term "lessons learned" refers to information taken from DOE and industry operating experience, which is used to improve operations and safety.

Lessons learned contribute to operational safety by preventing future similar events from occurring, improving techniques for performing operations such that a risk reduction occurs, and improving management control systems that affect safety.

g. Describe stop work authority and the role of personnel in its application.

The following is taken from DOE G 440.1-1B.

Any stop work authority should be exercised in a justifiable and responsible manner. All workers, supervisors, managers, and occupational safety and health professionals are responsible for being cognizant of the conditions in their workplaces and for being prepared to stop work when these conditions pose an imminent danger of death or serious physical harm. When a reasonable person views the circumstances as imminent danger of death or serious physical harm, a stop work order should be issued.

Before a stop work order is issued, the person issuing it should ensure that the work stoppage itself would not negatively impact the safety and health of workers. Contractors should have procedures in place that address stop work authority, and workers should be trained to those procedures.

h. Describe the key elements of a lockout/tagout system.

Protection of Personnel

The operator must establish and implement operations practices that address the following elements for the installation and removal of LO/TO:

- Procedures, roles, and responsibilities associated with the development, documentation, review, installation, and removal of a LO/TO
- Compliance with OSHA rules, 29 CFR 1910, and/or 29 CFR 1926 requirements for the protection of workers using LO/TO
- Compliance with NFPA standard 70E electrical safety requirements using LO/TO
- Description and control of the tags, locks, lockboxes, chains, and other components utilized for the LO/TO
- Training and qualification in LO/TO and special considerations for DOE facilities (e.g., operational limitations, or seismic issues) from the mass of locks or chains

18. Personnel must demonstrate a familiarity level knowledge of DOE O 231.1A, *Environment, Safety, and Health Reporting*, and DOE M 231.1-2, *Occurrence Reporting and Processing of Operations Information*.

[Note: DOE O 231.1A and DOE M 231.1-2 were cancelled by DOE O 232.2, *from which the information for all of the KSAs in this competency statement is taken*.]

a. State the purpose of DOE O 231.1A, *Environment, Safety and Health Reporting*.

The purpose of DOE O 232.2 is to

- ensure that DOE and NNSA are informed about events that could adversely affect the health and safety of the public or the workers, the environment, DOE missions, or the credibility of the Department; and
- promote organizational learning consistent with DOE's ISMS goal of enhancing mission safety, and sharing effective practices to support continuous improvement and adaptation to change.

b. Define the following terms:

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

Event

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

Condition

A condition is any as-found state, whether or not resulting from an event, that may have adverse safety, health, QA, 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

A facility is 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 un-irradiated components.

Notification Report

A notification report is the initial documented report to the Department of an event or condition that meets the reporting criteria defined in DOE O 232.2.

Occurrence Report

An occurrence report is a documented evaluation of a reportable occurrence 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.

Reportable Occurrence

A reportable occurrence is an occurrence to be reported in accordance with the criteria defined in DOE O 232.2.

Facility Representative (FR)

For each major facility or group of lesser facilities, an FR is an individual or designee assigned responsibility by the head of field element/operations organization (including NNSA) for monitoring the performance of the facility and its operations. This individual should be the primary point of contact with the facility operating personnel and will be responsible to the appropriate Secretarial Officer/Deputy Administrator (NNSA) and head of field element/operations organization for implementing the requirements of DOE O 232.2.

c. Discuss the occurrence-reporting responsibilities of a facility representative.

In addition to other requirements prescribed in DOE O 232.2, FRs or designee, or selected line management staff if an FR is not assigned, are responsible for the following:

- Evaluate facility implementation of the notification and reporting process to ensure it is compatible with and meets the requirements of DOE O 232.2
- Ensure that occurrences that may have generic or programmatic implications are identified and elevated to the head of the field element for appropriate action

- Review and assess reportable occurrence information from facilities under their cognizance to determine the 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
- Elevate any unresolved issues regarding actions or determinations on a reportable occurrence to the program manager for resolution and direction

d. State the different categories of reportable occurrences and discuss each.

The categories are

- Operational emergency
- Significance category 1
- Significance category 2
- Significance category 3
- Significance category 4
- Significance category R

Operational Emergencies (OEs)

Operational emergencies are major unplanned or abnormal events or conditions that: involve or affect DOE/NNSA facilities and activities by causing, or having the potential to cause, serious health and safety or environmental impacts; require resources from outside the immediate/affected area or local event scene to supplement the initial response; and, require time-urgent notifications to initiate response activities at locations beyond the event scene. Operational emergencies are the most serious occurrences and require an increased alert status for onsite personnel and, in specified cases, for offsite authorities.

Significance Category 1

These occurrences are non-OE events that caused actual harm; posed the potential for immediate harm or mission interruption due to safety system failure and required prompt mitigative action; or constituted an egregious noncompliance with regulatory requirements that created the potential for actual harm or mission interruption.

Significance Category 2

This category comprises circumstances that reflected degraded safety margins—necessitating prompt management attention along with modified normal operations—to prevent an adverse effect on safe facility operations; worker or public safety and health, including significant personnel injuries; regulatory compliance; or public/business interests.

Significance Category 3

Significance category 3 includes events or circumstances with localized implications including personnel injury, environmental releases, equipment damage, or hazardous circumstances that were locally contained and did not immediately suggest broader systemic concerns.

Significance Category 4

Significance category 4 occurrences are events or circumstances that were mitigated or contained by normal operating practices, but where reporting provides potential learning opportunities for others.

Significance Category R

Significance category R occurrences are those identified as recurring, either directly or through periodic analysis of occurrences and other non-reportable events.

e. State the major criteria groups of categorized occurrences and discuss each.

Major Criteria Groups

The 10 major groups of categorized occurrences are as follows:

- Group 1—Operational emergencies
- Group 2—Personnel safety and health
- Group 3—Nuclear safety basis
- Group 4—Facility status
- Group 5—Environmental
- Group 6—Contamination/radiation control
- Group 7—Nuclear explosive safety
- Group 8—Packaging and transportation
- Group 9—Noncompliance notifications
- Group 10—Management concerns/issues

Group 1—Operational Emergencies

- An operational emergency not requiring classification
- An alert
- A site area emergency
- A general emergency

Group 2—Personnel Safety and Health

- Subgroup A—Occupational injuries
- Subgroup B—Occupational exposure
- Subgroup C—Fires
- Subgroup D—Explosions
- Subgroup E—Hazardous electrical energy control
- Subgroup F—Hazardous energy control (other than electrical)

Group 3—Nuclear Safety Basis

- Subgroup A—Technical safety requirement (TSR) and other hazard control violations (excluding nuclear criticality
- Subgroup B—Documented safety analysis (DSA) inadequacies
- Subgroup C—Nuclear criticality safety control violations

Group 4—Facility Status

- Subgroup A—Safety SSC degradation (nuclear facilities)
- Subgroup B—Operations

- Subgroup C—S/CI and defective items or material

Group 5—Environmental

- Subgroup A—Releases
- Subgroup B—Ecological and cultural resources

Group 6—Contamination/Radiation Control

- Subgroup A—Loss of control of radioactive materials
- Subgroup B—Spread of radioactive contamination
- Subgroup C—Radiation exposure
- Subgroup D—Personnel contamination

Group 7—Nuclear Explosive Safety

- Damage to a nuclear explosive that results in a credible threat to nuclear explosive safety
- A near miss event during nuclear explosive operations where the potential for significant consequences was substantially increased
- An event during nuclear explosive operations that resulted in an adverse effect on safety

Group 8—Packaging and Transportation

- Any offsite transportation incident involving hazardous materials that would require immediate notice pursuant to 49 CFR 171.15(b)
- Any deviation that would require a written report to the NRC or to DOE headquarter certifying official (HCO)/NNSA CO
- Any offsite transportation of hazardous material, including radioactive material, whose quantity or nature (e.g., physical or chemical composition) is such that it is noncompliant with the receiving facilities waste acceptance criteria or other receipt requirements and the receiving organization's operations were significantly impacted or disrupted
- Any transportation activity for onsite transfer resulting in onsite release of radioactive materials, hazardous materials, hazardous substances, hazardous waste, or marine pollutants that is above permitted levels and exceeds the reportable quantities specified in 40 CFR 302 or 40 CFR 355
- Violation of applicable hazardous materials regulations requirements for activities listed in 49 CFR 171.1(b) performed during the preparation of offsite hazardous materials shipments and discovered during shipment in commerce or at the receiving site
- Any onsite transfer of hazardous material, including radioactive material, whose quantity or nature (e.g., physical or chemical composition) is such that it is noncompliant with the receiving facilities waste acceptance criteria or other receipt requirements and the receiving organization's operations were significantly impacted or disrupted (e.g., material cannot be accepted, possessed, or stored at that facility; must be treated or repackaged to be accepted; or exceeds a license or permit limit)
- Unauthorized deviation from DOE instructions to commercial motor carriers for DOE hazardous materials shipments (e.g., designated route, prohibited route, designated time of the day)

Group 9—Noncompliance Notifications

- Any written notification from an outside regulatory agency that a site/facility is considered to be in noncompliance with a schedule or requirement
- Any packaging or transportation violation of regulations discovered by the Department of Transportation (DOT) during onsite inspections or compliance reviews that results in fines greater than $5,000 or unsatisfactory/conditional satisfactory ratings

Group 10—Management Concerns and Issues

- Any event resulting in the initiation of a Federal accident investigation board (AIB), as categorized by DOE O 225.1B, *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 to an otherwise occurrence reporting and processing system reportable event, where something physically happened that was unexpected or unintended, or where no or only one barrier prevented an event from having a reportable consequence
- Any occurrence that may result in a significant concern by affected state, tribal, or local officials, press, or general population; that could damage the credibility of the Department; or that may result in inquiries to headquarters (HQ)
- Any occurrence of such significant immediate interest to offsite personnel and organizations that it warrants prompt notification to the DOE HCO, and which is not already designated elsewhere in this set of reporting criteria to have prompt notification (denoted by having an asterisk (*) next to the significance category)

19. Personnel must demonstrate a familiarity level knowledge of 10 CFR 830 Subpart A, "Quality Assurance," and DOE O 414.1C, *Quality Assurance*.

[Note: DOE O 414.1C was cancelled by DOE O 414.1D.]

a. Discuss the objectives and applicability of the DOE quality requirements, including the relationship between 10 CFR 830 Subpart A and DOE O 414.1C, and the relationship between DOE quality requirements and American National Standard ASME NQA-1 for nuclear facility applications.

The following is taken from DOE O 414.1D.

Objectives (Purpose)

The purpose of DOE O 414.1D:

- Ensure DOE and NNSA products and services meet or exceed customers' requirements and expectations.
- Achieve quality for all work based upon the following principles:
  - All work, as defined in DOE O 414.1D, is conducted through an integrated and effective management system.
  - Management support for planning, organization, resources, direction, and control is essential to QA.

    - Performance and quality improvement require thorough, rigorous assessments and effective corrective actions.
    - All personnel are responsible for achieving and maintaining quality.
    - Risks and adverse mission impacts associated with work processes are minimized while maximizing reliability and performance of work products.
- Establish additional process-specific quality requirements to be implemented under a QAP for the control of S/CIs, and nuclear safety software as defined in DOE 414.1D.

Applicability

Departmental Applicability

Except for the equivalencies and exemptions in DOE O 414.1D, paragraph 3.c., DOE O 414.1D applies to all work conducted by or for DOE, including work for nuclear and non-nuclear facilities.

Contractors

Except for the equivalencies and exemptions in paragraph 3.c. of DOE O 414.1D, the contractor requirements document (CRD) sets forth requirements of DOE O 414.1D that will apply to contracts that include the CRD.

Relationship to 10 CFR 830

When the contractor conducts activities or provides items or services that affect or may affect the safety of DOE (including NNSA) nuclear facilities, it must conduct work in accordance with the QA requirements of 10 CFR 830, subpart A, and the additional requirements of the DOE O 414.1D CRD, unless the work falls within one or more of the exclusions found in 10 CFR 830.2.

Relationship to ASME NQA-1

Each departmental element and associated field element(s) must identify and assign a senior manager to have responsibility, authority, and accountability to ensure the development, implementation, assessment, maintenance, and improvement of the QAP. Using a graded approach, the organization must develop a QAP and implement the approved QAP. The QAP must use appropriate national or international consensus standards in whole or in part, consistent with regulatory requirements and secretarial officer (SO) direction. When standards do not fully address these requirements, the gaps must be addressed in the QAP. An example of a currently acceptable standard is ASME NQA-1-2008 with the NQA-1a-2009 addenda, *Quality Assurance Requirements for Nuclear Facility Applications.*

b. Discuss 10 CFR 830.4, “General Requirements”; 10 CFR 830, Subpart A, “Quality Assurance Requirements”; and DOE O 414.1C, “Requirements”; including the Federal responsibilities and applicability of the requirements to DOE and its contractors.

10 CFR 830.4, “General Requirements”

- No person may take or cause to be taken any action inconsistent with the requirements of this part.
- A contractor responsible for a nuclear facility must ensure implementation of, and compliance with, the requirements of this part.

- The requirements of this part must be implemented in a manner that provides reasonable assurance of adequate protection of workers, the public, and the environment from adverse consequences, taking into account the work to be performed and the associated hazards.
- If there is no contractor for a DOE nuclear facility, DOE must ensure implementation of, and compliance with, the requirements of this part.

10 CFR 830, Subpart A, "Quality Assurance Requirements"

Contractors conducting activities, including providing items or services, that affect, or may affect, the nuclear safety of DOE nuclear facilities must conduct work in accordance with the QA criteria in 10 CFR 830.122, "Quality Assurance Criteria."

The contractor responsible for a DOE nuclear facility must do the following:

- Submit a QAP to DOE for approval and regard the QAP as approved 90 days after submittal, unless it is approved or rejected by DOE at an earlier date.
- Modify the QAP as directed by DOE.
- Annually submit any changes to the DOE-approved QAP to DOE for approval. Justify in the submittal why the changes continue to satisfy the QA requirements.
- Conduct work in accordance with the QAP.

The QAP must do the following:

- Describe how the QA criteria of 10 CFR 830.122 are satisfied.
- Integrate the QA criteria with the SMS, or describe how the QA criteria apply to the SMS.
- Use voluntary consensus standards in its development and implementation, where practicable and consistent with contractual and regulatory requirements, and identify the standards used.
- Describe how the contractor responsible for the nuclear facility ensures that subcontractors and suppliers satisfy the criteria of 10 CFR 830.122.

DOE O 414.1D Requirements

Quality Assurance Program Development and Implementation

Each departmental element and associated field element(s) must identify and assign a senior manager to have responsibility, authority, and accountability to ensure the development, implementation, assessment, maintenance, and improvement of the QAP. Using a graded approach, the organization must develop a QAP and implement the approved QAP. The QAP must do the following:

- Describe the graded approach used in the QAP.
- Implement QA criteria as defined in DOE O 414.1D, attachment 2, as well as the requirements in DOE O 414.1D, attachment 3 for all facilities, and for nuclear facilities, the requirements in DOE O 414.1D, attachment 4.
    - Describe how the criteria/requirements are met, using the documented graded approach.
    - Flow down the applicable QA requirements and responsibilities throughout all levels of the organization.

- Use appropriate national or international consensus standards in whole or in part, consistent with regulatory requirements and SO direction. When standards do not fully address these requirements, the gaps must be addressed in the QAP.
- Clearly identify which standards, or parts of the standards, are used.

Quality Assurance Program Approval and Changes

Each departmental element and associated field element(s) must do the following:

- Submit a QAP to the designated DOE approval authority.
- Review the QAP annually, or on a periodic basis defined in the QAP, and update the QAP, as needed. Submit a summary of the review of the QAP and, if necessary, also submit the modified QAP to the DOE approval authority. Editorial changes to the QAP, that do not reduce or change commitments, do not require approval.
- Regard the QAP as approved 90 calendar days after receipt by the approval authority, unless approved or rejected at an earlier date.

Federal Technical Capability and Qualifications

Qualification for the functional areas identified in DOE O 414.1D, paragraphs 4.c.(1) and (2) are achieved as defined in the latest version of DOE O 426.1, *Federal Technical Capability*.

- Federal personnel directly responsible for the oversight of quality requirements governing defense nuclear facilities must be qualified in accordance with DOE-STD-1150-2002, *Quality Assurance Functional Area Qualification Standard* (or latest version).
- Federal personnel directly responsible for oversight of safety software QA activities of defense nuclear facilities must be qualified in accordance with DOE STD-1172-2003, *Safety Software Quality Assurance Functional Area Qualification Standard* (or latest version).

c. Describe, in general terms, the content and objectives of the quality assurance criteria in the following categories, as found in DOE O 414.1C:

- **Management**
- **Performance**
- **Assessment**

[Note: DOE O 414.1C was cancelled by DOE O 414.1D. DOE O 414.1D, from which the following is taken, lists the ten QA criteria individually, rather than in sections. The three major categories are now included in the criterion titles as shown below.]

Management

Criterion 1—Management/Program

- Establish an organizational structure, functional responsibilities, levels of authority, and interfaces for those managing, performing, and assessing the work.
- Establish management processes, including planning, scheduling, and providing resources for the work.

Criterion 2—Management/Personnel Training and Qualification

- Train and qualify personnel to be capable of performing their assigned work.
- Provide continuing training to personnel to maintain their job proficiency.

Criterion 3—Management/Quality Improvement

- Establish and implement processes to detect and prevent quality problems.
- Identify, control, and correct items, services, and processes that do not meet established requirements.
- Identify the causes of problems, and include prevention of recurrence as a part of corrective action planning.
- Review item characteristics, process implementation, and other quality-related information to identify items, services, and processes needing improvement.

Criterion 4—Management/Documents and Records

- Prepare, review, approve, issue, use, and revise documents to prescribe processes, specify requirements, or establish design.
- Specify, prepare, review, approve, and maintain records.

Performance

Criterion 5—Performance/Work Processes

- Perform work consistent with technical standards, ACs, and other hazard controls adopted to meet regulatory or contract requirements using approved instructions, procedures, or other appropriate means.
- Identify and control items to ensure proper use.
- Maintain items to prevent damage, loss, or deterioration.
- Calibrate and maintain equipment used for process monitoring or data collection.

Criterion 6—Performance/Design

- Design items and processes using sound engineering/scientific principles and appropriate standards.
- Incorporate applicable requirements and design bases in design work and design changes.
- Identify and control design interfaces.
- Verify or validate the adequacy of design products using individuals or groups other than those who performed the work.
- Verify or validate work before approval and implementation of the design.

Criterion 7—Performance/Procurement

- Procure items and services that meet established requirements and perform as specified.
- Evaluate and select prospective suppliers on the basis of specified criteria.
- Establish and implement processes to ensure that approved suppliers continue to provide acceptable items and services.

Criterion 8—Performance/Inspection and Acceptance Testing

- Inspect and test specified items, services, and processes using established acceptance and performance criteria.
- Calibrate and maintain equipment used for inspections and tests.

Assessment

Criterion 9—Assessment/Management Assessment

Ensure that managers assess their management processes and identify and correct problems that hinder the organization from achieving its objectives.

Criterion 10—Assessment/Independent Assessment

- Plan and conduct independent assessments to measure item and service quality, to measure the adequacy of work performance, and to promote improvement.
- Establish sufficient authority and freedom from line management for independent assessment teams.
- Ensure persons who perform independent assessments are technically qualified and knowledgeable in the areas to be assessed.

d. Discuss the quality requirements in the following attachments (and their supporting implementing guides) of DOE O 414.1C, how the quality requirements become nuclear safety requirements for contractors, and how they apply to Federal organizations:

- **Attachment 3, *Suspect/Counterfeit Items Prevention*, and the supporting guide, DOE G 414.1-3**

  [Note: DOE G 414.1-3 was cancelled by DOE G 414.1-2B chg. 1.]
- **Attachment 4, *Corrective Action Management Program*, and the supporting guide, DOE G 414.1-5**

  [Note: DOE O 414.1C was cancelled by DOE O 414.1D, which no longer contains an attachment that specifically addresses a corrective action management program. DOE G 414.1-5 was cancelled by DOE G 414.1-2B chg. 1.]
- **Attachment 5, *Safety Software Quality Requirements*, and the supporting guide, DOE G 414.1-4, *Safety Software Guide for Use with 10 CFR 830 Subpart A, Quality Assurance Requirements and DOE O 414.1C, Quality Assurance.***

  [Note: "Safety Software Quality Assurance Requirements for Nuclear Facilities" is now attachment 4 to DOE O 414.1D.]

Quality Requirements

Suspect/Counterfeit Item Prevention

The following is taken from DOE O 414.1D.

Attachment 3—Suspect/Counterfeit Items Prevention, states that the organization's QAP must do the following:

- Include an S/CI oversight and prevention process commensurate with the facility/activity hazards and mission impact.
- Identify the position responsible for S/CI activities and for serving as a point of contact with the Office of Health, Safety, and Security.
- Provide for training and informing managers, supervisors, and workers on S/CI processes and controls.
- Prevent introduction of S/CIs into DOE work by
  - engineering involvement in the development of procurement specifications; during inspection and testing; and when maintaining, replacing, or modifying equipment;

- identifying and placing technical and QA requirements in procurement specifications;
  - accepting only those items that comply with procurement specifications, consensus standards, and commonly accepted industry practices; and
  - inspecting inventory and storage areas to identify, control, and disposition for S/CIs.

- Include processes for inspection, identification, evaluation, and disposition of S/CIs that have been installed in safety applications and other applications that create potential hazards. Also address the use of supporting engineering evaluations for acceptance of installed S/CI as well as marking to prevent future reuse.
- Conduct engineering evaluations to be used in the disposition of identified S/CIs installed in safety applications/systems or in applications that create potential hazards. Evaluations must consider potential risks to the environment, the public and workers along with a cost/benefit impact, and a schedule for replacement (if required).
- Perform the evaluation to determine whether S/CIs installed in non-safety applications pose potential safety hazards or may remain in place. Disposition S/CIs identified during routine maintenance and/or inspections to prevent future use in these applications.
- Report to the DOE Inspector General per DOE O 414.1D, paragraph 3, and DOE O 221.1A, *Reporting Fraud, Waste, and Abuse to the Office of Inspector General*, dated 03-22-01 (or latest version).
- Collect, maintain, disseminate, and use the most accurate, up to date information on S/CIs and suppliers.
- Conduct trend analyses for use in improving the S/CI prevention process.

The following is taken from DOE G 414.1-2B chg. 1.

Section 5.0—Guidance on S/CIs, states that organizations, as part of their QAPs, should establish effective controls and processes that will 1) ensure items and services meet specified requirements; 2) prevent entry of S/CI(s) into the DOE supply chain; and 3) ensure detection, control, reporting, and disposition of S/CI(s). Section 5.0 also provides guidance for documenting and implementing an effective S/CI process that will meet the DOE O 414.1D requirements for S/CI.

- Ensure that items intended for application in safety systems and mission critical facilities comply with design and procurement documents.
- Maintain current, accurate information on S/CIs and associated suppliers using all available sources within the government and industry and disseminate relevant information on S/CIs to field organizations and contractors.
- Identify, control, and dispose of S/CIs that create potential hazards in safety systems and applications.
- Report discoveries of and disseminate information about S/CIs to field organizations, contractors, and government agencies.
- Train and inform managers, supervisors, and workers of S/CI controls and indicators, including prevention, detection, and disposition of S/CIs.

These controls should also include obtaining contractual remedies from suppliers of S/CIs.

Corrective Action Requirements

The following is taken from DOE O 414.1D.

Corrective actions are defined as measures taken to rectify conditions adverse to quality and, where necessary, to preclude repetition.

One of the purposes of DOE O 414.1D requires DOE and contractors "to achieve quality for all work based upon the following principles," one of which is "performance and quality improvement require thorough, rigorous assessments and effective corrective actions." Also, QA criterion 3—Management/Quality Improvement, requires DOE and contractors to identify the causes of problems, and include prevention of recurrence as a part of corrective action planning.

The following is taken from DOE G 414.1-2B chg. 1.

Section 4.3.2.3—Corrective Action/Resolution of Problems Affecting Quality, states that the identification and reporting process should be documented and include a standard categorization of problem findings based on significance, criticality, severity, and potential impact on the safety, security, and mission of the site/organization. A corrective action/resolution process should consist of the appropriate steps, such as (the list is neither all inclusive nor limited to) the following:

- Identifying a condition adverse to quality, and/or significant condition adverse to quality
- Taking appropriate actions as required to mitigate, stabilize and/or prevent further progression of unsafe conditions or conditions adverse to quality
- Documenting the condition adverse to quality and/or significant condition adverse to quality
- Evaluating its significance and extent
- Analyzing the problem and determining its causes
- Reporting the planned actions to the organization identifying the problem
- Assigning responsibility for correcting the problem
- Taking prompt corrective (remedial) action and documenting that action
- Training or retraining personnel as appropriate
- Taking steps to prevent recurrence
- Verifying implementation
- Documenting closure
- Determining effectiveness of the corrective and preventive actions for significant problems
- Tracking and trending conditions adverse to quality as appropriate
- Communicating lessons learned as appropriate

Safety Software Quality Requirements

The following is taken from DOE O 414.1D

Attachment 4—Safety Software Quality Assurance Requirements for Nuclear Facilities, states that management of safety software must include the following elements:

- Involve the facility design authority, as applicable, in: the identification of requirements specification; acquisition; design; development; verification and validation; configuration management; maintenance; and retirement.
- Identify, document, control, and maintain safety software inventory. The inventory entries must include at a minimum the following: software description; software name; version identifier; safety software designation; grade level designation; specific nuclear facility application used; and the responsible individual.
- Establish and document grading levels for safety software using the graded approach.
- Using the consensus standard selected and the grading levels established and approved above, select and implement applicable safety software QA work activities from the list below:
  - Software project management and quality planning
  - Software risk management
  - Software configuration management
  - Procurement and supplier management
  - Software requirements identification and management
  - Software design and implementation
  - Software safety analysis and safety design methods
  - Software verification and validation
  - Problem reporting and corrective action
  - Training of personnel in the design, development, use, and evaluation of safety software

The following is taken from DOE G 414.1-4.

The Department's objectives for safety software requirements include the following:

- Grading software QA requirements based on risk, safety, facility life-cycle, complexity, and project quality requirements
- Applying software QA requirements to software life-cycle phases
- Developing procurement controls for acquisition of computer software and hardware that are provided with supplier-developed software and/or firmware
- Documenting and tracking customer requirements
- Managing software configuration throughout the life-cycle phases
- Performing verification and validation processes
- Performing reviews of software configuration items, including reviewing the safety implications identified in the failure analysis and fault tolerance design
- Training personnel who use and apply software in safety applications

The scope of DOE G 414.1-4 includes software applications that meet safety software definitions as stated in DOE O 414.1D. This includes software applications important to safety that may be included or associated with SSCs for less than hazard category 3 facilities. Safety software includes safety system software, safety and hazard analysis software and design software, and safety management and AC software.

Although DOE G 414.1-4 has been developed for DOE nuclear facility software, it may also be useful for ensuring the quality of other software important to mission critical functions, environmental protection, health and safety protection, safeguards and security (S&S), emergency management, or assets protection.

The following is taken from DOE O 414.1D.

How Quality Requirements Become Nuclear Safety Requirements for Contractors

When the contractor conducts activities or provides items or services that affect or may affect the safety of DOE (NNSA) nuclear facilities, it must conduct work in accordance with the QA requirements of 10 CFR 830, subpart A and the additional requirements of the DOE O 414.1D CRD, unless the work falls within one or more of the exclusions found in 10 CFR 830.2.

Applicability of QA requirements to Federal Organizations

Each departmental element and associated field element(s) must identify and assign a senior manager to have responsibility, authority, and accountability to ensure the development, implementation, assessment, maintenance, and improvement of the QAP. Using a graded approach, the organization must develop a QAP and implement the approved QAP.

e. Describe the Federal responsibilities for review, approval, and oversight of contractor quality assurance programs developed under 10 CFR 830 and DOE O 414.1C.

The following is taken from DOE O 414.1D.

Secretarial Officers

- Secretarial officers, other than the NNSA, act as the approval authority or delegate such authority, as appropriate, for QAPs within the SO's organization, and the DOE field elements and contractors within the purview of that secretarial office. The NNSA SOs act as the approval authority for QAPs within the SO's organization.
- Secretarial officers, other than NNSA, ensure review and approval of new or revised QAPs for
  - field elements under their purview; and
  - contractors within the purview of the secretarial office, if approval authority is not delegated.
- Ensure the QAPs are reviewed, and either rejected or approved within 90 calendar days of receipt. Requests for review/approval that are not approved or rejected within 90 calendar days from receipt will be deemed approved.

Field Element Managers

- Field element managers of sites, other than NNSA sites, where approval authority is delegated to the FEM, review and approve any new or revised QAPs for work under the FEM's purview. Where authority is not delegated to the FEM, review, comment on, and submit the QAPs to the SO for approval.
- Field element managers of NNSA sites, review and approve any new or revised QAPs for work under the FEM's purview, including the FEM and contractor QAPs.

20. Personnel must demonstrate a familiarity level knowledge of DOE O 151.1C, *Comprehensive Emergency Management System*, and its implementing guides.

The information for each of the regulations and directives listed in CS-20a is taken from that regulation or directive.

a. Describe the relevant requirements, purpose, interrelationships and importance of the following regulations and directives:

- **10 CFR 830, "Nuclear Safety Management"**
- **29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response"**
- **DOE O 151.1C, *Comprehensive Emergency Management System***
- **DOE G 151.1-1A, *Emergency Management Fundamentals and the Operational Emergency Base Program: Emergency Management Guide***
- **DOE G 151.1-2, *Technical Planning Basis: Emergency Management Guide***
- **DOE G 151.1-3, *Programmatic Elements: Emergency Management Guide***
- **DOE G 151.1-4, *Response Elements: Emergency Management Guide***
- **DOE G 151.1-5, *Biosafety Facilities: Emergency Management Guide***

10 CFR 830, "Nuclear Safety Management"

Purpose

10 CFR 830 governs the conduct of DOE contractors, DOE personnel, and other persons conducting activities, including providing items and services that affect, or may affect, the safety of DOE nuclear facilities.

10 CFR 830.4, "General Requirements"

- No person may take or cause to be taken any action inconsistent with the requirements of this part.
- A contractor responsible for a nuclear facility must ensure implementation of, and compliance with, the requirements of this part.
- The requirements of this part must be implemented in a manner that provides reasonable assurance of adequate protection of workers, the public, and the environment from adverse consequences, taking into account the work to be performed and the associated hazards.
- If there is no contractor for a DOE nuclear facility, DOE must ensure implementation of, and compliance with, the requirements of this part.

The requirements in 10 CFR 830 are DOE nuclear safety requirements and are subject to enforcement by all appropriate means, including the imposition of civil and criminal penalties in accordance with the provisions of 10 CFR 820.

29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response"

29 CFR 1910.120 covers the following operations, unless the employer can demonstrate that the operation does not involve employee exposure or the reasonable possibility for employee exposure to safety or health hazards:

- Clean-up operations required by a governmental body, whether Federal, state, local or other involving hazardous substances that are conducted at uncontrolled hazardous waste sites
- Corrective actions involving clean-up operations at sites covered by RCRA as amended
- Voluntary clean-up operations at sites recognized by Federal, state, local or other governmental bodies as uncontrolled hazardous waste sites
- Operations involving hazardous wastes that are conducted at treatment, storage, and disposal facilities regulated by 40 CFR 264 and 40 CFR 265 pursuant to RCRA; or by agencies under agreement with EPA to implement RCRA regulations

- Emergency response operations for releases of, or substantial threats of releases of, hazardous substances without regard to the location of the hazard

Sites covered by RCRA and those involved in emergency response to releases of hazardous substances require the development and implementation of an emergency response plan to handle anticipated emergencies prior to the commencement of emergency response operations. The plan shall be in writing and available for inspection and copying by employees, their representatives and OSHA personnel.

DOE O 151.1C, Comprehensive Emergency Management System

Objectives

- To establish policy and to assign and describe roles and responsibilities for the DOE emergency management system. The emergency management system provides the framework for development, coordination, control, and direction of all emergency planning, preparedness, readiness assurance, response, and recovery actions. The emergency management system applies to DOE and NNSA.
- To establish requirements for comprehensive planning, preparedness, response, and recovery activities of emergency management programs or for organizations requiring DOE/NNSA assistance.
- To describe an approach to effectively integrate planning, preparedness, response, and recovery activities for a comprehensive, all-emergency management concept.
- To integrate public information and emergency planning to provide accurate, candid, and timely information to site workers and the public during all emergencies.
- To promote more efficient use of resources through greater flexibility (i.e., the graded approach) in addressing emergency management needs consistent with the changing missions of the Department and its facilities.
- To ensure that the DOE emergency management system is ready to respond promptly, efficiently, and effectively to any emergency involving DOE/NNSA facilities, activities, or operations, or requiring DOE/NNSA assistance.
- To integrate applicable policies and requirements, including those promulgated by other Federal agencies and interagency emergency plans into the Department's emergency management system. In compliance with the statutory requirements in 42 USC 7274k, DOE hereby finds that this Order is necessary for the fulfillment of current legal requirements and conduct of critical administrative functions.
- To eliminate duplication of emergency management effort within the Department.

Requirements

[Note: Due to the complexity and comprehensive nature of the requirements, only the following general information will be provided.]

DOE/NNSA sites/facilities, including DOE/NNSA transportation activities, DOE/NNSA offices in the field, and DOE HQ offices, must develop and participate in an integrated and comprehensive emergency management system to ensure the following:

- The Department can respond effectively and efficiently to OEs and energy emergencies and can provide emergency assistance so that appropriate response measures are taken to protect workers, the public, the environment, and the national security.

- Emergencies are recognized, categorized and, as necessary, classified (determine the emergency class) promptly, and parameters associated with the emergency are monitored to detect changed or degraded conditions.
- Emergencies are reported and notifications are made
- Reentry activities are properly and safely accomplished, and recovery and post-emergency activities commence properly.

Non-mandatory implementation guidance for this Order is published separately in the multi-volume DOE G 151.1-1 series of emergency management guides. These guides provide non-mandatory, supplemental information about preferred methods for implementing requirements, including lessons learned, suggested practices, instructions, and suggested performance measures.

DOE G 151.1-1A, Emergency Management Fundamentals and the Operational Emergency Base Program: Emergency Management Guide

DOE G 151.1-1A provides information about the emergency management fundamentals imbedded in the requirements of DOE O 151.1C, as well as acceptable methods of meeting the requirements for the operational emergency base program, which ensures that all DOE facilities have effective capabilities for all emergency response.

The DOE approach to emergency management is built upon three guiding principles or conceptual “foundation stones” of emergency management. These key concepts are:

1. Effective response is the last line of defense against adverse consequences. Regardless of how sound the fundamental safety programs and controls may be, events will sometimes happen that have adverse health effects on people and/or the environment. This principle expresses the DOE position that if controls should fail, the facility/site or activity must be prepared to take actions to limit or prevent adverse health and safety impacts to workers and the public.
2. Planning, preparedness, response, and recovery must be specific to and commensurate with the hazards. While the basic emergency management framework is the same for all DOE facilities/sites or activities, the specific planning and response measures for each hazard are to be tailored to the hazard, such that they are specific (i.e., technically appropriate) to the hazard and commensurate with (in size, scope, or scale) the magnitude of the hazard and its potential impacts.
3. Early recognition is vital to timely, effective, and commensurate response. By developing a full understanding of possible scenarios and the indications that would point to an actual or impending event, emergency management will increase the likelihood of successful warning and intervention to prevent or limit health impacts. Analyzing scenarios and developing recognition indicators provides the basis for tailoring the response to the actual or potential hazard.

The DOE comprehensive emergency management system is based on a three-tiered management structure consisting of facilities/sites or activities, cognizant field element, and HQ, with each tier having specific roles and responsibilities during an emergency as follow:

- The facility/site or activity manages the tactical response to the emergency by directing the mitigative actions necessary to resolve the problem, protect the workers, the public, and the environment, and return the facility/site to a safe condition.

- The cognizant field elements oversee the facility/site response and provide local assistance, guidance, and operational direction to the facility/site management; the cognizant field element also coordinates the tactical response to the event with tribal, state, and local governments.
- DOE HQ provides strategic direction to the response, provides assistance and guidance to the cognizant field elements, and evaluates the broad impacts of the emergency on the DOE complex. DOE HQ also coordinates with other Federal agencies on a national level, provides information to representatives of the executive and legislative branches of the Federal government, and responds to inquiries from the national media.

DOE G 151.1-2, Technical Planning Basis: Emergency Management Guide

DOE G 151.1-2 assists DOE/NNSA field elements and operating contractors in identifying and analyzing hazards at facilities and sites to provide the technical planning basis for emergency management programs. The five chapters of DOE G 151.1-2 are summarized below.

Chapter 1—Hazards Surveys

DOE and NNSA elements must ensure that a hazards survey is prepared, maintained, and used for emergency planning purposes. The hazards survey, which is based on an examination of the features and characteristics of the facility, identifies the generic types of emergency events and conditions, including natural phenomena such as earthquakes and tornadoes, wildland fires, and other serious events involving or affecting health and safety, the environment, and S&S at the facility and the potential impacts of such emergencies to be addressed by the DOE comprehensive emergency management system.

Chapter 2—Hazards Assessments

A hazards assessment must be performed for a facility/site or activity when at least one hazardous material requiring quantitative analysis is identified through the hazardous material screening process conducted as part of the hazards survey. Emergency planning hazards assessments (EPHAs) involve the application of rigorous hazards analysis techniques that provide sufficient detail to assess a broad spectrum of postulated events or conditions involving the potential release of hazardous materials and to analyze the resulting consequences.

Chapter 3—Emergency Planning Zones (EPZs)

The DOE comprehensive emergency management system requires the integration of emergency management programs for both radioactive and non-radioactive hazardous materials. Consistent with this approach, an EPZ concept that integrates protective action planning related to all potential hazardous material releases is endorsed as a planning tool. The EPZ is an area within which the facility/site should support the local, state, and/or tribal authorities in planning and preparedness activities to protect people living and working there.

Chapter 4—Maintaining Hazards Surveys and Hazards Assessments

Hazards surveys and EPHAs should be maintained so that they accurately reflect changes in the facility design, operations, safety features, inventories of hazardous materials, and features of the surrounding area. In the absence of other overriding requirements on the mechanics of this maintenance process, the guidelines specified in this chapter should be applied.

Chapter 5— Using Hazard Surveys and Hazards Assessments

The hazards surveys identify the generic types of emergencies applicable to the facility. From these emergencies, potential OEs can be identified and categorization criteria developed to ensure that the prompt notification requirement for OEs is met.

Based on completed EPHAs, the requirements in DOE O 151.1C are tailored to develop an emergency management program that addresses the unique hazards and operating environment of each facility or activity.

DOE G 151.1-3, Programmatic Elements: Emergency Management Guide

DOE G 151.1-3 provides acceptable methods of meeting the requirements of DOE O 151.1C for programmatic elements that sustain the emergency management program and maintain the readiness of the program to respond to an emergency. The four chapters of DOE G 151.1-3 are summarized below.

Chapter 1—Program Administration

Each manager or administrator of a DOE/NNSA contractor-operated facility/site or activity subject to DOE O 151.1C shall designate an individual to administer the emergency management program. This individual shall perform the following:

- Develop and maintain the emergency plan
- Develop the emergency readiness assurance plan and its annual updates
- Develop and conduct training and exercise programs
- Coordinate assessment activities
- Develop related documentation
- Develop a system to track and verify correction of findings or lessons learned
- Coordinate emergency resources

Chapter 2—Training and Drills

DOE and NNSA field elements must ensure that a coordinated program of training and drills for developing and/or maintaining specific emergency response capabilities is an integral part of the emergency management program. The program must apply to emergency response personnel and organizations that the facility/site expects to respond to onsite emergencies. Emergency-related information must be available to offsite response organizations.

Chapter 3—Exercises

DOE and NNSA field elements must establish a formal exercise program that validates all elements of a facility/site or activity emergency management program over a five-year period. The exercise program should validate both facility- and site-level emergency management program elements by initiating a response to simulated, realistic emergency events or conditions in a manner that, as nearly as possible, replicates an integrated emergency response to an actual event.

Chapter 4—Readiness Assurance

DOE and NNSA field elements must put a readiness assurance program in place to ensure that emergency plans, implementing procedures, and resources are adequate and sufficiently maintained, exercised, and evaluated and that improvements are made in response to identified needs**.** Readiness assurance programs provide assurances that the key activities of emergency management (planning, preparedness and response) are effective in maintaining an adequate and reliable response.

DOE G 151.1-4, Response Elements: Emergency Management Guide

DOE G 151.1-4 provides acceptable methods for meeting the requirement of DOE O 151.1C for response elements that respond or contribute to response as needed in an emergency. The ten chapters of DOE G 151.1-4 are summarized below.

Chapter 1—Emergency Response Organization (ERO)

DOE and NNSA field elements must ensure an ERO for each facility/site or activity is established and maintained and ensure that these EROs are compliant with the national incident management system (NIMS). The ERO is a structured organization with overall responsibility for initial and ongoing emergency response to an OE and for mitigation of the consequences. The ERO establishes effective control of response capabilities at the scene of an event/incident and integrates ERO activities with those of local agencies and organizations that provide onsite response services.

Chapter 2—Offsite Response Interfaces

DOE and NNSA field elements must establish and maintain effective interfaces to ensure that emergency response activities are integrated and coordinated with the Federal, tribal, state, and local agencies and organizations responsible for emergency response and protection of the workers, public, and environment. Interfaces with offsite response entities should be in accordance with the requirements of the national response plan and NIMS.

Chapter 3—Emergency Facilities and Equipment

DOE and NNSA field elements must ensure that emergency facilities and equipment, adequate to support emergency response, are available, operable, and maintained. At a minimum, facilities should include an adequate and viable command center. Emergency equipment includes, but is not limited to, PPE, detectors, and decontamination equipment.

Chapter 4— Emergency Categorization and Classification

DOE and NNSA field elements must ensure that major unplanned or non-routine abnormal events or conditions involving or affecting DOE or NNSA facilities/sites or activities be recognized promptly and categorized as OEs. The requirement applies to events or conditions that cause or have the potential to cause

- serious health and safety impacts onsite or offsite to workers or the public
- serious detrimental effects on the environment
- direct harm to people or the environment as a result of degradation of safeguards or security conditions
- release of (or loss of control over) hazardous materials

Chapter 5—Notifications and Communications

DOE and NNSA field elements must ensure that initial emergency notifications are made promptly, accurately and effectively to workers and emergency response personnel/organizations, appropriate DOE/NNSA elements, and other Federal, tribal, state, and local organizations and authorities. Following the initial notifications, accurate and timely follow-up notifications or emergency status updates should be made when conditions change, when the classification is upgraded, or when the emergency is terminated. Also, continuous, effective, and accurate communications among response components and/or organizations should be reliably maintained throughout an OE.

Chapter 6—Consequence Assessment

DOE and NNSA field elements must ensure that the impacts of the release of (or loss of control over) hazardous materials (i.e., radioactive, chemical) be evaluated during an OE. DOE O 151.1C requires that estimates of onsite and offsite consequences of an actual or potential release of hazardous materials be correctly calculated and assessed in a timely manner throughout the emergency. Consequence assessments are to be integrated with event classification and protective action decision-making functions, incorporate facility and field indications and measurements into the assessments, and be effectively coordinated with offsite agencies.

Chapter 7—Protective Actions and Re-entry

DOE and NNSA field elements must ensure that protective actions be promptly and effectively implemented or recommended for implementation, as needed, to minimize the consequences of emergencies and to protect the health and safety of workers and the public. Protective actions can be implemented individually or in combination to reduce exposures from a wide range of hazardous material types. Such protective actions can include evacuation, sheltering, decontamination of people, medical care, ad hoc respiratory protection, control of access, shielding, radio-protective prophylaxis (e.g., administration of stable iodine, chelating agents, and diuretics), control of foodstuffs and water, relocation, decontamination of land and equipment, and changes in livestock and agricultural practices.

Chapter 8—Emergency Medical Support

DOE and NNSA field elements must ensure that medical support for contaminated or injured personnel is planned and promptly and effectively implemented. In addition, DOE O 151.1C requires that arrangements with offsite medical facilities providing the support to transport, accept, and treat contaminated, injured personnel be documented.

Chapter 9—Emergency Public Information

DOE and NNSA facilities/sites and activities must ensure that accurate, candid and timely information is provided to workers, the news media, and the public during an emergency to establish facts and avoid speculation. DOE O 151.1C requires that emergency public information efforts be coordinated with DOE and NNSA (if appropriate); tribal, state, and local governments; and Federal EROs, as appropriate. An additional responsibility of the emergency public information program is to inform workers and the public of emergency plans and planned protective actions before emergencies.

Chapter 10—Termination and Recovery

DOE and NNSA field elements must ensure compliance with the requirements of emergency termination and recovery. DOE O 151.1C requires that OEs be terminated only after predetermined criteria have been met and formal termination of the response phase has been coordinated with DOE/NNSA HQ and offsite agencies. Depending on the nature and severity of the emergency, recovery may involve a variety of activities directed at restoring the facility and area affected by the emergency to a safe, stable pre-incident condition. Recovery should include the following elements:

- Communication and coordination with tribal, state, and local government and other Federal agencies
- Planning, management, and organization of the associated recovery activities
- Ensuring the health and safety of the workers and public

DOE G 151.1-5, Biosafety Facilities: Emergency Management Guide

The purpose of DOE G 151.1-5 is to assist DOE/NNSA field elements and operating contractors in incorporating hazardous biological agents/toxins into emergency management programs. The intended result is an integrated and comprehensive emergency management program that provides assurances of a timely and effective response to an onsite release of a radioactive, toxic chemical, or hazardous biological material. Note that the guidance presented in this document does not explicitly address acts of terrorism in which biological agents or toxins, not owned or controlled by DOE/NNSA, are brought onto a DOE/NNSA site or facility.

It is not the intent of this guide to establish operational biosafety requirements for biosafety facilities. Topics will be introduced to familiarize emergency management personnel with various concepts related to hazardous biological materials that they must be cognizant of in order to address integration of hazardous biological materials with site-wide emergency management planning. Likewise, the discussions can also raise the awareness of biosafety experts to recognize aspects of their discipline that are important to emergency management personnel.

b. State what is meant by an operational emergency.

The following is taken from DOE O 151.1C.

Operational emergencies are major unplanned or abnormal events or conditions that involve or affect DOE/NNSA facilities and activities by causing or having the potential to cause serious health and safety or environmental impacts; require resources from outside the immediate/affected area or local event scene to supplement the initial response; and, require time-urgent notifications to initiate response activities at locations beyond the event scene.

c. Describe the purpose of a facility emergency plan and implementing procedures.

The following is taken from DOE O 151.1C

The emergency plan must document the emergency management program and describe the provisions for response to an OE. Emergency plan implementing procedures must describe how emergency plans must be implemented.

The following is taken from DOE G 151.1-3

Emergency plans and procedures:

- An emergency plan documents the emergency management program, including provisions for response to an OE; emergency plan implementing procedures describe how the emergency plan will be implemented.
- Clearly state roles, responsibilities, and requirements associated with program administration, EROs, individual positions, operations, and interfaces.
- Describe the integration and coordination of the emergency management program with the DOE ISMS.

d. Discuss the requirements for developing the hazards survey and the emergency planning hazards assessment.

The following is taken from DOE O 151.1C

Hazards Survey

A hazards survey must be used to identify the conditions to be addressed by the comprehensive emergency management program.

- Each hazards survey must include the following:
    - Identify (e.g., in matrix or tabular form) the emergency conditions (e.g., fires, work place accidents, natural phenomena, etc.)
    - Describe the potential health, safety, or environmental impacts
    - Indicate the need for further analyses of hazardous materials in an EPHA, based on the results of the hazardous material screening process described in paragraph 3b of DOE O 151.1C
    - Identify the planning and preparedness requirements that apply to each type of hazard
- Each hazards survey may cover multiple facilities. One hazards survey may be prepared to cover an entire site.
- Hazards surveys must be updated every three years and prior to significant changes to the site/facility or to hazardous material inventories. For example, significant changes are those changes which would result in an unreviewed safety question (USQ) for nuclear facilities, as defined in 10 CFR 830, or in an unreviewed safety issue for accelerator facilities, as defined in DOE O 420.2B. Changes that result in a reduction of hazards with no adverse effect on safety or emergency preparedness or response may be included in the next scheduled review and update.

Emergency Planning Hazards Assessment

- The release of or loss of control of hazardous materials must be quantitatively analyzed in an EPHA.
    - If the EPHA indicates the potential for an alert, site area emergency, or general emergency, as defined in chapter V of DOE O 151.1C, the results of the analysis must be used to determine the necessary personnel, resources, and equipment for the operational emergency hazardous material program.
    - If the quantitative analysis indicates that all events would be classified as less than an alert, an EPHA is not required to be maintained. The results of the hazardous material screening process and the quantitative analysis may be incorporated

directly into the hazards survey or may be incorporated by reference in the hazards survey. The minimum program requirements must encompass the requirements of 29 CFR 1910.120, and the requirements specified in chapter III of DOE O 151.1C.

- An accurate and timely method for tracking changes in operations processes, or accident analyses that involve hazardous materials (e.g., introduction of new materials, new uses, significant changes in inventories, modification of material environments) must be established and maintained for each facility/activity. The method must allow sufficient time for emergency management personnel to review the EPHA and modify plans and procedures, as necessary. For example, significant changes are those changes which would result in an USQ for nuclear facilities, as defined in 10 CFR 830, or in an unreviewed safety issue for accelerator facilities, as defined in DOE O 420.2B.
- The EPHA must be reviewed at least every three years and updated prior to significant changes to the site/facility or hazardous material inventories. Changes that result in a reduction of hazards with no adverse effect on safety or emergency preparedness and response may be included in the next scheduled review and update.
- The EPHA must include a determination of the size of the EPZ. The EPZ is the geographic area surrounding the site/facility for which special planning and preparedness actions are taken or need to be taken to reduce or minimize the impact to onsite personnel and public health and safety in the event of an OE involving hazardous materials. Assumptions, methodology, models, and evaluation techniques used in the EPHA must be documented.
- The Office of Secure Transportation (OST) must develop an EPHA for OST shipments to provide the technical planning basis for the OST operational emergency hazardous material program.
- An EPHA must be developed for shipments that do not satisfy governing DOT regulations and specifications for commercial hazardous materials transport. However, if a shipment satisfies DOT regulations and specifications, then an EPHA is not required.

e. Describe the key roles and safety considerations during emergency response:

- **National Incident Management System**
- **Incident Command System**
- **Incident commander**
- **Emergency director**

National Incident Management System

The following is taken from DOE G 151.1-1A.

For years, DOE requirements and guidance have discussed the need to have an incident command system (ICS) at the facility/site level that could seamlessly integrate response assets from the surrounding jurisdictions. The NIMS is designed to achieve the same integration at all levels of government. The Department of Homeland Security (DHS) promulgated NIMS in March 2004, under the authority of Homeland Security Presidential Directive-5. The NIMS is the nationwide template enabling Federal, state, local, and tribal governments and private-sector and nongovernmental organizations to work together effectively and efficiently to prevent, prepare for, respond to, and recover from emergencies.

All Federal departments/agencies were required to develop a NIMS implementation plan. The DOE NIMS implementation plan was published in February 2005, requiring all departmental elements to complete implementation of NIMS by September 30, 2005, or when their surrounding jurisdictions implemented NIMS.

The DHS made preparedness grant funding for state, territorial, tribal and local governments contingent upon NIMS compliance after Federal fiscal year 2006.

Most local jurisdictions, as well as all DOE/NNSA facilities/sites, should have achieved NIMS compliance by this time.

Incident Command System

The following is taken from 29 CFR 1910.120.

The ICS is an organized approach to effectively control and manage operations at an emergency incident. The individual in charge of the ICS is the senior official responding to the incident. This enables one individual in charge to make decisions and give directions; and, all actions and communications are coordinated through one central point of command. Such a system should reduce confusion, improve safety, organize and coordinate actions, and should facilitate effective management of the incident.

Incident Commander

According to DOE G 151.1-4, the incident commander maintains operational control of the response at the incident scene and transmits information to the command center or the emergency operations center.

Emergency Director

The following is taken from DOE G 151.1-4.

The emergency director or similar title, should have unilateral authority and responsibility to implement the facility/site emergency plan and employ overall emergency management responsibility during response to an OE. Full authority and responsibility implies that this individual should either initially perform, or oversee, the following minimum functions: detect or assess, categorize and classify (as necessary) the emergency event or conditions; carry out initial notifications; implement protective actions onsite; issue offsite protective action recommendations; and initiate response by appropriate emergency resources. The position may be transferred to more senior officials once the ERO is fully staffed.

f. Discuss the requirements for testing emergency plans and for interfacing with state and local officials and the public.

The following is taken from DOE O 151.1C.

Testing Emergency Plans

A formal exercise program must be established to validate all elements of the emergency management program over a five-year period. Each exercise must have specific objectives and must be fully documented (e.g., by scenario packages that include objectives, scope, timelines, injects, controller instructions, and evaluation criteria). Exercises must be evaluated. A critique process, which includes gathering and documenting observations of the participants, must be established. Corrective action items identified as a result of the critique process must be incorporated into the emergency management program.

- Sites/facilities
  - Each DOE/NNSA facility subject to this chapter must exercise its emergency response capability annually and include at least facility-level evaluation and critique. Evaluations of annual facility exercises by departmental entities (e.g., cognizant field element, program secretarial officer (PSO) or HQ Office of Security and Safety Performance Assurance) must be performed periodically so that each facility has an external departmental evaluation at least every three years.
  - Site-level ERO elements and resources must participate in a minimum of one exercise annually. This site exercise must be designed to test and demonstrate the site's integrated emergency response capability. For multiple facility sites, the basis for the exercise must be rotated among facilities.
  - Offsite response organizations must be invited to participate in site-wide exercises at least once every three years.
  - Annual emergency response exercises must be supported by documentation that contains, but is not limited to, the exercise scope, its objectives and corresponding evaluation criteria, a narrative description of the scenario, timeline, and a list of participants. Documentation for site exercises must be approved by the cognizant field element. After approval, the cognizant field element submits the approved exercise package to the PSO(s), and the Director, Office of Emergency Operations for information, preferably 30 days prior to the conduct of the exercise.
  - Evaluation reports for facility and site exercises must be completed within 30 working days and submitted to the cognizant field element, the PSO(s), and the Director, Office of Emergency Operations.
  - Corrective action plans must be completed within 30 working days of receipt of the final facility and site exercise evaluation report.
  - Completion of corrective actions for all facility and site exercises must include a verification and validation process, independent of those who performed the corrective action, that verifies that the corrective action has been put in place and that validates that the corrective action has been effective in resolving the original finding. Corrective actions involving revision of procedures or training of personnel should be completed before the next exercise.

- Emergency response assets—Exercises of each of the Department's radiological emergency response assets must be conducted at least once every three years. These assets include the Accident Response Group, Nuclear Emergency Support Team, Federal Radiological Monitoring and Assessment Center, Aerial Measuring System, National Atmospheric Release Advisory Center, Radiation Emergency Assistance Center/Training Site, and Radiological Assistance Program.

Offsite Response Interfaces

Effective interfaces must be established and maintained to ensure that emergency response activities are integrated and coordinated with the Federal, tribal, state, and local agencies and organizations responsible for emergency response and protection of the workers, public, and environment.

The contractor at all DOE/NNSA facilities must coordinate with state, tribal, and local agencies and organizations responsible for offsite emergency response (e.g., "911" emergencies) and for protection of the health and safety of the public.

SAFETY BASIS REQUIREMENTS AND DOCUMENTATION

21. Personnel must demonstrate a familiarity level knowledge of the Unreviewed Safety Question (USQ) process as discussed in 10 CFR 830, Subpart B, "Nuclear Safety Management."

a. Describe the purpose of the USQ process.

The following is taken from 10 CFR 830.3.

The USQ process is the mechanism for keeping a safety basis current by reviewing potential USQs, reporting USQs to DOE, and obtaining approval from DOE prior to taking any action that involves a USQ.

b. Discuss the reasons for performing a USQ determination.

The following is taken from 10 CFR 830.203.

The contractor responsible for a hazard category 1, 2, or 3 DOE nuclear facility must implement the DOE-approved USQ procedure in situations where there is a

- temporary or permanent change in the facility as described in the existing DSA
- temporary or permanent change in the procedures as described in the existing DSA
- test or experiment not described in the existing DSA or
- potential inadequacy of the DSA because the analysis potentially may not be bounding or may be otherwise inadequate

c. Define and discuss key USQ terms.

[Note: the following USQ-associated terms are not all-inclusive. Other terms may be included by the Qualifying Official.]

The following definitions are taken from DOE-HDBK-1188-2006.

Documented Safety Analysis
A DSA is 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 provides the basis for ensuring safety.

The following is taken from DOE G 424.1-1B.

If a DSA modification is made part of the resolution of the potentially inadequate safety analysis or the justification for continued operation, then in accordance with 10 CFR

830.207, a safety evaluation report (SER) is needed. If not done earlier, then any needed changes to the safety basis should be made at the next annual update.

Margin of Safety

Margin of safety is that margin built into the safety analyses of the facility as set forth in the authorization basis acceptance limits.

The following is taken from DOE G 424.1-1B.

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.

Safety Analysis

A safety analysis is a documented process

- to provide systematic identification of hazards within a given DOE operation;
- to describe and analyze the adequacy of the measures taken to eliminate, control, or mitigate identified hazards; and
- to analyze and evaluate potential accidents and their associated risks.

Safety Analysis Report

An SAR is that report which documents the adequacy of safety analysis to ensure that the facility can be constructed, operated, maintained, shut down, and decommissioned safely and in compliance with applicable laws and regulations.

Safety Evaluation Report

An SER is a DOE document that describes the extent and detail of DOE review of an SAR or equivalent analysis report, the bases for approving the SAR (or equivalent), and any conditions of SAR (or equivalent) approval. Approval signifies that DOE has accepted the analysis as appropriately documenting the safety basis of a facility and as serving as the basis for operational controls necessary to maintain an acceptable operating safety envelope.

Technical Safety Requirements

Technical safety requirements are those requirements that define the conditions, safe boundaries, and the management or ACs 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 exposures due to inadvertent criticality. Technical safety requirements consist of safety limits (SLs), operating limits, SRs, ACs, use and application instructions, and the basis thereof.

d. Describe the situations that require a USQ determination.

See CS-21b for an explanation of this KSA.

The information for KSAs e and f is taken from DOE G 424.1-1B.

e. Define the conditions for a USQ.

Four criteria define a USQ (see CS-21b). Three can be addressed by answering seven questions. The fourth potential inadequate safety analysis criterion also invokes the seven questions as described later in section 3.3 of DOE G 424.1-1B.

1. Could the proposed change increase the probability of an accident previously evaluated in the facility's existing safety analyses?
2. Could the proposed change increase the consequences (to workers or the public) of an accident previously evaluated in the facility's existing safety analyses?
3. Could the proposed change increase the probability of a malfunction of equipment important to safety previously described in the facility's existing safety analyses?
4. Could the proposed change increase the consequences of a malfunction of equipment important to safety described in the facility's existing safety analyses?
5. 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?
6. 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?
7. Could the proposed change reduce a margin of safety?

If the answer to any of these questions is yes, the change is considered a USQ.

f. Describe contractor responsibilities for performing USQ determinations.

Contractors are expected to provide a detailed procedure on how to perform a USQ determination. Specific guidance on how to conduct a USQ determination is in DOE G 424.1-1B, attachment A.

The contractor's USQ procedures should include documenting defensible technical explanations based on sound engineering judgment for each of the answers to the seven questions. It is inappropriate to perform extensive analyses or to set a numerical margin for increases in the probability or consequences within which a positive USQ determination would not be triggered.

Specific responsibilities of those performing or reviewing USQ determinations should be clearly defined. Documentation should also be discussed in the implementing procedures. The procedures should identify the level of detail necessary to document performance of a USQ determination and conclusions reached and include a list of references relied on to reach the conclusions as well as guidance for the retention of records.

g. Describe site actions for identified potential inadequacy of previous safety analyses.

The following is taken from 10 CFR 830.203(g).

If a contractor responsible for a hazard category 1, 2, or 3 DOE nuclear facility discovers or is made aware of a potential inadequacy of the DSA, it must

- take action, as appropriate, to place or maintain the facility in a safe condition until an evaluation of the safety of the situation is completed;
- notify DOE of the situation;
- perform a USQ determination and notify DOE promptly of the results; and
- submit the evaluation of the safety of the situation to DOE prior to removing any operational restrictions initiated to meet the first bullet (▪) above.

The information for KSAs h and i is taken from DOE G 424.1-1B.

h. Discuss site actions to be taken for a USQ.

The USQ process determines if final approval by the contractor is sufficient or DOE review and approval are required. DOE wants to review and approve those changes that involve a USQ (that is, when the USQ determination is positive) to verify that the safety controls are adequate to provide an acceptable level of safety to the public and workers. The existence of a positive USQ determination does not mean that the change is unsafe but only that DOE is to be responsible for the final approval action.

i. Discuss the qualification and training requirements for personnel performing safety evaluations.

Implementing procedures should establish the training and qualifications for personnel performing the USQ process such as educational background, years and/or types of work experience and knowledge of the facility, understanding of DOE facility safety basis requirements (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 10 CFR 830.203, "Unreviewed Safety Questions Process," including any facility-specific procedures. The recommended interval for retraining is every two years. The contractor should maintain a list of those personnel who are currently qualified to perform the USQ process.

22. Personnel must demonstrate a familiarity level knowledge of the Documented Safety Analysis (DSA) and Technical Safety Requirements (TSRs) of 10 CFR 830 Subpart B, "Safety Basis Requirements," and the DOE standards and guides supporting implementation of 10 CFR 830 Subpart B.

The information for KSAs a and b is taken from DOE-HDBK-1188-2006.

a. Define and compare the terms "hazard" and "risk."

Hazard

A hazard is 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).

Risk

Risk is the quantitative or qualitative expression of possible loss that considers both the probability that an event will occur and the consequence of that event.

b. Explain and compare the terms "safety basis," "design basis," and "authorization basis."

Safety Basis

Safety basis is the combination of information relating to the control of hazards at a nuclear facility (including design, engineering analyses, and ACs) upon which DOE depends for its conclusion that activities at the facility can be conducted safely.

Design Basis

Design basis is composed of design inputs, the design constraints, and the design analysis and calculations. It includes topical areas such as seismic qualification, fire protection, and safe shutdown. It encompasses consideration of such factors as plant availability, plant efficiency, costs, and maintainability, and that subset that relates to safety and the authorization basis.

Authorization Basis

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 facility operations. The authorization basis is described in documents such as the facility SAR and other safety analyses; hazard classification documents, the TSRs, DOE-issued SERs; and facility-specific commitments made in order to comply with DOE Orders or policies.

c. Discuss the relationship of DSAs to TSRs.

The following is taken from DOE G 423.1-1A.

The DSA required by 10 CFR 830.204, "Documented Safety Analysis," furnishes the technical basis for 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.

d. Describe the contractor responsibilities for TSRs and DSAs.

Documented Safety Analysis

The following is taken from 10 CFR 830.204.

The contractor responsible for a hazard category 1, 2, or 3 DOE nuclear facility must obtain approval from DOE for the methodology used to prepare the DSA for the facility unless the contractor uses a methodology set forth in table 2 of appendix A to 10 CFR 830.

The DSA for a hazard category 1, 2, or 3 DOE nuclear facility must, as appropriate for the complexities and hazards associated with the facility, do the following:

- Describe the facility (including the design of SSCs) and the work to be performed

- Provide a systematic identification of both natural and man-made hazards associated with the facility
- Evaluate normal, abnormal, and accident conditions, including consideration of natural and man-made external events, identification of energy sources or processes that might contribute to the generation or uncontrolled release of radioactive and other hazardous materials, and consideration of the need for analysis of accidents which may be beyond the design basis of the facility
- Derive the hazard controls necessary to ensure adequate protection of workers, the public, and the environment; demonstrate the adequacy of these controls to eliminate, limit, or mitigate identified hazards; and define the process for maintaining the hazard controls current at all times and controlling their use
- Define the characteristics of the safety management programs necessary to ensure the safe operation of the facility, including (where applicable) QA, procedures, maintenance, personnel training, conduct of operations, emergency preparedness, fire protection, waste management, and radiation protection

Technical Safety Requirements

The following is taken from 10 CFR 830.205.

A contractor responsible for a hazard category 1, 2, or 3 DOE nuclear facility must do the following:

- Develop TSRs that are taken from the DSA
- Prior to use, obtain DOE approval of TSRs and any change to TSRs
- Notify DOE of any violation of a TSR

A contractor may take emergency actions that depart from an approved TSR when no actions consistent with the TSR are immediately apparent, and when these actions are needed to protect workers, the public or the environment from imminent and significant harm. Such actions must be approved by a certified operator for a reactor or by a person in authority as designated in the TSRs for nonreactor nuclear facilities. The contractor must report the emergency actions to DOE as soon as practicable.

The following is taken from DOE G 423.1-1A.

10 CFR 830.205, “Technical Safety Requirements,” requires DOE contractors responsible for category 1, 2, and 3 DOE nuclear facilities to develop TSRs. These TSRs identify the limitations to each DOE-owned, contractor-operated nuclear facility based on the DSA and any additional safety requirements established for the facility. Although not required by 10 CFR 830.205, there also may be a need to establish TSRs for safe operation of radiological facilities.

The information for KSAs e and f is taken from DOE G 423.1-1A.

e. Define the following terms and discuss the purpose of each:

- **Safety limit**
- **Limiting control settings**
- **Limiting conditions for operation**
- **Surveillance requirements.**

There are three types of limits identified by appendix A to subpart B of 10 CFR 830: SLs, limiting control settings (LCSs), and limiting conditions for operation (LCOs). The intent of these limits is to ensure that the operating regime is restricted to the bounds of safe operation as defined by the safety analyses.

Safety Limits

Safety limits 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.

The term "needed for the facility function" means the process variable is operator controlled to accomplish the facility mission and, if the variable were left unchecked, would initiate an event that challenges the passive safety boundary.

Limiting Control Settings

Limiting control settings define the settings on safety systems that control process variables to prevent exceeding an SL.

Limiting control settings 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.

Limiting Conditions for Operation

Limiting conditions for operation define the limits that represent the lowest functional capability or performance level of safety SSCs required to perform an activity safely.

Limiting conditions for operation 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.

Surveillance Requirements

Surveillance requirements consist of short descriptions of the type of surveillance required and its frequency of performance.

These statements should be as brief as possible but should identify those requirements needed to ensure compliance with the related operating limits. Each SR should begin with a verb. Use of terms and sentence structure among requirements should be consistent.

Surveillance requirements 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.

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.

In areas for which the DSA does not directly supply all of the input for the TSR (e.g., surveillance frequencies and acceptance criteria), national and international codes, standards, and guides should be used wherever possible. Where no code, standard, or guide is applicable, other documents (e.g., reliability analyses, failure modes and effects analyses, manufacturer documentation, information from operating history, or engineering judgment) may provide the basis.

g. Discuss the conditions that constitute a violation of TSRs.

The following is taken from DOE G 423.1-1A.

Although the TSR elements have an importance hierarchy, a TSR violation can occur for each type of TSR. Violations of a TSR occur as a result of the following four circumstances:

1. Exceeding an SL
2. Failure to complete an ACTION statement within the required time limit following exceeding an LCS or failing to comply with an LCO
3. Failure to perform a surveillance within the required time limit
4. 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.

A grace period is sometimes provided to perform a missed surveillance to provide time for the performance of the missed surveillance, thereby avoiding the need for a facility to take immediate, possibly unnecessary corrective action. Entering the grace period remains a TSR violation even though an immediate corrective action may not be required.

h. State the general requirements for a DSA and for a preliminary documented safety analysis.

Documented Safety Analysis

The following is taken from DOE G 421.1-2A.

In accordance with 10 CFR 830.204, a DSA must provide a systematic identification of both natural and man-made hazards to demonstrate that all relevant accidents have been considered, and appropriate preventative and mitigative measures have been taken to ensure adequate protection of workers, the public, and the environment. The facility documentation (equipment specifications, procedures, safety programs, etc.) should be in sufficient detail to support the safety analyses.

In accordance with 10 CFR 830.204, safe harbor provisions for the preparation of DSAs must conform to one of the methodologies set forth in table 2 of appendix A to subpart B of 10 CFR 830 or an alternate methodology approved by DOE. These methodologies are called safe harbors in 10 CFR 830.

Preliminary Documented Safety Analysis (PDSA)

The PDSA for a new facility prepared under the guidance of DOE-STD-1189-2008, *Integrations of Safety into the Design Process*, is of the same format as a DOE-STD-3009-94, *Preparation Guide for U.S. DOE Nonreactor Nuclear Facility Safety Analysis Reports,* DSA for existing facilities. However, the process of establishing an operational safety basis for a new facility is different from that for an existing facility because the safety in design process of DOE-STD-1189-2008 results in a well documented safety design basis. Appendix B of DOE-STD-3009-94 contains guidance for transitioning a PDSA to an operational DSA for new facilities. The intent of the appendix is to bring the safety design basis information developed during the design process into the operational DSA.

23. Personnel must demonstrate a familiarity level knowledge of DOE O 420.1B, *Facility Safety*.

[Note: DOE O 420.1B was cancelled by DOE O 420.1B chg. 1, from which the information for all of the KSAs in this competency statement is taken.]

a. Discuss the purpose and applicability of DOE O 420.1B, *Facility Safety*.

Purpose (Objective)

The objective of DOE O 420.1B is to establish facility and programmatic safety requirements for DOE, including NNSA, for nuclear and explosives safety design criteria, fire protection, criticality safety, natural phenomena hazards (NPH) mitigation, and the system engineer program.

Applicability

- DOE O 420.1B applies to all DOE elements with responsibility for DOE-owned or leased facilities, except for the exclusions in DOE O 420.1B, paragraph 3c.
- The DOE O 420.1B CRD sets forth requirements that are to be applied to contractors with responsibility for the design, construction, management, operation, decontamination, decommissioning, or the demolition of DOE sites or facilities.

b. Discuss the requirements imposed by DOE O 420.1B on the contractors that operate DOE nuclear facilities.

Regardless of the performer of the work, the contractor is responsible for complying with requirements of the CRD. The contractor is responsible for flowing down the requirements to subcontractors at any tier to the extent necessary to ensure the contractor's compliance with the requirements and the safe performance of work. In doing so, the contractor must not flow down requirements to subcontractors unnecessarily or imprudently.

- The CRD establishes facility safety requirements for DOE and NNSA contractors responsible for design, construction, operation, management, decontamination or decommissioning of DOE sites or facilities. Contractors must comply with the CRD requirements to the extent set forth in their contracts.
- Chapters of the CRD may have general and specific requirements. In complying with the CRD, contractors must determine acceptability of design and operations based on a comparison with available safety basis information.
- In complying with the CRD, contractors must ensure that any work done is consistent with any other safety, design, or other analyses or requirements applicable to the affected facility. In particular, work must be performed in accordance with the ISM requirements of 48 CFR 970.5223-1, and the QA requirements of either subpart A of 10 CFR 830, or DOE O 414.1D. All new construction, as a minimum, must comply with national consensus industry standards and the model building codes applicable for the state or region supplemented in a graded manner with additional safety requirements for the associated hazards in the facility that are not addressed by the codes.
- DOE implementation guidance and technical standards referenced in the CRD are not mandatory; however they must be considered in conjunction with the specific requirements. Such guidance, along with both DOE and industry standards referenced therein, represent acceptable methods to satisfy the provisions of the CRD. Alternate methods that satisfy the requirements of the CRD are also acceptable. Any implementation method selected must be justified to ensure that an adequate level of safety commensurate with the identified hazards is achieved.

c. Discuss, in general terms, the focus and content of the following sections of DOE O 420.1B:

- **Nuclear safety**
- **Fire protection**
- **Nuclear criticality safety**
- **Natural phenomena hazards mitigation**
- **Explosives safety**
- **Safety systems engineer and configuration management**

Nuclear Safety

The objectives of nuclear safety are as follows:

- To ensure that new DOE hazard category 1, 2, and 3 nuclear facilities are designed and constructed in a manner that ensures adequate protection to the public, workers, and the environment from nuclear hazards
- To ensure that major modifications to hazard category 1, 2, and 3 nuclear facilities comply with the design and construction requirements for new hazard category 1, 2, and 3 nuclear facilities

- To ensure that new DOE nuclear reactors comply with the requirements of DOE O 420.1B and the design requirements of DOE Order 5480.30, *Nuclear Reactor Safety Design Criteria*.

Requirements

Integration of design with safety

- Safety analyses must be used to establish the following:
  - Identity and functions of safety class and safety significant SSCs
  - Significance to safety of functions performed by safety class and safety significant SSCs
- Safety analyses must address the following:
  - Hazards inherent to the facility and its activities
  - Natural phenomena hazards
  - External man-induced hazards
- Safety must be integrated into design early and throughout the design process consistent with DOE-STD-1189.

Nuclear facility design

- Nuclear facility design objectives must include multiple layers of protection to prevent or mitigate the unintended release of radioactive materials to the environment, otherwise known as defense-in-depth.
- Defense-in-depth must include all of the requirements specified in DOE O 420.1B, chapter 1, section 3.b.(2).
- Hazard category 1, 2, and 3 nuclear facilities must be sited, designed, and constructed in a manner that ensures adequate protection of the health and safety of the public, workers, and the environment from the effects of accidents involving radioactive materials release.
- Hazard category 1, 2, and 3 nuclear facilities with uncontained radioactive material must have the means to confine the uncontained radioactive materials to minimize their potential release in facility effluents during normal operations and during and following accidents.
- Hazard Category 1, 2, and 3 nuclear facilities must be designed as follows:
  - To facilitate safe deactivation, decommissioning, and decontamination at the end of facility life, including incorporation of design considerations during the operational period that facilitate future decontamination and decommissioning
  - To facilitate inspections, testing, maintenance, repair, and replacement of safety SSCs as part of a reliability, availability, and maintainability program with the objective that the facility is maintained in a safe state
  - To keep occupational radiation exposures within statutory limits and ALARA
- Facility process systems must be designed to minimize waste production and mixing of radioactive and non radioactive wastes.
- Safety SSCs and safety software must be designed, commensurate with the importance of the safety functions performed, to perform their safety functions when called upon and to meet the QAP requirements of either 10 CFR 830, subpart A, or DOE O 414.1C as applicable.
- Safety class electrical systems must be designed to preclude single-point failure.

- New DOE nuclear reactors must comply with the requirements of DOE O 420.1B, as well as the design requirements of DOE Order 5480.30.

Fire Protection

The objective of fire protection is to establish DOE O 420.1B as the primary requirement for a comprehensive fire protection program for DOE sites, facilities, and emergency service organizations to minimize the potential for the following:

- Occurrence of a fire or related event
- Fires that cause an unacceptable onsite or offsite release of hazardous or radiological material that could impact the health and safety of employees, the public, or the environment
- Unacceptable interruption of vital DOE programs as a result of fire and related hazards
- Property loss from fire exceeding limits established by DOE
- Fire damage to critical process controls and safety class SSCs

Requirements

General requirements include the following:

- Fire protection for DOE facilities, sites, activities, design, and construction must do the following:
  - Provide a level of safety sufficient to fulfill requirements for highly protected risk
  - Prevent loss of safety functions and safety systems as determined by safety analysis and provide defense-in-depth
  - Meet or exceed applicable building codes for the region and NFPA codes and standards
- Acceptable, documented fire protection programs must be developed, implemented, and maintained.
- A comprehensive fire protection design program for facilities and supporting systems must be developed, implemented, and maintained.

Nuclear Criticality Safety

The objective of nuclear criticality safety is to establish requirements for a criticality safety program (CSP) applicable to DOE nuclear facilities and activities, including transportation activities, with potential for criticality hazards so that adequate protection is provided to the public, workers, and the environment.

Requirements

General requirements include the following:

- Criticality safety programs must be implemented to ensure that fissionable material operations will be evaluated and documented to demonstrate that operations will be sub-critical under both normal and credible abnormal conditions.
- No single credible event or failure can result in a criticality.
- The CSP description document must describe how the contractor will implement the requirements in the CRD including the standards invoked by chapter 3 of DOE O 420.1B. The CSP description document must be approved by DOE and implemented as approved.

- Criticality safety programs must include the requirements specified in DOE O 420.1B, chapter III, section 3.a.(4).
- Nuclear criticality safety staff responsible for implementing the CSP must be trained and qualified in accordance with a qualification program approved by DOE, unless the qualification program is compliant with DOE-STD-1135-99, *Guidance for Nuclear Criticality Safety Engineering Training and Qualification*.

Natural Phenomena Hazards Mitigation

The objective of NPH mitigation is to establish requirements for DOE facility design, construction, and operations that protect the public, workers, and the environment from the impact of all NPH events (e.g., earthquake, wind, flood, and lightning).

Requirements

DOE facilities and operations must be analyzed to ensure that SSCs and personnel will be able to perform their intended safety functions effectively under the effects of NPH. Where no specific requirements are identified, model building codes or national consensus industry standards must be used consistent with the intended SSC functions.

Natural phenomena mitigation design

- Facility SSCs must be designed, constructed, and operated to withstand NPH.
- The design and construction of new facilities and major modifications to existing facilities and SSCs must address the following:
  - Potential damage to and failure of SSCs resulting from both direct and indirect NPH events
  - Common cause/effect and interactions resulting from failures of other SSCs
  - Compliance with seismic requirements of EO 12699, “Seismic Safety of Federal and Federally Assisted or Regulated New Building Construction”
- Additions and modifications to existing DOE facilities must not degrade SSC performance during an NPH occurrence.

Explosives Safety

The objective of explosives safety is to establish mandatory design and construction standards for safety in new DOE explosives facilities and for major modifications to such facilities. Explosives facilities include facilities and locations used for storage or operations with explosives or ammunition.

Requirements

New DOE explosives facilities and all modifications to existing explosives facilities must be designed consistent with the DOE explosives safety requirements established in DOE M 440.1 1A, *DOE Explosives Safety Manual*, dated 1-9-06 and technical standards referenced in that manual.

Blast resistant design to protect personnel and facilities must be based on the TNT equivalency of the maximum quantity of explosives and propellants permitted, increased by 20 percent in accordance with Department of Defense, DoD TM5-1300.

System Engineer Program

The objective of chapter V of DOE O 420.1B is to establish requirements for a system engineer program for hazard category 1, 2, and 3 nuclear facilities and to ensure continued operational readiness of the systems within its scope.

Requirements

General requirements include the following:

- Hazard category 1, 2, and 3 nuclear facilities must have a system engineer program, as well as a qualified cognizant system engineer assigned to each system within the scope of the program.
- The system engineer program must be incorporated into the ISMS and must flow down from site and facility implementing procedures, and must define cognizant system engineer functions, responsibilities, and authorities.
- A graded approach must be used in applying the requirements of the system engineer program.

Configuration Management

An objective of the system engineer program is to ensure operational readiness of the systems within its scope. To achieve this, the principles of configuration management must be applied to these systems. Consequently, the following requirements are considered an integral part of the systems engineer program:

- Configuration management must be used to develop and maintain consistency among system requirements and performance criteria, documentation, and physical configuration for the SSCs within the scope of the program.
- Configuration management must integrate the elements of system requirements and performance criteria, system assessments, change control, work control, and documentation control.
- System design basis documentation and supporting documents must be compiled and kept current using formal change control and work control processes or, when design basis information is not available, documentation must include the following:
    - System requirements and performance criteria essential to performance of the system's safety functions
    - The basis for system requirements
    - A description of how the current system configuration satisfies the requirements and performance criteria
- Key design documents must be identified and consolidated to support facility safety basis development and documentation.
- System assessments must include periodic review of system operability, reliability, and material condition. Reviews must assess the system for the following:
    - Ability to perform design and safety functions
    - Physical configuration as compared to system documentation
    - System and component performance in comparison to established performance criteria

- System maintenance and repair must be controlled through a formal change control process to ensure that changes are not inadvertently introduced and that required system performance is not compromised.

- Systems must be tested after modification to ensure continued capability to fulfill system requirements.

OVERSIGHT

24. Personnel must demonstrate a familiarity level knowledge of DOE P 226.1, *Department of Energy Oversight Policy*, and its implementing Order DOE O 226.1A, *Implementation of Department of Energy Oversight Policy*.

[Note: DOE P 226.1 was cancelled by DOE P 226.1B and DOE O 226.1A was cancelled by DOE O 226.1B.]

a. Discuss the purpose and scope of DOE P 226.1A, *Department of Energy Oversight Policy*.

The following is taken from DOE P 226.1B.

Purpose and Scope

The purpose of this policy is to establish the DOE's expectations for the implementation of a comprehensive and robust oversight process that enables the Department's mission to be accomplished effectively and efficiently while maintaining the highest standard of performance for safety and security. As used in this policy, any reference to DOE is also meant to include the NNSA.

The scope of this policy covers operational aspects of ES&H; S&S; cyber security; and emergency management.

The information for KSAs b and c is taken from DOE O 226.1B.

b. Discuss DOE's oversight model.

DOE oversight encompasses activities performed by DOE organizations to determine whether Federal and contractor programs and management systems, including assurance and oversight systems, are performing effectively and complying with DOE requirements. Oversight programs include operational awareness activities, onsite reviews, assessments, self-assessments, performance evaluations, and other activities that involve evaluation of contractor organizations and Federal organizations that manage or operate DOE sites, facilities, or operations.

c. Describe the roles and responsibilities of the Central Technical Authorities, the Chief of Defense Nuclear Safety and the Chief of Nuclear Safety, program offices and field offices, facility representatives and safety system oversight personnel.

Central Technical Authorities

- Maintain awareness of the implementation of nuclear safety requirements and guidance consistent with principles of ISM across the organization (including, for example, reviewing DSAs, authorization agreements, and readiness reviews as necessary to evaluate the adequacy of safety controls and implementation).

- Periodically review DOE organizations to determine whether sufficient numbers of qualified Federal and dedicated support personnel are provided to effectively fulfill the organizations' nuclear safety responsibilities.
- Periodically assess DOE HQ and field element programs for oversight of high consequence activities, such as high hazard nuclear operations.

Chief of Defense Nuclear Safety/Chief of Nuclear Safety

See CS-27e for a description of the responsibilities of these positions.

Heads of Field Elements/Heads of Contracting Activities

- Establish oversight programs and implement the requirements in DOE O 426.1B.
- Notify the contracting officer of affected contracts so that the CRD, or its applicable requirements, may be incorporated into those affected contracts as appropriate.
- Establish and implement line management oversight programs and processes at the field element level to meet the requirements of DOE O 426.1B, and hold personnel accountable for implementing these programs and processes.
- Approve the initial contractor assurance system description. Review and assess the effectiveness of the contractor assurance system.
- Establish performance expectations and communicate same to contractors through formal contract mechanisms.
- Use the results of DOE line and independent oversight and contractor assurance systems to make informed decisions about corrective actions and the acceptability of risks and to improve the effectiveness and efficiency of programs and site operations.

Facility Representatives

The following is taken from DOE-STD-1063-2011.

- Operational awareness. An FR shall be thoroughly familiar with their assigned facility, operating procedures, facility authorization bases, operating organizational structure, and key process control personnel.
- Communication. The FR shall maintain frequent communication with field element supervision.
- Availability. The FR shall be available to respond to facility events and serve as the DOE presence for special operations.
- Independence. An FR should be in a position to provide information to DOE line management independent of programmatic responsibilities.
- Scope of reviews. The FR shall observe, evaluate, and report on the effectiveness of the operating contractor in multiple areas important to safe, efficient operations, such as operational performance, quality assurance, management controls, emergency response readiness activities, and assurance of worker health and safety.
- Oversight routine. FRs should vary their day-to-day presence in assigned facilities to show a degree of unpredictability and spontaneity based on the FR's judgment regarding what is appropriate to observe and assess.
- Stop work authority. The FR shall stop work in the following instances, or in accordance with the guidance provided by the FEM:
  - Conditions exist that pose an imminent danger to the health and safety of workers or the public.

    - Conditions exist that, if allowed to continue, could adversely affect the safe operation of, or could cause serious damage to, equipment or the facility.
    - Conditions exist that, if allowed to continue, could result in the release, from the facility to the environment, of radiological or chemical effluents that exceed regulatory limits.

- Relationship of FR with DOE managers. FRs should periodically meet with line/program managers and senior line managers within the field element to provide information related to the assigned facilities.
- Relationship of FR with other DOE oversight personnel. Descriptions of senior technical safety managers and safety system oversight and their relationships to FRs can be found in DOE O 426.1.
- Relationship of FR with operating contractor. FRs occupy a unique position in the transmission of information between DOE and its contractors. In defining the relationship between an FR and contractor, the following points are emphasized:
    - The FR functions as a part of DOE line management and, therefore, should exercise authority consistent with specific program and management guidance established by the field element.
    - The FR is the primary point of contact for the contractor to notify DOE of reportable occurrences as prescribed in DOE M 231.1-2.
    - The contractor is responsible for the safe and efficient operation of the facility. No FR activity or inactivity can diminish the contractor's responsibility.
    - The FR is responsible for determining that the contractor is operating the facility in a safe and efficient manner, consistent with the established safety expectations and requirements.
    - Although the FR identifies deficiencies, the ultimate responsibility for identifying and correcting deficiencies rests with the operating contractor.
    - Minor events or problems are frequently clues that indicate more general problems in the contractor's organization, management, personnel abilities, or practices.
    - The FR shall adhere to certain rules of conduct, or protocol, while performing assigned duties, including the facility's approved conduct of operations procedures. Formal protocols should be established.

Safety System Oversight Personnel (Office of Health, Safety, and Security)

The HSS is responsible for the following:

- Serves as office of primary interest for DOE O 226.1B.
- Distributes lessons learned resulting from independent oversight appraisals and/or corrective actions as part of the Department's operating experience program.
- Coordinates any changes, revisions, or directives developed in support of DOE O 226.1B.
- Consults with the PSO or NNSA Administrator on request for exemptions/equivalencies from DOE O 226.1B.
- Conducts independent oversight, and ensures that high priority is placed on independent oversight of operational awareness activities and appraisals of high consequence activities.

d. Describe the roles and responsibilities of the DOE's Office of Independent Oversight.

[Note: The Office of Independent Assessment was replaced by HSS's Office of Enforcement and Oversight, from which the following is taken.]

The independent oversight program is implemented by HSS's Office of Enforcement and Oversight. The mission of this program is to provide DOE line management, Congress, and other stakeholders with an independent evaluation of the effectiveness of DOE policy and line management performance in safety and security, and other critical areas as directed by the Secretary of Energy. The Office of Enforcement and Oversight performs this mission by conducting activity, facility, site, and Department-wide performance-based assessments that are designed to verify that the Department's S&S interests are protected, that the Department can effectively respond to emergencies, and that departmental employees, the public, and the environment are protected from hazardous operations and materials. The outcome of these assessments are reports that provide information and analysis regarding the effectiveness, vulnerabilities, and trends in DOE safety and security programs, and identify issues requiring corrective action as well as recommended areas for improvement.

e. Describe "assurance systems" as found in DOE P 226.1.

The information for KSAs e and f is taken from DOE P 226.1B.

Assurance systems are tailored to meet the needs and unique risks of each site or activity, include methods to perform rigorous self-assessments, conduct feedback and continuous improvement activities, identify and correct negative performance trends, and share lessons learned.

f. Describe the attributes of effective oversight.

Attributes of effective assurance and oversight processes include the following:

- Assurance systems are tailored to meet the needs and unique risks of each site or activity, include methods to perform rigorous self-assessments, conduct feedback and continuous improvement activities, identify and correct negative performance trends, and share lessons learned
- DOE oversight programs are designed and conducted commensurate with the level of risk of the activities
- The oversight of activities with potentially high consequences is given high priority and greater emphasis.

g. Discuss the requirements imposed by DOE O 226.1 on the contractors that operate DOE nuclear facilities.

The following is taken from DOE O 226.1B.

The contractor must establish an assurance system that includes assignment of management responsibilities and accountabilities and provides evidence to assure both DOE's and the contractor's managements that work is being performed safely, securely, and in compliance with all requirements; risks are being identified and managed; and that the systems of control are effective and efficient.

The contractor assurance system, at a minimum, must include the following:

- A method for validating the effectiveness of assurance system processes. Third party audits, peer reviews, independent assessments, and external certification may be used and integrated into the contractor's assurance system to complement, but not replace, internal assurance systems.
- Rigorous, risk-informed, and credible self-assessment and feedback and improvement activities. Assessment programs must be risk-informed, formally described and documented, and appropriately cover potentially high consequence activities.
- A structured issues management system that is formally described and documented and that
  - captures program and performance deficiencies (individually and collectively) in systems that provide for timely reporting, and taking compensatory corrective actions when needed; and
  - contains an issues management process that is capable of categorizing the significance of findings based on risk and priority and other appropriate factors that enable contractor management to ensure that problems are evaluated and corrected on a timely basis.
- Timely and appropriate communication to the contracting officer, including electronic access of assurance-related information.
- Continuous feedback and improvement, including worker feedback mechanisms, improvements in work planning and hazard identification activities, and lessons learned programs.
- Metrics and targets to assess the effectiveness of performance, including benchmarking of key functional areas with other DOE contractors, industry, and research institutions.

The contractor must submit an initial contractor assurance system description to the contracting officer for DOE review and approval. That description must clearly define processes, key activities, and accountabilities. An implementation plan that considers and mitigates risks should also be submitted if needed and should encompass all facilities, systems, and organization elements. Once the description is approved, timely notification must be made to the contracting officer of significant assurance system changes prior to the changes being made.

To facilitate appropriate oversight, contractor assurance system data must be documented and readily available to DOE. Results of assurance processes must be analyzed, compiled, and reported to DOE as requested by the contracting officer.

h. Describe criteria review and approach documents and their use in the performance of oversight activities.

The following is taken from DOE-STD-3006-2010.

Criteria review and approach documents list the criteria that the technical experts (team members) plan to use to evaluate and describe the objective evidence that is gathered to determine whether the criteria have been met. The review approach consists of evaluating a sampling of documents, hardware/systems, people, and performance.

Criteria review and approach documents are used in the implementation plan to establish the depth of the review and provide guidance to the review team members. As such, the quality of these documents significantly impacts the overall quality of the review. CRADs are a key component of the implementation plan for the review.

The team leader assembles a review team to assist in the preparation of the implementation plan, which includes the CRADs that the team members use to conduct the review. Together, the CRADs incorporate the complete review scope specified in the plan of action.

i. Describe the role of the Defense Nuclear Facilities Safety Board in oversight of DOE defense nuclear facilities.

The following is taken from the Defense Nuclear Facilities Safety Board (DNFSB), Our Mission.

Congress created the DNFSB as an independent agency within the executive branch to identify the nature and consequences of potential threats to public health and safety at DOE's defense nuclear facilities, to elevate such issues to the highest levels of authority, and to inform the public. Under its legislative mandate, the DNFSB plays a key role in maintaining the future viability of the nation's nuclear deterrent capability by

- ensuring that the health and safety of the public and the workers at DOE's defense nuclear facilities located throughout the United States are adequately protected, as DOE maintains the readiness of the nuclear arsenal, dismantles surplus weapons, disposes of excess radioactive materials, cleans up surplus defense nuclear facilities, and constructs new defense nuclear facilities;
- enhancing the safety and security at our nation's most sensitive defense nuclear facilities when hazardous nuclear materials and components are placed in more secure and stable storage; and
- providing for the early identification of health and safety vulnerabilities, allowing the Secretary of Energy to address issues before they become major problems.

25. Personnel must demonstrate a familiarity level knowledge of DOE O 210.2, *DOE Corporate Operating Experience Program*.

[Note: DOE O 210.2 was replaced by DOE O 210.2A, from which the information for all of the KSAs in this competency statement is taken.]

a. Describe the objectives of DOE O 210.2, *DOE Corporate Operating Experience Program*.

The purpose of DOE O 210.2A is to

- institute a DOE wide program for the management of operating experience complex-wide to prevent adverse operating incidents and facilitate the sharing of good work practices among DOE sites, while enabling tailored local operating experience programs based on the nature of work, hazards, and organizational complexities. Operating experiences can be found in all disciplines;

- provide the systematic review, identification, collection, screening, evaluation, and dissemination of operating experience from U.S. and foreign government agencies and industry, professional societies, trade associations, national academies, universities, and DOE and its contractors;
- define the DOE corporate operating experience program so that it can be integrated into major management programs—reinforcing the core functions and guiding principles of DOE's ISMS—and enhance mission accomplishment, QA, safety, and reliability.

b. Describe the types of information that are collected and analyzed.

A formal process must be established to review and evaluate operating experience from DOE and related government or industry programs, technologies, and facilities.

Internal sources of operating experience are the DOE corporate operating experience program documents from DOE contractors and DOE HQ and field elements.

External sources of operating experience, as applicable, are:

- U.S. and foreign industry
- Other Federal agencies such as the Chemical Safety and Hazard Investigation Board, the National Transportation Safety Board, and NASA
- The NRC and EPA
- Foreign government and foreign industry experience
- International agencies involved with energy issues such as the International Energy Agency and the International AEA

c. Describe the types of operating experience reports that are developed.

Table 10 illustrates the various types of operating experience reports.

Table 10. DOE corporate operating experience program documents

Operating experience (OE) document	Purpose
OE level 1 (OE-1)	To inform the DOE complex of the most significant events or trends of concern to DOE management, including assessments and required actions with close-out verification in a formal response.
OE-2	To inform the DOE complex (or affected sites) of potentially significant safety issues (e.g., conduct of operations [CONOPS]; S/CI, or defective items). Must include a statement of actions required (or recommended for NNSA) and formal method of feedback.
OE-3	To inform senior HQ and field management when an event(s) or a trend(s) warrants attention by senior HQ or field management, but the issue does not warrant an OE-1 or OE-2 report. Highlights important ES&H issues for senior management's attention and potential action.
Operating experience summary	To inform the DOE complex of DOE or external operating experience from which sites could benefit. Consists of a compilation of informative operating experience-based articles.
S/CI-D data collection sheet	To provide information on S/CI-Ds with potential impact to DOE operations. Developed from review of occurrence reports, the government/industry data exchange program, the Institute of Nuclear Power Operations, and other sources.
DOE lessons learned report	To provide feedback communications on identified program/mission-specific lessons learned across the DOE complex.

Source: DOE O 210.2A

26. Personnel must demonstrate a familiarity level knowledge of DOE O 225.1A, *Accident Investigations*.

[Note: DOE O 225.1A was cancelled by DOE O 225.1B.]

a. Describe the accident investigation process.

The following is taken from DOE O 225.1B.

Upon determination that an accident investigation will be conducted, the head of the HQ element must appoint an AIB. Alternatively, if the head of the HQ element and HSS agree that it is in the best interest of DOE, HSS will serve as the appointing official. Federal accident investigations must be conducted as follows.

1. *Appoint the AIB*
   - Within three calendar days of the accident occurrence, the appointing official must formally appoint DOE Federal employees to an AIB. If the appointment of an AIB is

delayed beyond three calendar days, the rationale for the delay must be explained and documented in the accident investigation report.

  - The AIB must consist of a chairperson and three to six members, at least one of whom must be a DOE accident investigator. All AIB members must be DOE Federal employees with subject matter expertise in areas related to the accident, including knowledge of the Department's ISM directives.

- Both the chairperson and the DOE accident investigator must be selected from a different duty station than the accident location.
- The AIB must be appointed in writing. The appointment letter/memorandum must specify the scope of the investigation, the individuals being appointed, special provisions of the investigation, and a specified completion date for the final report. The appointment letter must release all members of the AIB from their normal responsibilities/duties for the period of time the AIB is convened. The scope of the investigation must include gathering facts, analyzing causes, developing conclusions, and developing judgments of need pertaining to DOE and contractor organizations and management systems that could have or should have prevented the accident.
- The appointing official or his/her representative must brief the AIB members on their roles and responsibilities and other pertinent information within three calendar days of their appointment.
- The DOE AIB chairperson must meet the following criteria:
  - Be a DOE manager with demonstrated managerial competence, preferably a member of the senior executive service, or at a senior general service grade level determined to be appropriate by the appointing official
  - Be knowledgeable of DOE accident investigation techniques and experienced in conducting accident investigations through participation in at least one Federal accident investigation, or have equivalent accident investigation experience, as determined to be appropriate and documented by the appointing official.

- An AIB must have either a chairperson or a DOE accident investigator who meets the full experience and training requirements to serve in those AIB positions. Other AIB and staff personnel need not meet these requirements.
- The AIB may be supported by appropriate advisors and consultants who may be Federal, contractor, and/or consultant personnel as determined by the AIB chairperson. Investigative and technical expertise may be requested from other heads of the HQ elements and/or HSS.
- The AIB chairperson and members must meet the following criteria:
  - Report only to the appointing official or his/her representative, as identified in the letter/memorandum of appointment, during the investigation
  - Be independent of the direct line management chain responsible for day-to-day operation or oversight of the facility, area, or activity involved in the accident
  - Not include both a supervisor and his/her direct-report subordinate

2. *Investigate the Accident*

   - The AIB must conduct a thorough investigation of individuals, organizations, management systems, and facilities having an interest in or potential impact on the accident, as well as the operation or oversight of the facility, area, or activity involved in the accident.

- The AIB must determine the facts of the accident by examining the accident scene, examining DOE and contractor documentation, interviewing witnesses and other personnel directly associated with the accident, and performing engineering tests and analyses as appropriate. Information provided to the AIB (e.g., witness statements, interview notes) must be protected to the full extent provided by law. The AIB must also examine policies, standards, and requirements that apply to the accident being investigated, as well as DOE and contractor management systems that could have contributed to or prevented the accident.
- The AIB must analyze the facts and derive causal factors (direct, root, and contributing causes) associated with human performance and the SMS. Each identified root and contributing causal factor must support a corresponding judgment of need.
- The AIB must evaluate the effectiveness of the SMS (as defined by the Department's ISM directives), the adequacy of policy implementation, and the effectiveness of line management oversight as they relate to the accident.
- Prior to completion of the investigation, the AIB must conduct an internal review of the investigation process to ensure the following:
  - The pertinent facts, standards, and requirements relating to the accident are identified and thoroughly analyzed, and causal factors are determined by employing the core analytical techniques.
  - Judgments of need are stated and can be supported by the facts and analysis contained in the report, so that the report can serve as a stand-alone document.
  - The accident investigation report can be used to promote the values and concepts of a learning organization.

3. *Report Investigation Results*
   - The AIB must develop an accident investigation report. The purpose of the report is to tell what happened and why it happened in order to use this understanding to prevent future accidents. The report must do the following:
     - Identify the causes (both individual and organizational) that contributed to the accident to help explain how failure succeeded in a normally reliable and safe system.
     - Help identify essential learning organizational opportunities.
     - Demonstrate that the judgments of need are based on objective analysis and application of the core analytical techniques using the facts to develop the root and contributing causes.
     - Also identify DOE and contractor management systems that, if corrected, could have prevented the accident so those systems can be addressed and corrected to prevent recurrence.
   - The AIB must offer the facts underlying the draft investigation report to the affected DOE and contractor management for their review for factual accuracy before the report is completed.
   - Before completion of the accident investigation report, the AIB chairperson must do the following:
     - Conduct a review of the report to ensure its technical accuracy, completeness, and internal consistency.

- Ensure that the report includes results from an analysis of management control, safety systems, and human performance, which may have contributed to the accident.
- Ensure that the report is reviewed by qualified and authorized personnel to determine that it does not include classified or unclassified controlled nuclear information, official use only information, or information protected by the Privacy Act of 1974, as amended. Documentation that these reviews have been conducted must be retained as part of the investigation file.
- Forward an electronic copy of the draft report to the HSS Office of Corporate Safety Analysis for quality review. The AIB will work with the HSS staff to address relevant comments.

- The AIB chairperson and AIB members must sign and date the final draft accident investigation report. Should any AIB member wish to offer an opinion different from that of the AIB, the report must include a section for the minority opinion. The AIB chairperson and the AIB member wishing to provide a minority opinion will coordinate on development of the final report. The minority opinion must identify where facts, analysis, conclusions, and judgments of need differ from the opinions expressed by the chairperson and other AIB members.
- The AIB must submit the final draft report to the appointing official for acceptance within the required time frame to ensure that the accident investigation has met the scope and any special provisions of the appointing letter/memorandum. Once the final draft accident investigation report is accepted in writing by the appointing official, the report is considered final. AIB team members may then be released by the chairperson as appropriate.
- A statement signed and dated by the appointing official must be included in the final report accepting the investigation report, including the AIB's identified causal factors, conclusions, and judgments of need.
- The appointing official must publish and distribute the final report within seven calendar days of report acceptance; provide an electronic version of the final report (in pdf format) to HSS for posting on the DOE accident investigation program website; and distribute to organizations identified in the judgments of need.
- The chairperson of an AIB must conduct a formal briefing on the outcome of the investigation. The appointing official for the investigation must coordinate and arrange for appropriate representatives to attend this formal briefing at a mutually convenient time and location.

b. Describe the roles and responsibilities of key participants in accident investigations.

The following is taken from DOE O 225.1B.

Appointing Official

- Review the list of AIB candidates and eliminate those who have a potential conflict of interest. Both the chairperson and the DOE accident investigators are required to be selected from a different duty station than the accident location. Formally appoint DOE employees to AIBs, normally within three calendar days of determining that an AIB is required. The appointment must be in writing.

- Ensure that the AIB's authority is clear about investigating all potential causes of a given accident, including with no restrictions, DOE organizations and management systems up to and beyond the level of the appointing official.
- Ensure that the AIB is briefed on its roles and responsibilities stressing the AIB's authority and scope, normally within three calendar days of appointment.
- Accept the investigation report by signing and dating a statement to this effect, which is subsequently incorporated into the final report. Once accepted, the report is considered final and the AIB is released from its responsibilities.
- Publish and distribute the accident investigation report, normally within seven calendar days of report acceptance.

AIB Chairperson

- Manage the investigation process and represent DOE in all matters regarding the accident investigation.
- Ensure that a thorough and competent investigation is completed.
- Document the situation and obtain guidance from general counsel and HSS where a conflict between another government agency's Code of Federal Regulations and DOE O 225.1B is identified during the accident investigation.
- Notify the Director, HSS Office of Enforcement, of any potential regulatory noncompliance issues identified during the investigation.
- Submit the draft accident investigation report to the HSS Office of Corporate Safety Analysis for quality review and assurance that the report meets the DOE accident investigation program's objectives and standards.
- Refer allegations and evidence of criminal or suspected unlawful activity that are identified in the course of the accident investigation to the Office of Inspector General in accordance with DOE O 221.1A, *Reporting Fraud, Waste and Abuse to the Office of Inspector General.*
- As the spokesperson for the AIB, coordinate AIB activities and general progress with all relevant and appropriate internal and external stakeholders having an interest in the accident, employing the local Office of External Affairs for interface as appropriate.
- Ensure that the AIB is supported by appropriate advisors and consultants with specialized expertise as deemed necessary. If additional technical resources (e.g., subject matter experts, team coordinator, and administrative personnel), logistical support, and/or investigative time is needed to produce a high quality investigation and report, notify the appointing official and head of the field element when those needs are recognized so that requested support can be acquired early in the investigation.

The following is taken from DOE G 225.1A-1 (archived).

AIB Members

Board members are primarily responsible for collecting and analyzing information, reaching conclusions regarding causal factors, identifying judgments of need, and writing the report. Board members should use a broad range of investigative and analytical techniques to make these determinations.

c. Describe accident investigation data collection and data analysis techniques.

[Note: DOE O 225.1B does not address data collection and analysis techniques or the development of conclusions and judgments of need. Therefore, the information for KSAs c and d is taken from DOE G 225.1A-1 (archived).]

Data Collection Techniques

There are three types of evidence: physical, human (given through witness statements or interviews), and documentary (including photographic media). The collection and control of physical evidence is an important element of preserving the accident scene and an important role of readiness teams. Some physical evidence can safely be left intact at a protected accident scene. However, other evidence may be located remotely from the scene, may have been removed during emergency response or casualty evacuation activities, or may be too perishable to safely remain at the scene. Such evidence should be protected from damage or contamination and safely stored for delivery and transfer to the board. It may not be apparent whether some items are evidence—that is, whether they are significant to the investigation. When in doubt, it is best to be conservative in treating items as evidence. It is easy to discard items later that are not needed but difficult or impossible to recover needed items that were not preserved. Additional information concerning collecting and controlling evidence is contained in section IV, paragraphs 3.2.2, 3.2.3, and 3.3, of DOE G 225.1A-1.

Physical and documentary evidence should be preserved and secured as it is collected. These steps are necessary to prevent alteration and to establish the accuracy and validity of collected evidence. Evidence should be stored in a secured area and access to the evidence limited to those who have a need to examine and use it during the accident investigation. No evidence should be released without the authorization of the board chairperson.

Data Analysis Techniques

A suite of analytical techniques available to support the accident investigation process is listed in table 11. Change analysis, barrier analysis, root cause analysis, and events and causal factors charting and analysis are all considered core analytical techniques for accident investigations. They are easy to learn and use, are efficient, and meet the needs of DOE's accident investigation program. While many techniques could be used on most accidents, those used must be suitable for the type and complexity of the accident. For example, causation for a complex accident could not be determined through the use of only one technique, such as barrier analysis.

For complex accidents, more rigorous techniques, such as those that employ complicated analytical trees, may be necessary to ensure that accident causation is identified. Two examples are management oversight and risk tree and project evaluation tree.

Other analytical techniques could be used, if needed, for specific situations such as scientific modeling (e.g., for incidents involving criticality and atmospheric dispersion), material and structural analysis, human factors analysis, software hazards analysis, common cause failure analysis, or sneak circuit analysis. In certain situations, an integrated accident event matrix may be developed to determine the actions and interactions of personnel around the time of the accident. The application of analytical techniques for a given accident is determined by the board chairperson, in consultation with board members and advisors/consultants who have expertise in available techniques.

Table 11. Accident investigation analytical techniques

Core Analytical Techniques
For the basic accident with few system failures, these analytical techniques may be used: ▪ Barrier analysis ▪ Change analysis ▪ Root cause analysis (manual or automated) ▪ Events and causal factors charting and analysis
Complex Analytical Techniques
For complex accidents with multiple system failures, the analytical techniques may include fault or analytic tree analysis, and the core analytical techniques listed above.
Specific Analytical Techniques
This pool of analytical techniques should be used to select techniques for specific investigations (depending on the nature and complexity of the accident) as determined by subject matter experts and the board chairperson: ▪ Human factors analysis ▪ Integrated accident event matrix ▪ Failure modes and effects analysis ▪ Software hazards analysis ▪ Common cause failure analysis ▪ Sneak circuit analysis ▪ 72-hour profile ▪ Materials and structural analysis ▪ Scientific modeling (e.g., for incidents involving criticality and atmospheric dispersion)

Source: DOE G 225.1A-1

d. Describe the development of conclusions and judgments of need.

Conclusions

Conclusions are significant deductions taken from the investigation's analytical results.

They are taken from and supported by the facts and the results from testing and the various analyses conducted. Conclusions are statements that answer two of the questions the accident investigation addresses: what happened and why it happened. Conclusions may include concise recapitulations of the causal factors (direct, contributing, and root causes) of the accident, as determined by analysis of the facts. An example of a conclusion is, "XYZ contractor failed to adequately implement a medical surveillance program, thereby allowing an individual with medical restrictions to work in violation of those restrictions. This was a contributing factor to the accident." Conclusions also may be statements that alleviate potential confusion or issues that may have originally been suspected causes (e.g., welds did not fail during the steam line rupture). Conclusions may also address significant concerns arising out of the accident or address unsubstantiated concerns or inconclusive results (e.g., blood tests on the injured worker did not conclusively establish his blood alcohol content at the time of the accident).

Where appropriate, conclusions may be used to highlight positive aspects of performance revealed during the investigation (e.g., implementation of comprehensive response procedures prevented the fire from spreading to areas containing dispersible radioactive materials, averting a significant escalation in the consequences of the fire).

When developing conclusions, the investigator should do the following:

- Organize conclusions sequentially, preferably in chronological order, or in logical sets (e.g., hardware, procedures, people, organizations)
- Base conclusions on the facts and results from subsequent analysis of the facts
- Include only substantive conclusions that bear directly on the accident and that reinforce significant facts and pertinent analytical results that led to the accident's causes
- Keep conclusions as short as possible and, to the extent possible, limit reference citations (if used) to one per conclusion

Judgments of Need

The judgments of need are the board's decisions regarding the managerial controls and safety measures necessary to prevent or minimize the probability or severity of a recurrence. Judgments of need should also provide the basis for subsequent corrective actions. DOE O 225.1A requires that each accident investigation report contain judgments of need for corrective actions based on an objective analysis of the facts and the causal factors, including DOE or contractor management systems, that could have prevented the accident. Judgments of need should not include accident investigation process issues (e.g., evidence control, preservation of the accident scene, readiness, etc.) unless they have a direct impact on the accident. These concerns should be noted in a separate memorandum to the appointing official, with a copy to site management and the Assistant Secretary for Environment, Safety and Health.

Judgments of need should be constructed so they clearly identify the organization that is to implement corrective actions to prevent recurrence of the accident. The board should avoid generic statements and focus on processes and systems, not individuals. Judgments of need should focus on causal factors. Being specific and concise is essential; vague, generalized, broad-brush, sweeping solutions introduced by "should" statements ought to be avoided. Sentences listing judgments of need may start, "A need exists…" or, "There is a need to…" As an example, a judgment of need might be worded, "There is a need for XYZ Corporation to ensure that an adequate hazards analysis is performed prior to changes in work tasks that affect the safety and health of personnel." A judgment of need does not tell management how to do something; instead, it simply identifies the need. Corrective action plans are prepared to address the judgments of need. The resulting corrective actions are the responsibility of line management. If the board finds the need to make specific recommendations, they should be listed in a separate communication and not in the body of the report or transmittal letter to the appointing official.

27. Personnel must demonstrate a familiarity level knowledge of DOE O 410.1, *Central Technical Authority Responsibility Regarding Nuclear Safety Requirements*.

The information for all of the KSAs in this competency statement is taken from DOE O 410.1.

a. State the purpose of DOE O 410.1, *Central Technical Authority Responsibility Regarding Nuclear Safety Requirements*.

The objectives of DOE O 410.1 are to:

- establish central technical authority (CTA) and Chief of Nuclear Safety/Chief of Defense Nuclear Safety responsibilities and requirements directed by the Secretary of Energy in the development and issuance of DOE regulations and directives, including standards that affect nuclear safety;
- identify CTA authorities and actions for specific regulations and directives;
- establish related responsibilities and requirements for other departmental elements;
- establish responsibilities and requirements for addressing nuclear safety regulations and directives in contracts.

b. Define the following terms:

- **Exception**
- **Exemption**

Exception

The situation that exists when WSSs, S/RIDs, approved ISMS or similar processes are used to modify an applicable CRD provision for inclusion in a contract, and a knowledgeable person would reasonably conclude that the apparent meaning of the CRD provision has not been met by its contractual treatment. Exceptions are taken to provide relief from what would be a requirement were a CRD provision included in the contract as it is written in the directive where it appears.

Exemption

Exemptions may apply to Federal personnel and/or contractors. For Federal personnel, an exemption is formal and final relief from the need to comply with applicable requirements of DOE regulations and directives. For contractors, an exemption is a formal and final release from a provision in a DOE Order, notice, or manual that has been included in their contract; or from one or more requirements in a regulation.

c. List all the documents and directives that require Central Technical Authorities/Chief of Nuclear Safety/Chief of Defense Nuclear Safety concurrence before they are issued.

Central technical authority concurrence is required on directives included pursuant to 48 CFR 970.5204-2 paragraphs (b) and (c) in all new prime management and operating, management and integration, design, and construction contracts for DOE nuclear facilities.

Note: In the following, "CTA" includes all CTAs having responsibilities for nuclear facilities that are covered by a particular contract or that would be affected by granting an exemption or exception:

- CTA concurrence is required prior to approval of exemptions to 10 CFR 830 and prior to approval of exemptions or exceptions to the directives listed in attachment 1 of DOE O 410.1.
- CTA concurrence is required prior to approval of a methodology other than that given in table 2-1, appendix A of subpart B to 10 CFR 830 for preparation of a DSA for a hazard category 1, 2 or 3 nuclear facility.

- CTA concurrence is required on the directives included pursuant to 48 CFR 970.5204-2 paragraph (b) and paragraph (c) in requests for proposals (RFPs) for new prime contracts for DOE nuclear facilities prior to the release of the RFP. CTA concurrence is required prior to contract award if changes are made to the included directives after initial RFP is released.
- CTA concurrence is required on directives included pursuant to 48 CFR 970.5204-2 paragraph (b) and paragraph (c) prior to approving revisions to existing prime contracts when both of the following conditions exist:
  - The revisions involve construction, major modification, or initiation of program work.
  - Any of the CRD provisions of directives listed in attachment 1 that are applicable to the construction, major modification or new program work were not previously included in the contract.
- Implementation of WSSs, S/RIDs, or approved ISMS processes used to tailor the requirements included in new or revised contracts pursuant to 48 CFR 970.5204-2 paragraph (c) must be consistent with the following requirements:
  - Directives listed in attachment 1 of DOE O 410.1, and subsequent revisions, must be evaluated for applicability within 12 months of issuance or within the time period identified in the directive, whichever is shorter.
  - Methodologies listed in table 2-1, appendix A of subpart B to 10 CFR 830 must be implemented as written when used for the development of DSAs for hazard category 1, 2, or 3 nuclear facilities, unless DOE approves the use of an alternative methodology.
  - As directives listed in attachment 1 are revised, or new directives are added to attachment 1, an integrated listing (organized by regulation or directive number as appropriate) must be developed and maintained to indicate which provisions of the new or revised CRDs have been implemented, omitted, and implemented with exceptions or in a modified form in prime contracts. Treatment of directives already in prime contracts as of the date of this order is not included in this requirement, but the treatment of future revisions to those directives is subject to this requirement
  - As directives listed in attachment 1 are revised, or new directives are added to attachment 1, justifications must be documented and maintained for the life of the prime contract that explain the contractual treatment of new or revised CRD provisions not included in the contract as written in the CRD. Treatment of directives already in contracts as of the date of this order is not included in this requirement, but the treatment of future revisions to those directives is subject to this requirement.
- CTA concurrence is required prior to approval of a revision to, or cancellation of, 10 CFR 830 or the directives and regulations listed in attachment 2 of DOE O 410.1.

d. State the responsibilities of the Central Technical Authorities.

Note: In the following subsections, when more than one CTA is responsible for nuclear facilities to which a directive is applicable, or that are covered by a particular contract or that would be affected by granting an exemption or exception, all responsible CTAs must concur on the associated action.

The responsibilities of the CTA are the following:

- Concur with exemptions to 10 CFR 830 and exemptions or exceptions to the directives listed in attachment 1 of DOE O 410.1 for directives, within the time limits for both exemptions and exceptions; for exemptions to 10 CFR 830, no later than 30 days before the time limit for approval elapses.
- Concur with revision or cancellation of directives and regulations listed in attachment 2 of DOE O 410.1.
- Concur with new regulations and directives that the CTA identifies as affecting nuclear safety.
- For structures, activities and operations for which they are responsible
  - concur with the directives included in RFPs and in new prime contracts for nuclear facilities;
  - concur with the directives included in prime contract revisions that allow for construction, major modification or new program work when both of the following conditions apply: 1) any of the CRD provisions of directives listed in attachment 1 of DOE O 410.1 are applicable to the construction, major modification or new program work, and 2) the applicable CRD provisions are not already included in the prime contract.
- Identify documents that affect nuclear safety by approving changes to attachments 1 and 2 of DOE O 410.1 for existing documents, and by notifying the office of primary interest or the preparing activity for new documents as early in the coordination process as possible, preferably during pre-coordination, that CTA concurrence will be required.
- Concur with the use of any methodology other than that given in table 2-1, appendix A of subpart B to 10 CFR 830 to prepare a DSA for a hazard category 1, 2 or 3 nuclear facility within 150 calendar days of receipt of the request for concurrence.

e. State the responsibilities of the Chief of Nuclear Safety and Chief of Defense Nuclear Safety.

The responsibilities of the Chief of Nuclear Safety and the Chief of Defense Nuclear Safety are as follows:

- Develops and maintains a baseline list of known exemptions to 10 CFR 830 and exemptions or exceptions taken in prime contracts for nuclear facilities to directives identified in attachment 1 of DOE O 410.1.
- Evaluates requests for exemptions to 10 CFR 830 and for exceptions or exemptions to directives identified in attachment 1 of DOE O 410.1 and for each request, provides the CTA a written summary of the evaluation along with a recommendation regarding concurrence.
- Evaluates requests for revision or cancellation of regulations and directives listed in attachment 2 of DOE O 410.1; and, for each request, provides the CTA a written summary of the evaluation along with a recommendation regarding concurrence.
- Evaluates new and revised regulations and other documents for inclusion in attachments 1 and 2 of DOE O 410.1 and provides the CTA a written summary of the evaluation and justification for each document recommended for inclusion as early in the coordination process as possible, preferably during pre-coordination.

- Evaluates RFPs and new or revised nuclear facility contracts for adequacy of the directives included and provides the CTA written summaries of the evaluations along with recommendations regarding concurrence.
- Maintains a list of approved deviations from the double contingency principle (DOE O 420.1B).
- Evaluates the use of any methodology other than that given in table 2-1, appendix A of subpart B to 10 CFR 830 to prepare a DSA for a hazard category 1, 2 or 3 nuclear facility and for each request, provides the CTA a written summary of the evaluation along with a recommendation regarding concurrence.

SECURITY

28. Personnel must demonstrate a familiarity level knowledge of DOE security programs, including DOE O 470.4A, *Safeguards and Security Program*, and its implementing manuals.

[Note: DOE O 470.4A was cancelled by DOE O 470.4B.]

a. Discuss information security programs, including control of classified materials, as described in DOE M 470.4-4, *Information Security*.

[Note: DOE M 470.4-4 was cancelled by DOE O 471.6, *Information Security*, from which the following is taken.]

Classified information in all forms must be protected in accordance with all applicable laws, regulations, policies, directives, and other requirements; and must only be processed on information systems that have received authority to operate at the appropriate classification for the information according to DOE Office of the Chief Information Officer directives.

The Office of the Chief Information Officer provides DOE directives

- for the security of the information systems that store classified information, and
- to ensure that classified information is only processed on information systems that achieve the appropriate requirements for national security systems.

When information is prepared on classified information systems, the hard copy output (which includes paper, microfiche, film, and other media) must be correctly marked either according to its classification per review of the output, or as a working paper.

Classified matter may be transmitted by approved electronic means. When using this method, both the transmitting and receiving systems must be approved for the classification level and category of the information to be transmitted. Facilities also must have an approved security plan and a procedure(s) for transmitting the information by electronic means.

b. Discuss physical protection programs, including security areas, intrusion detection, and access controls, as described in DOE M 470.4-2, *Physical Protection*.

[Note: DOE M 470.4-2 was cancelled by DOE O 473.3, *Protection Program Operations*, from which the following is taken.]

Security Areas

Security areas are established to provide protection to a wide array of S&S interests under the Department's purview, to include nuclear weapons, SNM, classified information, buildings, facilities, government property, employees and other interests.

General Access Areas

General access areas may be established to allow access to certain areas with minimum security requirements documented in security plans approved by the officially designated Federal security authority. These designated areas are accessible to all personnel including the public. DOE line management should establish security requirements for those areas designated as general access areas.

Property Protection Areas

Property protection areas are security areas that are established to protect employees and government buildings, facilities, and property. These security areas will be established with security requirements documented in security plans approved by the cognizant security office. The requirements for these areas must be configured to protect government-owned property and equipment against damage, destruction, or theft and must provide a means to control public access. Protection may include physical barriers, access control systems, biometric systems, protective personnel or persons assigned administrative or other authorized security duties, intrusion detection systems, locks and keys, etc.

Limited Areas

Limited areas are security areas designated for the protection of classified matter and category III and higher quantities of SNM and to serve as a concentric layer of protection. Limited area boundaries shall be defined by physical barriers encompassing the designated space and access controls to ensure that only authorized personnel are allowed to enter them.

Protected Areas

Protected areas are security areas typically located within a limited area that are established to protect category II or greater quantities of SNM and may also contain classified matter. The PA provides concentric layers of security for the material access area (MAA). In addition to meeting limited area requirements, the following apply to a PA.

Protected areas must be encompassed by physical barriers that identify the boundaries, surrounded by a perimeter intrusion detection and assessment system (PIDAS), and equipped with access controls that ensure only authorized personnel are allowed to enter and exit.

Special Designated Security Areas

Other areas with access restrictions include central alarm stations (CASs), secondary alarm stations (SASs), sensitive compartmented information facilities, special access program facilities, classified conferencing rooms, secure communications centers, and automated information system centers.

Intrusion Detection and Assessment Systems

The intrusion detection and assessment systems must be configured to support interior and exterior applications. Intrusion detection and assessment systems and/or visual observation by protective force personnel must be used to protect classified matter, government property, and SNM to ensure breaches of security barriers or boundaries are detected and responded to appropriately. The systems must be configured so that only authorized personnel may make adjustments.

Access Controls

Entry control points must be located within the PIDAS and protected by the PIDAS when not in use. This configuration must provide a continuous PIDAS zone at the barrier that encompasses the entry control point. The entry control point should permit entry of only one person at a time into PAs and MAAs. Electronic entry control point search equipment (e.g., metal detectors) must annunciate locally to a protective force staffed entry control point instead of annunciating at the CAS and SAS.

Automated access control systems may be used in place of or in conjunction with protective or other authorized personnel to meet access requirements.

- Both the CAS and SAS must monitor the automated access control system's intrusion alarm events.
- Badge readers at PAs and MAAs must have anti-passback protection.

c. Describe how the design basis threat is used in safeguards and security planning in accordance with DOE M 470.4-1, *Safeguards and Security Program Planning and Management*.

[Note: "Design basis threat" is now "graded security protection" and is the subject of DOE O 470.3B, Graded Security Protection (GSP) Policy. This Order is classified as (Secret/RD/NOFORN) and is not available on the directives portal. For distribution, contact John Fitzgibbons, 301-903-1361, john.fitzgibbons@hq.doe.gov.]

The following is taken from DOE M 470.4-1 chg. 1 (archived), which may be helpful.

While the graded security protection provides specific descriptions of threats that all components of the S&S system must be capable of defeating, analysis of terrorism should be an ongoing process. Although each analysis relies on information included in previous assessments, judgments with respect to threats to Federal and DOE-affiliated personnel, facilities, and assets begin anew with each analysis.

d. Discuss the basic requirements of material control and accountability per DOE M 470.4-6, *Nuclear Material Control and Accountability*.

[Note: DOE M 470.4-6 was cancelled by DOE O 474.2 chg. 1, *Nuclear Material Control and Accountability*, from which the following is taken.

A comprehensive material control and accountability (MC&A) plan developed and implemented by the site/facility operator that defines the program at the site, must be approved by DOE line management. The plan must provide the safeguards authorization for the site/facility operator to possess accountable nuclear materials and must specify how those materials are accounted for and controlled on a graded safeguards basis (see attachment 2, table C, of DOE O 474.2 chg. 1). It must include all fundamental commitments that define the bounds within which the MC&A program will function and the detailed level of performance.

DOE line management must conduct a rigorous review of the MC&A plan prior to its approval. Approval must be for a limited time period; subsequent approval will be contingent upon compliance with commitments and practices described in the plan and adequate performance. The plan must include the commitments that define the bounds within which the MC&A program will function and the metrics and risk assessments that will be used to demonstrate performance. The plan must demonstrate that the MC&A program meets the objectives listed below for each MC&A element.

Program Management Objectives

- Ensure that documentation is sufficient to maintain a comprehensive, effective, and cost-efficient program to control and account for nuclear materials.
- Define MC&A system elements with performance goals that reflect consequence of loss or misuse of the material managed by the program.
- Be graded based on the consequence of loss and contain control and accounting mechanisms for nuclear material.
- Establish and maintain an evaluation program that monitors the effectiveness of the MC&A system.
- Respond effectively and efficiently to material loss indicators, anomalous conditions, and degradation of system performance.
- Management ensures the integration of MC&A with S&S and other site programs.

Material Control Objectives

- Detect, assess and deter unauthorized access to nuclear material.
- Detect, assess and communicate alarms to response personnel, in time to impede unauthorized use of nuclear material.
- Provide loss detection capability for nuclear material and, when not in its authorized location, be able to provide accurate information needed to assist in locating the material in a timely manner.
- The material containment and surveillance program in conjunction with other security program elements must have the capability to detect, assess, and respond to unauthorized activities and anomalous conditions/events.
- In coordination with security organizations, material control measures ensure that appropriate protection and controls are applied to nuclear materials according to the quantity and attractiveness of the material.

Measurement Objectives

- The measurements program must provide measured values with uncertainties sufficient to detect theft or diversion of nuclear material.
- The measurement control program must ensure the quality of measurements made for MC&A purposes.

Material Accounting Objectives

- Accurate records of nuclear materials inventory are maintained and transactions and adjustments are made.

- The accounting system
  - provides data and reports on nuclear material sufficient to support local, national, and international commitments;
  - must accurately reflect the nuclear material inventory and have sufficient controls to ensure data integrity;
  - provides data and reports on accountable nuclear material to nuclear materials management safeguards system; and
  - must use material balance areas as the basis of the accounting structure with key measurement points established to localize and identify inventory differences.

Physical Inventory Objectives

- The physical inventory, in conjunction with other MC&A elements, ensures that accountable nuclear materials are not missing.
- The physical inventory program ensures that discrepancies between the physical inventory and the accounting records system are detected and resolved.

e. Discuss the responsibilities of field elements and contractor employees in identifying classified information as defined in DOE M 470.4-4, *Information Security*.

[Note: DOE M 470.4-4 was cancelled by DOE O 471.6, which does not address responsibilities for identifying classified information. Instead, field element and contractor responsibilities are addressed in DOE O 475.2A, *Identifying Classified Information*, from which the following is taken.]

Managers of Field Elements

- Ensure that contracting officers are notified of any contracts generating classified information, documents, or material so that DEAR clause 952.204-70, "Classification/Declassification," DEAR clause 970.5204-1 for management and operation and other facilities management contracts, and the contents of the CRD for DOE O 475.2A are incorporated into those contracts.
- Ensure that a satisfactory level of performance of the requirements in DOE O 475.2A is maintained, to include holding personnel accountable for implementing the requirements, as appropriate.
- Ensure that classified information contained in documents or material is correctly identified and the appropriate classifier markings are placed on such documents or material.
- Ensure that documents or material identified in DOE O 475.2A, attachment 4, *Classification/Declassification Review Requirements*, as requiring a review are reviewed for classification or declassification, as appropriate.
- Ensure that comprehensive searches are conducted for documents responsive to mandatory declassification review requests under 10 CFR 1045 and section 3.5 of EO 13526 in response to an inquiry from the Director, Office of Classification.
- Ensure that classification guidance for sensitive compartmented information programs or special access programs concerning information under the HQ or field element's purview is developed and that the Director, Office of Classification, or his or her designee is provided access to such classification guidance.

- Nominate a Federal employee to serve as program classification officer, field element classification officer, or HQ classification representative, as appropriate, in accordance with the requirements in DOE O 475.2A, attachment 2, *Appointment of Classification Officials*.
- Ensure that work in a classified subject area funded by a non-DOE entity is not started until classification guidance that has been certified by a classification officer or HQ classification representative is provided.
- Ensure that all employees authorized access to classified information complete a classification awareness briefing when they first receive their clearances and at least annually thereafter.
- Ensure that employees who formally challenge the classification of information are not subject to retribution.
- Ensure that self-assessments are conducted and that self-assessment reports are submitted to the Director, Office of Classification, through the Associate Administrator for Defense Nuclear Security for NNSA elements, in accordance with DOE O 475.2A, attachment 5, *Classification Program Evaluations*.
- Ensure that the performance contract or other system used to rate personnel performance includes the management of classified information as a critical element or item to be evaluated in the rating of program classification officers, classification officers, HQ classification representatives, original classifiers, derivative declassifiers, and those derivative classifiers who make a significant number of classification determinations annually.

DOE Employees with Authorized Access to Classified Information

- Ensure that each document or material that the employee originates, modifies, or possesses in a classified subject area and that is potentially classified or potentially classified at a higher classification level or more restrictive category is reviewed by a derivative classifier.
- Ensure that any classified document or material that he or she possesses that is marked with a specific date or event for declassification that has passed is not declassified until a derivative declassifier has reviewed it and confirmed that it is declassified.
- Submit any formal challenges to the classification of specific information and any declassification proposals to the appropriate classification official.

Contractor Classification Officer

- Manages the contractor classification program for the contractor.
- Ensures the satisfactory performance of the contractor classification program through self-assessments and by maintaining operational awareness of the classification issues at his or her site in accordance with DOE O 475.2A, attachment 5, *Classification Program Evaluations*.
- Develops and conducts classification training for derivative classifiers that he or she appoints.
- Ensures that all classification training and awareness briefings satisfy requirements in DOE O 475.2A, attachment 6, *Classification Education Program*.

- Appoints contractor derivative classifiers and ensures that these officials are technically competent in the specific areas of their classification authorities and terminates these authorities when appropriate.
- Ensures that contractor derivative classifiers and derivative declassifiers have appropriate and up-to-date classification guidance.
- Ensures that classified information in documents requested under statute or EO is identified, reviewed, and bracketed in accordance with DOE O 475.2A, attachment 7, *Freedom of Information Act/Privacy Act and Mandatory Declassification Review Requirements*, and DOE O 475.2A, attachment 8, *Bracketing and Redaction Procedures*, and forwards such bracketed documents to the Director, Office of Classification.
- Compiles statistics concerning the contractor classification program and forwards them to the Director, Office of Classification, when requested.
- As needed, prepares draft classification guidance that is more detailed and tailored to the needs of his or her site and is based on other current classification guidance and forwards such guidance to the Director, Office of Classification, for approval, through the Associate Administrator for Defense Nuclear Security for concurrence for NNSA elements.
- Conducts a cover-to-cover review of guidance developed by his or her organization at least once every 5 years to ensure it is up-to-date and notifies the Director, Office of Classification, through the Associate Administrator for Defense Nuclear Security for NNSA elements.
- Evaluates the impact of new or revised classification guidance issued by the Office of Classification upon existing classification guidance developed by his or her organization and submits proposed updates for any affected classification guidance within 90 calendar days to the Director, Office of Classification, through the Associate Administrator for Defense Nuclear Security for concurrence for NNSA elements.
- Conducts any interagency coordination required to declassify a document or material containing information under the cognizance of another agency except when the document or material relates to litigation or is requested under statute or EO.
- For non-DOE-funded work performed by the contractor, certifies that classification guidance provided by the funding entity does not contradict DOE classification guidance.
- Ensures that contractor documents subject to section 3.3 of EO 13526 are reviewed prior to such documents becoming 25 years old.
- Notifies the Director, Office of Classification, through the Associate Administrator for Defense Nuclear Security for NNSA elements, of any large-scale declassification reviews of documents containing more than 25,000 pages being conducted at his or her site.
- Delegates in writing any functions that he or she has been assigned by this CRD to qualified individuals as necessary to implement the contractor classification program. This does not include classification and declassification authorities, which are non-delegable.

Bibliography and Suggested Reading

***Code of Federal Regulations* (CFR)**

10 CFR 70.4, "Definitions." January 1, 2011.
10 CFR 820, "Procedural Rules for DOE Nuclear Activities." January 1, 2012.
10 CFR 830, "Nuclear Safety Management." January 1, 2012.
10 CFR 830, Subpart A, "Quality Assurance Requirements." January 1, 2012.
10 CFR 830, Subpart B, "Safety Basis Requirements." January 1, 2012.
10 CFR 830.3, "Definitions." January 1, 2012.
10 CFR 830.4, "General Requirements." January 1, 2012.
10 CFR 830.203, "Unreviewed Safety Question Process." January 1, 2012.
10 CFR 830.204, "Documented Safety Analysis." January 1, 2012.
10 CFR 830.205, Technical Safety Requirements."January 1, 2012.
10 CFR 835, "Occupational Radiation Protection." January 1, 2012.
10 CFR 850, "Chronic Beryllium Disease Prevention Program." January 1, 2012.
10 CFR 851, "Worker Safety and Health Program." January 1, 2012.
10 CFR 851.23, "Safety and Health Standards." January 1, 2012.
29 CFR 1910, "Occupational Safety and Health Standards." July 1, 2011.
29 CFR 1910.39, "Fire Protection Plans." July 1, 2011.
29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response." July 1, 2011.
29 CFR 1910.1001, "Asbestos." July 1, 2011.
29 CFR 1910.1200, "Hazard Communication." July 1, 2011.
29 CFR 1926, "Safety and Health Regulations for Construction Industry." July 1, 2011.
29 CFR 1960, "Basic Program Elements for Federal Employee Occupational Safety and Health and Related Matters." July 1, 2011
40 CFR 355, "Emergency Planning and Notification." July 1, 2011.
48 CFR 970.5204-2, "Laws, Regulations, and DOE Directives." October 1, 2011.
48 CFR 970.5223-1, "Integration of Environment, Safety, and Health into Work Planning and Execution." October 1, 2011.

American Industrial Hygiene Association, *What is an Industrial Hygienist?* 2012.

American National Standards Institute, ANSI Z87.1-2003, *Industrial Eyewear Impact Statement.* 2003.

Defense Nuclear Facilities Safety Board, DNFSB web page, *Our Mission*. No date.

Executive Order EO 12856, "Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements". August 1993.

Extension Toxicology Network, (EXTOXNET)

Dose-Response Relationships in Toxicology. September 1993
Glossary. September 1993.

Federal Register

10 CFR 820 and 835, "Procedural Rules for DOE Nuclear Activities and Occupational Radiation Protection"; Final Rule. June 8, 2007.

10 CFR 850 and 851, "Chronic Beryllium Disease Prevention Program; Worker Safety and Health Program"; Final Rule. February 9, 2006.

Institute of Electrical and Electronics Engineers, IEEE Std 384-2008, *Standard Criteria for Independence of Class 1E Equipment and Circuits*. 2008.

International Organization for Standardization (ISO), ISO 14001, *Environmental Management Systems—Requirements with Guidance for Use*, Abstract. 2004.

Interactive Learning Paradigms, Inc., MSDS HyperGlossary. February 7, 2011.

MSDSonline.com, homepage. No date.

National Fire Protection Association

NFPA 70E, *Standard for Electrical Safety in the Workplace*. 2012.

NFPA 101, *Life Safety Code*. 2012.

National Institute for Occupational Safety and Health

Electrical Safety, section 7, *Safety Model Stage 3-Controlling Hazards: Safe Work Environment*. March 2009.

Preventing Occupational Hearing Loss—A Practical Guide, appendix F. June 1996.

National Safety Council, *Fundamentals of Industrial Hygiene*. 2002.

Texas State, Office of Risk Management, Office Safety, Office Electrical Safety. May 2011.

U.S. Congress

Atomic Energy Act. 1954.

Clean Air Act. 1993.

Comprehensive Environmental Response, Compensation, and Liability Act. 1980.

Emergency Planning and Community Right-to-Know Act. 1986.

Federal Facilities Compliance Act. October 6, 1992.

National Environmental Policy Act. 1969.

Occupational Safety and Health Act. 1970.

Pollution Prevention Act of 1990. 1990.

Resource Conservation and Recovery Act. 1976.

Safe Drinking Water Act. 1974.

Solid Waste Disposal Act. 1965.

Superfund Amendment Reauthorization Act. 1986.

Toxic Substances Control Act. 1976.

U.S. Department of Defense, Directive 5100.52-M, *Nuclear Weapon Accident Response Procedures*, chapter 9, Radioactive Materials, Characteristics, Hazards and Health Considerations. September 1990.

U.S. Department of Energy Directives (Guides, Manuals, Orders, and Policies)

DOE Guide 151.1-1A, *Emergency Management Fundamentals and the Operational Emergency Base Program: Emergency Management Guide.* July 11, 2007.
DOE Guide 151.1-2, *Technical Planning Basis: Emergency Management Guide.* July 11, 2007.
DOE Guide 151.1-3, *Programmatic Elements: Emergency Management Guide.* July 11, 2007.
DOE Guide 151.1-4, *Response Elements*. July 11, 2007.
DOE Guide 151.1-5, *Biosafety Facilities: Emergency Management Guide.* July 11, 2007.
DOE Guide 225.1A-1, *Implementation Guide for Use with DOE O 225.1 Accident Investigations* (archived). November 26, 1997.
DOE Guide 414.1-2B admin chg. 1, *Quality Assurance Program Guide*. September 27, 2011.
DOE Guide 414.1-4, *Safety Software Guide for Use with 10 CFR 830 Subpart A, Quality Assurance Requirements, and DOE O 414.1C, Quality Assurance.* June 17, 2005.
DOE Guide 420.1-3, *Implementation Guide for DOE Fire Protection and Emergency Services Programs for Use with DOE O 420.1B, Facility Safety*. September 27, 2007.
DOE Guide 421.1-2A, *Implementation Guide for Use in Developing Documented Safety Analyses to Meet Subpart B of 10 CFR 830.* December 19, 2011.
DOE Guide 423.1-1A, *Implementation Guide for Use in Developing Technical Safety Requirements.* November 2, 2010.
DOE Guide 424.1-1B, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements.* April 8, 2010.
DOE Guide 430.1-1 appendix A, *Dictionary*. March 28, 1997.
DOE Guide 440.1-1B, *Worker Safety and Health Program for DOE (Including the National Nuclear Security Administration) Federal and Contractor Employees*. October 20, 2011.
DOE Guide 440.1-3, *Occupational Exposure Assessment* (archived). March 30, 1998.
DOE Guide 440.1-8, *Implementation Guide for Use with 10 CFR Part 851, Worker Safety and Health Programs* (archived). December 27, 2006.
DOE G 441.1-1C admin chg. 1, *Radiation Protection Programs Guide for Use with Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection*. July 8, 2011.
DOE Guide 450.4-1C, *Integrated Safety Management System Guide*. September 29, 2011.
DOE Manual 231.1-2, *Occurrence Reporting and Processing of Operations Information*. August 19, 2003.
DOE Manual 435.1-1 chg. 2, *Radioactive Waste Management Manual*. June 8, 2011.
DOE M 470.4-1 chg. 1, *Safeguards and Security Program Planning and Management* (archived). August 26, 2005.
DOE Order 142.3A, *Unclassified Foreign Visits and Assignments Program*. October 14, 2010.
DOE Order 151.1C, *Comprehensive Emergency Management System*. November 2, 2005.
DOE Order 210.2A, *DOE Corporate Operating Experience Program*. April 8, 2011.
DOE Order 225.1B, *Accident Investigations*. March 24, 2011.
DOE Order 226.1B, *Implementation of Department of Energy Oversight Policy*. April 25, 2011.
DOE Order 231.1B, *Environment, Safety, and Health Reporting*. June 27, 2011.

DOE Order 232.2, *Occurrence Reporting and Processing of Operations Information*. August 30, 2011.
DOE Order 360.1C, *Federal Employee Training*. July 6, 2011.
DOE Order 410.1, *Central Technical Authority Responsibility Regarding Nuclear Safety Requirements*. August 28, 2007.
DOE Order 414.1D, *Quality Assurance*. April 25, 2011.
DOE Order 420.1B chg. 1, *Facility Safety*. April 19, 2010.
DOE Order 422.1, *Conduct of Operations*. June 29, 2010.
DOE Order 426.1 chg. 1, *Federal Technical Capability*. September 20, 2011.
DOE Order 433.1B, *Maintenance Management Program for DOE Nuclear Facilities*. April 21, 2010.
DOE Order 435.1, *Radioactive Waste Management*. August 28, 2001.
DOE Order 436.1, *Departmental Sustainability*. May 2, 2011.
DOE Order 440.1B, *Work Protection Program for DOE (Including the National Nuclear Security Administration) Federal Employees*. May 17, 2007.
DOE Order 450.2, *Integrated Safety Management*. April 25, 2011.
DOE Order 451.1B chg. 2, *National Environmental Policy Act Compliance Program*. June 25, 2010.
DOE Order 458.1 chg. 2, *Radiation Protection of the Public and the Environment*. June 6, 2011.
DOE Order 470.4B, *Safeguards and Security Program*. July 26, 2011.
DOE Order 471.6, *Information Security*. June 20, 2011.
DOE Order 473.3, *Protection Program Operations.* June 29, 2011.
DOE Order 474.2 chg. 1, *Nuclear Material Control and Accountability.* August 3, 2011.
DOE Order 475.2A, *Identifying Classified Information*. February 1, 2011.
DOE Policy 226.1B, *Department of Energy Oversight Policy*. April 25, 2011.
DOE Policy 450.4A, *Integrated Safety Management Policy*. April 25, 2011.

U.S. Department of Energy Handbooks and Standards

DOE-HDBK-1019-93, *Nuclear Physics and Reactor Theory*. January 1993.
DOE-HDBK-1079-94, *Primer on Tritium Safe Handling Practices*. December 1994.
DOE-HDBK-1092-2004, *DOE Handbook: Electrical Safety*. December 2004.
DOE-HDBK-1113-2008, *Radiological Safety Training for Uranium Facilities*. April 2008.
DOE-HDBK-1122-2009 CN 2, part 6, *Radiological Control Technician Training, Fundamental Academic Training Study Guide Phase I*. 2011.
DOE-HDBK-1129-2008, *Tritium Handling and Safe Storage*. December 2008.
DOE-HDBK-1130-2008, *Radiological Worker Training*. December 2008
DOE-HDBK-1131-2007 CN 1, *General Employee Radiological Training*. June 2009.
DOE-HDBK-1145-2008, *Radiological Safety Training for Plutonium Facilities*. April 2008.
DOE-HDBK-1188-2006, *Glossary of Environment, Safety and Health Terms*. January 2006.
DOE-STD-1044-93, CN 1, *Guide to Good Practices for Equipment and Piping Labeling*. December 1998.
DOE-STD-1045-93 CN 1, *Guide to Good Practices for Notifications and Investigation of Abnormal Events*. December 1998.
DOE-STD-1063-2011, *Facility Representatives*. February 2011.

DOE-STD-1072-94, *Guideline to Good Practices For Facility Condition Inspections at Doe Nuclear Facilities* (archived). June 1994.
DOE-STD-1098-2008, CN 1, *Radiological Control*. May 2009.
DOE-STD-1128-2008, *Guide of Good Practices for Occupational Radiological Protection in Plutonium Facilities*. December 2008.
DOE-STD-1136-2009, *Guide of Good Practices for Occupational Radiological Protection in Uranium Facilities*. July 2009.
DOE-STD-1189-2008, *Integration of Safety into the Design Process.* March 2008.
DOE-STD-3006-2010, *Planning and Conducting Readiness Reviews*. 2010.
DOE-STD-3009-94 CN 3, *Preparation Guide for U.S. DOE Nonreactor Nuclear Facility Safety Analysis Reports*. March 2006.
DOE-STD-6005-2001, *Industrial Hygiene Practices*. April 2001.

U.S. Department of Energy Other References

Acquisition Guide, chapter 70.8, *Performance-based Contracting.* No date.
Brookhaven National Laboratory, Information Oversight, Price-Anderson Amendments Act. January 30, 2006.
DOE Action Plan, *Lessons Learned from the Columbia Space Shuttle Accident and Davis-Besse Reactor Pressure-Vessel Head Corrosion Event*. June 2005.
DOE/Nuclear Criticality Safety Program website, Nuclear Criticality Safety Engineer Training (NCSET): http://ncsp.llnl.gov/trainingMain.html
Energy.gov, Office of NEPA Policy and Compliance, *DOE, NEPA and You*. 2010.
LA-13638, *A Review of Criticality Accidents.* May 2000.
Memorandum of Understanding between the U.S. Department of Labor and the U.S. Department of Energy. August 28, 1992.
Oak Ridge Associated Universities, Conduct of operations training course lesson: *Investigation and Notifications*. August 7, 1996.
Oak Ridge National Laboratory, Frequently Asked Questions. October 2011.
PNNL-12199, *A Brief History of Nuclear Criticality Accidents in Russisa–1953-1997*. April 1999.

Office of Health, Safety and Security

Environmental Policy, Resource Conservation and Recovery Act. August 4, 2011.
Federal Employee Occupational Safety and Health (FEOSH) Program Overview. No date.
HSS CRAD 64-10, rev 2, *Performance Based Inspection of Worker Safety and Health Utilizing the ISM Core Functions: Inspection Criteria, Approach, and Lines of Inquiry*. June 9, 2009.

U.S. Department of Homeland Security, Federal Emergency Management Agency

FEMA, the Life Safety Group, *How to use a Portable Fire Extinguisher*. 2006.
FEMA, *Introduction to Fire Inspection Principles and Practices*, Common Fire Hazards. February 1996.

U.S. Department of Labor

Memorandum of Understanding between the U.S. Department of Labor, Occupational Safety and Health Administration and the U.S. Environmental Protection Agency, Office of Enforcement. November 23, 1990.

Occupational Safety and Health Administration (OSHA), *DOE Transition, Background*. No date.
OSHA, *OSH Act, OSHA Standards, Inspections, Citations and Penalties.* May 1996
OSHA, Draft Model Training Program for Hazard Communication.
Wage and Hour division, *What are the Davis-Bacon and Related Acts?* No date.

U.S. Environmental Protection Agency
Compliance and Enforcement, Federal Facilities Enforcement. January 2, 2009.
Frequently Asked Questions, What is the Solid Waste Disposal Act of 1965? December 15, 2008.
Laws and Regulations, Summary of CERCLA. August 11, 2011.
NEPA, Basic Information. October 12, 2011.
Radiation Protection Programs, Waste Management, Mixed Waste, About Mixed-Waste. July 8, 2011.
Radiation Protection, References, Transuranic Radioactive Waste. July 8, 2011.
Wastes, Hazardous Waste, Waste Types. July 26, 2011.
Radiation Protection, References, Low-Level Radioactive Waste. July 8, 2011.
RCRA Orientation Manual. January 2003.
Tribal Enterprises Topics, Regulatory Requirements. October 16, 2008.

U.S. Nuclear Regulatory Commission, Westinghouse Systems Course R-304P, part 7, *Radiation Monitoring Systems*. November 2000.

Weitz and Luxenberg PC, Learn More about the Harmful Effects of Radiation Contamination. 2012.

General Technical Base
Qualification Standard
Reference Guide
March 2012