General Technical Base
Qualification Standard

DOE-STD-1146-2007
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The Functional Area Qualification Standard References Guides are developed to assist operators, maintenance personnel, and the technical staff in the acquisition of technical competence and qualification within the Technical Qualification Program (TQP).

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ACRONYMS

ac	alternating current
AC	administrative control
ACGIH	American Conference of Governmental Industrial Hygienists
AEA	Atomic Energy Act
AIB	accident investigation board
AIHA	American Industrial Hygiene Association
ALARA	as low as reasonably achievable
ANSI/ANS	American National Standards Institute/American Nuclear Society
APR	airborne particulate radioactivity
ASME	American Society of Mechanical Engineers
BEI	biological exposure indices
Bq	becquerel
c	speed of light
CAA	Clean Air Act
CAS	contractor assurance system
CBD	chronic beryllium disease
CBDPP	Chronic Beryllium Disease Prevention Program
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ci	curie
C/kg	coulomb/kilogram
CDNS	Chief of Defense Nuclear Safety
CNS	Chief of Nuclear Safety
CONOPS	conduct of operations
CPAM	continuous particulate air monitor
CRAD	criteria review and approach document
CRD	contractor requirements document
CSE	cognizant system engineer
CSO	cognizant secretarial officer
CTA	central technical authority
CWA	Clean Water Act
dBA	decibel
dc	direct current
DEAR	Department of Energy Acquisition Regulation
DNFSB	Defense Nuclear Facilities Safety Board
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
dpm	disintegrations per minute
DSA	documented safety analysis
EA	environmental assessment
EIS	environmental impact statement
EMS	environmental management system
EO	Executive Order

EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-To-Know Act
EPHA	emergency planning hazard assessment
ERO	emergency response organization
ESFI	Electrical Safety Foundation International
ES&H	environment, safety, and health
FFCA	Federal Facilities Compliance Act
FHA	fire hazard analysis
GAA	general access area
GHS	Globally Harmonized System
GOCO	government-owned contractor-operated
GSA	General Services Administration
GSP	graded security protection
Gy	gray
HCS	hazard communication standard
HEPA	high efficiency particulate absolute
HLMW	high-level mixed waste
HQ	DOE headquarters
HSS	Office of Health, Safety, and Security
Hz	hertz
IAG	interagency agreement
IBC	International Building Code
ICS	incident command system
ISM	integrated safety management
JON	judgments of need
kg	kilogram
kg bw	body per kilogram of body weight
KSA	knowledge, skill, and ability
LA	limited area
LCO	limiting condition for operation
LCS	limiting control setting
LLMW	low-level mixed waste
LLW	low-level waste
LOTO	lockout/tagout
MACT	maximum achievable control technology
MC&A	material control and accountability
MeV	mega electron volt
mg/m^3	milligrams per cubic meter
MOU	memorandum of understanding
mrem	millirem
MSDS	material safety data sheets
MTRU	mixed transuranic waste
NAAQS	National Ambient Air Quality Standards
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
NPL	National Priority Site List
NRC	U.S. Nuclear Regulatory Commission
N&S	necessary and sufficient
ODFSA	Officially Designated Federal Security Authority
ODSA	Officially Designated Security Authority
OE	operational emergency
OED	operating experience document
OSHA	Occupational Safety and Health Administration
PCB	polychlorinated biphenyl
PDSA	preliminary documented safety analysis
PEL	permissible exposure limit
PIN	personal identification number
PISA	potential inadequacy of the safety analysis
PNOV	preliminary notice of violation
PPA	Pollution Prevention Act
PPE	personal protective equipment
ppm	parts per million
PRM	process radiation monitoring
PrPA	property protection area
PSO	program secretarial officer
Pu	plutonium
PWS	performance work statement
QA	quality assurance
QAP	quality assurance program
RCRA	Resource Conservation and Recovery Act
rem	roentgen equivalent man
RF	radio frequency
RFP	request for proposal
SAC	specific administrative control
SARA	Superfund Amendments and Reauthorization Act
SC	significance category
S/CI	suspect/counterfeit items
SDS	safety data sheet
SDWA	Safe Drinking Water Act
SERC	State Emergency Response Commission
SI	International System of Units
SL	safety limit
SME	subject matter expert
SMS	safety management system
SNM	special nuclear material
SO	secretarial officer

SOMD	site occupational medical director
SOO	statement of objectives
S/RID	standards/requirements identification document
S&S	safeguards and security
SSC	structure, system, and component
SSO	safety system oversight
SSP	site sustainability plan
SSPP	strategic sustainability performance plan
SSQA	safety software quality assurance
STD	standard
STEL	short-term exposure limit
Sv	sievert
TLD	thermoluminescent dosimeter
TLV	threshold limit value
TQP	Technical Qualification Program
TRU	transuranic
TSCA	Toxic Substance Control Act
TSR	technical safety requirement
TWA	time-weighted average
U	uranium
USQ	unreviewed safety question
USQD	unreviewed safety question determination
V	volt
WSS	work smart standard

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 Qualification Standard. Information essential to meeting the qualification requirements is provided; however, some competency statements 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 has been developed to address the competency statements in the March 2015 reaffirmed edition of DOE Standard (STD)-1146-2007, *General Technical Base Qualification Standard*. The qualification standard contains 28 competency statements.

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, abbreviations, and symbols 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 qualification standard. 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 June 2016. 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 a qualification standard 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.

This reference guide includes streaming videos to help bring the learning experience alive. To activate the video, click on any hyperlink under the video title. Note: Hyperlinks to video are shown in entirety, due to current limitations of eReaders and must be accessed through Google Chrome.

TECHNICAL COMPETENCIES

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

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

The following is taken from Lawrence Berkeley National Laboratory, *Nuclear Science—A Guide to the Nuclear Science Wall Chart.*

The forces of gravity and electromagnetism are familiar in everyday life. Two new forces are introduced when discussing nuclear phenomena: the strong and weak interactions. When two protons encounter each other, they experience all four of the fundamental forces of nature simultaneously. The weak force governs beta decay and neutrino interactions with nuclei. The strong force, which is generally called the nuclear force, is actually the force that binds quarks together to form baryons (3 quarks) and mesons (a quark and an anti-quark). The nucleons of everyday matter, neutrons and protons consist of the quark combinations uud and udd, respectively. The symbol u represents a single up quark, while the symbol d represents a single down quark.

The force that holds nucleons together to form an atomic nucleus can be thought to be a residual interaction between quarks inside each individual nucleon. This is analogous to what happens in a molecule. The electrons in an atom are bound to its nucleus by electromagnetism: when two atoms are relatively near, there is a residual interaction between the electron clouds that can form a covalent bond. The nucleus can thus be thought of as a "strong force molecule."

The force between two objects can be described as the exchange of a particle. The exchange particle transfers momentum and energy between the two objects, and is said to mediate the interaction. A simple analogue of this is a ball being thrown back and forth between two people. The momentum imparted to the ball by one person gets transferred to the other person when she catches the ball. The potential energy associated with each force acting between two protons is characterized by both the strength of the interaction and the range over which the interaction takes place. In each case the strength is determined by a coupling constant, and the range is characterized by the mass of the exchanged particle. The potential energy, U, between two protons a distance r apart is written as

$$U = \frac{C^2}{r}\exp\left(-r / R\right)$$

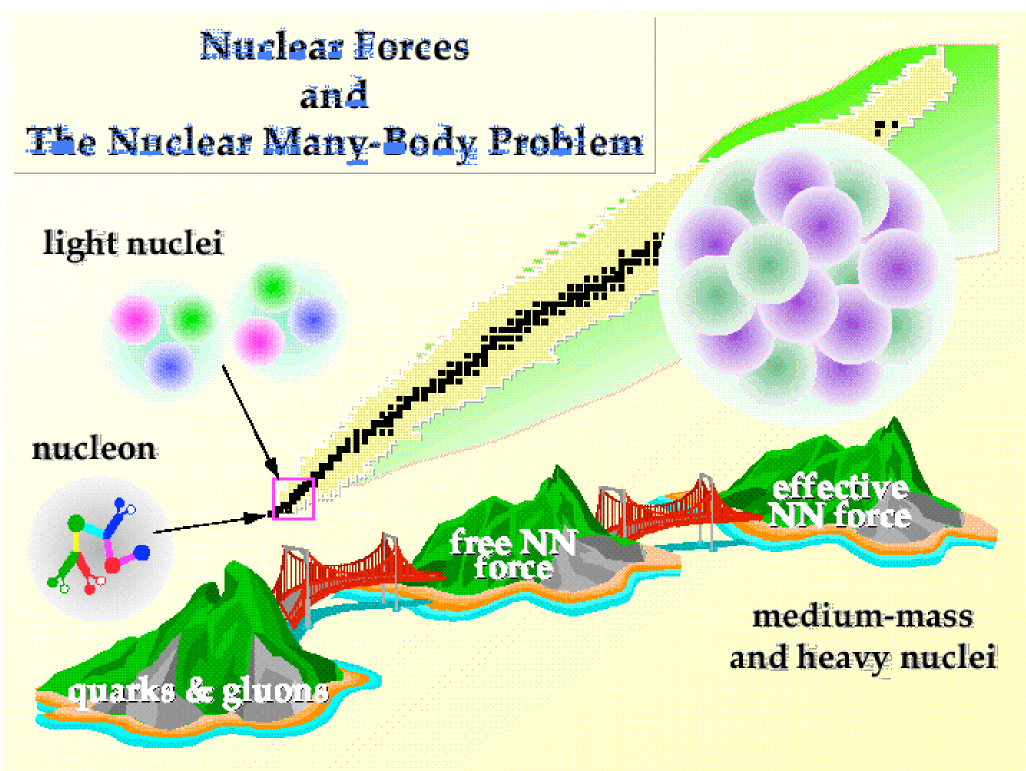
where R is the range of the interaction, and C is the strength of the interaction. In each case the interaction is due to the exchange of some particle whose mass determined the range of the interaction, R = h/mc. The exchanged particle is said to mediate the interaction.

Table 1 shows a comparison between the coupling constants and ranges of the four forces acting between two protons. Although the graviton has not yet been observed, it is thought that there is an exchange particle associated with gravity and that eventually gravity will be described in a unified theory with the other three forces of nature.

Table 1. Forces acting between protons

Interaction	Gravity	Weak	Electromagnetism	Strong
				Residual
Exchange particle	Graviton	Z^0	Photon	Pion
Mass $mc^2 (eV)$	0	91×10^9	0	135×10^6
Coupling constant $C^2 (J\ m)$	1.87×10^{-64}	3.22×10^{-31}	2.31×10^{-28}	2.5×10^{-27}
Range (m)	∞	2×10^{-18}	∞	1.5×10^{-15}

Strength and range of the four fundamental forces between two protons. Note that the strong force acts between quarks by an exchange of gluons. The residual strong force between two protons can be described by the exchange of a neutral pion. Note the W± is not included as an exchange particle for the weak interaction because it is not exchanged in the simplest proton-proton interaction.
Source: Lawrence Berkeley Laboratory, Nuclear Science—A Guide to the Nuclear Science Wall Chart



Source: Lawrence Berkeley Laboratory, Nuclear Science—A Guide to the Nuclear Science Wall Chart
Figure 1. A representation of the strong force

The range of the gravitational and electromagnetic forces is infinite, while the ranges of the strong and weak forces are very short. Also, the strength of the interaction depends on the separation between the two protons. Both gravitation and electromagnetism are of infinite range and their strengths decrease as the separation, r, increases—falling off as $1/r^2$. On the other hand, because the exchange particles for the strong and weak forces have a large mass, the force associated with them is zero outside of a short range.

Note that the strong force between two protons is a residual interaction. The quarks inside the nucleons interact through the exchange of gluons that carry a quantum number called "color" (i.e., a "color-neutral" object does not feel the strong force, like an electrically neutral object does not feel electromagnetism). Figure 1 shows three different ways that the strong force can be viewed.

The theory of strong interactions among quarks and gluons is called quantum chromodynamics. A very successful model of describing this residual force is by the exchange of the p (pi) meson, or pion. This description, dating back to the work of Yukawa in the 1930s, works extremely well except at very short distances, and is generally used to describe most of the properties of complex nuclei. Exactly at what distance inside the nucleus, or correspondingly at what values of momentum transferred between the nucleons, the pion exchange model breaks down is the subject of much current research in nuclear physics. It is presently thought that this transition occurs somewhere around momentum transfers of 1 GeV/c.

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

The following is taken from Boston University, *Nuclear Binding Energy and the Mass Defect.*

A neutron has a slightly larger mass than the proton. These are often given in terms of an atomic mass unit, where one atomic mass unit (u) is defined as 1/12th the mass of a carbon-12 atom.

Einstein's famous equation relates energy and mass:

$$E = mc^2$$

That equation can be used to prove that a mass of 1 u is equivalent to an energy of 931.5 MeV (mega electron volts).

Table 2. Binding energy and the mass defect

Particle	Mass in kilograms (kg)	Mass (u)	Mass (in MeV divided by the speed of light (MeV/c^{2})
1 atomic mass unit	1.660540×10^{-27}kg	1.000 u	931.5 MeV/c^2
Neutron	$1.6749949 \times 10^{-27}$kg	1.008664 u	939.57 MeV/c^2
Proton	1.672623×10^{-27}kg	1.007276 u	938.28 MeV/c^2
Electron	9.109390×10^{-31}kg	0.00054858 u	0.511 MeV/c^2

Boston University, Nuclear Binding Energy and the Mass Defect

There is something strange about table 2. The carbon-12 atom has a mass of 12.000 u, and yet it contains 12 objects (6 protons and 6 neutrons) that each have a mass greater than 1.000 u, not to mention a small contribution from the 6 electrons.

This is true for all nuclei, that the mass of the nucleus is a little less than the mass of the individual neutrons, protons, and electrons. This missing mass is known as the mass defect, and represents the binding energy of the nucleus.

The binding energy is the energy that is put in to split the nucleus into individual protons and neutrons. To find the binding energy, add the masses of the individual protons, neutrons, and electrons, subtract the mass of the atom, and convert that mass difference to energy. For carbon-12 this gives:

Mass defect = Dm = 6 * 1.008664 u + 6 * 1.007276 u + 6 * 0.00054858 u - 12.000 u = 0.098931 u.

The binding energy in the carbon-12 atom is therefore 0.098931 u * 931.5 MeV/u = 92.15 MeV.

In a typical nucleus the binding energy is measured in MeV, considerably larger than the few eV associated with the binding energy of electrons in the atom. Nuclear reactions involve changes in the nuclear binding energy, which is why nuclear reactions give you much more energy than chemical reactions; those involve changes in electron binding energies.

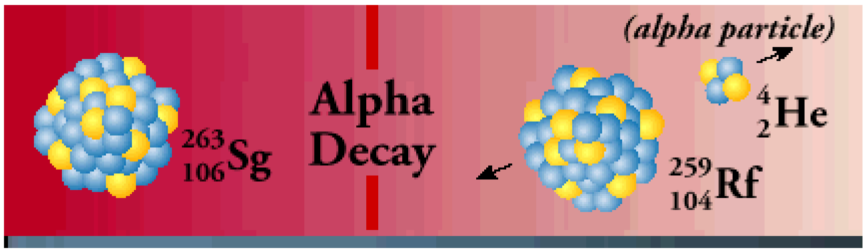
Video 1. Binding energy and mass defect
https://www.youtube.com/watch?v=_Yeeo-rJ1k0

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 Decay

The following is taken from Lawrence Berkeley Laboratory, *Alpha Decay*.



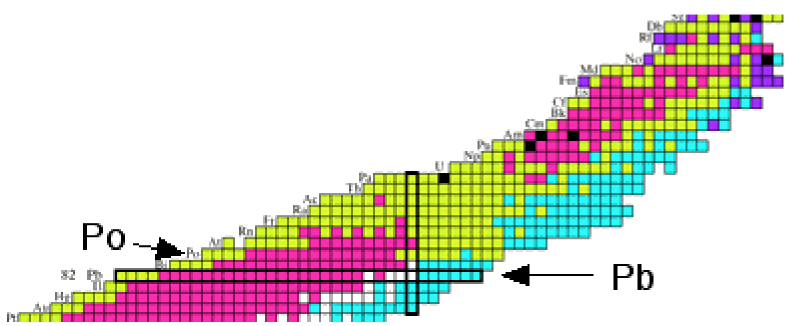
Source: Lawrence Berkeley Laboratory, Alpha Decay

Figure 2. Alpha decay

In alpha decay, shown in figure 2, the nucleus emits a 4He nucleus, an alpha particle. Alpha decay occurs most often in massive nuclei that have too large a proton to neutron ratio. An alpha particle, with its two protons and two neutrons, is a very stable configuration of particles. Alpha radiation reduces the ratio of protons to neutrons in the parent nucleus, bringing it to a more stable configuration. Many nuclei more massive than lead decay by this method.

Consider the example of ^{210}Po decaying by the emission of an alpha particle. The reaction can be written $_{210}$Po Θ $_{206}$Pb + $_{4}$He. This polonium nucleus has 84 protons and 126 neutrons. The ratio of protons to neutrons is Z/N = 84/126, or 0.667. A $_{206}$Pb nucleus has 82 protons and 124 neutrons, which gives a ratio of 82/124, or 0.661. This small change in the Z/N ratio is enough to put the nucleus into a more stable state, and as shown in figure 3 brings the "daughter" nucleus (decay product) into the region of stable nuclei in the chart of the nuclides.

In alpha decay, the atomic number changes, so the original (or parent) atoms and the decay-product (or daughter) atoms are different elements and therefore have different chemical properties.



Source: Lawrence Berkeley Laboratory, Alpha Decay

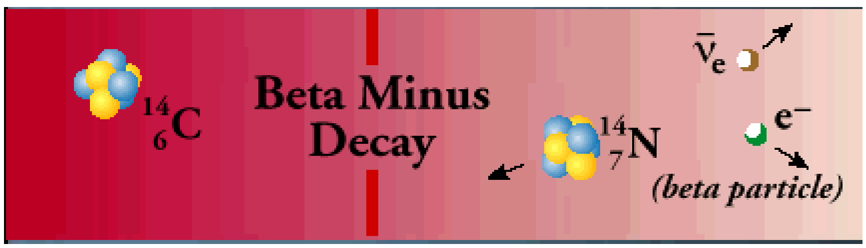
Figure 3. Upper end of the chart of the nuclides

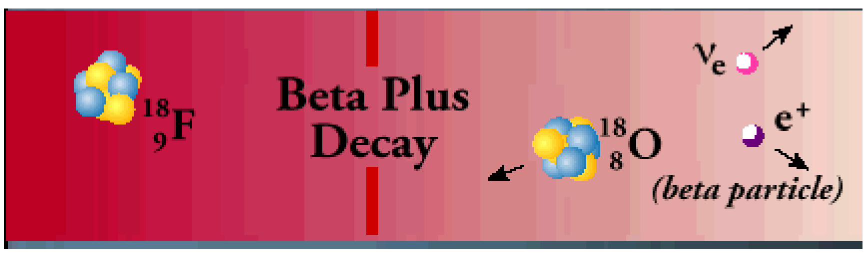
In the alpha decay of a nucleus, the change in binding energy appears as the kinetic energy of the alpha particle and the daughter nucleus. Because this energy must be shared between these two particles, and because the alpha particle and daughter nucleus must have equal and opposite momenta, the emitted alpha particle and recoiling nucleus will each have a well-defined energy after the decay. Because of its smaller mass, most of the kinetic energy goes to the alpha particle.

Video 2. Alpha decay
https://www.youtube.com/watch?v=CwExbnOzc4o

Beta-Minus Decay and Beta-Plus Decay

The following is taken from Lawrence Berkeley Laboratory, *Beta Decay.*





Beta particles are electrons or positrons (electrons with positive electric charge, or antielectrons). Beta decay occurs when, in a nucleus with too many protons or too many neutrons, one of the protons or neutrons is transformed into the other. In beta minus decay, a neutron decays into a proton, an electron, and an antineutrino: n ∅ p + e - +. In beta plus decay, a proton decays into a neutron, a positron, and a neutrino: p ∅ n + e+ +*ν*. Both reactions occur because in different regions of the chart of the nuclides, one or the other will move the product closer to the region of stability. These particular reactions take place because conservation laws are obeyed. Electric charge conservation requires that if an electrically neutral neutron becomes a positively charged proton, an electrically negative particle (in this case, an electron) must also be produced. Similarly, conservation of lepton number requires that if a neutron (lepton number = 0) decays into a proton (lepton number = 0) and an electron (lepton number = 1), a particle with a lepton number of -1 (in this case an antineutrino) must also be produced. The leptons emitted in beta decay did not exist in the nucleus before the decay–they are created at the instant of the decay.

An isolated proton, a hydrogen nucleus with or without an electron, does not decay. However within a nucleus, the beta decay process can change a proton to a neutron. An isolated neutron is unstable and will decay with a half-life of 10.5 minutes. A neutron in a nucleus will decay if a more stable nucleus results; the half-life of the decay depends on the isotope.

If it leads to a more stable nucleus, a proton in a nucleus may capture an electron from the atom (electron capture), and change into a neutron and a neutrino.

Proton decay, neutron decay, and electron capture are three ways in which protons can be changed into neutrons or vice-versa; in each decay there is a change in the atomic number, so that the parent and daughter atoms are different elements. In all three processes, the number *A* of nucleons remains the same, while both proton number, *Z*, and neutron number, *N*, increase or decrease by 1.

In beta decay the change in binding energy appears as the mass energy and kinetic energy of the beta particle, the energy of the neutrino, and the kinetic energy of the recoiling daughter nucleus. The energy of an emitted beta particle from a particular decay can take on a range of values because the energy can be shared in many ways among the three particles while still obeying energy and momentum conservation.

Video 3. Beta decay
http://wn.com/beta_decay

Electron Capture

The following is taken from Georgia State University, Hyperphysics, *Electron Capture*.

Electron capture is one form of radioactivity. A parent nucleus may capture one of its orbital electrons and emit a neutrino. This is a process which competes with positron emission and has the same effect on the atomic number. Most commonly, it is a K-shell electron which is captured, and this is referred to as K-capture.

This is a schematic that grossly distorts the picture relative to a scale model of the atom. The electron orbit radii are tens of thousands of times the diameter of the nucleus.

A typical example is the decay of beryllium.

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

The capture of the electron by a proton in the nucleus is accompanied by the emission of a neutrino. The process leaves a vacancy in the electron energy level from which the electron came, and that vacancy is either filled by the dropping down of a higher-level electron with the emission of an X-ray or by the ejection of an outer electron in a process called the Auger effect**.**

Video 4. Electron capture
https://www.youtube.com/watch?v=sg_XoUDsP08

d. Define the following terms:

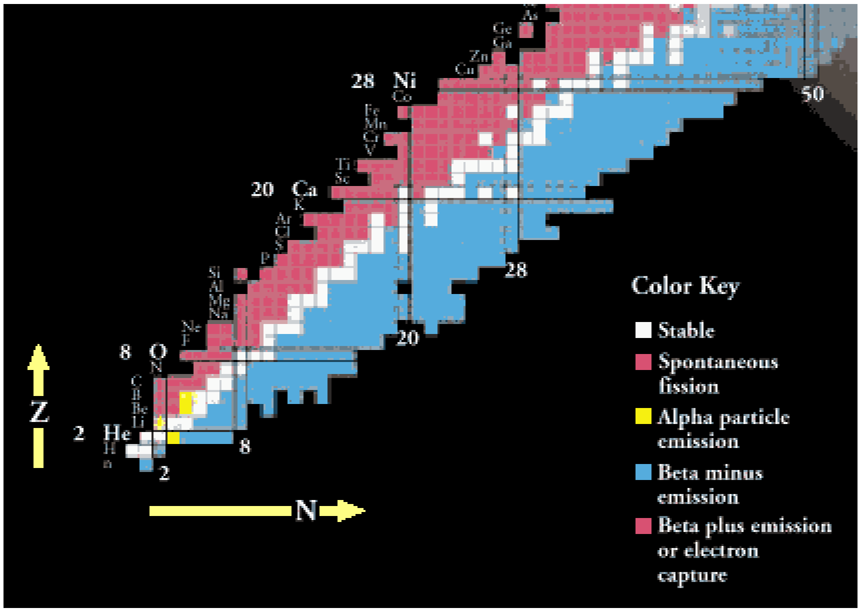
- **Radioactivity**
- **Radioactive decay constant**
- **Activity**
- **Radioactive half-life**
- **Radioactive equilibrium**

Radioactivity

The following is taken from Lawrence Berkeley National Laboratory, *Radioactivity*.

In radioactive processes, particles or electromagnetic radiation are emitted from the nucleus. The most common forms of radiation emitted have been traditionally classified as alpha (a), beta (b), and gamma (g) radiation. Nuclear radiation occurs in other forms, including the emission of protons or neutrons or spontaneous fission of a massive nucleus.

Of the nuclei found on earth, the vast majority are stable. This is so because almost all short-lived radioactive nuclei have decayed during the history of the earth. There are approximately 270 stable isotopes and 50 naturally occurring radioisotopes (radioactive isotopes). Thousands of other radioisotopes have been made in the laboratory.



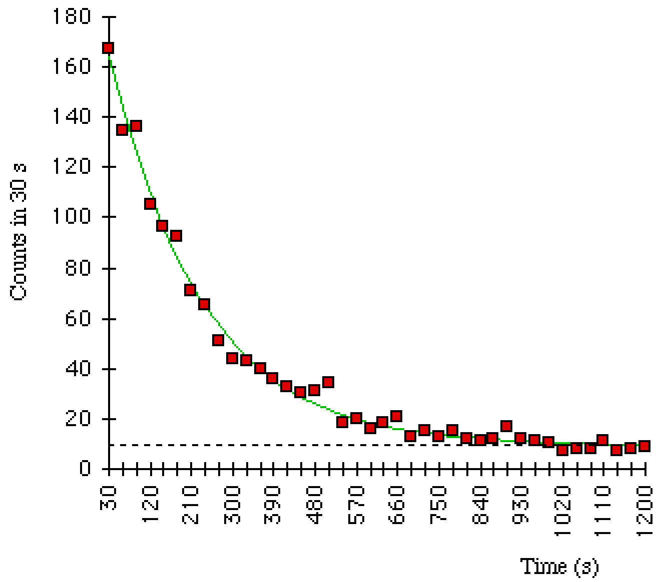
Source: Lawrence Berkeley National Laboratory, Radioactivity

Figure 4. Partial chart of the nuclides

Radioactive decay will change one nucleus to another if the product nucleus has a greater nuclear binding energy than the initial decaying nucleus. The difference in binding energy (comparing the before and after states) determines which decays are energetically possible and which are not. The excess binding energy appears as kinetic energy or rest mass energy of the decay products.

The chart of the nuclides, part of which is shown in figure 4 is a plot of nuclei as a function of proton number, *Z*, and neutron number, *N*. All stable nuclei and known radioactive nuclei, both naturally occurring and man-made, are shown on this chart, along with their decay properties. Nuclei with an excess of protons or neutrons in comparison with the stable nuclei will decay toward the stable nuclei by changing protons into neutrons or neutrons into protons, or else by shedding neutrons or protons either singly or in combination. Nuclei are also unstable if they are excited, that is, not in their lowest energy states. In this case the nucleus can decay by getting rid of its excess energy without changing *Z* or *N* by emitting a gamma ray.

Nuclear decay processes must satisfy several conservation laws, meaning that the value of the conserved quantity after the decay, taking into account all the decay products, must equal the same quantity evaluated for the nucleus before the decay. Conserved quantities include total energy (including mass), electric charge, linear and angular momentum, number of nucleons, and lepton number (sum of the number of electrons, neutrinos, positrons and antineutrinos–with antiparticles counting as -1).



137Ba decay data, counting numbers of decays observed in 30-second intervals. The best-fit exponential curve is shown. The points do not fall exactly because of statistical counting fluctuations.
Source: Lawrence Berkeley National Laboratory, Radioactivity
Figure 5. Exponential process

The probability that a particular nucleus will undergo radioactive decay during a fixed length of time does not depend on the age of the nucleus or how it was created. Although the exact lifetime of one particular nucleus cannot be predicted, the mean (or average) lifetime of a sample containing many nuclei of the same isotope can be predicted and measured. A convenient way of determining the lifetime of an isotope is to measure how long it takes for one-half of the nuclei in a sample to decay–this quantity is called the half-life, $t_{1/2}$. Of the original nuclei that did not decay, half will decay after another half-life, leaving one-quarter of the original sample after a total time of two half-lives. After three half-lives, one-eighth of the original sample will remain and so on. Measured half-lives vary from tiny fractions of seconds to billions of years, depending on the isotope.

The number of nuclei in a sample that will decay in a given interval of time is proportional to the number of nuclei in the sample. This condition leads to radioactive decay showing itself as an exponential process, as shown in figure 5. The number, N, of the original nuclei remaining after a time t from an original sample of N_0 nuclei is

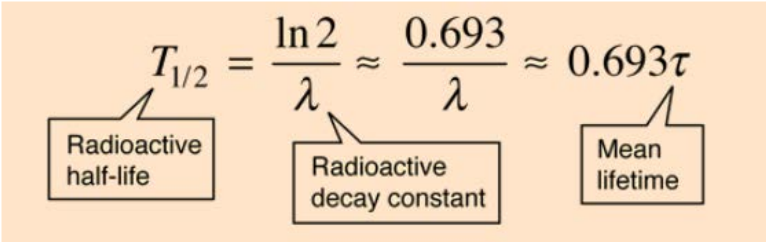
$$N = N_0 e^{-(t/T)}$$

where T is the mean lifetime of the parent nuclei. From this relation, it can be shown that $t_{1/2} = 0.693T$.

Radioactive Decay Constant

The following is taken from Georgia State University, Hyperphysics, *Radioactive Decay Constant.*

The rate of radioactive decay is typically expressed in terms of either the radioactive half-life, or the radioactive decay constant. They are related as follows:



The decay constant is also sometimes called the disintegration constant. The half-life and the decay constant give the same information, so either may be used to characterize decay. Another useful concept in radioactive decay is the average lifetime. The average lifetime is the reciprocal of the decay constant as defined here.

For example, free neutrons decay with a half-life of about 10.3 minutes. This corresponds to a decay constant of .067/min and an average lifetime of 14.8 minutes or 890 seconds.

For geologic dating processes involving long half-lives, like potassium-argon dating, the decay constant is typically expressed in yr^{-1} and the half-life in years.

Activity

The following is taken from Wikipedia, *Specific Activity.*

Specific activity is the activity per quantity of a radionuclide and is a physical property of that radionuclide.

Activity is a quantity related to radioactivity. The International System of Units (SI) unit of activity is the becquerel (Bq), equal to one reciprocal second.

Since the probability of radioactive decay for a given radionuclide is a fixed physical quantity, the number of decays that occur in a given time of a specific number of atoms of that radionuclide is also a fixed physical quantity (if there are large enough numbers of atoms to ignore statistical fluctuations).

Thus, specific activity is defined as the activity per quantity of atoms of a particular radionuclide. It is usually given in units of Bq/g, but another commonly used unit of activity is the curie (Ci) allowing the definition of specific activity in Ci/g.

Radioactive Half-Life

The following is taken from Georgia State University, Hyperphysics, *Radioactive Half-Life.*

The radioactive half-life for a given radioisotope is the time for half the radioactive nuclei in any sample to undergo radioactive decay. After two half-lives, there will be one fourth the original sample, after three half-lives one eight the original sample, and so forth.

Video 5. Nuclear half-life
https://www.youtube.com/watch?v=opjJ-3Tkfyg

Radioactive Equilibrium

The following is taken from Nulceonica.net, *Radioactive Equilibrium.*

The equilibrium reached by a radioactive series in which the rate of decay of each nuclide is equal to its rate of production. It follows that all rates of decay of the different nuclides within the sample are equal when radioactive equilibrium is achieved. For example, in the uranium (U) series, U-238 decays to throium-234. Initially, the rate of production of thorium will exceed the rate at which it is decaying and the thorium content of the sample will rise. As the amount of thorium increases, its activity increases; eventually a situation is reached in which the rate of production of thorium is equal to its rate of decay. The proportion of thorium in the sample will then remain constant. Thorium decays to produce protactinium-234; some time after the stabilization of the thorium content, the protactinium content will also stabilize. When the whole radioactive series attains stabilization, the sample is said to be in radioactive equilibrium.

Video 6. Radioactive equilibrium
https://www.youtube.com/watch?v=bTrgXZ7T6Yk

e. Describe the following neutron-nucleus interactions:

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

Elastic Scattering

The following is taken from Wikipedia, *Elastic Scattering*.

Elastic scattering is a form of particle scattering in scattering theory, nuclear physics and particle physics. In this process, the kinetic energy of a particle is conserved in the center-of-mass frame, but its direction of propagation is modified. Furthermore, while the particle's kinetic energy in the center-of-mass frame is constant, its energy in the lab frame is not. Generally, elastic scattering describes a process where the total kinetic energy of the system is conserved. During elastic scattering of high-energy subatomic particles, linear energy transfer takes place until the incident particle's energy and speed has been reduced to the same as its surroundings, at which point the particle is stopped.

For particles with the mass of a proton or greater, elastic scattering is one of the main methods by which the particles interact with matter. At relativistic energies, protons, neutrons, helium ions, and HZE ions will undergo numerous elastic collisions before they are dissipated. This is a major concern with many types of ionizing radiation, including galactic cosmic rays, solar proton events, free neutrons in nuclear weapon design and nuclear reactor design, spaceship design, and the study of the earth's magnetic field. In designing an effective biological shield, proper attention must be made to the linear energy transfer of the particles as they propagate through the shield. In nuclear reactors, the neutron's mean free path is critical as it undergoes elastic scattering on its way to becoming a slow-moving thermal neutron.

Besides elastic scattering, charged particles also undergo effects from their elementary charge, which repels them away from nuclei and causes their path to be curved inside an electric field. Particles can also undergo inelastic scattering and capture due to nuclear reactions. Protons and neutrons do this more often than heavier particles. Neutrons are also capable of causing fission in an incident nucleus. Light nuclei like deuterium and lithium can combine in nuclear fusion.

Inelastic Scattering

The following is taken from Wikipedia, *Inelastic Scattering.*

In chemistry, nuclear physics, and particle physics, inelastic scattering is a fundamental scattering process in which the kinetic energy of an incident particle is not conserved (in contrast to elastic scattering). In an inelastic scattering process, some of the energy of the incident particle is lost or increased. Although the term is historically related to the concept of inelastic collision in dynamics, the two concepts are quite distinct; the latter refers to processes in which the total kinetic energy is not conserved. In general, scattering due to inelastic collisions will be inelastic, but, since elastic collisions often transfer kinetic energy between particles, scattering due to elastic collisions can also be inelastic.

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

Capture

The following is taken from Wikipedia, *Neutron Capture*.

Neutron capture is a nuclear reaction in which an atomic nucleus and one or more neutrons collide and merge to form a heavier nucleus. Since neutrons have no electric charge they can enter a nucleus more easily than positively charged protons, which are repelled electrostatically.

Neutron capture plays an important role in the cosmic nucleosynthesis of heavy elements. In stars it can proceed in two ways: as a rapid or a slow process. Nuclei of masses greater than 56 cannot be formed by thermonuclear reactions (i.e. by nuclear fusion), but can be formed by neutron capture.

Absorption

The following is taken from Wikipedia, *Absorption*.

In physics, absorption of electromagnetic radiation is the way in which the energy of a photon is taken up by matter, typically the electrons of an atom. Thus, the electromagnetic energy is transformed into internal energy of the absorber, for example thermal energy. The reduction in intensity of a light wave propagating through a medium by absorption of a part of its photons is often called attenuation. Usually, the absorption of waves does not depend on their intensity (linear absorption), although in certain conditions (usually, in optics), the medium changes its transparency dependently on the intensity of waves going through, and saturable absorption (or nonlinear absorption) occurs.

Fission

The following is taken from Wikipedia, *Nuclear Fission*.

In nuclear physics and nuclear chemistry, nuclear fission is either a nuclear reaction or a radioactive decay process in which the nucleus of an atom splits into smaller parts (lighter nuclei). The fission process often produces free neutrons and photons (in the form of gamma rays), and releases a very large amount of energy even by the energetic standards of radioactive decay.

Fission is a form of nuclear transmutation because the resulting fragments are not the same element as the original atom. The two nuclei produced are most often of comparable but slightly different sizes, typically with a mass ratio of products of about 3 to 2, for common fissile isotopes. Most fissions are binary fissions (producing two charged fragments), but occasionally (2 to 4 times per 1,000 events), three positively charged fragments are produced, in a ternary fission. The smallest of these fragments in ternary processes ranges in size from a proton to an argon nucleus.

Particle Ejection

The following is taken from Integrated Publishing, *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.

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

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

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

The following is taken from Georgia State University, Hyperphysics, *Liquid Drop Model of the Nucleus.*

Scattering experiments suggest that nuclei have approximately constant density, so that the nuclear radius can be calculated by using that density as if the nucleus were a drop of a uniform liquid. A liquid drop model of the nucleus would take into account the fact that the forces on the nucleons on the surface is different from those on nucleons on the interior where they are completely surrounded by other attracting nucleons. This is something similar to taking account of surface tension as a contributor to the energy of a tiny liquid drop. The volume of the liquid drop is proportional to the mass number A, and the surface would then be proportional to the two-thirds power of A.

The first step toward a liquid drop model of the nucleus would then be to postulate a volume term and a surface term in the form:

$$E_b \approx \underset{\text{Volume term}}{C_1 A} \quad \underset{\text{Surface term}}{- C_2 A^{2/3}}$$

This simple model in fact gives a reasonable approximation of the variation of nuclear binding energy with mass number when the constants have the values

$$C_1 = 15.75 MeV, \quad C_2 = 17.8 MeV$$

Another contribution to the binding energy would be the coulomb repulsion of the protons, so there should be a negative term proportional to the square of the atomic number Z.

The Pauli principle favors nuclei in which A=2Z, so the empirical model of binding energy contains a term of the form

$$\Delta E_b^{Pauli} \approx \frac{-(23.7 MeV)(A - 2Z)^2}{A}$$

The Pauli principle also favors nuclear configurations with even numbers of neutrons and protons. In the liquid drop model, this is included by using the even-odd nucleus as a reference and adding a correction term which is positive for even-even nuclei and negative for odd-odd nuclei. This strategy for modeling the nuclear binding energy is attributed to Weizsaecker and called the Weizsaecker formula**.**

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

Fissile Material

The following is taken from U.S. Nuclear Regulatory Commission, Glossary, *Fissile Material*.

A nuclide that is capable of undergoing fission after capturing low-energy thermal (slow) neutrons. Although sometimes used as a synonym for fissionable material, this term has acquired its more-restrictive interpretation with the limitation that the nuclide must be fissionable by thermal neutrons. With that interpretation, the three primary fissile materials are U-233, U-235, and plutonium (Pu)-239. This definition excludes natural uranium and depleted uranium that have not been irradiated, or have only been irradiated in thermal reactors.

Fissionable Material

The following is taken from U.S. Nuclear Regulatory Commission, Glossary, *Fissionable Material*.

A nuclide that is capable of undergoing fission after capturing either high-energy (fast) neutrons or low-energy thermal (slow) neutrons. Although formerly used as a synonym for fissile material, fissionable materials also include those (such as U-238) that can be fissioned only with high-energy neutrons. As a result, fissile materials (such as U-235) are a subset of fissionable materials.

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

Fertile Material

The following is taken from U.S. Nuclear Regulatory Commission, Glossary, *Fertile Material*.

A material, which is not itself fissile (fissionable by thermal neutrons), that can be converted into a fissile material by irradiation in a reactor. There are two basic fertile materials: U-238 and thorium-232. When these fertile materials capture neutrons, they are converted into fissile Pu-239 and U-233, respectively.

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

The following is taken from U.S. Nuclear Regulatory Commission, *Radiation Basics.*

In some elements, the nucleus can split as a result of absorbing an additional neutron, through a process called nuclear fission. Such elements are called fissile materials. One particularly notable fissile material is U-235. This is the isotope that is used as fuel in commercial nuclear power plants.

When a nucleus fissions, it causes three important events that result in the release of energy. Specifically, these events are the release of radiation, release of neutrons (usually two or three), and formation of two new nuclei.

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

The following is taken from U.S. Nuclear Regulatory Commission, Glossary. *Criticality*.

Criticality is the normal operating condition of a reactor, in which nuclear fuel sustains a fission chain reaction. A reactor achieves criticality (and is said to be critical) when each fission event releases a sufficient number of neutrons to sustain an ongoing series of reactions.

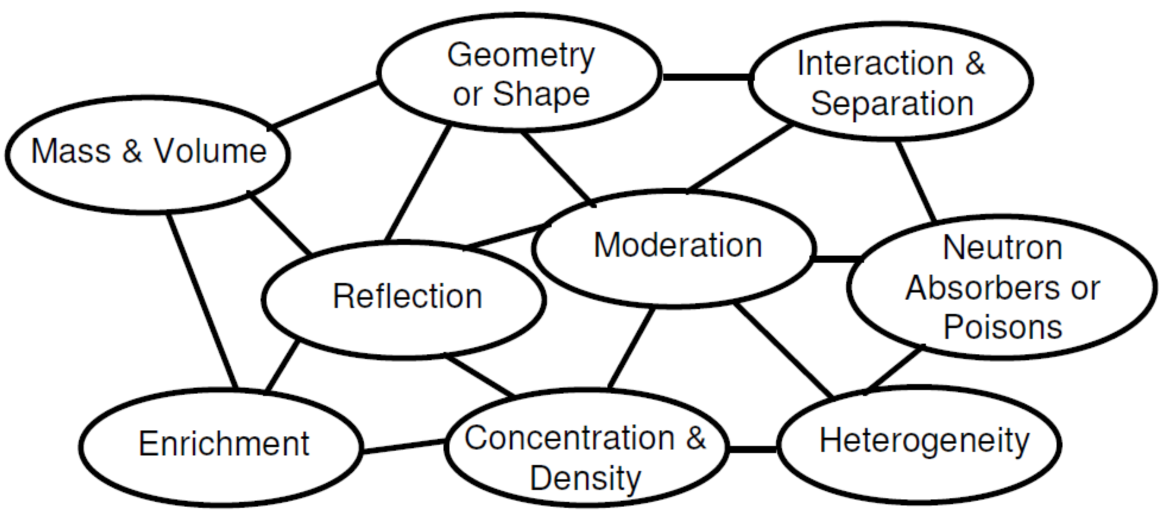
e. List five factors that affect criticality.

The following is taken from U.S. Nuclear Regulatory Commission, *Nuclear Criticality Safety Directed Self-Study Course,* Module 4, "Nuclear Criticality Safety Controls."

To maintain a system in a subcritical state, factors that can affect nuclear criticality must be controlled. These factors are

- mass
- volume
- enrichment
- geometry and shape
- interaction and separation
- moderation
- reflection
- concentration and density
- neutron absorber or poisons
- heterogeneity

These factors are interdependent. (See figure 6.) Changes made to one of the factors may affect the parameters on the other factors.



Source: U.S. Nuclear Regulatory Commission

Figure 6. Nuclear criticality safety control factors

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.

Refer to competency 2f for a discussion of the hazards associated with unwanted criticality.

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

a. Define the term "ionizing radiation."

The following is taken from Wikipedia, *Ionizing Radiation*.

Ionizing radiation is radiation that carries enough energy to free electrons from atoms or molecules, thereby ionizing them. Ionizing radiation is made up of energetic subatomic particles, ions, or atoms moving at relativistic speeds, and electromagnetic waves on the high-energy end of the electromagnetic spectrum.

b. Describe how nuclear radiation is generated.

The following is taken from Answers.com, *How is Nuclear Radiation Generated?*

By definition, nuclear radiation is generated by a nuclear reaction of some kind. There are three basic types of nuclear reactions that result in radiation: decay, fission, and fusion.

In all three cases, there is a nuclear reaction, and there is something left over. That leftover bit flies away from the reaction, or is radiated.

Nuclear radiation can also be classified based on what flies away. Alpha, beta, and gamma radiation result when different things are left over. Alpha radiation can be blocked by a piece of paper, but has huge amounts of energy. Gamma radiation can only be stopped by lead sheets or large amounts of concrete.

An atom bomb begins with fission. This occurs when a nucleus splits into two pieces. Often there will be a tiny bit of leftover energy, which can radiate away.

A hydrogen bomb also uses fusion. This occurs when two nuclei fuse together. Again, a tiny bit of leftover can radiate away.

Radioactive decay always occurs spontaneously. It just happens, nothing makes it happen. Decay can produce any type of radiation. Most of the radiation from nuclear weapons that harms people is actually produced by decay. The energy of the bomb produces isotopes (unstable versions of normal elements) that later decay. Isotopes behave chemically like the normal elements, so the body can be tricked into storing and using them. Then when they decay, they can blast the cell with radiation at point blank range.

Ironically, most of the radiation damage occurs when the radiation strikes a water molecule. The body is full of those. The radiation, called ionizing radiation ionizes the water molecule, knocking an oxygen atom off. This oxygen atom (now a “free radical”) can damage chemically whatever it next hits.

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

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

Alpha

The following is taken from Jefferson Lab, *What are Alpha Rays? How are They Produced?*

Alpha rays are actually high speed particles. Early researchers tended to refer to any form of energetic radiation as rays, and the term is still used. An alpha particle is made up of two protons and two neutrons, all held together by the same strong nuclear force that binds the nucleus of any atom. In fact, an alpha particle really is a nucleus—it is the same as the nucleus of a common atom of helium, but it does not have any electrons around it, and it is traveling very fast. Alpha particles are a type of ionizing radiation.

To describe the production of alpha particles, we have to define radioactive decay. This process can be thought of as follows. Certain combinations of neutrons and protons in a nucleus are stable. For example, in a stable bismuth atom there are 83 protons and 126 neutrons. This is called bismuth-209 (126 + 83 = 209). It will always be bismuth-209. But if one more neutron is added to this atom, making it bismuth-210, it would now be unstable, or radioactive. The atom will eventually spontaneously change or decay, to become more stable. There are only certain ways it can do this. One way is to emit an alpha particle. In this transition, it spits out a piece of itself (the alpha particle), and becomes more stable. The alpha particle is the radiation given off during the process of alpha decay. Since it lost two protons and two neutrons, the old bismuth atom is now an atom of thallium-206. This thallium is more stable, but is also radioactive. It will decay again (but not by alpha decay), this time becoming a completely stable atom of lead. Only relatively heavy atoms—like bismuth—can go through alpha decay. Lighter radioactive elements go through other types of transitions to become stable.

Another way to produce alpha particles is to force an atom to emit one. This is done by taking advantage of certain properties of various atoms. Here is an example. Take some regular atoms of boron-10 (five protons, five neutrons), and expose this boron to a field of slow-moving neutrons; some of the boron atoms will absorb a neutron. When this happens, the outcome is not what one would expect. The boron-10 does not just become stable boron-11. A likely possibility is that the excited boron atom will emit an alpha particle, becoming stable lithium in the process. There are other atoms that behave in this fashion.

Although alpha radiation travels very fast, it can easily be blocked or shielded. Alpha particles have an electric charge because of the protons. As they move through matter, they are constantly interacting with other charged particles, such as electrons. This process transfers the motion (energy) of the alpha particle to the electrons, actually knocking the electrons free in the process. This is known as ionization. These interactions cause the alpha particle to lose its energy and come to rest. Imagine a cue ball as it is traveling along on a pool table, running into other billiard balls and eventually stopping. With alpha particles, this happens in a very short distance, even in air. Alpha particles will lose all their energy in just a couple inches of travel in air. Once an alpha particle is stopped, it grabs the first two free electrons it can find, and becomes an atom of helium.

Alpha radiation is not hazardous if the source is external to the body. Alpha particles do not penetrate deeply enough into the body to reach living tissue. If the source of the alpha radiation is internal to the body, then the ionization mentioned earlier can damage living tissue. So, safety practices for handling alpha-emitting materials are centered on preventing inhalation or ingestion of the material.

Gamma

The following is taken from Wikipedia, *Gamma Ray*.

Gamma radiation, also known as gamma rays, and denoted by the Greek letter γ, refers to electromagnetic radiation of an extremely high frequency and therefore consists of high-energy photons. Gamma rays are ionizing radiation, and are thus biologically hazardous. They are classically produced by the decay of atomic nuclei as they transition from a high energy state to a lower state known as gamma decay, but may also be produced by other processes.

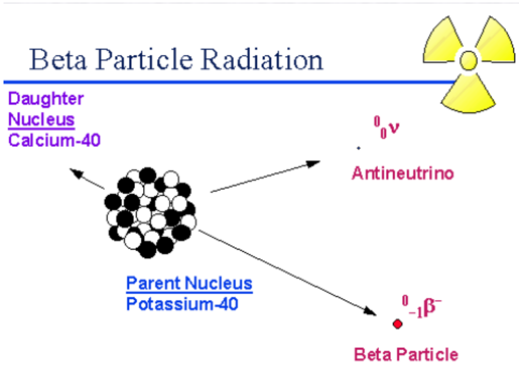
Gamma rays typically have frequencies above 10 exahertz (or >1019 Hz), and therefore have energies above 100 keV and wavelengths less than 10 picometers (10−12 meter), which is less than the diameter of an atom. However, this is not a hard and fast definition, but rather only a rule-of-thumb description for natural processes. Electromagnetic radiation from radioactive decay of atomic nuclei is referred to as gamma rays no matter its energy, so that there is no lower limit to gamma energy derived from radioactive decay. This radiation commonly has energy of a few hundred keV, and almost always less than 10 MeV. In astronomy, gamma rays are defined by their energy, and no production process needs to be specified.

Beta

The following is taken from Idaho State University, *Beta Particle Radiation.*

Beta decay is a radioactive process in which an electron is emitted from the nucleus of a radioactive atom, along with an unusual particle called an antineutrino. The neutrino is an almost massless particle that carries away some of the energy from the decay process.

Because this electron is from the nucleus of the atom, it is called a beta particle to distinguish it from the electrons which orbit the atom.



Like alpha decay, beta decay occurs in isotopes which are neutron rich (i.e., have a lot more neutrons in their nucleus than they do protons). Atoms that undergo beta decay are located below the line of stable elements on the chart of the nuclides, and are typically produced in nuclear reactors. When a nucleus ejects a beta particle, one of the neutrons in the nucleus is transformed into a proton. Since the number of protons in the nucleus has changed, a new daughter atom is formed which has one less neutron but one more proton than the parent. For example, when rhenium-187 decays (which has a Z of 75) by beta decay, osmium-187 is created (which has a Z of 76). Beta particles have a single negative charge and weigh only a small fraction of a neutron or proton. As a result, beta particles interact less readily with material than alpha particles. Depending on the beta particle's energy (which depends on the radioactive atom), beta particles will travel up to several meters in air, and are stopped by thin layers of metal or plastic.

Video 7. Alpha, beta, and gamma radiation
https://www.youtube.com/watch?v=T3Fr0eJQ3lA

Neutron

The following is taken from Wikipedia, *Neutron Radiation.*

Neutron radiation is a kind of ionizing radiation that consists of free neutrons. A result of nuclear fission or nuclear fusion, it consists of the release of free neutrons from atoms, and these free neutrons react with nuclei of other atoms to form new isotopes, which, in turn, may produce radiation.

Neutron radiation was discovered as a result of observing a beryllium nucleus reacting with an alpha particle thus transforming into a carbon nucleus and emitting a neutron, Be(α, n)C. The combination of an alpha particle emitter and an isotope with a large (α, n) nuclear reaction probability is still a common neutron source.

The neutrons in nuclear reactors are generally categorized as slow (thermal) neutrons or fast neutrons depending on their energy. Thermal neutrons are similar in energy distribution (the Maxwell-Boltzmann distribution) to a gas in thermodynamic equilibrium but are easily captured by atomic nuclei and are the primary means by which elements undergo atomic transmutation.

To achieve an effective fission chain reaction, the neutrons produced during fission must be captured by fissionable nuclei, which then split, releasing more neutrons. In most fission reactor designs, the nuclear fuel is not sufficiently refined to be able to absorb enough fast neutrons to carry on the fission chain reaction, due to the lower cross section for higher-energy neutrons, so a neutron moderator must be introduced to slow the fast neutrons down to thermal velocities to permit sufficient absorption. Common neutron moderators include graphite, ordinary (light) water and heavy water. A few reactors (fast neutron reactors) and all nuclear weapons rely on fast neutrons. This requires certain changes in the design and in the required nuclear fuel. The element beryllium is particularly useful due to its ability to act as a neutron reflector or lens. This allows smaller quantities of fissile material to be used and is a primary technical development that led to the creation of neutron bombs.

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

The following is taken from Wikipedia, *Radiation Protection.*

Particle radiation consists of a stream of charged or neutral particles, both charged ions and subatomic elementary particles. This includes solar wind, cosmic radiation, and neutron flux in nuclear reactors.

Alpha particles (helium nuclei) are the least penetrating. Even very energetic alpha particles can be stopped by a single sheet of paper.

Beta particles (electrons) are more penetrating, but still can be absorbed by a few millimeters of aluminum. However, in cases where high energy beta particles are emitted shielding must be accomplished with low density materials, for example, plastic, wood, water, or acrylic glass (Plexiglas, Lucite). This is to reduce generation of Bremsstrahlung X-rays. In the case of beta+ radiation (positrons), the gamma radiation from the electron-positron annihilation reaction poses additional concern.

Neutron radiation is not as readily absorbed as charged particle radiation, which makes this type highly penetrating. Neutrons are absorbed by nuclei of atoms in a nuclear reaction. This most often creates a secondary radiation hazard, as the absorbing nuclei transmute to the next heavier isotope, many of which are unstable.

Video 8. The distance and shielding effects of nuclear radiation
https://www.youtube.com/watch?v=aZNNfLDqMzA

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

The following is taken from U.S. Nuclear Regulatory Commission, *Backgrounder on Biological Effects of Radiation.*

We tend to think of the effects of radiation in terms of how it impacts living cells. For low levels of exposure, the biological effects are so small they may not be detected. The body is able to repair damage from radiation, chemicals, and other hazards. Living cells exposed to radiation could 1) repair themselves, leaving no damage; 2) die and be replaced, much like millions of body cells do every day; or 3) incorrectly repair themselves, resulting in a biophysical change.

The data on links between radiation exposure and cancer are mostly based on populations receiving high-level exposures. Much of this information comes from survivors of the atomic bombs in Japan and people who have received radiation for medical tests and therapy. Cancers associated with high-dose exposure include leukemia, breast, bladder, colon, liver, lung, esophagus, ovarian, multiple myeloma, and stomach cancers.

The time between radiation exposure and the detection of cancer is known as the latent period. This period can be many years. It is often not possible to tell exactly what causes any cancer. In fact, the National Cancer Institute says other chemical and physical hazards and lifestyle factors make significant contributions to many of these same diseases.

The data show high doses of radiation may cause cancers. But there are no data to establish a firm link between cancer and doses below about 10,000 millirem (mrem).

Even so, the regulations assume any amount of radiation may pose some risk. They aim to minimize doses to radiation workers and the public. The international community bases standards for radiation protection on something called the linear, no-threshold model. The idea is that risk increases as the dose increases. And there is no threshold below which radiation doses are safe. This model is a conservative basis for international and U.S. Nuclear Regulatory Commission (NRC) radiation dose standards. This means the model may overestimate risk.

High radiation doses tend to kill cells. Low doses may damage or alter a cell's genetic code. High doses can kill so many cells that tissues and organs are damaged immediately. This in turn may cause a rapid body response often called acute radiation syndrome. The higher the radiation dose, the sooner the effects of radiation will appear, and the higher the probability of death.

Many atomic bomb survivors in 1945 and emergency workers at the 1986 Chernobyl nuclear power plant accident experienced this syndrome. Among plant workers and firefighters battling the fire at Chernobyl, 134 received high radiation doses—80,000 to 1,600,000 mrem and suffered from acute radiation sickness. Of these, 28 died within the first three months from their radiation injuries. Two workers died within hours of the accident from nonradiological injuries.

Because radiation affects different people in different ways, it is not possible to say what dose is going to be fatal. However, experts believe that 50 percent of people would die within thirty days after receiving a dose of 350,000 to 500,000 mrem to the whole body, over a period ranging from a few minutes to a few hours. Health outcomes would vary depending on how healthy the person is before the exposure and the medical care they receive. If the exposure affects only parts of the body, such as the hands, effects will likely be more localized, such as skin burns.

Low doses spread out over a long period would not cause an immediate problem. The effects of doses less than 10,000 mrem over many years, if any, would occur at the cell level. Such changes may not be seen for many years or even decades after exposure.

Genetic effects and cancer are the primary health concerns from radiation exposure. Cancer would be about five times more likely than a genetic effect. Genetic effects might include stillbirths, congenital abnormalities, decreased birthweight, and infant and childhood mortality. These effects can result from a mutation in the cells of an exposed person that are passed on to their offspring. These effects may appear in the direct offspring if the damaged genes are dominant. Or they may appear several generations later if the genes are recessive.

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

The following is taken from Laboratory Safety and Management, *Hazards of Alpha and Beta Particles and Gamma Radiation.*

Alpha

Alpha particles are normally unable to penetrate the epidermis of the skin, especially when it is a considerable distance from the target. However, when present in large amounts within a close distance, they are able to penetrate the epidermis and enter the body, thus becoming hazardous.

Alpha particles can also enter the body via other routes including oral, ingestion, inhalation, and even absorption into the bloodstream. However when inside the body, with no epidermis to stop their movements, they are able to travel just enough distances into tissues to cause considerable damage.

This can lead to cancer, particularly lung cancer when alpha particles have been inhaled. However, tissues are not the only things that get damaged. If the alpha particles accumulate in an organ, they will also damage the cells of that particular organ resulting in organ damage.

Beta

Humans can be exposed to beta particles in a number of ways.

Potassium and carbon found naturally in our bodies are weak beta particle emitters. Direct exposure to beta particles, especially from concentrated emitters, can result in the burning of the skin or erythema. When inside the body, beta particles enter directly into the tissue, causing alteration of cell function, thereby affecting DNA in the cells. With a deeper penetration power, beta particles are able to cause more diverse cellular damage, and can be more hazardous than alpha particles.

Beta particles radiation can result in both acute and chronic health effects. Acute effects are presented when an individual is exposed to a concentrated source of beta particles. Chronic effects are more often observed with a long-term exposure to fairly low levels of beta particles. Exposure to beta particles often causes cancer, dependent on the location where the beta particles accumulate in the body. For example, accumulation of beta particles in the bone or teeth can lead to bone cancer.

Gamma

Humans exposed to gamma photons—either from naturally occurring potassium that can be found in soil, water or food, or by ingestion, inhalation or absorption into the body—can present with adverse health effects. Once inside the body, gamma photons are exposed to all tissues due to their high penetrating power, and this results in direct ionization of the atoms in the tissues or secondary ionization via the transfer of their energy to the electrons of the atoms in the tissue that will then produce ions. However, the extent of the tissue damage is less severe than that of exposure to alpha or beta particles as only a small amount of gamma photons are actually absorbed into the tissues. They also might be retained in the tissue or excreted in the urine and feces.

However, external exposure to gamma particles is much more hazardous. With their high energy levels, they can travel longer distances so regardless of how far the source is away from the victim, they can still penetrate the skin and interact with the tissue and organs. Therefore, their effects from external exposure are more serious than that of alpha and beta particles.

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

The following is taken from U.S. Nuclear Regulatory Commission, *Measuring Radiation.*

There are four different but interrelated units for measuring radioactivity, exposure, absorbed dose, and dose equivalent. These can be remembered by the mnemonic R-E-A-D, as follows:

1. Radioactivity refers to the amount of ionizing radiation released by a material. Whether it emits alpha or beta particles, gamma rays, x-rays, or neutrons, a quantity of radioactive material is expressed in terms of its radioactivity (or simply its activity), which represents how many atoms in the material decay in a given time period. The units of measure for radioactivity are the Ci and Bq.
2. Exposure describes the amount of radiation traveling through the air. Many radiation monitors measure exposure. The units for exposure are the roentgen (R) and coulomb/kilogram (C/kg).
3. Absorbed dose describes the amount of radiation absorbed by an object or person that is, the amount of energy that radioactive sources deposit in materials through which they pass. The units for absorbed dose are the radiation absorbed dose (rad) and gray (Gy).
4. Dose equivalent (or effective dose) combines the amount of radiation absorbed and the medical effects of that type of radiation. For beta and gamma radiation, the dose equivalent is the same as the absorbed dose. By contrast, the dose equivalent is larger than the absorbed dose for alpha and neutron radiation, because these types of radiation are more damaging to the human body. Units for dose equivalent are the roentgen equivalent man (rem) and sievert (Sv), and biological dose equivalents are commonly measured in 1/1000th of a rem (known as a millirem or mrem).

For practical purposes, 1 R (exposure) = 1 rad (absorbed dose) = 1 rem or 1000 mrem (dose equivalent).

Note that a measure given in Ci tells the radioactivity of a substance, while a measure in rem (or mrem) tells the amount of energy that a radioactive source deposits in living tissue.

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

The following is taken from the Health Physics Society, *Quality Factor*.

The quality factor is the factor by which the absorbed dose (rad or Gy) must be multiplied to obtain a quantity that expresses, on a common scale for all ionizing radiation, the biological damage (rem or Sv) to the exposed tissue. It is used because some types of radiation, such as alpha particles, are more biologically damaging to live tissue than other types of radiation when the absorbed dose from both is equal. The term, quality factor, has now been replaced by "radiation weighting factor" in the latest system of recommendations for radiation protection.

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

The following is taken from U.S. Nuclear Regulatory Commission, *ALARA.*

As defined in 10 CFR 20.1003, "Definitions," ALARA is an acronym for "as low as (is) reasonably achievable," which means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical, consistent with the purpose for which the licensed activity is undertaken, taking into account the state of technology, the economics of improvements in relation to state of technology, the economics of improvements in relation to benefits to the public health and safety, and other societal and socioeconomic considerations, and in relation to utilization of nuclear energy and licensed materials in the public interest.

The following is taken from North Carolina University, *Radiation Safety and ALARA.*

The three major principles to assist with maintaining doses ALARA are as follows:

1. Time—Minimizing the time of exposure directly reduces radiation dose.
2. Distance—Doubling the distance between the body and the radiation source will divide the radiation exposure by a factor of four.
3. Shielding— Using absorber materials such as Plexiglas for beta particles and lead for X-rays and gamma ray.

Video 9. ALARA

https://www.youtube.com/watch?v=Psy_VWTKIY0

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

- **Plutonium**
- **Uranium**
- **Tritium**

Plutonium

HAZARDS

The following is taken from The Encyclopedia of Earth, *Health Effects of Plutonium.*

Plutonium may remain in the lungs or move to the bones, liver, or other body organs. It generally stays in the body for decades and continues to expose the surrounding tissues to radiation. This may eventually increase the chance of developing cancer, but it would be several years before such cancer effects became apparent. The experimental evidence is inconclusive, and studies of some human populations who have been exposed to low levels of plutonium have not definitely shown an increase in cancer. However, plutonium has been shown to cause cancers and other damage in laboratory animals, and might affect the ability to resist disease (immune system). We do not know if plutonium causes birth defects or affects the ability to have children. However, radioactivity from other radioactive compounds can produce these effects. If plutonium can reach these sensitive target tissues, radioactivity from plutonium may produce these effects.

Plutonium is odorless and tasteless so you cannot tell if you are being exposed to plutonium. If you breathe in plutonium, some of it will be retained in your body. When discussing harmful health effects, the amount of plutonium that caused these effects is usually given as the amount of plutonium retained or deposited in the body rather than as the amount that was in the air.

There is no information from studies in humans or animals to identify the specific levels of exposures to plutonium in air, food, or water that have resulted in harmful effects. However, it is generally assumed that any amount of absorbed radiation, no matter how small, may cause some damage. When expressed as the amount of radioactivity deposited in the body per kilogram of body weight (kg bw) as a result of breathing in plutonium, studies in dogs report that 100,000 pCi plutonium/kg bw caused serious lung damage within a few months, 1,700 pCi/kg bw caused harm to the immune system, and 1,400 pCi/kg bw caused bone cancer after four years. In each of these cases the dogs were exposed to the plutonium in air for one day.

HANDLING

The following is taken from International Atomic Energy Agency, *Safe Handling and Storage of Plutonium.*

The most important factors to keep in mind when evaluating systems or operations using plutonium are to

- avoid criticality
- avoid fire and explosion
- maintain containment to avoid contamination
- avoid internal exposure to plutonium
- ensure safeguards
- provide adequate physical protection
- keep external exposures at ALARA levels

The primary approach to plutonium safety involves planning; personnel practices; and engineered controls, such as the use of glove boxes, remote handling systems, geometrically safe containers, high efficiency particulate absolute (HEPA) filtration, and dynamic ventilation systems.

Further safety considerations include administrative standards and controls such as mass limitations, training, procedures, postings, personnel and area radiation monitoring, and emergency response. The combination of all these elements provides the basis for a comprehensive safety program.

STORAGE

The following is taken from International Atomic Energy Agency, *Safe Handling and Storage of Plutonium.*

The storage of plutonium entails ongoing attention, as the heat and gases generated during storage can be significant. Safe storage can be achieved if

- mass and geometry controls are observed;
- cooling is provided for storage vaults;
- for long-term storage (longer than one year), plutonium is stored as the oxide (PuO2), metal, stable alloy, or stable compound (not yet identified) in a sealed container; it is necessary to use the proper atmosphere, such as a vacuum or dry inert atmosphere;
- storage containers are kept free of organics;
- storage containers are kept free of moisture;
- ongoing monitoring, surveillance, and maintenance are conducted; and
- emergency procedures are developed and practiced.

A significant level of expertise has been gained over the last 50 years on the safe handling and storage of plutonium—particularly with high Pu-238 and Am-241 content. This expertise allows large-scale operations to be conducted safely, relative to workers, the general public, and the environment.

Uranium

HAZARDS

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

The principal industrial hazards associated with uranium 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 byproducts or reactants of common chemical processes. Hydrogen can be generated by reaction of water with uranium metal, and finely divided uranium or uranium chips with a large surface-area-to-volume ratio can ignite spontaneously.

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

The chemical toxicity of uranium is a primary concern in establishing control limits. A heavy metal, uranium 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 uranium 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. The International Commission on Radiological Protection, *Publication 103*, 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 uranium hazards as follows:

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

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 plutonium 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
- Administrative criticality controls
- 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 uranium 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 uranium 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 personal protective equipment (PPE).

Engineered controls

- 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 uranium 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/100cm^2.

Personal protective equipment

- 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 helium 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 helium 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 shall demonstrate a familiarity level knowledge of contamination control and theory.

a. Define the term "contamination" and list three types of contamination.

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

Radioactive contamination is radioactive material that is uncontained and in an unwanted place. Table 3 lists and describes the three types of radioactive contamination.

Table 3. 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

Source: DOE-HDBK-1130-2008

b. Describe three ways to control contamination.

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

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

1. Prevention
2. Engineering controls
3. PPE

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 HEPA 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.
- HEPA filters are used to remove radioactive particles from the air.

CONTAINMENT

Permanent and temporary containments are used for contamination control. Examples include vessels, pipes, cells, glove bags, 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 5.

Removable contamination is measured by a transfer test using a suitable sampling material. Common materials used for the monitoring are the standard paper disk smear or cloth smear. The standard technique involves wiping approximately 100 cm of the surface of interest using moderate pressure. A common sampling practice used to ensure a 100 cm^2 sample is to wipe a 16-square inch “S” shape on the surface (i.e., four inches by four inches).

Qualitative, large area wipe surveys may be taken using other materials, such as Masslin cloth or Kim wipe, to indicate the presence of removable contamination. These are commonly used when exact levels of contamination are not required.

Fixed contamination is measured by use of a direct survey technique. This technique, commonly referred to as "frisking," indicates the total contamination on a surface apparent to the detector from fixed and removable. To evaluate the fixed component the removable level must be subtracted from the total, when non-removable levels are to be recorded.

Appendix D to 10 CFR 835 lists contamination levels in units of dpm/100 cm^2. Typical evaluation of fixed contamination monitoring includes adjusting the portable instrument count rate (counts per minute) to account for the area of the monitoring instrument (probe area) and the instrument efficiency to obtain units of dpm/100 cm^2.

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

The following is taken from Wikipedia, *Radioactive Contamination.*

Internal Contamination

Radioactive contamination can enter the body through ingestion, inhalation, absorption, or injection. This will result in a committed dose of radiation.

For this reason, it is important to use PPE when working with radioactive materials. Radioactive contamination may also be ingested as the result of eating contaminated plants and animals or drinking contaminated water or milk from exposed animals. Following a major contamination incident, all potential pathways of internal exposure should be considered.

Prevention

The following is taken from DOE-HDBK-1122-2009, Part 3.

Methods to prevent internal contamination include the following:

- Inhalation—Assessment of conditions, use of engineering controls (e.g., ventilation systems), respiratory protection equipment
- Ingestion—Proper radiological controls and work practices (e.g., no eating, drinking, or chewing in a contamination area)
- 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 following is taken from DOE-STD-1122-2009, Part 5.

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.

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:

1. In vivo—Analysis of living tissue
2. In vitro—Analysis of excreted samples

Bioassay programs are designed to fulfill two needs:

1. Evaluate effectiveness of contamination control practices.
    - Routine bioassay programs use submission and analysis of samples from workers in facilities where the likelihood of intake exists.
    - Primarily limited to urinalysis due to ease of sample collection.
    - Also includes initial, routine, and termination whole body counts.
2. Evaluate potential consequences of accidental inhalation or ingestion of large quantities of radioactive materials.
    - Can involve all types of bioassay measurements with collection and analysis of nasal, urine, and fecal samples.
    - Whole body counts provide immediate indications for given radionuclides if individual(s) involved are free of external contamination.

In Vivo Measurements

The amount of materials is estimated by counting radiation emitted by radioactive materials in the body.

Only good for radioactive materials that emit gamma radiation of sufficient abundance and energy to be detected and statistically measured.

With use of expensive, sophisticated spectroscopy, most contributors (radionuclides present) can be identified.

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 include urine, feces, blood, sputum, saliva, hair, and nasal discharges.

Calculation requires knowledge of and use of metabolic models, which allow use of activity in samples to be related to activity present in the body.

Resulting dose calculations to quantify committed and effective doses are estimates.

- This is due partly to use of default values for measurements that cannot be readily made such as mass of particular organs, volumes of particular fluids, etc., in lieu of actual values for individual involved.
- Another contributing factor is different metabolism from one individual to another.

f. Describe the types of personal protective equipment.

The following is taken from DOE-HDBK-1122-2009, Part 5.

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;
- the area of the body at risk; and
- competing hazards (e.g., 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;
- Is only applicable when the potential for body contact with contaminated surfaces is very low;
- are generally worn for hands-off tours and inspections in areas with removable contamination at levels one to ten times the values in table 2-2 of the Radiological Control Standard; and
- 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;

- have low protection when body contact with contaminated surfaces is prolonged (since contamination can be ground into the cloth);
- have low protection is low when the surface is wet;
- can provide increased degree of protection by use of more than one pair at a time to protect the body; and
- are 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; and
- provide limited protection from tritium and other highly permeating radionuclides being transported through the coveralls to the skin surface.

Disposable coveralls
- are used for work involving mixed hazards (e.g., asbestos, polychlorinated biphenyls [PCBs], etc.) where reuse is not desirable;
- include Tyvek, Gortex, etc., which provide moderate protection from radioactive contamination; but
- also can be easily torn.

Hand Protection

Surgical gloves
- require minimal requirement;
- are normally used in only light contamination work areas;
- provide a high degree of dexterity; but
- are fairly easily torn or punctured.

Rubber gloves
- are lightweight;
- provide good gripping surface;
- are normally used in moderate to heavy contamination locations; and
- have greater puncture, abrasion and solvent resistance, but afford a lower degree of dexterity than surgical gloves.

Neoprene gloves
- mounted to various containment devices allow access by the wearer into the device;
- are used to provide protection for the wearer when working inside a containment device in which highly contaminated materials are present;
- are usually of arm length attached to dry boxes, glove boxes and bags, or other cabinets;
- provide a gas tight seal to the structure; and
- are normally taped to the sleeve of the lab coat, coveralls, plastic suit, etc. and are tabbed to permit easy removal.

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 lower leg area below coveralls from contamination. Different constructions used include

- 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; and
- are normally are constructed of plastic or rubber.

Respiratory Protection

Full-face masks—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—Used to prevent inhalation of particulate and gaseous radionuclides by the wearer in a non-life-threatening atmosphere.

Self-contained breathing apparatus—Used to provide a portable source of breathing air to the user when entering an atmosphere which may be immediately dangerous to life and health.

Medical approval, training, and fit testing are required prior to respiratory protection use.

- Systems should be in place to verify these criteria in the field.
- The wearer should be clean-shaven in the area of fit.
- The wearer should perform fit checks of his/her respirators to ensure a proper seal.

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

The following is taken from Slider.com, *Radioactive 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 properly disposed of.

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. Some radioisotopes may be generally distributed throughout the body and rapidly removed, as is the case with tritiated water. Some radioisotopes may target specific organs and have much lower removal rates. For instance, the thyroid gland takes up a large percentage of any iodine that enters the body. If large quantities of radioactive iodine are inhaled or ingested, the thyroid may be impaired or destroyed, while other tissues are affected to a lesser extent. Radioactive iodine is a common fission product; it was a major component of the radiation released from the Chernobyl disaster, leading to many cases of pediatric thyroid cancer and hypothyroidism. On the other hand, radioactive iodine is used in the diagnosis and treatment of many diseases of the thyroid precisely because of the thyroid's selective uptake of iodine.

Radioactive contamination can enter the body through ingestion, inhalation, absorption, or injection. For this reason, it is important to use PPE when working with radioactive materials. Radioactive contamination may also be ingested as the result of eating contaminated plants and animals or drinking contaminated water or milk from exposed animals. Following a major contamination incident, all potential pathways of internal exposure should be considered.

Decontamination of external contamination is often as simple as removing contaminated clothing and cleaning contaminated skin. Internal decontamination is much more difficult, depending on the radionuclide in question.

5. Personnel shall 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.

Thermoluminescent Dosimeters

The following is taken from Wikipedia, *Thermoluminescent Dosimeter*.

The two most common types of thermoluminescent dosimeters (TLDs) are calcium fluoride and lithium fluoride, with one or more impurities to produce trap states for energetic electrons. The former is used to record gamma exposure, the latter for gamma and neutron exposure. Other types include beryllium oxide, calcium sulfate doped with thulium. As the radiation interacts with the crystal it causes electrons in the crystal's atoms to jump to higher energy states, where they stay trapped due to intentionally introduced impurities (usually manganese or magnesium) in the crystal, until heated. Heating the crystal causes the electrons to drop back to their ground state, releasing a photon of energy equal to the energy difference between the trap state and the ground state. The electrons can also drop back to ground state after a long period of time; this effect is called fading and is dependent on the incident radiation energy and intrinsic properties of the TLD material. As a result, each material possesses a limited shelf life after which dosimetric information can no longer be obtained. This varies from several weeks in calcium fluoride to up to two years.

Self-Reading Dosimetry

The following is taken from DOE-HDBK-1122-2009, Part 5.

Direct reading ion chamber utilizes two electrodes:

1. Fiber electrometer (fixed and moveable components)
2. Metal frame

As chamber is ionized the charge is decreased on the movable and fixed fiber.

The movement of the fiber is proportional to the dose received.

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

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

Criticality

The following is taken from DOE-STD-1128-2013.

The nuclear criticality safety program evaluation and documentation should include an assessment of the need for criticality accident detection devices and alarm systems, and installation of such equipment where total risk to personnel will be reduced.

Per the criticality safety program, the basic elements and control parameters of programs for nuclear criticality safety shall satisfy the requirements of the applicable American National Standards Institute/American Nuclear Society's (ANSI/ANS) nuclear criticality safety standards.

As specified in ANSI/ANS-8.3, *Criticality Accident Alarm System,* the need for criticality alarm systems shall be evaluated for all activities in which the inventory of fissionable material in individual unrelated work areas exceeds 700 g of U-235, 520 g of U-233, 450 g of Pu-239, or 450 g of any combination of these three isotopes.

ANSI/ANS-8.3 provides several additional requirements regarding criticality alarm systems. 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. Information on sound levels of the alarm can be found in ANSI/ANS-8.3. 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 2 m from the reacting material within 60 sec. The alarm signal shall activate promptly (i.e., within 0.5 sec) when the dose rate at the detectors equals or exceeds a value equivalent to 20 rad/min at 2 m from the reacting material. A visible or audible warning signal shall be provided at a normally occupied location to indicate system malfunction or loss of primary power. Each alarm system should be tested at least once every three months. An evacuation drill shall be conducted at least annually.

Criticality alarm systems may consist of one to several detectors per unit. In multi-detector units (e.g., three detectors), at least two detectors shall be at the alarm level before initiating the alarm; in redundant systems, failure of any single channel shall be into the trip state.

Area

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

In addition to the requirements and recommendations of Article 551 of DOE-STD-1098-2008, area radiation monitors (not to include area monitoring dosimeters discussed in Article 514) 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.

Area radiation monitors should not be substituted for radiation exposure surveys in characterizing a workplace.

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

In addition to the requirements of Article 562, area radiation monitors should be tested periodically (e.g., quarterly) to verify audible alarm system operability and audibility under ambient working conditions and operability of visual alarms when so equipped.

If installed instrumentation is removed from service for maintenance or calibration, a radiation monitoring program providing similar detection capability should be provided, consistent with the potential for unexpected increases in radiation dose rates.

Where an area radiation monitor is incorporated into a safety interlock system, the circuitry should be such that a failure of the monitor either prevents entry into the area or prevents operation of the radiation producing device. If the circuitry is required to ensure compliance with the high radiation area access control requirements of 10 CFR 835.502, “High and Very High Radiation Areas,” then the circuitry shall be fail-safe.

Process

The following is taken from *Westinghouse Technology Systems Manual*, Section 16.0, “Radiation Monitoring System.”

The process radiation monitoring (PRM) system monitors 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, such as the component cooling water system, process monitors are provided to indicate process stream malfunctions. This is accomplished by detecting the normal background radiation of the system and by alerting the operator with an annunciator if an accumulation of radioactive material occurs in the system. In addition to providing continuous indication and alarms, the PRM 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 set point, the system will perform its automatic function, which ensures that the discharge of radioactive material to the environs is limited. The PRM system can monitor a process stream with one of two types of monitors: in-line monitors and off-line monitors.

IN-LINE MONITOR

An in-line monitor has the detector probe directly immersed in the process stream. The advantage of this type of monitoring is that the detector probe will be provided a representative sample of the process and responds rapidly to activity changes. The disadvantages of this monitor are that if the process has a turbulent flow the detector probe must be protected by placing it in a well, which lowers the sensitivity of the probe, and if the probe fails, the system must either be secured or a means of bypassing flow around the probe must be provided (only for directly immersed probes).

OFF-LINE MONITOR

An off-line monitor contains piping, valves, detector probes (usually two in parallel), and a motive force device, such as a pump or a fan. This monitor will take suction on the process stream, pass the flow to the detector, and then return the sample to the process stream. The advantages of this monitor are that with lower flow rates, the detector probe can be directly immersed into the sample stream without a protection well, therefore increasing probe sensitivity, and if a detector fails, it can be isolated (by inlet and outlet valves), and the process stream is not affected.

The disadvantages of this monitor are that it may not be receiving a representative sample of the process stream and may not be as responsive to rapid changes of activity in the process. At the time of this writing there is no preferred method of process monitoring.

Airborne

The following is taken from Wikipedia, *Airborne Particulate Radioactivity Monitoring.*

Continuous particulate air monitors (CPAMs) have been used for years in nuclear facilities to assess airborne particulate radioactivity (APR). In more recent times they may also be used to monitor people in their homes for the presence of man-made radioactivity. These monitors can be used to trigger alarms, indicating to personnel that they should evacuate an area.

In nuclear power plants, CPAMs are used for measuring releases of APR from the facility; monitoring levels of APR for protection of plant personnel; monitoring the air in the reactor containment structure to detect leakage from the reactor systems; and to control ventilation fans, when the APR level has exceeded a defined threshold in the ventilation system.

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

a. Discuss the purpose and general requirements of 10 CFR 835, "Occupational Radiation Protection," including 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 rules in 10 CFR 835 establish radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the conduct of DOE activities.

Access Training
The following is taken from 10 CFR 835.901.

Each individual shall complete radiation safety training on the topics established at10 CFR 835.901, "Radiation Safety Training," commensurate with the hazards in the area and the required controls
- before being permitted unescorted access to controlled areas
- before receiving occupational dose during access to controlled areas at a DOE site or facility

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
- before 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 both 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, "Radiation Protection Programs"
- Individual exposure reports that may be requested in accordance with 10 CFR 835.801, "Reports to Individuals"

When an escort is used in lieu of training the escort shall

- have completed radiation safety training, examinations, and performance demonstrations required for entry to the area and performance of the work; and
- ensure that all escorted individuals comply with the documented radiation protection program.

Radiation safety training shall be provided to individuals when there is a significant change to radiation protection policies and procedures that may affect the individual and at intervals not to exceed 24 months. Such training provided for individuals subject to the requirements of 10 CFR 835.901(b)(1) and (b)(2) shall include successful completion of an examination.

Dose Limits

The following is taken from 10 CFR 835.202.

Except for planned special exposures conducted consistent with 10 CFR 835.204, "Planned Special Exposures," and emergency exposures authorized in accordance with 10 CFR 835.1302, "Emergency Exposure Situations," 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 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, "Occupational Dose Limits for General Employees," and 10 CFR 835.207, "Occupational Dose Limits for Minors."

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

The following is taken from 10 CFR 835.601.

Except as otherwise provided in 10 CFR 835, postings and labels required shall include the standard radiation warning trefoil in black or magenta imposed upon a yellow background.

Signs required by 10 CFR 835 shall be clearly and conspicuously posted and may include radiological protection instructions.

The posting and labeling requirements may be modified to reflect the special considerations of DOE activities conducted at private residences or businesses. Such modifications shall provide the same level of protection to individuals as the existing provisions in 10 CFR 835.

The following is taken from 10 CFR 835.602.

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 total effective dose 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.

The following is taken from 10 CFR 835.603.

Each access point to radiological areas and radioactive material areas shall be posted with conspicuous signs bearing the wording provided in this section.

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.

The following is taken from 10 CFR 835.605.

Except as provided at 10 CFR 835.606, “Exceptions to Labeling Requirements,” each item or container of radioactive material shall bear a durable, clearly visible label bearing the standard radiation warning trefoil and the words “Caution, Radioactive Material,” or “Danger, Radioactive Material.” The label shall also provide sufficient information to permit individuals handling, using, or working in the vicinity of the items or containers to take precautions to avoid or control exposures.

Access Requirements

The following is taken from 10 CFR 835.501.

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
- ACs

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.

Differences in Radiological Terminology between the 1998 and 2007 revisions of 10 CFR 835

The following is taken from the Federal Register.

Table 4. 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-1098-2008, *Radiological Control*.

DOE has developed DOE-STD-1098-2008 to assist line managers in meeting their responsibilities for implementing occupational radiological control programs.

DOE has established regulatory requirements for occupational radiation protection in 10 CFR 835. Failure to comply with these requirements may lead to appropriate enforcement actions as authorized under the Price Anderson Act Amendments. While DOE-STD-1098-2008 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).

DOE-STD-1098-2008 supplements DOE G 441.1-1C, *Radiation Protection Programs Guide for Use with Title 10, Code of Federal Regulations, Part 835, Occupational Radiation Protection,* and serves as a secondary source of guidance for achieving compliance with 10 CFR 835. While there is significant overlap between DOE G 441.1-1C and DOE-STD-1098-2088, this standard differs from the guide in intent and detail. In contrast to the macroscopic view adopted by the guide, DOE-STD-1098-2008 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 DOE-STD-1098-2008 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. The specific administrative instruments used at DOE sites vary widely, as would be expected given the varying nature of DOE facilities and activities and their associated hazards.

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

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**

The following discussions are taken from DOE M 453.1-1, Admin Chg 2 unless stated otherwise.

Low Level Radioactive Waste

Low-level radioactive waste is radioactive waste that is not high-level radioactive waste, spent nuclear fuel, transuranic waste (TRU), byproduct material, or naturally occurring radioactive material.

Hazardous Waste

The following is taken from DOE G 430.1-1.

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

TRU waste is radioactive waste containing more than 100 nanocuries of alpha-emitting TRU isotopes per gram of waste, with half-lives greater than 20 years, except for 1) high-level radioactive waste; 2) waste that the secretary of Energy has determined, with the concurrence of the administrator of the Environmental Protection Agency (EPA), does not need the degree of isolation required by the 40 CFR 191, "Environmental Radiation Protection Standards for Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes"; or 3) waste that the NRC has approved for disposal on a case-by-case basis in accordance with 10 CFR 61, "Licensing Requirements for Land Disposal of Radioactive Waste."

High-Level Radioactive Waste

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

Mixed Hazardous Waste

Waste that contains source, special nuclear, or byproduct material subject to the Atomic Energy Act (AEA) of 1954, as amended, and a hazardous component 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 U.S. Nuclear Regulatory Commission, *Low-Level Radioactive Waste.*

Low-level radioactive waste is a general term for a wide range of items that have become contaminated with radioactive material or have become radioactive through exposure to neutron radiation. A variety of industries, hospitals and medical institutions, educational and research institutions, private or government laboratories, and nuclear fuel cycle facilities generate low-level waste (LLW) as part of their day-to-day use of radioactive materials. Some examples include radioactively contaminated protective shoe covers and clothing;

cleaning rags, mops, filters, and reactor water treatment residues; equipment and tools; medical tubes, swabs, and hypodermic syringes; and carcasses and tissues from laboratory animals. The radioactivity in these wastes can range from just above natural background levels to much higher levels, such as seen in parts from inside the reactor vessel in a nuclear power plant. LLW is typically stored onsite by licensees either until it has decayed away and can be disposed of as ordinary trash, or until the accumulated amount becomes large enough to warrant shipment to an LLW disposal site.

Hazardous Waste

The following is taken from Wikipedia, *Hazardous Waste.*

Hazardous waste is waste that poses substantial or potential threats to public health or the environment. In the United States, the treatment, storage, and disposal of hazardous waste is regulated under the RCRA. Hazardous wastes are defined under RCRA in 40 CFR 261 where they are divided into two major categories: characteristic wastes and listed wastes.

Characteristic hazardous wastes are materials that are known or tested to exhibit one or more of the following four hazardous traits:

1. Ignitability
2. Reactivity
3. Corrosivity
4. Toxicity

Listed hazardous wastes are materials specifically listed by regulatory authorities as a hazardous waste which are from non-specific sources, specific sources, or discarded chemical products.

Transuranic Waste

The following is taken from U.S. Nuclear Regulatory Commission, *Transuranic Waste.*

Material contaminated with transuranic elements—artificially made, radioactive elements, such as neptunium, plutonium, americium, and others—that have atomic numbers higher than uranium in the periodic table of elements. TRU is primarily produced from recycling spent fuel or using plutonium to fabricate nuclear weapons.

High-Level Radioactive Waste

The following is taken from U.S. Nuclear Regulatory Commission, *High-Level Waste.*

High-level radioactive wastes are the highly radioactive materials produced as a byproduct of the reactions that occur inside nuclear reactors. High-level wastes take one of two forms:

1. Spent (used) reactor fuel when it is accepted for disposal
2. Waste materials remaining after spent fuel is reprocessed

Spent nuclear fuel is used fuel from a reactor that is no longer efficient in creating electricity, because its fission process has slowed. However, it is still thermally hot, highly radioactive, and potentially harmful. Until a permanent disposal repository for spent nuclear fuel is built, licensees must safely store this fuel at their reactors.

Mixed Hazardous Waste

The following is taken from U.S. Environmental Protection Agency, *Mixed Wastes.*

Mixed waste contains radioactive and hazardous waste components. As a result, treatment and regulation are complex. Mixed wastes are regulated by the RCRA and the AEA. In general, the requirements of RCRA and AEA are consistent and compatible. However, in cases where requirements of the two acts are found to be inconsistent, the AEA takes precedence.

DOE produces three types of mixed waste:

1. Low-level mixed waste (LLMW)—Results from research, development, and production of nuclear weapons. An estimated 226,000 cubic meters (m^3) of DOE LLMW will require management over the next twenty years.
2. High-level mixed waste (HLMW)—Results from reprocessing spent nuclear fuel and irradiated targets from reactors. These wastes often contain highly corrosive components, organics, or heavy metals that are regulated under RCRA. DOE has about 399,000 m^3 of HLMW stored in large tanks at four locations across the U.S.
3. Mixed transuranic waste (MTRU)—Contains radioactive elements heavier than uranium and a hazardous waste component. MTRU is primarily generated from nuclear weapons fabrication, plutonium bearing reactor fuel fabrication, and spent fuel reprocessing.

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**

Low-Level Radioactive Waste

The following is taken from U.S. Nuclear Regulatory Commission, *Low-Level Waste Disposal*.

LLW disposal occurs at commercially operated LLW disposal facilities that must be licensed by either NRC or agreement states. The facilities must be designed, constructed, and operated to meet safety standards. The operator of the facility must also extensively characterize the site on which the facility is located and analyze how the facility will perform for thousands of years into the future.

There are three existing LLW disposal facilities in the United States that accept various types of LLW. All are in agreement states.

The Low-level Radioactive Waste Policy Amendments Act of 1985 gave the states responsibility for the disposal of their low-level radioactive waste. The Act encouraged the states to enter into compacts that would allow them to dispose of waste at a common disposal facility. Most states have entered into compacts; however, no new disposal facilities have been built since the Act was passed.

Video 10. Low-level radioactive waste disposal at the Nevada National Security Site
https://www.youtube.com/watch?v=ekqDp5y9lio

Hazardous Waste

The following is taken from Michigan Tech, *Hazardous Waste Disposal Procedures.*

RULES FOR HAZARDOUS WASTE ACCUMULATION

- A generator must perform a "waste determination" to see if a waste is regulated under RCRA. That determination can be based on the generator's knowledge of the waste composition or through chemical analysis if the composition is unknown. The waste determination must be made no later than the moment a substance becomes a waste. Documentation supporting this waste determination must be kept on file for three years.
- Hazardous waste must be accumulated and stored at the point of generation until removed by Occupational Safety and Health Services and must be
  - collected in a container that is compatible with its contents under all conditions that it might be subjected to during accumulation, storage, and shipment;
  - kept tightly sealed except when adding waste to the container;
  - handled only by personnel trained in the requirements of these hazardous waste rules;
  - removed from the accumulation area within three days if the quantity of any one waste exceeds fifty-five gallons; and
  - labeled with the words "hazardous waste," the waste identification number, the accumulation start date, and a chemical description.

Video 11. Hazardous waste management for generators
https://www.youtube.com/watch?v=BjbRKlJnnWcl

Transuranic Waste

The following is taken from DOE M 435.1-1.

STORAGE

Storage prohibitions—TRU 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.

Storage integrity—TRU 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.

Container inspection—A process shall be developed and implemented for inspecting and maintaining containers of TRU waste to ensure container integrity is not compromised.

Retrievable earthen-covered storage—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
TRU waste shall be treated as necessary to meet the waste acceptance requirements of the facility receiving the waste for storage or disposal.

DISPOSAL
TRU waste shall be disposed in accordance with the requirements of 40 CFR 191.

For off-normal or emergency situations involving liquid TRU waste storage or treatment, spare capacity with adequate capabilities shall be maintained to receive the largest volume of liquid contained in any one storage tank or treatment facility. Tanks or other facilities that are designated TRU waste contingency storage shall be maintained in an operational condition when waste is present and shall meet the requirements of DOE O 435.1, Chg 1, *Radioactive Waste Management*, and DOE M 435.1-1.

High-Level Radioactive Waste
The following is taken from DOE M 435.1-1.

The following requirements apply to facilities intended for management of high-level waste awaiting pretreatment, treatment, or disposal, unless stated otherwise.

OPERATION OF CONFINEMENT SYSTEMS.
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.

STRUCTURAL INTEGRITY PROGRAM.
Leak-tight tanks in-service—A structural integrity program shall be developed for each high-level waste 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

- verifying the current leak-tightness and structural strength of each tank in service;
- identifying corrosion, fatigue, and other critical degradation modes;
- adjusting the chemistry of tank waste, calibrating cathodic protection systems, wherever employed, and implementing other necessary corrosion protection measures;
- providing credible projections as to when structural integrity of each tank can no longer be assured; and
- identifying the additional controls necessary to maintain an acceptable operating envelope.

In-service tanks that have leaked or are suspect—For each high-level waste 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. The modified program shall be capable of

- verifying the structural strength of each tank in-service which has leaked or is suspect;
- identifying corrosion, fatigue and other critical degradation modes;

- adjusting the chemistry of tank waste, calibrating cathodic protection systems, wherever employed, and implementing other necessary corrosion protection measures;
- determining which of the tanks that have leaked or are suspect may remain in service by identifying an acceptable safe operating envelope;
- providing credible projections as to when the acceptable safe operational envelope can no longer be assured; and
- identifying the additional controls necessary to maintain the acceptable safe operational envelope.

When physical activities, as part of a structural integrity program, pose additional vulnerabilities, alternative measures shall be implemented to provide an acceptable storage operational envelope.

Other storage components—The structural integrity of other storage components shall be verified to assure leak tightness and structural strength.

CANISTERED WASTE FORM STORAGE

Canisters of immobilized high-level waste awaiting shipment to a repository shall be

- stored in a suitable facility;
- segregated and clearly identified to avoid commingling with low-level, mixed low-level, or TRU waste; 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 high-level waste. Facilities and operating procedures for storage of vitrified high-level waste 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-0351P, for non-vitrified, immobilized high-level waste.

DISPOSAL

Disposal of high-level waste 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 Waste

The following is taken from DOE M 435.1-1.

Mixed waste is radioactive waste that contains source, special nuclear, or byproduct 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, 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.

- HLMW—unless demonstrated otherwise, all HLMW 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 shall 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)**

NEPA

The following is taken from U.S. Environmental Protection Agency, *What is the National Environmental Policy Act?*

NEPA was signed into law on January 1, 1970. NEPA requires Federal agencies to assess the environmental effects of their proposed actions prior to making decisions. The range of actions covered by NEPA is broad and includes
- making decisions on permit applications
- adopting Federal land management actions
- constructing highways and other publicly owned facilities

Using the NEPA process, agencies evaluate the environmental and related social and economic effects of their proposed actions. Agencies also provide opportunities for public review and comment on those evaluations.

Video 12. NEPA Citizen's Guide
https://www.youtube.com/watch?v=0DAWOui0UzU

RCRA

The following is taken from U.S. Environmental Protection Agency, *Resource Conservation and Recovery Act (RCRA) Overview.*

The EPA has largely focused on building the hazardous and municipal solid waste programs, and fostering a strong societal commitment to recycling and pollution prevention. Ensuring responsible waste management practices is a far-reaching and challenging task that engages EPA headquarters, regions, state agencies, tribes and local governments, as well as everyone who generates waste.

It is important to look at the RCRA program's nationwide accomplishments to understand where it is now and where it is headed in the future.
- Developing a comprehensive system and Federal/state infrastructure to manage hazardous waste from "cradle-to-grave"

- Establishing the framework for states to implement effective municipal solid waste and nonhazardous secondary material management programs
- Preventing contamination from adversely impacting our communities and resulting in future Superfund sites
- Restoring 18 million acres of contaminated lands, nearly equal to the size of South Carolina, and making the land ready for productive reuse through the RCRA Corrective Action Program
- Creating partnership and award programs to encourage companies to modify manufacturing practices in which to generate less waste and reuse materials safely
- Enhancing perceptions of wastes as valuable commodities that can be part of new products through its sustainable materials management efforts
- Bolstering the nation's recycling infrastructure and increasing the municipal solid waste recycling rate from less than 7 percent to almost 34.3 percent

The RCRA program has evolved in response to changes in waste generation and management aspects that could not have been foreseen when the program was first put in place. The RCRA program is needed to address continuing challenges, including the following:

- Highly toxic waste
- Wastes from increasingly efficient air and water pollution control devices
- Population growth that places larger demands on our natural resources
- Long-term stewardship of facilities that closed with waste in place

Video 13. RCRA
https://www.youtube.com/watch?v=E-OKq5ZBSI0

CERCLA

The following is taken from U.S, Environmental Protection Agency, *Summary of The Comprehensive Environmental Response, Compensation, and Liability Act.*

The Comprehensive Environmental Response, Compensation, and Liability Act—otherwise known as CERCLA or Superfund—provides a Federal Superfund to clean up uncontrolled or abandoned hazardous waste sites as well as accidents, spills, and other emergency releases of pollutants and contaminants into the environment. Through CERCLA, EPA was given power to seek out those parties responsible for any release and ensure their cooperation in the cleanup.

EPA cleans up orphan sites when potentially responsible parties cannot be identified or located, or when they fail to act. Through various enforcement tools, EPA obtains private party cleanup through orders, consent decrees, and other small party settlements. EPA also recovers costs from financially viable individuals and companies once a response action has been completed.

EPA is authorized to implement the Act in all 50 states and U.S. territories. Superfund site identification, monitoring, and response activities in states are coordinated through the state environmental protection or waste management agencies.

The Superfund Amendments and Reauthorization Act (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 the Emergency Planning and Community Right-to-Know Act (EPCRA).

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 Pollution Discharge Elimination System (NPDES)**
- **Clean Air Act (CAA)**
- **Emergency Planning and Community Right-To-Know Act (EPCRA)**
- **Federal Facilities Compliance Act (FFCA)**
- **Pollution Prevention Act of 1990 (PPA)**
- **Safe Drinking Water Act (SDWA)**
- **Superfund Amendment Reauthorization Act (SARA)**
- **Toxic Substance Control Act (TSCA)**
- **Solid Waste Disposal Act (SWDA)**

Clean Water Act (CWA), National Pollution Discharge Elimination System (NPDES)

The following is taken from U.S. Environmental Protection Agency, *Summary of the Clean Water Act.*

The CWA establishes the basic structure for regulating discharges of pollutants into the waters of the United States and regulating quality standards for surface waters. The basis of the CWA was enacted in 1948 and was called the Federal Water Pollution Control Act, but the Act was significantly reorganized and expanded in 1972. "Clean Water Act" became the Act's common name with amendments in 1972.

Under the CWA, EPA has implemented pollution control programs such as setting wastewater standards for industry. The Act also sets water quality standards for all contaminants in surface waters.

The CWA made it unlawful to discharge any pollutant from a point source into navigable waters, unless a permit was obtained. EPA's National Pollutant Discharge Elimination System (NPDES) permit program controls discharges. Point sources are discrete conveyances such as pipes or man-made ditches. Individual homes that are connected to a municipal system, use a septic system, or do not have a surface discharge do not need an NPDES permit; however, industrial, municipal, and other facilities must obtain permits if their discharges go directly to surface waters.

Video 14. The Clean Water Act
https://www.youtube.com/watch?v=Fbmc3L9j4Os

Clean Air Act (CAA)

The following is taken from U.S. Environmental Protection Agency, *Summary of the Clean Air Act.*

The CAA is the comprehensive Federal law that regulates air emissions from stationary and mobile sources. Among other things, this law authorizes EPA to establish National Ambient Air Quality Standards (NAAQS) to protect public health and public welfare and to regulate emissions of hazardous air pollutants.

One of the goals of the Act was to set and achieve NAAQS in every state by 1975 to address the public health and welfare risks posed by certain widespread air pollutants. The setting of these pollutant standards was coupled with directing the states to develop state implementation plans, applicable to appropriate industrial sources in the state, to achieve these standards. The Act was amended in 1977 and 1990 primarily to set new goals (dates) for achieving attainment of NAAQS since many areas of the country had failed to meet the deadlines.

Section 112 of the CAA addresses emissions of hazardous air pollutants. Prior to 1990, CAA established a risk-based program under which only a few standards were developed. The 1990 CAA Amendments revised Section 112 to first require issuance of technology-based standards for major sources and certain area sources. Major sources are defined as a stationary source or group of stationary sources that emit or have the potential to emit 10 tons per year or more of a hazardous air pollutant or 25 tons per year or more of a combination of hazardous air pollutants. An area source is any stationary source that is not a major source.

For major sources, Section 112 requires that EPA establish emission standards that require the maximum degree of reduction in emissions of hazardous air pollutants. These emission standards are commonly referred to as maximum achievable control technology or MACT standards. Eight years after the technology-based MACT standards are issued for a source category, EPA is required to review those standards to determine whether any residual risk exists for that source category and, if necessary, revise the standards to address such risk.

Video 15. The Clean Air Act
https://www.youtube.com/watch?v=Yl9X4UDN_Tg

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

The following is taken from U.S. Environmental Protection Agency, *Summary of the Emergency Planning and Community Right-To-Know Act.*

Authorized by Title III of the SARA, EPCRA was enacted by Congress as the national legislation on community safety. This law is designed to help local communities protect public health, safety, and the environment from chemical hazards.

To implement EPCRA, Congress requires each state to appoint a State Emergency Response Commission (SERC). The SERCs are required to divide their states into emergency planning districts and to name a local emergency planning committee for each district.

Broad representation by firefighters, health officials, government and media representatives, community groups, industrial facilities, and emergency managers ensures that all necessary elements of the planning process are represented.

Video 16. Emergency Planning and Community Right-To-Know Act
https://www.youtube.com/watch?v=z-hcXwlQ26M

Federal Facilities Compliance Act (FFCA)

The following is taken from DOE Office of Health, Safety, and Security (HSS), *Federal Facility Compliance Act.*

Congress enacted the FFCA, which effectively overturned the Supreme Court's ruling. In the legislation Congress specifically waived sovereign immunity with respect to RCRA for Federal facilities.

Under section 102, the FFCA amends 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." It should be noted that Federal agents, employees, and officers are not liable for civil penalties; however, they are subject to criminal sanctions. No departments, agencies, or instrumentalities are subject to criminal sanctions.

Section 104 (1) and (2) require EPA to conduct annual RCRA inspections of all Federal facilities. As part of the first inspection conducted under this authority, EPA is required to "conduct a comprehensive groundwater monitoring evaluation," unless such an evaluation was conducted in the preceding twelve months. Authorized states are also given authority to conduct inspection of Federal facilities for the purpose of enforcing compliance with the state hazardous waste program.

Under section 104(4), the Federal agency is required to reimburse EPA for reasonable service charges associated with conducting the inspections of its facilities. States are allowed to recover the costs of inspections under the authority granted in section 102(3). In the case of corrective action DOE can expect more frequent progress inspections by the regulator and that all eligible expenses incurred will have to be reimbursed. It should be noted that on an annual basis, EPA negotiates interagency agreements (IAGs) with other Federal agencies, including DOE, for reimbursement for these costs. Once the IAGs are executed and processed, only a few basic steps must be followed to use and track these funds appropriately.

Pollution Prevention Act of 1990 (PPA)

The following is taken from U.S. Environmental Protection Agency, *Summary of the Pollution Prevention Act.*

The PPA focused industry, government, and public attention on reducing the amount of pollution through cost-effective changes in production, operation, and raw materials use. Opportunities for source reduction are often not realized because of existing regulations, and the industrial resources required for compliance, focus on treatment and disposal.

Source reduction is fundamentally different and more desirable than waste management or pollution control. Source reduction refers to practices that reduce hazardous substances from being released into the environment prior to recycling, treatment or disposal. The term includes equipment or technology modifications, process or procedure modifications, reformulation or redesign of products, substitution of raw materials, and improvements in housekeeping, maintenance, training, or inventory control.

Pollution prevention includes practices that increase efficiency in the use of energy, water, or other natural resources, and protect the resource base through conservation.

Safe Drinking Water Act (SDWA)

The following is taken from U.S. Environmental Protection Agency, *Summary of the Safe Drinking Water Act.*

The SDWA was established to protect the quality of drinking water in the United States. This law focuses on all waters actually or potentially designed for drinking use, whether from above ground or underground sources.

The Act authorizes EPA to establish minimum standards to protect tap water and requires all owners or operators of public water systems to comply with these primary (health-related) standards. The 1996 amendments to SDWA require that EPA consider a detailed risk and cost assessment, and best available peer-reviewed science, when developing these standards. State governments, which can be approved to implement these rules for EPA, also encourage attainment of secondary standards (nuisance-related). Under the Act, EPA also establishes minimum standards for state programs to protect underground sources of drinking water from endangerment by underground injection of fluids.

Video 17. Safe Drinking Water Act
https://www.youtube.com/watch?v=GJ8uissUTA8

Superfund Amendment Reauthorization Act (SARA)

The following is taken from U.S. Environmental Protection Agency, *Superfund Amendment Reauthorization Act (SARA).*

The SARA amended the CERCLA on October 17, 1986. SARA reflected EPA's experience in administering the complex Superfund program during its first six years and made several important changes and additions to the program. SARA

- stressed the importance of permanent remedies and innovative treatment technologies in cleaning up hazardous waste sites
- required Superfund actions to consider the standards and requirements found in other state and Federal environmental laws and regulations
- provided new enforcement authorities and settlement tools
- increased state involvement in every phase of the Superfund program
- increased the focus on human health problems posed by hazardous waste sites
- encouraged greater citizen participation in making decisions on how sites should be cleaned up
- increased the size of the trust fund to $8.5 billion

SARA also required EPA to revise the hazard ranking system to ensure that it accurately assessed the relative degree of risk to human health and the environment posed by uncontrolled hazardous waste sites that may be placed on the national priorities list (NPL).

Toxic Substance Control Act (TSCA)

The following is taken from U.S. Environmental Protection Agency, *Summary of the Toxic Substance Control Act (TSCA).*

The TSCA provides EPA with authority to require reporting, recordkeeping and testing requirements, and restrictions relating to chemical substances and/or mixtures. Certain substances are generally excluded from TSCA, including, among others, food, drugs, cosmetics, and pesticides.

TSCA addresses the production, importation, use, and disposal of specific chemicals, including PCBs, asbestos, radon, and lead-based paint.

Various sections of TSCA provide authority to

- require, under Section 5, pre-manufacture notification for new chemical substances before manufacture;
- require, under Section 4, testing of chemicals by manufacturers, importers, and processors where risks or exposures of concern are found;
- issue significant new use rules, under Section 5, when it identifies a significant new use that could result in exposures to, or releases of, a substance of concern;
- maintain the TSCA inventory, under Section 8, which contains more than 83,000 chemicals. As new chemicals are commercially manufactured or imported, they are placed on the list.
- require those importing or exporting chemicals, under Sections 12(b) and 13, to comply with certification reporting and/or other requirements;
- require, under Section 8, reporting and recordkeeping by persons who manufacture, import, process, and/or distribute chemical substances in commerce; and
- require, under Section 8(e), that any person who manufactures, processes, or distributes in commerce a chemical substance or mixture and who obtains information that reasonably supports the conclusion that such substance or mixture presents a substantial risk of injury to health or the environment to immediately inform EPA, except where EPA has been adequately informed of such information. EPA screens all TSCA submissions as well as voluntary "for your information" submissions. The latter are not required by law, but are submitted by industry and public interest groups for a variety of reasons.

Solid Waste Disposal Act (SWDA)

The following is taken from the U.S. Environmental Protection Agency, *RCRA Orientation Manual 2014*, Chapter II, "Managing Nonhazardous Solid Waste."

Congress enacted the SWDA of 1965 to address the growing quantity of solid waste generated in the United States and to ensure its proper management. Subsequent amendments to the SWDA, such as RCRA, have substantially increased the Federal government's involvement in solid waste management.

During the 1980s, solid waste management issues rose to new heights of public concern in many areas of the United States because of increasing solid waste generation, shrinking disposal capacity, rising disposal costs, and public opposition to the siting of new disposal facilities. These solid waste management challenges continue today, as many communities are struggling to develop cost-effective, environmentally protective solutions. The growing amount of waste generated has made it increasingly important for solid waste management officials to develop strategies to manage wastes safely and cost-effectively.

RCRA encourages environmentally sound solid waste management practices that maximize reuse.

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

- **DOE O 436.1, *Departmental Sustainability***
- **DOE O 451.1 B, Chg 3, *National Environmental Policy Act Compliance Program***
- **DOE O 435.1, Chg 1, *Radioactive Waste Management***
- **DOE O 458.1, Chg 3, *Radiation Protection of the Public and the Environment***

DOE O 436.1, Departmental Sustainability

PURPOSE

DOE O 436.1 provides requirements and responsibilities for managing sustainability within DOE to 1) 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; 2) institute wholesale cultural change to factor sustainability and greenhouse gas reductions into all DOE corporate management decisions; and 3) ensure DOE achieves the sustainability goals established in its strategic sustainability performance plan (SSPP) pursuant to applicable laws, regulations and Executive Orders (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 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 EPCRA, the PPA at DOE facilities, related statutory and administrative requirements.

- Prepare and submit an annual SSPP to the Office of Management and Budget and the Council on Environmental Quality. The SSPP will describe the actions that the Department will take to achieve its sustainability goals.
  - Define specific goals and milestones in each annual DOE SSPP, including updates of other related initiatives. The goals and milestones will remain in effect unless a subsequent SSPP voids a goal or milestone included in a previous annual submission.

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. SSPs must

- be completed and submitted to the Sustainability Performance Office through the appropriate line management per annual guidance;
- 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; and
- ensure that DOE sites use an environmental management system (EMS) 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 EMS as being certified to or conforming to the International Organization for Standardization's (ISO) 14001:2015, *Environmental Management Systems—Requirements with Guidance for Use*, in accordance with the accredited registrar provisions of the international standard or the self-declaration instructions.

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.

- Sites must maintain an assessment of applicable alternative financing mechanisms to be reviewed annually, and updated as appropriate.
- Verified savings from all sustainability projects must be reinvested, consistent with Federal regulations and DOE guidance, to further additional sustainability projects at that site.

DOE O 451.1 B, Chg 3, National Environmental Policy Act Compliance Program

PURPOSE

The purpose of DOE O 451.1B, Chg 3, is to establish DOE internal requirements and responsibilities for implementing NEPA, the Council on Environmental Quality Regulations Implementing the Procedural Provisions of NEPA (40 CFR 1500-1508), and the DOE NEPA implementing procedures. The goal of establishing the requirements and responsibilities presented 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 environmental assessment (EA) and environmental impact statements (EISs) that include development of a schedule. For an EIS, the schedule, absent extraordinary circumstances, will provide for completion of a final EIS within fifteen months of the issuance of the notice of intent.
- NEPA quality assurance (QA) plans and public participation plans.
- Annual NEPA planning summaries. An annual NEPA planning summary will describe briefly 1) the status of ongoing NEPA compliance activities; 2) any EAs

expected to be prepared in the next twelve months; 3) any EISs expected to be prepared in the next twenty-four months; and 4) the planned cost and schedule for completion of each NEPA review identified. Every three years starting with 1995, the annual NEPA planning summary for each field organization will include an evaluation of whether a site-wide EIS would facilitate future NEPA compliance efforts.

- 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.
- Opportunity, whenever possible, for interested parties to review an EA prior to DOE approval.

DOE O 435.1, Chg 1, Radioactive Waste Management

PURPOSE

The objective of DOE O 435.1, Chg 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 ensure the following:

- Protect the public from exposure to radiation from radioactive materials. Requirements for public radiation protection are in DOE 458.1, Chg 3.
- Protect the environment—Requirements for environmental protection are in DOE O 231.1B, Admin Chg 1, *Environment, Safety, and Health Reporting*, and DOE O 458.1, Chg 3.
- Protect workers—Requirements for radiation protection of workers are in 10 CFR 835. Requirements for industrial safety are in DOE O 440.1B, Chg 2, *Worker Protection Management for DOE Federal and Contractor Employees.*
- 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, *Radioactive Waste Management Manual*.

DOE, within its authority, may impose such requirements, in addition to those established in DOE O 435.1, Chg 1, as it deems appropriate and necessary to protect the public, workers, and the environment, or to minimize threats to property.

DOE O 458.1, Chg 3, Radiation Protection of the Public and the Environment

PURPOSE

The purpose of DOE O 458.1, Chg 3, 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.

The objectives of DOE O 458.1, Chg 3 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, Chg 3;
- to control the radiological clearance of DOE real and personal property;
- to ensure that potential radiation exposures to members of the public are ALARA;
- to 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
- to provide protection of the environment from the effects of radiation and radioactive material.

REQUIREMENTS

The requirements in DOE O 458.1, Chg 3, include the following topics, which are too comprehensive to include here. Please refer to the Order for a complete description of the requirements.

- Environmental radiological protection program
- Public dose limit
- Temporary dose limits
- ALARA
- Demonstrating compliance with the public dose limit
- Airborne radioactive 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 436.1 as a reference, discuss the concept of an environmental management system.

An EMS is a management tool enabling an organization of any size or type to

- identify and control the environmental impact of its activities, products or services;
- improve its environmental performance continually; and
- implement a systematic approach to setting environmental objectives and targets, to achieving these, and to demonstrating that they have been achieved.

e. Using DOE O 458.1, Chg 3 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).

A documented ALARA process must be implemented to optimize control and management of radiological activities so that doses to members of the public (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.

9. Personnel shall 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:

- **Clean-up operations**
- **Corrective actions**
- **Voluntary cleanup operations**
- **Operations involving hazardous wastes**
- **Emergency response operations**

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 (including, but not limited to, the EPA NPL, state priority site lists, sites recommended for the EPA NPL, and initial investigations of government-identified sites which are conducted before the presence or absence of hazardous substances has been ascertained).

Corrective actions involving clean-up operations at sites covered by RCRA.

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 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.

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.

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. In situations covered by the hazard communication standard, 29 CFR 1910.1200, “Hazard Communication,” training required by that standard need not be duplicated.

Risks to consider include, but are not limited to

- exposures exceeding the permissible exposure limits (PELs) and published exposure levels
- immediately dangerous to life or health concentrations
- potential skin absorption and irritation sources
- potential eye irritation sources
- explosion sensitivity and flammability ranges
- oxygen deficiency

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, “Occupational Safety and Health Standards.”

10. Personnel shall 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.

The following is taken from U.S. Environmental Protection Agency, *National Environmental Policy Act.*

NEPA requires Federal agencies to take into account the environmental impacts of Federal decisions that could significantly affect the environment. In implementing NEPA, Federal agencies have to assess the environmental impacts of decisions and inform the public of any impacts. The public has the right to comment on any proposed EIS before action is taken.

The following is taken from U.S. Environmental Protection Agency, *Overview of the Enforcement Process for Federal Facilities.*

Generally, RCRA, SDWA, and CAA confer penalty or order authority upon EPA against Federal facilities. Thus, these statutes authorize EPA to assess penalties or issue orders. To address noncompliance at Federal facilities in these instances, and once a decision is made that the violations merit a formal EPA enforcement response, an enforcement action commonly proceeds in one of four ways:

1. Issuance of a field citation or expedited settlement offer with a pre-determined penalty
2. Pre-complaint negotiated settlement

3. Issuance of an administrative compliance order (unilateral or consensual)
4. Issuance of an administrative complaint

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

The following is taken from DOE Office oh Health, Safety, and Security, *Resource Conservation and Recovery Act.*

Hazardous wastes, mixed wastes, and nonhazardous solid wastes are generated, handled, and managed at facilities throughout the DOE complex. DOE headquarters (HQ) provides technical assistance and support to departmental programs and sites on issues related to implementation and compliance with the RCRA hazardous and solid waste management regulations. HQ also provides technical assistance and guidance on newly promulgated regulations, and coordinates the review and advocates departmental interests regarding proposed RCRA regulatory initiatives applicable to DOE operations. HQ serves as the corporate resource and conducts the following activities in support of DOE program and field offices:

- Provide technical support and compliance assistance
- Research and evaluate regulatory compliance issues
- Develop guidance on compliance topics and new requirements
- Track emerging regulatory initiatives
- Coordinate DOE response to emerging policies and rulemakings
- Conduct document reviews
- Participate in independent assessments and conduct onsite assistance visits
- Interface with EPA on regulatory compliance issues
- Coordinate DOE input on certain RCRA reporting requirements.

In addition, HQ provides technical assistance and guidance to departmental elements in regard to compliance with the RCRA underground storage tank requirements.

The following is taken from U.S. Environmental Protection Agency, *Resource Conservation and Recovery Act (RCRA) Training Module about Enforcement and Compliance.*

When EPA determines that a facility is in noncompliance with the hazardous waste regulations, an enforcement action may be taken. Under RCRA, EPA uses three types of enforcement mechanisms: administrative, civil, and criminal actions. EPA has substantial latitude in deciding which action or combination of actions to pursue, depending on the nature and severity of the problem.

Administrative Actions

An administrative action is a nonjudicial enforcement action taken by EPA or a state under its own authority. These actions can be broken down into two general categories: informal and formal. Both of these actions provide for enforcement response outside the court system. This means EPA takes direct enforcement action against the violator based on its authority granted by the statute, and does not rely on a court of law for enforcement authority.

Informal Actions

Once a decision is made to utilize an informal enforcement mechanism, the facility owner and operator should be given notice of its noncompliance and the steps to take to correct the violations. Examples of informal actions are letters or phone calls to the facility. For informal actions, EPA or the state notifies the facility owner and operator that the facility is out of compliance with hazardous waste regulations. Informal actions are most appropriate where the violation is a minor threat to human health and the environment. A warning letter, sometimes referred to as a notice of violation, may be sent, which lays out the specific actions that need to be taken by the facility owner and operator to correct the violation(s). The letter should require demonstration of a facility's return to compliance within an appropriate time frame, not to exceed 90 days, to ensure that enforcement is escalated appropriately should the facility fail to return to full physical compliance by the established date.

Formal Actions (Administrative Orders)

In cases where a facility has been classified as a significant non-complier or the facility owner and operator have failed to respond to an informal action, EPA can issue an administrative order. Administrative orders impose enforceable legal duties. For example, orders can be used to compel the facility owner and operator to comply with specific regulations, to take corrective action, to perform testing, monitoring, or analysis, or to pay fines.

11. Personnel shall 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. To achieve this objective, DOE has established guiding principles and core safety management functions. An effective ISM system addresses these DOE-wide principles and core functions while also considering site-specific factors, conditions, analyses, and processes, including the following:

- The types of potentially hazardous work at the site, including but not limited to operations, maintenance, construction, decontamination and decommissioning, laboratory activities, and research and development
- Results of design and conceptual studies, environmental analyses, safety analyses, hazard reduction analyses, pollution prevention/waste minimization, and risk analyses
- All types of hazards at the site, including chemical, physical, biological, ergonomic, environmental, nuclear, and transportation

Management and workers should understand that safety is an integral part of each work activity. Accordingly, safety should be a prime consideration in the work practices of all personnel from the secretary and contractor senior official, through all management levels, to the worker performing the activity.

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 G 450.4-1C.

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

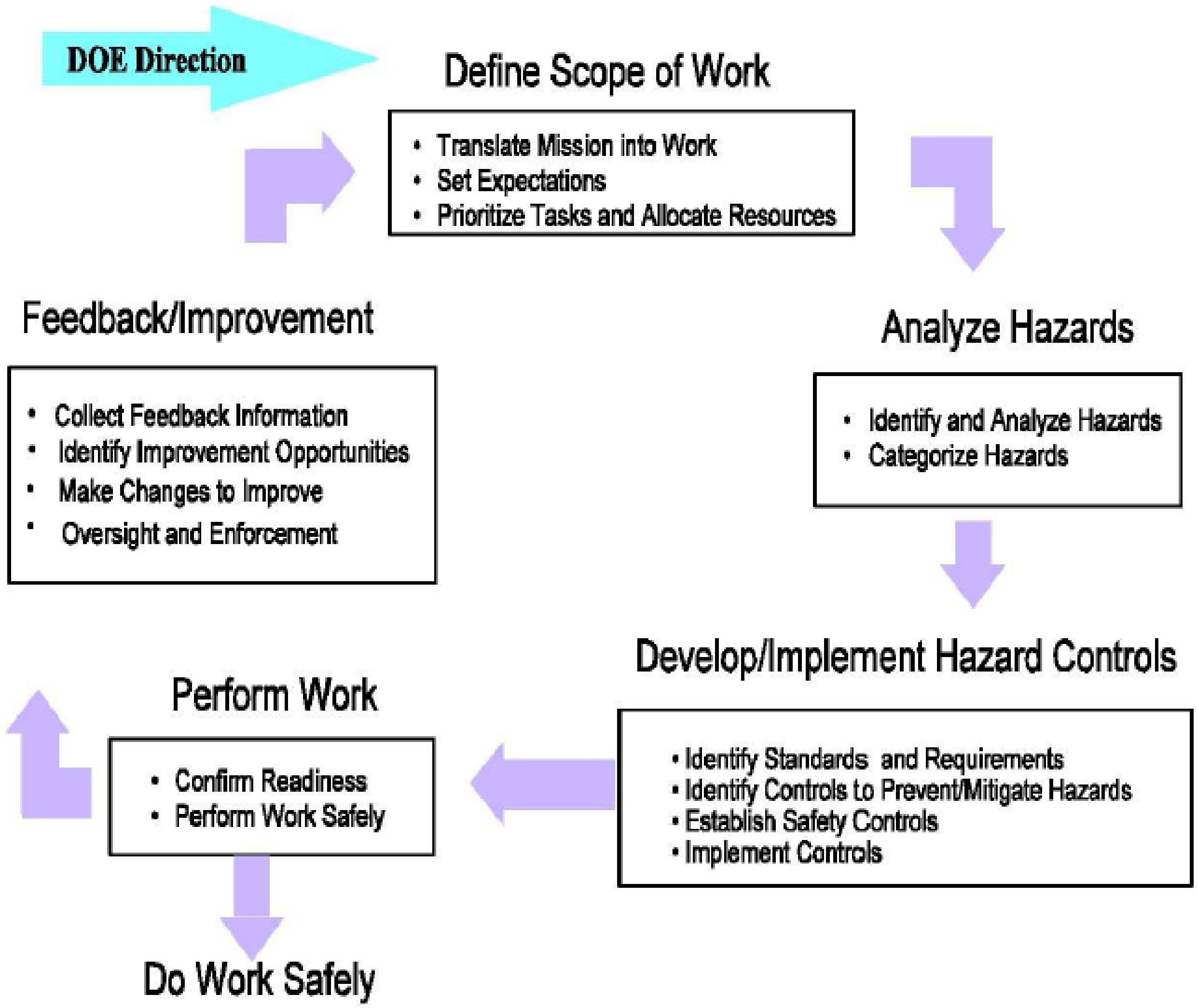
1. Line management responsibility for safety—Line management is directly responsible for the protection of the workers, the public, and the environment.
2. Clear roles and responsibilities—Clear and unambiguous lines of authority and responsibility for ensuring safety are established and maintained at 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 7 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 7. 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 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 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 that support implementation of ISM, including the following:
- **DOE O 450.2, *Integrated Safety Management***
- **DOE G 450.4-1C, I*ntegrated Safety Management System Guide***
- **Standards/Requirements identification documents (S/RIDs) and work smart standards (WSS)**
- **Contract reform and performance-based contracting**

DOE O 450.2, Integrated Safety Management

PURPOSE
The purpose of DOE O 450.2 is to ensure that DOE/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.

REQUIREMENTS
DOE line management organizations must document their approach for ensuring that both their DOE offices and their contractors establish ISM systems, including the implementing mechanisms, processes, and methods to be used in an ISM.

System description document—The ISM system 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 line managers must determine the adequacy for approval and frequency of updates of their DOE offices' and their contractors' ISM system description documents.

DOE line managers must determine the need for, and frequency of, DOE ISM declarations for facilities and activities based on hazards, risks, and contractor performance history and document their decisions concerning high consequence activities, such as high-hazard nuclear operations.

DOE line managers responsible for program and site offices' overall ISM system implementation must designate a representative to serve on the ISM Champions Council.

ISM Champions Council, functioning in accordance with its charter, must support line management in developing and sustaining vital, mature ISM systems throughout the Department so that work is reliably accomplished in a safe manner.

To ensure adequate safety in contractor management of DOE facilities while meeting mission goals, DOE line management must ensure that appropriate requirements are incorporated into contracts, oversee compliance, assess contractor performance against established performance measures, analyze relevant trends, and obtain relevant operational information for use as feedback to improve safety.

Line management and support organizations, with safety management responsibility, must develop, issue, and maintain, separately or as part of the ISM system description document, an organizational functions, responsibilities, and authorities document consistent with the hazards and complexity of the work. DOE's safety management responsibilities for ensuring adequate protection and safe operations must be met by DOE line management and cannot be delegated to contractors.

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

PURPOSE

The purpose of DOE G 450.4-1C is 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; and
- 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."

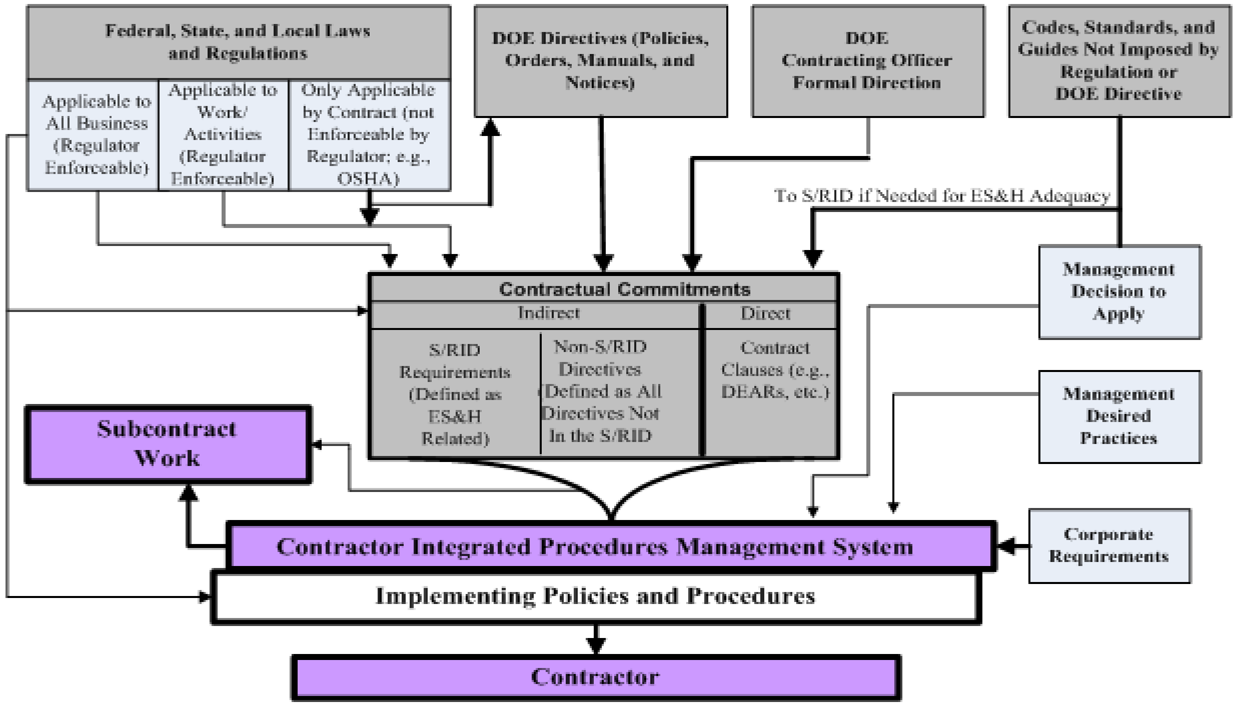
BACKGROUND

DOE G 450.4-1C was developed as part of DOE's ongoing efforts to continuously improve DOE safety management programs and directives. As one part of the continuous improvement effort, in calendar year 2009, DOE made a decision to phase out manuals as part of the revised directives system. Beginning in CY 2010, DOE undertook an effort to reform various DOE directives. As one part of this effort, DOE cancelled DOE M 450.4-1, *Integrated Safety Management System Manual*, and DOE M 411.1-1C, *Safety Management Functions, Responsibilities, and Authorities Manual*. In accordance with the revised DOE approach to Orders, the new ISM Order contains only the essential safety requirements and thus includes fewer details on approaches for implementing the essential requirements. Therefore, many of the implementing details and lessons learned from the previous manuals are captured in DOE G 450.4-1C for consideration by DOE line management as they implement the requirements of the new ISM Order and by contractors as they continue to implement the DEAR ISM clause.

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

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

ES&H 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 flowdown process is shown in figure 8.



Source: DOE G 440.1-8

Figure 8. Site system for flowing down ES&H and other requirements to the work

Work Smart Standards

The following is taken from DOE-HDBK-1148-2002.

For many routine activities, experience has been codified in formally promulgated standards and procedures. For other non-routine activities, guidance documents identify best practices that, while not prescriptive requirements, communicate what is known at the edge of formalized consensus standards. The result of the necessary and sufficient (N&S) process is a set of tailored ES&H standards. This set is termed the "work smart standards" set to emphasize the importance that the actual work definition plays in resolving safety uncertainty.

A WSS set is the principal product of a successful N&S process application. A WSS set includes all applicable Federal, state, and local laws and regulations as well as other standards that are necessary and sufficient to provide adequate protection for workers, the public, and the environment. The set must also be feasible for implementation, meaning that it can be implemented within expected resource and time constraints. The work of identifying standards is carried out by the identification team, operating within the protocols and documentation requirements previously established.

Experience has shown that properly performing the identification process will often require more time than initially expected. Identification team discovery time can be reduced if participants are provided adequate training, a well-thought-out charter or statement of work from the convened group, and strong liaison between the team and the convened group.

Contract Reform and Performance-Based Contracting

CONTRACT REFORM

The following is taken from EO 12931.

To make procurement more effective in support of mission accomplishment and consistent with recommendations of the National Performance Review, heads of executive agencies engaged in the procurement of supplies and services shall

- review agency procurement rules, reporting requirements, contractual requirements, certification procedures, and other administrative procedures over and above those required by statute, and, where practicable, replace them with guiding principles that encourage and reward innovation;
- review existing and planned agency programs to assure that such programs meet agency mission needs;
- ensure that procurement organizations focus on measurable results and on increased attention to understanding and meeting customer needs;
- increase the use of commercially available items where practicable, place more emphasis on past contractor performance, and promote best value rather than simply low cost in selecting sources for supplies and services;
- ensure that simplified acquisition procedures are used, to the maximum extent practicable, for procurements under the simplified acquisition threshold in order to reduce administrative burdens and more effectively support the accomplishment of agency missions;
- expand the use of the government purchase card by the agency and take maximum advantage of the micro-purchase authority provided in the Federal Acquisition Streamlining Act of 1994 by delegating the authority, to the maximum extent practicable, to the offices that will be using the supplies or services to be purchased;
- establish clear lines of contracting authority and accountability;
- establish career education programs for procurement professionals, including requirements for successful completion of educational requirements or mandatory training for entry level positions and for promotion to higher level positions, to ensure a highly qualified procurement work force;
- designate a procurement executive with agency-wide responsibility to oversee development of procurement goals, guidelines, and innovation, measure and evaluate procurement office performance against stated goals, enhance career development of the procurement work force, and advise the agency heads whether goals are being achieved; and
- review existing and planned information technology acquisitions and contracts to ensure that the agency receives the best value with regard to price and technology, and consider alternatives in cases where best value is not being obtained.

PERFORMANCE-BASED CONTRACTING

The following is taken from 48 CFR 37.601.

Performance-based contracts for services shall include

- a performance work statement (PWS);
- measurable performance standards (i.e., in terms of quality, timeliness, quantity, etc.) and the method of assessing contractor performance against performance standards; and
- performance incentives where appropriate. When used, the performance incentives shall correspond to the performance standards set forth in the contract.

The following is taken from 48 CFR 37.602.

A PWS may be prepared by the government or result from a statement of objectives (SOO) prepared by the government where the offeror proposes the PWS.

Agencies shall, to the maximum extent practicable

- describe the work in terms of the required results rather than either "how" the work is to be accomplished or the number of hours to be provided;
- enable assessment of work performance against measurable performance standards; and
- rely on the use of measurable performance standards and financial incentives in a competitive environment to encourage competitors to develop and institute innovative and cost-effective methods of performing the work.

Offerors use the SOO to develop the PWS; however, the SOO does not become part of the contract. The SOO shall, at a minimum, include

- purpose;
- scope or mission;
- period and place of performance;
- background;
- performance objectives (i.e., required results); and
- any operating constraints.

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

Purpose

The purpose of DOE P 450.4A is to establish 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.

Policy

It is the Department's policy that work be conducted safely and efficiently and in a manner that ensures protection of workers, the public, and the environment. To achieve this policy, effective safety requirements and goals are established; applicable national and international consensus standards are adopted; and where necessary to address unique conditions, additional standards are developed and effectively implemented. Implementing ISM requirements for Federal organizations are established through directives, and for contractor organizations through contract clauses.

The Department's ultimate safety goal is zero accidents, work-related injuries and illnesses, regulatory violations, and reportable environmental releases. The Department expects that for all activities and phases in the life cycle of missions (design, construction, research and development, operations, and decommissioning and decontamination), appropriate mechanisms are in place to ensure that exposures to workers, the public, and the environment to radiological and nonradiological hazards are maintained below regulatory limits. Furthermore, DOE expects that deliberate efforts are taken to keep exposures to radiation ALARA.

The Department will implement ISM systems 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 ISM systems for their operations and work practices, based upon the ISM guiding principles and core functions. 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 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 the 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 414.1D, Chg 1, to integrate the ISM system description with the quality assurance program.

The following is taken from 10 CFR 830.121.

The QA program must integrate the QA criteria with the SMS, or describe how the QA criteria apply to the SMS.

The following is taken from DOE O 414.1D, Chg 1.

Hazard controls are measures to eliminate, limit, or mitigate hazards to workers, the public, or the environment, including

- physical, design, structural, and engineering features;
- safety structures, systems, and components (SSCs);
- safety management programs;
- technical safety requirements (TSRs); and
- other controls necessary to provide adequate protection from hazards.

Safety management and AC software is software that performs a hazard control function in support of nuclear facility or radiological safety management programs or TSRs or other software that performs a control function necessary to provide adequate protection from nuclear facility or radiological hazards. This software supports eliminating, limiting, or mitigating nuclear hazards to workers, the public, or the environment as addressed in 10 CFR 830, "Nuclear Safety Management," and 835, the DEAR ISM system clause, and 48 CFR 970-5223.

When the contractor conducts activities or provides items or services that affect or may affect the safety of DOE nuclear facilities, it must conduct work in accordance with the QA requirements of 10 CFR 830, Subpart A, "Quality Assurance," and the additional requirements of the contractor requirements document (CRD) in DOE O 414.1D, Chg 1.

12. Personnel shall demonstrate a familiarity level knowledge of 10 CFR 851, "Worker Safety and Health Program," and DOE O 440.1B, Chg 2, *Worker Protection Program for DOE (including the National Nuclear Security Administration) Federal Employees*.

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

The following is taken from 10 CFR 851.11.

Contractors must submit to the appropriate head of DOE field element for approval a written worker safety and health program that provides the methods for implementing the requirements of Subpart C of 10 CFR 851.

If a contractor is responsible for more than one covered workplace at a DOE site, the contractor must establish and maintain a single worker safety and health program for the covered workplaces for which the contractor is responsible.

If more than one contractor is responsible for covered workplaces, each contractor must

- establish and maintain a worker safety and health program for the workplaces for which the contractor is responsible; and
- coordinate with the other contractors responsible for work at the covered workplaces to ensure that there are clear roles, responsibilities, and procedures to ensure the safety and health of workers at multi-contractor workplaces.

The worker safety and health program must describe how the contractor will

- comply with the requirements set forth in Subpart C of 10 CFR 851 that are applicable to the covered workplace, including the methods for implementing those requirements; and
- integrate the requirements set forth in Subpart C of 10 CFR 851 that are applicable to a covered workplace with other related site-specific worker protection activities and with the ISM system.

The head of DOE field element must complete a review and provide written approval of the contractor's worker safety and health program, within 90 days of receiving the document. The worker safety and health program and any updates are deemed approved 90 days after submission if they are not specifically approved or rejected by DOE earlier.

No work may be performed at a covered workplace unless an approved worker safety and health program is in place for the workplace.

Contractors must send a copy of the approved program to the associate undersecretary for Environment, Health, Safety and Security.

Contractors must furnish a copy of the approved worker safety and health program, upon written request, to the affected workers or their designated representatives.

Contractors must submit an update of the worker safety and health program to the appropriate head of DOE field element, for review and approval whenever a significant change or addition to the program is made, or a change in contractors occurs.

Contractors must submit annually to DOE either an updated worker safety and health program for approval or a letter stating that no changes are necessary in the currently approved worker safety and health program.

Contactors must incorporate in the worker safety and health program any changes, conditions, or workplace safety and health standards directed by DOE consistent with the requirements of 10 CFR 851 and DEAR 970.5204-2, “Laws, Regulations and DOE Directives,” and associated contract clauses.

If a contractor employs or supervises workers who are represented for collective bargaining by a labor organization, the contractor must

- give the labor organization timely notice of the development and implementation of the worker safety and health program and any updates thereto; and
- upon timely request, bargain concerning implementation of 10 CFR 851, consistent with the Federal labor laws.

b. Describe management responsibilities and worker rights and responsibilities.

The following is taken from 10 CFR 851.20.

Management Responsibilities

Contractors are responsible for the safety and health of their workforce and must ensure that contractor management at a covered workplace

- establish written policy, goals, and objectives for the worker safety and health program;
- use qualified worker safety and health staff to direct and manage the program;
- assign worker safety and health program responsibilities, evaluate personnel performance, and hold personnel accountable for worker safety and health performance;
- provide mechanisms to involve workers and their elected representatives in the development of the worker safety and health program goals, objectives, and performance measures and in the identification and control of hazards in the workplace;
- provide workers with access to information relevant to the worker safety and health program;
- establish procedures for workers to report without reprisal job-related fatalities, injuries, illnesses, incidents, and hazards and make recommendations about appropriate ways to control those hazards;
- provide for prompt response to such reports and recommendations;
- provide for regular communication with workers about workplace safety and health matters;
- establish procedures to permit workers to stop work or decline to perform an assigned task because of a reasonable belief that the task poses an imminent risk of death, serious physical harm, or other serious hazard to workers, in circumstances where the workers believe there is insufficient time to utilize normal hazard reporting and abatement procedures; and
- inform workers of their rights and responsibility by appropriate means, including posting the DOE-designated worker protection poster in the workplace where it is accessible to all workers.

Worker Rights and Responsibilities

Workers must comply with the requirements of 10 CFR 851, including the worker safety and health program, which are applicable to their own actions and conduct. Workers at a covered workplace have the right, without reprisal, to

- participate in activities described in this section on official time;
- have access to
  - DOE safety and health publications;
  - the worker safety and health program for the covered workplace;

- the standards, controls, and procedures applicable to the covered workplace;
- the safety and health poster that informs the worker of relevant rights and responsibilities;
- limited information on any recordkeeping log. Access is subject to Freedom of Information Act requirements and restrictions; and
- the DOE Form 5484.3 that contains the employee's name as the injured or ill worker.

- be notified when monitoring results indicate the worker was overexposed to hazardous materials;
- observe monitoring or measuring of hazardous agents and have the results of their own exposure monitoring;
- have a representative authorized by employees accompany the director or his authorized personnel during the physical inspection of the workplace for the purpose of aiding the inspection. When no authorized employee representative is available, the director or his authorized representative must consult, as appropriate, with employees on matters of worker safety and health;
- request and receive results of inspections and accident investigations;
- express concerns related to worker safety and health;
- decline to perform an assigned task because of a reasonable belief that, under the circumstances, the task poses an imminent risk of death or serious physical harm to the worker coupled with a reasonable belief that there is insufficient time to seek effective redress through normal hazard reporting and abatement procedures; and
- stop work when the worker discovers employee exposures to imminently dangerous conditions or other serious hazards; provided that any stop work authority must be exercised in a justifiable and responsible manner in accordance with procedures established in the approved worker safety and health program.

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

The following is taken from 10 CFR 851.21.

Contractors must establish procedures to identify existing and potential workplace hazards and assess the risk of associated workers injury and illness. Procedures must include methods to

- assess worker exposure to chemical, physical, biological, or safety workplace hazards through appropriate workplace monitoring;
- document assessment for chemical, physical, biological, and safety workplace hazards using recognized exposure assessment and testing methodologies and using accredited and certified laboratories;
- record observations, testing, and monitoring results;
- analyze designs of new facilities and modifications to existing facilities and equipment for potential workplace hazards;
- evaluate operations, procedures, and facilities to identify workplace hazards;
- perform routine job activity-level hazard analyses;
- review site safety and health experience information; and
- consider interaction between workplace hazards and other hazards such as radiological hazards.

Contractors must submit to the head of DOE field element a list of closure facility hazards and the established controls within 90 days after identifying such hazards. The head of DOE field element, with concurrence by the cognizant secretarial officer (CSO), has 90 days to accept the closure facility hazard controls or direct additional actions to either achieve technical compliance, or provide additional controls to protect the workers.

Contractors must perform the activities identified in 10 CFR 851.21, “Hazard Identification and Assessment,” initially to obtain baseline information and as often thereafter as necessary to ensure compliance with the requirements in 10 CFR 851.21.

The following is taken from 10 CFR 851.22.

Contractors must establish and implement a hazard prevention and abatement process to ensure that all identified and potential hazards are prevented or abated in a timely manner.

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.

For existing hazards identified in the workplace, contractors must

- prioritize and implement abatement actions according to the risk to workers
- implement interim protective measures pending final abatement
- protect workers from dangerous safety and health conditions

Contractors must select hazard controls based on the following hierarchy:

1. Elimination or substitution of the hazards where feasible and appropriate
2. Engineering controls where feasible and appropriate
3. Work practices and ACs that limit worker exposures
4. PPE

Contractors must address hazards when selecting or purchasing equipment, products, and services.

d. Discuss applicable safety and health standards.

The following is taken from 10 CFR 851.23.

Contractors must comply with the safety and health standards that are applicable to the hazards at their covered workplace that are listed in 10 CFR 851.23 and in DOE O 440.1B, Chg 2.

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

The following is taken from 10 CFR 851.31.

The CSO may forward the application to the associate undersecretary for Environment, Health, Safety and Security.

If the CSO does not forward the application to the associate undersecretary for Environment, Health, Safety and Security, the CSO must return the application to the contractor with a written statement explaining why the application was not forwarded.

Upon receipt of an application from a CSO, the associate undersecretary for Environment, Health, Safety and Security must review the application for a variance and make a written recommendation to

- approve the application
- approve the application with conditions
- deny the application

If an application submitted pursuant to 10 CFR 851.31(a) is determined by the associate undersecretary for Environment, Health, Safety and Security to be incomplete, the associate undersecretary may

- return the application to the contractor with a written explanation of what information is needed to permit consideration of the application
- request the contractor to provide necessary information

All variance applications submitted must include

- the name and address of the contractor;
- the address of the DOE site or sites involved;
- a specification of the standard, or portion thereof, from which the contractor seeks a variance;
- a description of the steps that the contractor has taken to inform the affected workers of the application, which must include giving a copy thereof to their authorized representative, posting a statement, giving a summary of the application and specifying where a copy may be examined at the place or places where notices to workers are normally posted; and
- a description of how affected workers have been informed of their right to petition the associate undersecretary for Environment, Health, Safety and Security or designee for a conference; and
- any requests for a conference, as provided in 10 CFR 851.34, "Requests for Conferences."

Contractors may apply for the following types of variances:

- Temporary variance—Applications for a temporary variance pursuant to paragraph (a) of this section must be submitted at least 30 days before the effective date of a new safety and health standard and, in addition to the content required by 10 CFR 851.31, must include
  - a statement by the contractor explaining the contractor is unable to comply with the standard or portion thereof by its effective date and a detailed statement of the factual basis and representations of qualified persons that support the contractor's statement;
  - a statement of the steps the contractor has taken and plans to take, with specific dates if appropriate, to protect workers against the hazard covered by the standard;

- a statement of when the contractor expects to be able to comply with the standard and of what steps the contractor has taken and plans to take, with specific dates if appropriate, to come into compliance with the standard;
- a statement of the facts the contractor would show to establish that
  - the contractor is unable to comply with the standard by its effective date because of unavailability of professional or technical personnel or materials and equipment needed to come into compliance with the standard or because necessary construction or alteration of facilities cannot be completed by the effective date;
  - the contractor is taking all available steps to safeguard the workers against the hazards covered by the standard; and
  - the contractor has an effective program for coming into compliance with the standard as quickly as practicable.

- Permanent variance—An application submitted for a permanent variance must, in addition to the content required in 10 CFR 851.31, include
  - a description of the conditions, practices, means, methods, operations, or processes used or proposed to be used by the contractor; and
  - a statement showing how the conditions, practices, means, methods, operations, or processes used or proposed to be used would provide workers a place of employment which is as safe and healthful as would result from compliance with the standard from which a variance is sought.

- National defense variance—An application submitted for a national defense variance must, in addition to the content required in10 CFR 851.31, include
  - a statement by the contractor showing that the variance sought is necessary to avoid serious impairment of national defense; and
  - a statement showing how the conditions, practices, means, methods, operations, or processes used or proposed to be used would provide workers a safe and healthful place of employment in a manner that, to the extent practical taking into account the national defense mission, is consistent with the standard from which a variance is sought.

  A national defense variance may be granted for a maximum of six months, unless there is a showing that a longer period is essential to carrying out a national defense mission.

The following is taken from 10 CFR 851.32.

Procedures for an Approval Recommendation

If the associate undersecretary for Environment, Health, Safety and Security recommends approval of a variance application, the associate undersecretary must forward to the undersecretary the variance application and the approval recommendation including a discussion of the basis for the recommendation and any terms and conditions proposed for inclusion as part of the approval.

If the undersecretary approves a variance, the undersecretary must notify the associate undersecretary for Environment, Health, Safety and Security who must notify the Office of Enforcement and the CSO who must promptly notify the contractor.

The notification must include a reference to the safety and health standard or portion thereof that is the subject of the application, a detailed description of the variance, the basis for the approval, and any terms and conditions of the approval.

If the undersecretary denies a variance, the undersecretary must notify the associate undersecretary for Environment, Health, Safety and Security who must notify the appropriate CSO who must notify the contractor.

The notification must include the grounds for denial.

APPROVAL CRITERIA
A variance may be granted if the variance

- is consistent with section 3173 of the National Defense Authorization Act;
- does not present an undue risk to worker safety and health;
- is warranted under the circumstances; and
- satisfies the requirements of 10 CFR 851.31, "Variance Process," for the type of variance requested.

Procedures for a Denial Recommendation

If the associate undersecretary for Environment, Health, Safety and Security recommends denial of a variance application, the associate undersecretary must notify the CSO of the denial recommendation and the grounds for the denial recommendation.

Upon receipt of a denial recommendation, the CSO may

- notify the contractor that the variance application is denied on the grounds cited by the associate undersecretary for Environment, Health, Safety and Security; or
- forward to the undersecretary the variance application, the denial recommendation, the grounds for the denial recommendation, and any information that supports an action different than that recommended by the associate undersecretary for Environment, Health, Safety and Security.

A denial of an application shall be without prejudice to submitting of another application;

A variance may be denied if

- enforcement of the violation would be handled as a de minimis violation (defined as a deviation from the requirement of a standard that has no direct or immediate relationship to safety or health, and no enforcement action will be taken);
- when a variance is not necessary for the conditions, practice, means, methods, operations, or processes used or proposed to be used by contractor; or
- the contractor does not demonstrate that the approval criteria are met.

f. Discuss the 10 CFR 851 enforcement process.

Investigations and Inspections

The following is taken from 10 CFR 851.40.

Note: For the purposes of this section “director” means a DOE official to whom the secretary assigns the authority to investigate the nature and extent of compliance with the requirements of 10 CFR 851.

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 10 CFR 851 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. A request for an investigation or inspection must describe the subject matter or activity to be investigated or inspected as fully as possible and include supporting documentation and information. The worker or worker representative has the right to remain anonymous upon filing a request for 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.

DOE shall not disclose information or documents that are obtained during any investigation or inspection unless the director directs or authorizes the public disclosure of the investigation. Prior to such authorization, DOE must determine that disclosure is not precluded by the Freedom of Information Act and 10 CFR 1004, “Freedom of Information Act.” Once disclosed pursuant to the director’s authorization, the information or documents are a matter of public record.

A request for confidential treatment of information for purposes of the Freedom of Information Act does not prevent disclosure by the director if the director determines disclosure to be in the public interest and otherwise permitted or required by law.

During the course of an investigation or inspection, any contractor may submit any document, statement of facts, or memorandum of law for the purpose of explaining the contractor’s position or furnish information which the contractor considers relevant to a matter or activity under investigation or inspection.

The director may convene an informal conference to discuss any situation that might be a violation of a requirement of this part, its significance and cause, any corrective action taken or not taken by the contractor, any mitigating or aggravating circumstances, and any other information. A conference is not normally open to the public and DOE does not make a transcript of the conference. The director may compel a contractor to attend the conference.

If facts disclosed by an investigation or inspection indicate that further action is unnecessary or unwarranted, the director may close the investigation without prejudice.

The director may issue enforcement letters that communicate DOE's expectations with respect to any aspect of the requirements of this part, including identification and reporting of issues, corrective actions, and implementation of the contractor's safety and health program; provided that an enforcement letter may not create the basis for any legally enforceable requirement pursuant to 10 CFR 851.

Settlement

The following is taken from 10 CFR 851.41.

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. A settlement conference is not open to the public and DOE does not make a transcript of the conference.

The director may resolve any issues in an outstanding proceeding with a consent order.

The director and the contractor, or a duly authorized representative thereto, must sign the consent order and indicate agreement to the terms contained therein.

A contractor is not required to admit in a consent order that a requirement of 10 CFR 851 has been violated.

DOE is not required to make a finding in a consent order that a contractor has violated a requirement of 10 CFR 851.

A consent order must set forth the relevant facts that form the basis for the order and what remedy, if any, is imposed.

A consent order shall constitute a final order.

Preliminary Notice of Violation

The following is taken from 10 CFR 851.42.

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 preliminary notice of violation (PNOV) to the contractor.

A PNOV must indicate

- the date, facts, and nature of each act or omission upon which each alleged violation is based;
- the particular requirement involved in each alleged violation;
- the proposed remedy for each alleged violation, including the amount of any civil penalty; and
- the obligation of the contractor to submit a written reply to the director within 30 calendar days of receipt of the PNOV.

A reply to a PNOV must contain a statement of all relevant facts pertaining to an alleged violation. The reply must

- state any facts, explanations, and arguments that support a denial of the alleged violation;
- demonstrate any extenuating circumstances or other reason why a proposed remedy should not be imposed or should be mitigated;
- discuss the relevant authorities that support the position asserted, including rulings, regulations, interpretations, and previous decisions issued by DOE; and
- furnish full and complete answers to any questions set forth in the preliminary notice.

Copies of all relevant documents must be submitted with the reply.

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.

A copy of the PNOV must be prominently posted, once final, at or near the location where the violation occurred until the violation is corrected.

Final Notice of Violation

The following is taken from 10 CFR 851.43.

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. The final notice of violation must state that the contractor may petition the Office of Hearings and Appeals for review of the final notice in accordance with 10 CFR 1003, Subpart G, “Private Grievances and Redress.”

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 pursuant to 10 CFR 851.42, “Preliminary 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 shall 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 following is taken from 29 CFR 1910.1.

Section 6(a) of the Williams-Steiger Occupational Safety and Health Act of 1970 provides that “without regard to chapter 5 of title 5, United States Code, or to the other subsections of this section, the secretary shall, as soon as practicable during the period beginning with the effective date of this Act and ending two years after such date, by rule promulgate as an occupational safety or health standard any national consensus standard, and any established Federal standard, unless he determines that the promulgation of such a standard would not result in improved safety or health for specifically designated employees.” The legislative purpose of this provision is to establish, as rapidly as possible and without regard to the rule-making provisions of the Administrative Procedure Act, 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 1) national consensus standards on whose adoption affected persons have reached substantial agreement, or 2) Federal standards already established by Federal statutes or regulations.

29 CFR 1910 carries out the directive to the secretary of Labor under section 6(a) of the Act. It contains occupational safety and health standards which have been found to be national consensus standards or established Federal standards.

29 CFR 1926, Safety and Health Regulations for Construction Industry

The following is taken from 29 CFR 1926.1.

29 CFR 1926 sets forth the safety and health standards promulgated by the secretary of Labor under section 107 of the Contract Work Hours and Safety Standards Act. The standards are published in subpart C of 29 CFR 1926 and following subparts.

Subpart B 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 and Related Matters

The following is taken from 29 CFR 1960.1.

Section 19 of the Occupational Safety and Health Act (the Act) contains special provisions to assure safe and healthful working conditions for Federal employees. Under that section, it is the responsibility of the head of each Federal agency to establish and maintain an effective and comprehensive occupational safety and health program which is consistent with the standards promulgated under section 6 of the Act. The secretary of Labor (the secretary), under section 19, is to report to the president certain evaluations and recommendations with respect to the programs of the various agencies, and the duties which section 24 of the Act imposes on the secretary of Labor necessarily extend to the collection, compilation and analysis of occupational safety and health statistics from the Federal government. The role of the General Services Administration (GSA) in this area stems from its duties as the government's principal landlord and from its specific safety and health responsibilities under 41 CFR 101, subchapter D, "Federal Property Management Regulations."

EO 12196, "Occupational Safety and Health Programs for Federal Employees," prescribes additional responsibilities for the heads of agencies, the secretary, and the GSA administrator. Among other duties, the secretary is required to issue basic program elements in accordance with which the heads of agencies shall operate their safety and health programs. The purpose of 29 CFR 1960 is to issue these basic program elements. Although agency heads are required to operate a program in accordance with the basic program elements, those elements contain numerous provisions which, by their terms, permit agency heads the flexibility necessary to implement their programs in a manner consistent with their respective missions, sizes, and organizations. Moreover, an agency head, after consultation with agency employees or their representatives and with appropriate safety and health committees may request the secretary to consider approval of alternate program elements; the secretary, after consultation with the Federal Advisory Council on Occupational Safety and Health, may approve such alternate program elements.

Under EO 12196, the secretary is required to perform various services for the agencies, including consultation, training, recordkeeping, inspections, and evaluations. Agencies are encouraged to seek such assistance from the secretary as well as advice on how to comply with the basic program elements and operate effective occupational safety and health programs. Upon the request of an agency, the Office of Federal Agency Safety and Health Programs will review proposed agency plans for the implementation of program elements.

Section 19 of the Act and the EO require specific opportunities for employee participation in the operation of agency safety and health programs. The manner of fulfilling these requirements is set forth in part in these program elements. These requirements are separate from but consistent with the Federal Service Labor Management Relations Statute and regulations dealing with labor-management relations within the Federal government.

EO 12196 and these basic program elements apply to all agencies of the executive branch. They apply to all Federal employees. They apply to all working conditions of Federal employees except those involving uniquely military equipment, systems, and operations.

No provision of the EO or 29 CFR 1960 shall be construed in any manner to relieve any private employer, including Federal contractors, or their employees of any rights or responsibilities under the provisions of the Act, including compliance activities conducted by the Department of Labor or other appropriate authority.

Federal employees who work in establishments of private employers are covered by their agencies' occupational safety and health programs. Although an agency may not have the authority to require abatement of hazardous conditions in a private sector workplace, the agency head must assure safe and healthful working conditions for his/her employees. This shall be accomplished by ACs, PPE, or withdrawal of Federal employees from the private sector facility to the extent necessary to assure that the employees are protected.

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

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

Federal agencies do not have contracts with DOE and, therefore, are not subject to the DOE's worker safety and health requirements. However, other Federal agencies are required under section 19(a) of the Occupational Safety and Health Act of 1970 (a) "to establish and maintain an effective and comprehensive occupational safety and health program" and to "provide safe and healthful places and conditions of employment" for their Federal employees. Federal agencies (except military personnel and uniquely military equipment, systems and operations) are also required by EO 12196 to adhere to OSHA regulations promulgated for that purpose and may be subject to inspections by OSHA. Contractors working under contract with these agencies would be subject to OSHA unless they are subject to another Federal regulator.

Examples of non-DOE Federal organizations performing work on DOE sites include the Department of Homeland Security, the Department of Defense (DoD), the Department of Interior, and the EPA. When a DOE contractor supports a non-DOE Federal organization pursuant to a contract with DOE on a DOE site, the contractor's work is covered by the Rule. When a non-DOE contractor is performing work for a non-DOE Federal organization on a DOE site, that contractor's work is not covered by the Rule. When a non-DOE Federal organization or its non-DOE contractor is performing work on a DOE site, DOE contractors should brief the non-DOE organizations' representatives on the site hazards and worker safety and health program prior to commencement of their work to protect those organizations' workers and to avert those workers from creating hazards to DOE contractor workers.

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

The following is taken from U.S. Department of Labor, *Department of Energy (DOE) and Nuclear Regulatory Commission (NRC) Collaborative Interactions with OSHA.*

OSHA collaborates with DOE and the NRC to provide protection for workers from occupational safety and health hazards. This collaboration is outlined in memorandums of understanding (MOUs) signed by OSHA with both DOE and NRC.

Under existing law, DOE regulates worker safety and health of contractor employees by implementing the DOE worker safety and health program at its facilities that are operated under the authority of sections 161(i)(3) and 234C of AEA. As a result of DOE exercising its authority over the safety and health of contractor employees, such employees are generally exempt from OSHA regulation pursuant to section 4(b)(1) of the Occupational Safety and Health (OSH) Act, 29 U.S.C. 653(b)(1). In situations in which DOE does not exercise occupational safety and health regulatory authority, that authority belongs either to Federal OSHA or state plan agencies.

The following is taken from U.S. Department of Labor, *Memorandums of Understanding.*

The purpose of this MOU is to formalize the working relationship between the two agencies with respect to contractor employees at DOE's government-owned contractor-operated

(GOCO) facilities. Pursuant to section 4(b)(1) of the OSH Act, the agencies agree that DOE has occupational safety and health regulatory authority over the working conditions of contractor employees at DOE's GOCO facilities and thus the OSH Act does not apply to those working conditions. At the same time, Federal workers are covered by EO 12196 and the requirements for Federal employee occupational safety and health programs, and OSHA may inspect their working conditions. The agencies agree that they may provide technical assistance and training to each other, among other things. Both parties agree that requests for technical assistance and/or consultation which involve a commitment of resources will require a specific IAG between the parties covering the scope of work, timing, and reimbursement.

This MOU delineates the procedures by which DOE will notify OSHA regarding the need for the agencies to address occupational safety and health regulatory authority at privatized facilities and operations at DOE sites, and describes procedures and criteria for Federal OSHA's or state plans' acceptance of occupational safety and health regulatory responsibilities at these facilities and operations.

d. Discuss workplace inspection techniques.

The following is taken from Occupational Safety and Health Administration, OSHA 2098, *OSHA Inspections.*

When the OSHA compliance officer arrives at the establishment, he or she displays official credentials and asks to meet an appropriate employer representative. Employers should always ask to see the compliance officer's credentials.

Employers may verify the OSHA Federal or state compliance officer credentials by calling the nearest Federal or state OSHA office. Compliance officers may not collect a penalty at the time of the inspection or promote the sale of a product or service at any time; anyone who attempts to do so is impersonating a government inspector and the employer should contact the Federal Bureau of Investigation or local law enforcement officials immediately.

Opening Conference

In the opening conference, the compliance officer explains how the establishment was selected and what the likely scope of the inspection will be. The compliance officer also will ascertain whether an OSHA-funded consultation visit is in progress or whether the facility is pursuing or has received an inspection exemption through the consultation program; if so, the inspection may be limited or terminated.

The compliance officer explains the purpose of the visit, the scope of the inspection, and the standards that apply. The compliance officer gives the employer information on how to get a copy of applicable safety and health standards as well as a copy of any employee complaint that may be involved (with the employee's name deleted, if the employee requests anonymity).

The compliance officer asks the employer to select an employer representative to accompany the compliance officer during the inspection.

The compliance officer also gives an authorized employee representative the opportunity to attend the opening conference and accompany the compliance officer during the inspection. If a recognized bargaining agent represents the employees, the agent ordinarily will designate the employee representative to accompany the compliance officer. Similarly, if there is a plant safety committee, the employee members of that committee will designate the employee representative (in the absence of a recognized bargaining agent). Where neither employee group exists, the employees themselves may select an employee representative, or the compliance officer may determine if any employee suitably represents the interest of other employees.

The Act does not require an employee representative for each inspection. Where there is no authorized employee representative, however, the compliance officer must consult with a reasonable number of employees concerning safety and health matters in the workplace.

Walkthrough

After the opening conference, the compliance officer and accompanying representatives proceed through the establishment to inspect work areas for safety and health hazards.

The compliance officer determines the route and duration of the inspection. While talking with employees, the compliance officer makes every effort to minimize any work interruptions. The compliance officer observes safety and health conditions and practices; consults with employees privately, if necessary; takes photos, videotapes, and instrument readings; examines records; collects air samples; measures noise levels; surveys existing engineering controls; and monitors employee exposure to toxic fumes, gases, and dusts.

An inspection tour may cover part or all of an establishment, even if the inspection resulted from a specific complaint, fatality, or catastrophe. If the compliance officer finds a violation in open view, he or she may ask permission to expand the inspection.

The compliance officer keeps all trade secrets observed confidential. The compliance officer consults employees during the inspection tour. He or she may stop and question workers, in private, about safety and health conditions and practices in their workplaces. Each employee is protected under the Act from discrimination by the employer for exercising his or her safety and health rights.

OSHA places special importance on posting and recordkeeping requirements. The compliance officer will inspect records of deaths, injuries, and illnesses that the employer is required to keep. He or she will check to see that a copy of the totals from the last page of OSHA form 300 are posted as required and that the OSHA workplace poster (OSHA 3165), which explains employees' safety and health rights, is prominently displayed. Where records of employee exposure to toxic substances and harmful physical agents are required, the compliance officer will examine them for compliance with the recordkeeping requirements.

The compliance officer also requests a copy of the employer's hazard communication program. Under OSHA's hazard communication standard (HCS), employers must establish a written, comprehensive communication program that includes provisions for container labeling, material safety data sheets (MSDS), and an employee training program.

The program must contain a list of the hazardous chemicals in each work area and the means the employer will use to inform employees of the hazards associated with these chemicals.

During the course of the inspection, the compliance officer will point out to the employer any unsafe or unhealthful working conditions observed. At the same time, the compliance officer will discuss possible corrective action if the employer so desires.

Some apparent violations detected by the compliance officer can be corrected immediately. When the employer corrects them on the spot, the compliance officer records such corrections to help in judging the employer's good faith in compliance. Although corrected, the apparent violations will serve as the basis for a citation and, if appropriate, a notice of proposed penalty. OSHA may reduce the penalties for some types of violations if they are corrected immediately.

Closing Conference

At the conclusion of the inspection, the compliance officer conducts a closing conference with the employer, employees, and/or the employees' representative. The compliance officer gives the employer and all other parties involved a copy of "Employer Rights and Responsibilities Following an OSHA Inspection" (OSHA 3000) for their review and discussion. The compliance officer discusses with the employer all unsafe or unhealthful conditions observed during the inspection and indicates all apparent violations for which he or she may issue or recommend a citation and a proposed penalty. The compliance officer will not indicate any specific proposed penalties but will inform the employer of appeal rights.

During the closing conference, the employer may wish to produce records to show compliance efforts and provide information that can help OSHA determine how much time may be needed to abate an alleged violation.

When appropriate, the compliance officer may hold more than one closing conference. This is usually necessary when the inspection includes an evaluation of health hazards, after a review of additional laboratory reports, or after the compliance officer obtains additional factual evidence while concluding an accident investigation. The compliance officer explains that OSHA area offices are full-service resource centers that inform the public of OSHA activities and programs. This includes information on new or revised standards, the status of proposed standards, comment periods, or public hearings. Additionally, area offices provide technical experts and materials and refer callers to other agencies and professional organizations as appropriate. The area offices promote effective safety and health programs through voluntary protection programs and provide information about study courses offered at the OSHA Training Institute or its satellite locations nationwide.

If an employee representative does not participate in either the opening or the closing conference held with the employer, the compliance officer holds a separate discussion with the employee representative, if requested, to discuss matters of direct interest to employees.

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

The following is taken from U.S. Department of Labor, *Hazard Communication.*

The HCS is now aligned with the Globally Harmonized System (GHS) of classification and labeling of chemicals. This update to the HCS will provide a common and coherent approach to classifying chemicals and communicating hazard information on labels and safety data sheets (SDSs). This update will also help reduce trade barriers and result in productivity improvements for American businesses that regularly handle, store, and use hazardous chemicals while providing cost savings for American businesses that periodically update SDSs and labels for chemicals covered under the HCS.

Hazard Communication Standard

To ensure chemical safety in the workplace, information about the identities and hazards of the chemicals must be available and understandable to workers. OSHA's HCS requires the development and dissemination of such information.

- Chemical manufacturers and importers are required to evaluate the hazards of the chemicals they produce or import, and prepare labels and SDSs to convey the hazard information to their downstream customers.
- All employers with hazardous chemicals in their workplaces must have labels and SDSs for their exposed workers, and train them to handle the chemicals appropriately.

Major Changes to the HCS

Hazard classification—Provides specific criteria for classification of health and physical hazards, as well as classification of mixtures.

Labels—Chemical manufacturers and importers will be required to provide a label that includes a harmonized signal word, pictogram, and hazard statement for each hazard class and category. Precautionary statements must also be provided.

Safety data sheets—Will now have a specified sixteen-section format.

Information and training—Employers are required to train workers by December 1, 2013 on the new labels elements and SDSs format to facilitate recognition and understanding.

Video 18. Understanding the GHS labeling system
https://www.youtube.com/watch?v=RvQNf1Y7E84

f. Discuss how the OSHA Rule is invoked on DOE Federal and contractor staff by 10 CFR 851 and DOE O 440.1B, Chg 2, respectively.

10 CFR 851

The following is taken from the Federal Register, 10 CFR 850 "Chronic Beryllium Disease Prevention Program," and 10 CFR 851, "Worker Safety and Health Program," final rule.

10 CFR 851.10,, "General Requirements," 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 10 CFR 851.10(a)(1) for the general duty clause is consistent with the language established in the OSH Act.

DOE O 440.1B, Chg 2

The following is taken from U.S. DOE Office of Health, Safety, and Security, *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 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.

14. Personnel shall 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 1910.39.

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

Written and oral fire prevention plans—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.

Minimum elements of a fire prevention plan—A fire prevention plan must include

- 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; and
- 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.

Fire Response Planning
The following is taken from DOE-STD-1066-2012.

DOE O 420.1C, Chg 1, *Facility Safety*, requires contractors to provide emergency response capabilities, as necessary, to meet site needs, as established by the baseline needs assessment, safety basis documentation, and applicable regulations, codes, and standards. A comprehensive, multi-faceted emergency response capability can be achieved in a number of ways. These include onsite emergency response organizations (EROs), such as the fire departments and fire brigades that currently exist at many DOE sites; offsite fire departments; or a combination of both, that can be relied on to meet emergency response objectives.

Control of Fires
The following is taken from DOE-STD-1066-2012.

DOE O 420.1C requires that multiple fire protection approaches be provided for property protection in areas where the maximum possible fire loss (MPFL) exceeds $150 million. When multiple fire protection approaches are required for other than nuclear safety (e.g., property protection, mission continuity, etc.), any two of the following are considered satisfactory:

- Automatic suppression systems, such as fire sprinklers, foam, gaseous, explosion suppression, or other specialized extinguishing systems plus appropriate alarms. An adequate extinguishing agent supply, storage, and distribution system is an essential element.
- Automatic fire detection, occupant warning, manual fire alarm, and fire alarm reporting systems (considered together) combined with a sufficiently staffed, properly equipped, and adequately trained fire department or brigade that is able and committed to respond in a timely and effective manner.
- Fire barriers of sufficient ratings.
- For outdoor locations, sufficiently rated fire barriers, or a combination of physical separation and barriers.

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

The following is taken from eHow, *Fire Hazards in the Workplace.*

All workplaces contain chemical, electrical, and other fire hazards that pose major health and safety threats if left unchecked. Objects that generate heat—such as computers—are just one potential trouble spot. Office materials like cardboard or paper, if left to pile up, offer an ideal opportunity for fires to break out. Adopting extension cords and power strips as permanent power sources can also overload the whole system, making a serious fire more likely.

Ignition Points
No fire can start without an ignition point. This terms refers to the minimum temperature at which a substance burns without the application of external heat. Examples include office equipment like computer monitors or microwave ovens used in staff kitchens. Even items

like cigarettes and matches also create ignition points, especially if employees must hurriedly put out smoking materials.

Fuel Sources

Every fire needs a fuel source. Many workplaces are careless in dealing with materials that burn easily, such as cardboard and paper. The type of hazard is unique to the workplace involved. Industrial sites like factories and workshops may contain flammable liquids, timber pallets, and packaging materials such as polystyrene. To ensure safe handling, employers must check the specific material's SDS for each substance.

Flammable Liquids and Vapors

Flammable liquids and vapors can burn once they mix with air or other oxygen sources. For this reason, solvent containers should be tightly sealed. Liquids or vapors also settle in low areas, and travel along the surface. To prevent static buildups that increase the risk of explosions, electrical equipment should be bonded or grounded along a conductive path.

Heat-Producing Devices

OSHA outlines numerous standards for dealing with fire hazards. One standard covers heat-producing devices and equipment, such as boilers, burners, fryers, heat exchangers, ovens and stoves. Companies must provide for the proper storage and maintenance of this equipment, while keeping it away from flammable liquid.

Electrical Hazards

Misused extension cords and multiple power strips are the most common causes for office fires. Using multiple power strips to power large appliances can overload outlets and branch circuits. The same rule holds true for extension cords, which provide power when a regular outlet is not available. Extension cords should never be left coiled up. Coiled extension cords cause inductive heating that could damage insulation, and ultimately, cause a fire.

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

The following is taken from National Fire Protection Association, NFPA 101, Chapter 1.

The NFPA 101, *Life Safety Code* addresses those construction, protection, and occupancy features necessary to minimize danger to life from the effects of fire, including smoke, heat, and toxic gases created during a fire.

The code establishes minimum criteria for the design of egress facilities so as to allow prompt escape of occupants from buildings or, where desirable, into safe areas within buildings.

The code addresses other considerations that are essential to life safety in recognition of the fact that life safety is more than a matter of egress. The code also addresses protective features and systems, building services, operating features, maintenance activities, and other provisions in recognition of the fact that achieving an acceptable degree of life safety depends on additional safeguards to provide adequate egress time or protection for people exposed to fire.

The code also addresses other considerations that, while important in fire conditions, provide an ongoing benefit in other conditions of use, including nonfire emergencies.

The purpose of the code is to provide minimum requirements, with due regard to function, for the design, operation, and maintenance of buildings and structures for safety to life from fire.

d. Discuss the purpose of a fire hazard analysis.

The following is taken from DOE-STD-1066-2012.

The purpose of a fire hazard analysis (FHA) is to conduct a comprehensive assessment of the risk from fire in a facility to verify that fire safety objectives are met. The FHA may also incorporate facilities, other than buildings, when they are exposed or are integral to the building operations. The FHA usually is broken down by building, but may be further broken down into fire areas. The FHA is also a vital tool for incorporating appropriate fire protection criteria into designs in accordance with DOE-STD-1189-2008, *Integration of Safety into the Design Process*, and for demonstrating compliance with DOE Orders and standards, building codes requirements, and fire protection standards. An FHA may also be required for facilities other than buildings if the value and hazard warrant.

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

- **Class A**
- **Class B**
- **Class C**
- **Class D**

The following is taken from Fire Equipment Manufacturer's Association, *Portable Fire Extinguishers.*

Types of Fire

Class A

Class A fires are fires in **ordinary combustibles** such as **wood, paper, cloth, trash, and plastics**.

Class B

Class B fires are fires in **flammable liquids** such as **gasoline, petroleum oil and paint**. Class B fires also include **flammable gases** such as **propane** and **butane**. Class B fires do not include fires involving cooking oils and grease.

Class C

Class C fires are fires involving **energized electical equipment** such as **motors, transformers, and appliances**. Remove the power and the Class C fire becomes one of the other classes of fire.

Class D

Class D fires are fires in **combustible metals** such as **potassium, sodium, aluminum, and magnesium**.

Class K

Class K fires are fires in **cooking oils and greases** such as **animals fats** and **vegetable fats**.

Source: Fire Equipment Manufacturer's Association, Types of Fire

Figure 9. Types of fire

Types of Fire Extinguishers

WATER AND FOAM

Water and foam fire extinguishers extinguish the fire by taking away the heat element of the fire triangle. Foam agents also separate the oxygen element from the other elements.

Water extinguishers are for class A fires only—they should not be used on class B or C fires. The discharge stream could spread the flammable liquid in a class B fire or could create a shock hazard on a class C fire.

CARBON DIOXIDE

Carbon dioxide fire extinguishers extinguish fire by taking away the oxygen element of the fire triangle and also by removing the heat with a very cold discharge.

Carbon dioxide can be used on class B and C fires. They are usually ineffective on class A fires.

DRY CHEMICAL
Dry chemical fire extinguishers extinguish the fire primarily by interrupting the chemical reaction of the fire triangle.

Today's most widely used type of fire extinguisher is the multipurpose dry chemical that is effective on class A, B, and C fires. This agent also works by creating a barrier between the oxygen element and the fuel element on class A fires.

Ordinary dry chemical is for class B and C fires only. It is important to use the correct extinguisher for the type of fuel. Using the incorrect agent can allow the fire to re-ignite after apparently being extinguished successfully.

WET CHEMICAL
Wet chemical is a new agent that extinguishes the fire by removing the heat of the fire triangle and prevents re-ignition by creating a barrier between the oxygen and fuel elements.

Wet chemical of 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.

CLEAN AGENT
Halogenated or clean agent extinguishers include the halon agents as well as the newer and less ozone-depleting halocarbon agents. They extinguish the fire by interrupting the chemical reaction of the fire triangle.

Clean agent extinguishers are primarily for class B and C fires. Some larger clean agent extinguishers can be used on class A, B, and C fires.

DRY POWDER
Dry powder extinguishers are similar to dry chemical except that they extinguish the fire by separating the fuel from the oxygen element or by removing the heat element of the fire triangle.

However, dry powder extinguishers are for class D or combustible metal fires, only. They are ineffective on all other classes of fires.

WATER MIST
Water mist extinguishers are a recent development that extinguish the fire by taking away the heat element of the fire triangle. They are an alternative to the clean agent extinguishers where contamination is a concern.

Water mist extinguishers are primarily for class A fires, although they are safe for use on class C fires as well.

CARTRIDGE OPERATED DRY CHEMICAL
Cartridge operated dry chemical fire extinguishers extinguish the fire primarily by interrupting the chemical reaction of the fire triangle.

Like the stored pressure dry chemical extinguishers, the multipurpose dry chemical is effective on class A, B, and C fires. This agent also works by creating a barrier between the oxygen element and the fuel element on class A fires. Ordinary dry chemical is for class B and C fires only.

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

Detection

The following is taken from Occupational Safety and Health Administration, *Fire Detection Systems.*

Automatic fire detection systems, when combined with other elements of an emergency response and evacuation plan, can significantly reduce property damage, personal injuries, and loss of life from fire in the workplace. Their main function is to quickly identify a developing fire and alert building occupants and emergency response personnel before extensive damage occurs. Automatic fire detection systems do this by using electronic sensors to detect the smoke, heat, or flames from a fire and providing an early warning.

If a workplace uses a fire detection system that was designed and installed to meet the fire protection requirements of a specific OSHA standard, it must also comply with the 29 CFR 1910.164, "Fire Detection Systems" standard.

Fire detectors work by sensing one or more products of fire. The three most common detectors are as follows:

1. Smoke detectors
2. Heat detectors
3. Flame detectors

SMOKE DETECTORS

Smoke detectors detect the visible or invisible smoke particles from combustion. The two main types are ionization detectors and photoelectric detectors.

Ionization Detectors

The ionization detector contains a small radioactive source that is used to charge the air inside a small chamber. The charged air allows a small current to cross through the chamber and complete an electrical circuit.

When smoke enters the chamber, it shields the radiation, which stops the current and triggers an alarm.

These detectors respond quickly to very small smoke particles (even those invisible to the naked eye) from flaming or very hot fires, but may respond very slowly to the dense smoke associated with smoldering or low-temperature fires.

Photoelectric Detectors

In a photoelectric smoke detector, a light source and light sensor are arranged so that the rays from the light source do not hit the light sensor. When smoke particles enter the light path, some of the light is scattered and redirected onto the sensor, causing the detector to activate an alarm. These detectors react quickly to visible smoke particles from smoldering fires, but are less sensitive to the smaller particles associated with flaming or very hot fires.

HEAT DETECTORS

Heat detectors are normally used in dirty environments or where dense smoke is produced. Heat detectors may be less sensitive, but are more appropriate than a smoke detector in these environments. The most common heat detectors either react to a broad temperature change or a predetermined fixed temperature.

Heat detectors use a set of temperature-sensitive resistors called thermistors that decrease in resistance as the temperature rises. One thermistor is sealed and protected from the surrounding temperature while the other is exposed. A sharp increase in temperature reduces the resistance in the exposed thermistor, which allows a large current to activate the detector's alarm.

FLAME DETECTORS

Flame detectors are line-of-sight devices that look for specific types of light (infrared, visible, ultraviolet) emitted by flames during combustion. When the detector recognizes this light from a fire, it sends a signal to activate an alarm.

Alarm and Communication Systems

The following is taken from U.S. General Administration Services, *Fire Alarm Systems*.

FIRE ALARM INSTALLATION

New and replacement fire alarm systems shall be installed in accordance with the requirements of NFPA 72, *National Fire Alarm and Signaling Code*, the International Building Code (IBC), and the appropriate GSA fire alarm system specification.

Special Requirements—The design requirements below supersede the requirements of NFPA 72 and the IBC:

All new and replacement fire alarm systems shall be addressable systems as defined in NFPA 72.

All new and replacement fire alarm systems installed in buildings having a total occupant load of 500 or more occupants or subject to 100 or more occupants below the level of exit discharge shall be a voice/alarm communication system. The voice/alarm communication system shall provide an automatic response to the receipt of a signal indicative of a fire emergency. Manual control capability shall also be provided to notify all occupants either on a selective or all-call basis during an emergency.

Fire alarm systems shall not be integrated with other building systems such as building automation, energy management, security, etc. Fire alarm systems shall be self-contained, stand-alone systems able to function independently of other building systems.

Each fire alarm system shall be provided with a hardwired mini-computer power conditioner to protect the fire alarm system from electrical surges, spikes, sags, over-voltages, brownouts, and electrical noise. The power conditioner shall be U.L. listed and shall have built-in overload protection.

Wiring supervision for fire alarm systems shall be provided as defined in NFPA 72 as follows:

- Interconnected riser loop or network (style 7, class A)
- Initiating device circuits (style B, class B)
- Signaling line circuit for each floor (style 4, class B)
- Signaling line circuit for network (style 7, class A)
- Notification appliance circuits (style Y, class B)

All fire alarm system wiring shall be solid copper and installed in conduit. Stranded wiring shall not be used.

Conduit shall be rigid metal or electrical metallic tubing, with a minimum inside diameter of $^{3}/_{4}$ inch that uses compression type fittings and couplings.

AUDIBLE NOTIFICATION APPLIANCES

Performance, location, and mounting of audible notification appliances shall be in accordance with the requirements of NFPA 72.

Special requirements—The design requirements below supersede the requirements of NFPA 72:

To ensure audible signals are clearly heard, the sound level shall be at least 70 decibels (dBA) throughout the office space, general building areas and corridors measured 5 feet above the floor. The sound level in other areas shall be at least 15 dBA above the average sound level or 5 dBA above any noise source lasting 60 seconds or longer.

The design for the placement and location of all audible notification appliances shall be based on the applicable calculation methods contained in the Society of Fire Protection Engineers, *Handbook of Fire Protection Engineering* for calculating sound attenuation through doors and walls.

Where voice communication systems are provided, fire alarm speakers shall be installed in elevator cabs and exit stairways; however, they shall only be activated to broadcast live voice messages (e.g., manual announcements only). The automatic voice messages shall be broadcast through the fire alarm speakers on the appropriate floors, but not in stairs or elevator cabs.

VISIBLE NOTIFICATION APPLIANCES

Placement and spacing of visible notification appliances shall be in accordance with the requirements of NFPA 72.

Special requirements—The design requirements below supersede the requirements of NFPA 72:

Visual notification appliances shall only be installed in projects that involve the installation of a new fire alarm system.

Visual notification appliances shall only be required to be installed in public and common areas. For the purposes of this requirement, visual notification appliances shall not be required to be installed in individual offices. Public and common areas include public rest rooms, reception areas, building core areas, conference rooms, open office areas, etc.

Visual notification appliance circuits shall have a minimum of 25 percent spare capacity to accommodate additional visual notification appliances being added to accommodate employees who are deaf or have hearing impairments.

Visual notification appliances shall not be installed in exit enclosures (e.g., exit stairs, etc.).

Extinguishing Systems

The following is taken from U.S. Department of Labor, *Fixed Extinguishing Systems.*

Fixed fire extinguishing/suppression systems are commonly used to protect areas containing valuable or critical equipment such as data processing rooms, telecommunication switches, and process control rooms. Their main function is to quickly extinguish a developing fire and alert occupants before extensive damage occurs by filling the protected area with a gas or chemical extinguishing agent.

A fire extinguishing system is an engineered set of components that work together to quickly detect a fire, alert occupants, and extinguish the fire before extensive damage can occur. All system components must be

- designed and approved for use on the specific fire hazards they are expected to control or extinguish
- protected against corrosion or either made or coated with a noncorrosive material if they may be exposed to a corrosive environment
- designed for the climate and temperature extremes to which they will be exposed

Typical elements and components include the following:

- Discharge nozzles—Discharge nozzles are used to disperse the extinguishing agent into the protected area.
- Piping—The piping system is used to transport the extinguishing agent from its storage container to the discharge nozzle.
- Control panel—The control panel integrates all devices and displays their operational status and condition.
- Discharge or warning alarm(s)—Electronic devices that provide an audible or visual alarm when detected.
- Hazard warning or caution signs—Hazard warning signs must be posted at the entrance to, and inside, areas protected by fixed extinguishing systems.
- Automatic fire detection device(s)—A device that detects fire and causes an alarm signal to be generated.
- Manual discharge station(s)—A device that provides a way to manually discharge the fire extinguishing system.

- Storage container(s) and extinguishing agent—The storage system discharges agent into the piping and through the discharge nozzles when activated by a manual or automatic device.

15. Personnel shall demonstrate a familiarity level knowledge of electrical safety for Department facilities necessary to identify safe and 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-1092-2013.

Low Voltage

A circuit operating at more than 50 volts (V) shall be treated as a hazardous circuit if the power in it can create electrical shocks, burns, or an explosion due to electric arcs. Observe all of the following rules for such circuits:

- Protective covers and/or barriers shall be installed over terminals and other energized parts to protect personnel.
- Suitable markings shall be applied to identify the hazard at the power source and at appropriate places.
- Magnetic forces, in normal-operation and short-circuit conditions, should be considered. Conductors that have appropriate physical strength, and are adequately braced and supported to prevent hazardous movement, should be used.

These guidelines for working on circuits operating at 50 V ac, or less, or at 100 V dc, or less, that are treated as hazardous shall be followed:

- Work on such circuits when they are de-energized.
- If it is essential to work on or near energized low-voltage, high-current circuits, operating at more than 50 V, observe the safety rules as if the circuits were operating at higher voltages. Refer to Section 2.1.2, “Considerations for Working on Energized Systems and Equipment,” and 2.12, “Work Practices.” Inductive circuits may create high-voltage hazards when interrupted. Circuit design should include a method to bleed off power safely, should an interruption occur.

High Voltage

When the output current of high-voltage supplies is below 5 milliamperes, the shock hazard to personnel is low. Where combustible atmospheres or mixtures exist, the hazard of ignition from a spark may exist. High-voltage supplies can present the following hazards:

- Faults, lightning, or switching transients can cause voltage surges in excess of the normal ratings.
- Internal component failure can cause excessive voltages on external metering circuits and low-voltage auxiliary control circuits.
- Overcurrent protective devices, such as fuses and circuit breakers for conventional applications, may not adequately limit or interrupt the total inductive energy and fault currents in highly inductive dc systems.
- Stored energy in long cable runs can be an unexpected hazard. Safety instructions should be in place to ensure proper discharge of this energy.

- Secondary hazards, such as startle or involuntary reactions from contact with high-voltage low-current systems, may result in a fall or entanglement with equipment.

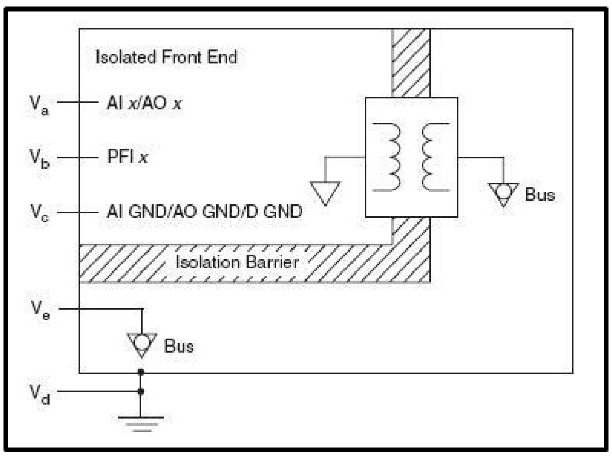
b. Describe basic electrical isolation devices and methods.

The following is taken from National Instruments, *Different Types of Isolation*.

Isolation is the means of physically and electrically separating two parts of a device. It protects computer circuitry and human operators, breaks ground loops, and improves common-mode voltage and noise rejection. It can be categorized into electrical and safety isolation. For electrical isolation, parts of a device are separated with isolation barriers that separate the card into sections. Multiple buses service each section individually. The three types of isolation can be listed from basic (low-level protection) to complete (high-level protection) in the order of channel-to-earth ground, bank, and channel-to-channel isolation.

Note: For the following diagrams, the diagonal hash marks indicate the isolation barrier; this separates circuitry. The transformer symbols represent electromagnetic isolation used to couple a signal across the isolation barrier by generating an electromagnetic field proportional to the electrical signal.

Channel-to-Earth Ground Isolation



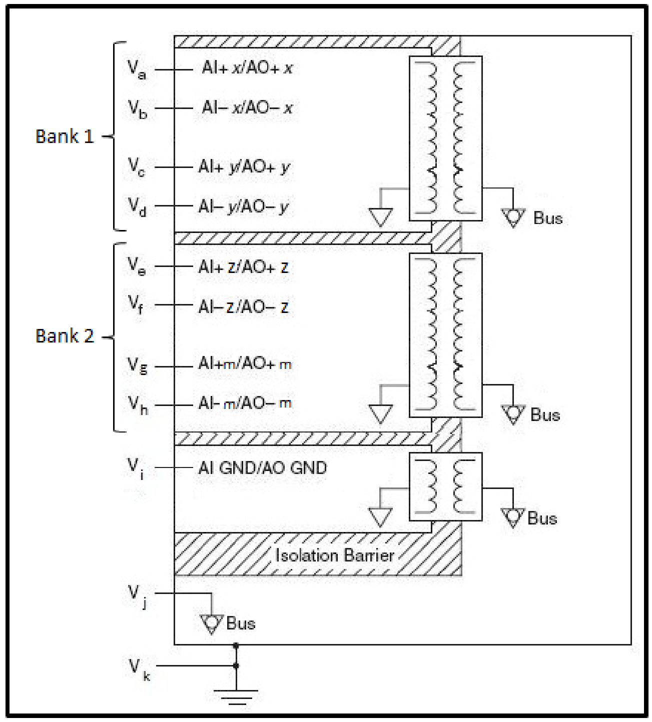
Source: National Instruments, Different Types of Isolation

Figure 10. Schematic of channel-to-earth isolation

Channels of the device and the device's earth ground are electrically isolated from one another. Channel-to-earth isolation is represented in figure 10. Voltages of the isolated front end ($V_{a\text{-}c}$) are on the same bus; these voltages are not isolated from one another. $V_{e,d}$ are on a separate bus and are isolated from the front end. This is the most fundamental type of isolation and this protection is covered by bank and channel-to-channel isolation. Channel-to-earth ground isolation can also be thought of as channel-to-bus isolation with only one bank.

Bank (Channel-to-Bus) Isolation

Channels of a device are banked (grouped) together to share a single isolation amplifier. Figure 11 represents bank isolation. In this topology, the common-mode voltage difference between channels is limited, but the common-mode voltage between the bank of channels and the non-isolated part of the measurement system can be large. In other words, individual channels are not isolated, but the channel groups are isolated from one another and earth ground. Bank 1, bank 2, $V_{i,}$ and $V_{j,k}$ are on separate buses and isolated from one another.



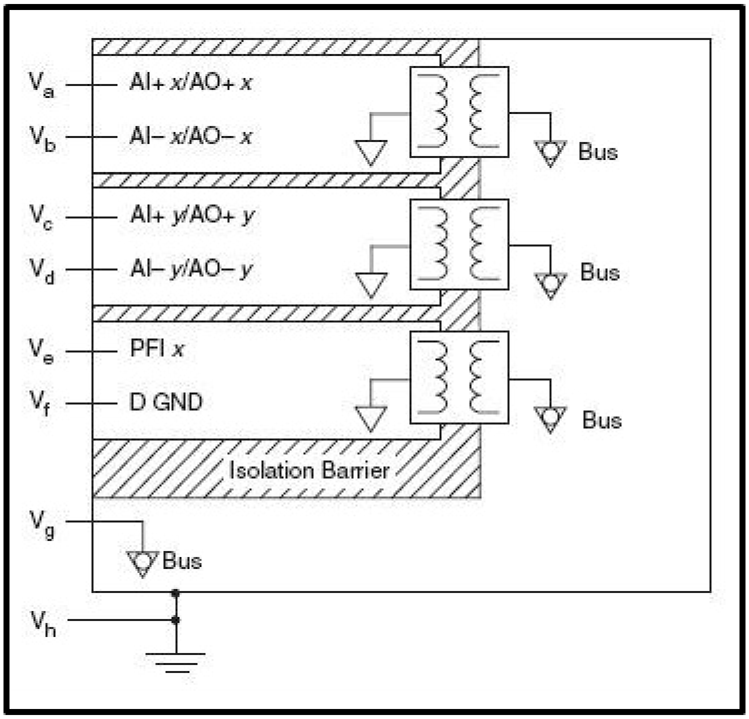
Source: National Instruments, Different Types of Isolation

Figure 11. Schematic of bank isolation

Channel-to-Channel Isolation

Each channel is isolated from every other channel and other non-isolated components. Figure12 represents channel-to-channel isolation. $V_{a,b}$, $V_{c,d}$, $V_{e,f,}$ and $V_{g,h}$ are all on separate buses and are isolated from one another.

Note: If the device has a channel-to-channel specification and has AI, AO, and DI/O, the DI/O channels are bank isolated from the other channel-to-channel isolated AI and AO channels.



Source: National Instruments, Different Types of Isolation

Figure 12. Schematic of channel-to-channel isolation

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

The following is taken from All About Circuits, *Physiological Effects of Electricity.*

How ac affects the body depends largely on frequency. Low-frequency (50 to 60 Hz) alternating current (ac) is used in the U.S. (60 Hz); it can be more dangerous than high-frequency ac and is three to five times more dangerous than direct current (dc) of the same voltage and amperage. Low-frequency ac produces extended muscle contraction (tetany), which may freeze the hand to the current's source, prolonging exposure. dc is most likely to cause a single convulsive contraction, which often forces the victim away from the current's source.

ac's alternating nature has a greater tendency to throw the heart's pacemaker neurons into a condition of fibrillation, whereas dc tends to just make the heart stand still. Once the shock current is halted, a "frozen" heart has a better chance of regaining a normal beat pattern than a fibrillating heart. This is why "defibrillating" equipment used by emergency medics works: the jolt of current supplied by the defibrillator unit is dc, which halts fibrillation and gives the heart a chance to recover.

In either case, electric currents high enough to cause involuntary muscle action are dangerous and are to be avoided at all costs.

Video 19. What's more dangerous AC or DC?
https://www.youtube.com/watch?v=ER6xeSdx0Vo

d. Describe basic office electrical safety precautions.

The following is taken from the National Safety Council, *Avoid Electrical Hazards in the Office.*

The high volume of electrical equipment in a typical office can expose workers to serious electrical hazards, including shocks, burns and fire, according to the Electrical Safety Foundation International (ESFI).

"Electrical accidents that occur in an office environment are usually a result of faulty or defective equipment, unsafe installation, or misuse of equipment—specifically, extension cords, power strips and surge protectors," ESFI President Brett Brenner said.

To protect against electrical incidents, ESFI recommends the following:

- Even when using a surge protector, make sure the electrical load is not too much for the circuit.
- Avoid overloading outlets with too many appliances. Never plug in more than one high-wattage appliance at a time.
- Unplug appliances when not in use to save energy and minimize the risk of shock and fire.
- Inspect electrical cords once a month to ensure they are not frayed, cracked, or otherwise damaged.
- Do not run electrical cords through high-traffic areas, under carpets or across doorways.
- Consider having a licensed electrician install additional outlets where needed, rather than relying on extension cords and power strips.
- Ensure all electrical equipment is certified by a nationally recognized laboratory, and read all manufacturers' instructions carefully.

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

The purpose of NFPA 70E is to provide a practical safe working area for employees relative to the hazards arising from the use of electricity.

NFPA 70E address electrical safety-related work practices, safety-related maintenance requirements, and other ACs 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 communication 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

16. Personnel shall 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 U.S. Department of Labor, OSHA 3143, *Informational Booklet on Industrial Hygiene.*

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

Under the Occupational Safety and Health Act, OSHA develops and sets mandatory occupational safety and health requirements applicable to the more than six million workplaces in the U.S. OSHA relies on, among many others, industrial hygienists to evaluate jobs for potential health hazards. Developing and setting mandatory occupational safety and health standards involves determining the extent of employee exposure to hazards and deciding what is needed to control these hazards, thereby protecting the workers. Industrial hygienists are trained to anticipate, recognize, evaluate, and recommend controls for environmental and physical hazards that can affect the health and well-being of workers. More than forty percent of the OSHA compliance officers who inspect America's workplaces are industrial hygienists. Industrial hygienists also play a major role in developing and issuing OSHA standards to protect workers from health hazards associated with toxic chemicals, biological hazards, and harmful physical agents. They also provide technical assistance and support to the agency's national and regional offices. OSHA also employs industrial hygienists who assist in setting up field enforcement procedures, and who issue technical interpretations of OSHA regulations and standards. Industrial hygienists analyze, identify, and measure workplace hazards or stressors that can cause sickness, impaired health, or significant discomfort in workers through chemical, physical, ergonomic, or biological exposures. Two roles of the OSHA industrial hygienist are to spot those conditions and help eliminate or control them through appropriate measures.

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 limit [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 (Inhalation, Ingestion, Dermal Injection)

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 a16bs 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 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 (Acute, Chronic, Concentration)

The following is taken from the University of Nebraska, *Toxicology and Exposure Guidelines.*

Human health effects caused by exposure to toxic substances fall into two categories: short-term and long-term effects. Short-term effects (or acute effects) have a relatively quick onset (usually minutes to days) after brief exposures to relatively high concentrations of material (acute exposures). The effect may be local or systemic. Local effects occur at the site of contact between the toxicant and the body. This site is usually the skin or eyes, but includes the lungs if irritants are inhaled or the gastrointestinal tract if corrosives are ingested. Systemic effects are those that occur if the toxicant has been absorbed into the body from its initial contact point, transported to other parts of the body, and cause adverse effects in susceptible organs. Many chemicals can cause local and systemic effects.

Long-term effects (or chronic effects) are those with a long period of time (years) between exposure and injury. These effects may occur after apparent recovery from acute exposure or as a result of repeated exposures to low concentrations of materials over a period of years (chronic exposure).

Health effects manifested from acute or chronic exposure are dependent upon the chemical involved and the organ it effects. Most chemicals do not exhibit the same degree of toxicity for all organs. Usually the major effects of a chemical will be expressed in one or two organs.

Permissible Exposure Limit (PEL)

The following is taken from Wikipedia, *Permissible Exposure Limit*.

The PEL is a legal limit in the United States for exposure of an employee to a chemical substance or physical agent such as loud noise. PELs are established by OSHA. Most of OSHA's PELs were issued shortly after adoption of the Occupational Safety and Health Act in 1970.

For chemicals, the chemical regulation is usually expressed in ppm, or sometimes in mg/m^3. Units of measure for physical agents such as noise are specific to the agent.

A PEL is usually given as a TWA, although some are STEL or ceiling limits. A TWA is the average exposure over a specified period of time, usually a nominal eight hours. This means that, for limited periods, a worker may be exposed to concentration excursions higher than the PEL, so long as the TWA is not exceeded and any applicable excursion limit is not exceeded. An excursion limit typically means that "...worker exposure levels may exceed three times the PEL-TWA for no more than a total of thirty minutes during a workday, and under no circumstances should they exceed five times the PEL-TWA, provided the PEL-TWA is not exceeded." Excursion limits are enforced in some states (for example, Oregon) and on the Federal level for certain contaminants such as asbestos.

A STEL is one that addresses the average exposure over a 15–30 minute period of maximum exposure during a single work shift. A ceiling limit is one that may not be exceeded for any period of time, and is applied to irritants and other materials that have immediate effects.

Time-Weighted Average (TWA)

The following is taken from Safeopedia, *Time Weighted Average*.

TWA is the average exposure within the workplace to any hazardous contaminant or agent using the baseline of an eight hour per day or forty hours per week work schedule. The TWA reflects the maximum average exposure to such hazardous contaminants to which workers may be exposed without experiencing significant adverse health effects over the standardized work period.

The TWA is expressed in units of ppm or mg/m^3.

TWA for the exposure to any substance may be used when the concentration and time of exposure varies. It is also applicable to short-term samples such as a fifteen-minute TWA. TWA considers particular variables, dose rate, and also the amount of time.

For example, if a worker is exposed to different doses of a chemical vapor for different amounts of time, one may find TWA to determine the worker's average amount of exposure to that particular chemical.

Threshold Limit Values (TLV)

The following is taken from American Conference of Governmental Industrial Hygienists, *TLV Chemical Substances Introduction.*

TLVs and biological exposure indices (BEIs) are developed as guidelines to assist in the control of health hazards. These recommendations or guidelines are intended for use in the practice of industrial hygiene, to be interpreted and applied only by a person trained in this discipline. They are not developed for use as legal standards and American Conference of Governmental Industrial Hygienists (ACGIH) does not advocate their use as such. However, it is recognized that in certain circumstances individuals or organizations may wish to make use of these recommendations or guidelines as a supplement to their occupational safety and health program. ACGIH will not oppose their use in this manner, if the use of TLVs and BEIs in these instances will contribute to the overall improvement in worker protection. However, the user must recognize the constraints and limitations subject to their proper use and bear the responsibility for such use.

Short-Term Exposure Limits (STEL)

The following is taken from Wikipedia, *Short-Term Exposure Limits.*

A STEL is the acceptable average exposure over a short period of time, usually fifteen minutes, as long as the TWA is not exceeded.

STEL is a term used in occupational health, industrial hygiene, and toxicology. The STEL may be a legal limit in the United States for exposure of an employee to a chemical substance.

Ceiling

The following is taken from University of Toronto, *Exposure Limits*.

The ceiling exposure value is the maximum airborne concentration of a biological or chemical agent to which a worker may be exposed at any time.

Action Level

The following is taken from 29 CFR 1910.1450.

Action level means a concentration designated in 29 CFR 1910 for a specific substance, calculated as an eight-hour TWA, which initiates certain required activities such as exposure monitoring and medical surveillance.

Parts Per Million (ppm)

The following is taken from The Engineering Toolbox, *Parts Per Million.*

ppm is commonly used as a measure of small levels of pollutants in air, water, body fluids, etc. ppm is the mass ratio between the pollutant component and the solution and ppm is defined as

$$ppm = 1{,}000{,}000\ m_c/m_s$$

where:
mc = mass of component
ms = mass of solution

Milligrams Per Cubic Meter

The following is taken from aqua-calc.com, *What is a Milligram Per Cubic Meter?*

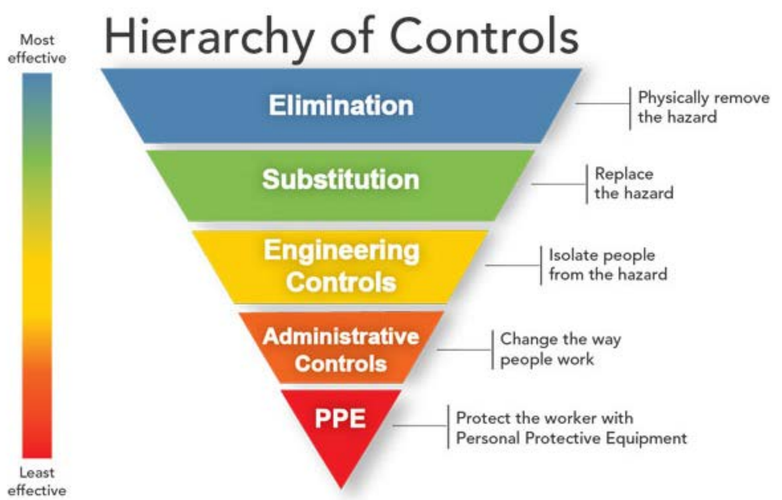
An mg/m^3 is a derived metric SI measurement unit of density used to measure volume in cubic meters in order to estimate weight or mass in milligrams.

Hierarchy of Controls (Engineering, Substitution, Administrative, PPE)

The following is from Center for Disease Control and Prevention, *Hierarchy of Controls.*

Controlling exposures to occupational hazards is the fundamental method of protecting workers. Traditionally, a hierarchy of controls has been used as a means of determining how to implement feasible and effective control solutions. One representation of this hierarchy is illustrated in figure 13.

The idea behind this hierarchy is that the control methods at the top of graphic are potentially more effective and protective than those at the bottom. Following this hierarchy normally leads to the implementation of inherently safer systems, where the risk of illness or injury has been substantially reduced.



Source: Center for Disease Control and Prevention, Hierarchy of Controls

Figure 13. Hierarchy of controls

ELIMINATION AND SUBSTITUTION

Elimination and substitution, while most effective at reducing hazards, also tend to be the most difficult to implement in an existing process. If the process is still at the design or development stage, elimination and substitution of hazards may be inexpensive and simple to implement. For an existing process, major changes in equipment and procedures may be required to eliminate or substitute for a hazard.

ENGINEERING CONTROLS

Engineering controls are favored over ACs and PPE for controlling existing worker exposures in the workplace because they are designed to remove the hazard at the source, before it comes in contact with the worker. Well-designed engineering controls can be highly effective in protecting workers and will typically be independent of worker interactions to provide this high level of protection. The initial cost of engineering controls can be higher than the cost of ACs or PPE, but over the longer term, operating costs are frequently lower, and in some instances, can provide a cost savings in other areas of the process.

ACS AND PPE

ACs and PPE are frequently used with existing processes where hazards are not particularly well-controlled. ACs and PPE programs may be relatively inexpensive to establish but, over the long term, can be very costly to sustain. These methods for protecting workers have also proven to be less effective than other measures, requiring significant effort by the affected workers.

Health Hazards (Chemical, Physical, Biological)

CHEMICAL

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

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 HCS.

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 5, feasible administrative or engineering controls shall be utilized. If such controls fail to reduce sound levels to permissible limits as specified in table 5, PPE shall be provided and used to reduce sound levels so that they fall within the levels of the table.

Table 5. 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 dBA 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 that 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 420.2-1A, *Accelerator Facility Safety Implementation Guide for DOE O 420.2C, 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 420.2-1A 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

The following is an example of a carcinogen control program taken from DOE Hanford Site, RPP 21795, *Carcinogen Control.*

Personnel or subcontractors who plan to introduce a new material must gain approval from industrial hygiene. Should the industrial hygienist discover that the material contains a carcinogen, they will consult with the carcinogen control subject matter expert (SME) and the SME will assist with the following:

- Determining whether the material shall be treated as a carcinogen. If the material is treated as a carcinogen, the limit of use of the material shall be established.
- Determining whether practical substitutes can effectively replace the proposed material. The evaluation will consider the application, as it relates to exposure potential.
- Determining if, based on usage quantities and activities, product specific operating procedures for safe use and disposal of the material shall be required for this material. As required, these procedures shall include emergency procedures should a spill or a major release occur.
- Ensuring that training is provided for all carcinogens regulated by OSHA, including asbestos.
- Providing technical assistance to ensure applicable regulatory requirements for the carcinogenic material are implemented.
- Obtaining approval for carcinogenic material procurement.

A written hazard assessment and use justification is required to procure products determined by the industrial hygienist to pose a carcinogen exposure hazard.

Procurement approval is accomplished by completing a hazard assessment and use justification for hazardous material procurement form with subsequent approval by the industrial hygienist.

The operational organization intending to use the carcinogen-containing material, with assistance from the organization’s industrial hygienist must determine whether the carcinogenic material contains an OSHA-regulated or OSHA-specific carcinogen and ensure that the requirements of the applicable OSHA standard are implemented.

Once use of a product containing a carcinogen begins, line management shall be responsible for requirements under this procedure, including

- notifying waste management when disposal of the carcinogen is necessary;
- providing industrial hygiene a current list of employees authorized to work with the carcinogen, and provide an annual update of the list;
- reviewing the use of the carcinogen on an annual basis, and substituting a noncarcinogenic material, when available; and
- notifying industrial hygiene should there be plans for altered use of the carcinogenic material from the original application.

All facilities that store or use carcinogens shall keep a current carcinogen inventory, and have it readily available. The inventory shall include the following:

- Carcinogen product name
- MSDS or SDS number
- Storage and use location
- Volume on hand
- Designation as an OSHA-regulated or OSHA-specific carcinogen

A regulated area must be established where each OSHA-regulated carcinogen is used regardless of exposure level, and where the use of an OSHA-specific carcinogen results in exposures greater than the PEL, STEL, or excursion limit.

The manager responsible for carcinogenic material usage shall consult industrial hygiene to obtain assistance in determining exposure potential and the need for establishing a regulated area based on potential or monitoring results. Authorized personnel working in a regulated area established for carcinogen exposures are required to

- have a baseline medical exam, with specific notation for that OSHA-regulated or OSHA-specific carcinogen; and
- be placed on a medical surveillance program specific for each OSHA-regulated or OSHA-specific carcinogen.

All employees who work with, or are potentially exposed to, carcinogens must be provided with documented, facility-specific training. Hazard communication program facility-specific training can satisfy this requirement.

A carcinogen label shall be placed on all carcinogenic material containers as determined by the industrial hygienist to pose a potential carcinogen exposure hazard, unless the material contains an acceptable GHS-HAZCOM label. The GHS of classification and labeling of chemicals requires the use of pictograms and may designate products with either the word "Danger" or "Warning" noted on the SDS and/or label.

All regulated work areas shall be posted with the appropriate warning sign. OSHA-approved signs are available at the sign shop or can be purchased commercially. The sign shop will add the name of the carcinogen in the product or the product identification number.

Employees must wash hands after using or handling carcinogens or expected carcinogens.

Eating, drinking, chewing, and food utensil storage is prohibited in work areas where carcinogenic materials are being used or stored.

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

Exposure Assessment and Monitoring

The following is taken from DOE STD-6005-2001 (Archived).

DOE and contractor line management are required to ensure that worker exposure assessments for chemical, physical, and biological agents and ergonomic stressors are documented and records maintained. Further, the results of these exposure assessments must be promptly communicated to the workers and supervisors who perform the tasks evaluated, and to the organization(s) responsible for effecting any needed corrective actions, such as operations, engineering or maintenance, as well as to affected disciplines such as occupational medicine, epidemiology, industrial safety, radiation protection, fire protection, and environmental protection, as appropriate.

DOE and contractor line management are required to ensure that periodic resurveys and/or exposure monitoring are conducted, as appropriate.

The frequency that evaluations are updated should be proportional to the risk presented by the hazard(s), the variability of the operation, the operation frequency, and the type and dependability of the controls limiting exposures. As a general rule

- industrial areas/activities should be evaluated at least annually, and more often if appropriate and/or when potentially serious health hazards are present;
- newly introduced or modified operations should be evaluated before starting or resuming operations, or when significant changes are made in adjacent work areas;
- frequently changing work sites/operations should be evaluated as often as necessary to reliably characterize health risks;
- occupied work areas initially determined to have no significant hazards should be evaluated at least once every three years or in accordance with applicable regulatory requirements; and
- unoccupied buildings should be evaluated initially and when their mission changes.

In addition to these periodic evaluations, additional evaluations may be performed in response to employee concerns or reported occurrences, injuries, or illnesses. DOE and contractor line management should also conduct a sufficient number of worksite inspections to determine compliance with standards and program requirements. The frequency and scope of such inspections will depend on the size, complexity, and nature of the operations of the worksite.

Engineering Controls

The following is taken from DOE STD-6005-2001 (Archived).

Change to a less hazardous process or substitute a less hazardous material or piece of equipment.

Isolate or enclose the process or operation to prevent worker exposure to hazardous agents.

Use mechanical ventilation or other engineered controls to prevent or reduce worker exposure to hazardous agents.

Respiratory Protection

The following is taken from DOE STD-6005-2001 (Archived).

When respiratory protection is required, DOE and contractor line management must ensure that National Institute for Occupational Safety and Health (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 DOE Office of Worker Health and Safety approval to use respiratory protection that has been tested and accepted for specific applications by the Los Alamos National Laboratory Respirator Studies Program.

DOE and contractor line management are also required by DOE O 440.1B, Chg 2, to follow the standards set forth in American National Standards Institute Z88.2, *Practices for Respiratory Protection*. When reporting occupational exposure levels to airborne contaminants, the exposure reported should clearly indicate the amount or concentration present in the ambient atmosphere and the type and protection factor of the respirator used.

PPE and Clothing

The following is taken from DOE STD-6005-2001 (Archived).

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; or
- emergency or escape situations.

Housekeeping

The following is taken from New Jersey Department of Health and Senior Services, *Controlling Chemical Exposure Industrial Hygiene Fact Sheets.*

Good housekeeping involves the prompt and complete removal of chemicals from room and work surfaces, including floors, walls, ceilings, doors, stairs, rafters, tables, chairs, machinery, equipment, and tools. The purpose of good housekeeping is to prevent chemicals from getting into the air or coming into contact with workers' skin or food. Housekeeping activities can themselves be a significant source of chemical exposure if good practices are not used. Housekeeping methods that should be avoided with chemicals are dry sweeping, dry dusting, use of compressed air for cleaning, and use of ordinary (non-HEPA) vacuum cleaners because they often create massive worker exposure. Recommended housekeeping methods are described below. What may seem like extraordinary methods are recommended to assure that surfaces are truly chemical-free. Surfaces just looking clean is not enough because chemicals may still be present in amounts capable of causing exposure.

Wet wiping—Wiping should be done using the three-bucket method. Assemble two buckets with clean water, an empty bucket for dirty excess cleaning solution, and a container of cleaning solution. To clean the work surface, pour cleaning solution onto a clean cloth. Wring excess solution into the empty bucket. Wipe the surface with the cloth. Add more cleaning solution to the cloth and continue wiping until all surfaces have been covered. Discard cloths as they become dirty. To rinse, dip and wring out a clean cloth in the first rinse bucket. Wipe off the work area. Rinse the cloth in the first bucket again and wring out thoroughly. Rinse the cloth in the second bucket and wring out thoroughly again. Continue wiping in this way until all surfaces have been rinsed. The rinse water in the buckets should be changed periodically, depending on the amount of contamination.

Wet mopping—Mopping should be done using the three-bucket method. To clean, assemble a bucket of cleaning solution, a mop and mop bucket for dirty rinse, and a bucket for clean rinse. Place the mop into the cleaning solution and then wring excess solution into the mop bucket. Mop small sections of the work area until the mop is dry. Slosh the mop in the clean rinse bucket and then wring into the mop bucket. Continue until the entire surface has been cleaned. To rinse, follow the same procedure except the bucket of cleaning solution is exchanged for a second rinse bucket. The rinse water in the buckets should be changed periodically, depending on the amount of contamination.

Vacuuming with a HEPA vacuum—Standard vacuums may allow fine dust into the air by allowing it to pass through normal bags and filters. HEPA vacuums are special vacuums with high-efficiency filters on the exhaust air stream. HEPA is a filter capable of removing 99.97 percent of particles down to 0.3 microns.

Some HEPA vacuums also have activated charcoal filters on the exhaust air stream; these are designed for mercury and some other volatile chemicals. Some HEPA vacuums are wet/dry. Most models are electric; some are pneumatic. Models come in capacities from 4 to 15 gallons. Most are portable floor models; some units are designed to be carried on the back.

Care to avoid chemical exposure must be taken when using a HEPA vacuum. Attachment nozzles should be used in a manner that does not cause the chemical to become airborne. Care must be taken especially when removing and replacing the disposable waste bag and HEPA filter; manufacturer's instructions should be followed. HEPA vacuum users should wear appropriate PPE.

Vacuuming with a central vacuum system—Some workplaces have installed a central vacuum system with ports for attaching cleaning hoses and tools. These are useful when large amount of material which would quickly fill a portable vacuum cleaner must be cleaned up. Central systems are commercially available; however, they must be customized for the layout of the particular workplace.

Air cleaning devices for the exhaust air should be isolated or placed outdoors. If it will be recirculated into the workplace, the exhaust should be HEPA-filtered.

Labeling

The following is taken from EHS Today, *A Guide to OSHA's New GHS Chemical Labeling Requirements.*

OSHA's new labeling requirements are expected to have the greatest impact on U.S.-based chemical manufacturers and chemical importers, with few mandatory changes slated for other general chemical storage. The HCS targets chemical manufacturers and importers to ensure their chemical containers will display a label similar to those now used in Europe and many other GHS adopters beginning June 1, 2015.

The GHS-inspired standards will require chemical manufacturers and importers to label chemical containers with 1) a harmonized signal word; 2) GHS pictogram(s); 3) a hazard statement for each hazard class and category; and 4) a precautionary statement. These elements are discussed in greater detail below:

- A harmonized signal word is used to indicate the relative level of severity of hazard and alert the reader to a potential hazard on the label. The signal words are "danger," used for the more severe hazards, and "warning," which is used for less severe hazards.
- The GHS pictogram is a symbol plus other graphic elements, such as a border, background pattern or color that is intended to convey specific information about the hazards of a chemical. Each pictogram consists of a different symbol on a white background within a red square frame set on a point (i.e., a red diamond).
- A hazard statement is assigned to a hazard class and category to describe the nature of the hazard(s) of a chemical, including, where appropriate, the degree of hazard.
- A precautionary statement is a phrase that describes recommended measures to minimize or prevent adverse effects resulting from exposure to or improper storage or handling of a hazardous chemical.

Employers who only store chemicals have the flexibility to use OSHA's new labeling system or choose to continue using the old NFPA 704, *Hazard Rating System or Hazardous Material Information System*. However, the information supplied on these labels must be consistent with the newly revised HCS (e.g., no conflicting hazard warnings or pictograms).

Keep in mind that OSHA plans to update the old, "alternative" labeling system requirements June 1, 2016. Since alternative labeling requirements may change in fewer than four years and employers must train employees to understand new label elements and the new SDS format by Dec. 13, 2013, voluntarily switching to the revised HCS labeling now likely will reduce costs over the long run and reduce confusion in the workplace.

The newly revised HCS outlines eight specific GHS pictograms for use on labels. Each is surrounded by a red border and designed to convey the health and physical hazards of chemicals. A ninth, environmental pictogram may be required by other agencies, but not by OSHA. Environmental hazards are not within OSHA's jurisdiction.

In addition to the new labeling requirements, chemical manufacturers now must supply customers with a GHS-standardized, sixteen-section SDS.

OSHA officials say the new changes provide "…a common and coherent approach to classifying chemicals and communicating hazard information on labels and SDSs." Once implemented, OSHA leaders believe the revised standard will improve the quality and consistency of hazard information in the workplace, making it safer for workers by providing easily understandable information on appropriate handling and safe use of hazardous chemicals.

This latest update, officials add, also will help reduce trade barriers and result in productivity improvements for American businesses that regularly handle, store, and use hazardous chemicals. Cost savings are also anticipated for American businesses that periodically update SDSs and labels for chemicals covered under the HCS.

Training

The following is taken from DOE-STD-6005-2001 (Archived).

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 a valuable resource 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 participating in activities such as inspecting worksites, identifying hazards, selecting work practice controls, and serving on worker protection committees.

DOE and contractor line management should ensure that cognizant line managers and supervisors are trained in

- the purpose and content of the worker protection program and their role in and responsibilities for implementing DOE-prescribed industrial hygiene requirements, including ensuring that employees follow established requirements and procedures for avoiding or minimizing exposures to occupational health hazards;
- recognition of occupational health hazards associated with the jobs assigned to employees working within their area of responsibility, the potential effects of those hazards on employee health, and the methods appropriate and required to control employee exposures; and
- the industrial hygiene components of the worker protection program.

DOE and contractor line management shall ensure that workers are trained in

- methods and observations that may be used to detect the presence of an occupational health hazard in the work area;.
- an understanding of the physical and health hazards of the chemicals, ergonomic stressors, and harmful physical and/or biological agents in the work area;
- measures that workers can take to protect themselves from these hazards, including use of engineering controls, specific procedures, or other controls;

- details of the chemical hazard communication, laboratory chemical hygiene plan, or hazardous waste operations and emergency response program(s) developed by DOE or the contractor; and
- details of any applicable operations or hazard-specific training programs.

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 thirty OSHA standards and proposed standards contain medical surveillance requirements. 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"

10 CFR 850.21, "HAZARD ASSESSMENT"
If the baseline inventory establishes the presence of beryllium, the responsible employer must conduct a beryllium hazard assessment that includes an analysis of existing conditions, exposure data, medical surveillance trends, and the exposure potential of planned activities. The exposure determinants, characteristics, and exposure potential of activities must be prioritized so that the activities with the greatest risks of exposure are evaluated first.

The responsible employer must ensure that

- the hazard assessment is managed by a qualified individual
- the individuals assigned to this task have sufficient knowledge and experience to perform such activities properly

10 CFR 850.24, "EXPOSURE MONITORING"
The responsible employer must ensure that

- exposure monitoring is managed by a qualified individual
- the individuals assigned to this task have sufficient industrial hygiene knowledge and experience to perform such activities properly

Initial monitoring—The responsible employer must perform initial monitoring in areas that may have airborne beryllium, as shown by the baseline inventory and hazard assessment. The responsible employer must apply statistically based monitoring strategies to obtain a sufficient number of sample results to adequately characterize exposures, before reducing or terminating monitoring.

- The responsible employer must determine workers' eight-hour TWA exposure levels by conducting personal breathing zone sampling.
- Exposure monitoring results obtained within the twelve months preceding the effective date of this part may be used to satisfy this requirement if the measurements were made as provided in 10 CFR 850.24.

Periodic exposure monitoring—The responsible employer must conduct periodic monitoring of workers who work in areas where airborne concentrations of beryllium are at or above the action level. The monitoring must be conducted in a manner and at a frequency necessary to represent workers' exposure, as specified in the Chronic Beryllium Disease Prevention Program (CBDPP). This periodic exposure monitoring must be performed at least every three months (quarterly).

Additional exposure monitoring—The responsible employer must perform additional monitoring if operations, maintenance, or procedures change, or when the responsible employer has any reason to suspect such a change has occurred.

Accuracy of monitoring—The responsible employer must use a method of monitoring and analysis that has an accuracy of not less than plus or minus 25 percent, with a confidence level of 95 percent, for airborne concentrations of beryllium at the action level.

Analysis—The responsible employer must have all samples collected to satisfy the monitoring requirements of this part analyzed in a laboratory accredited for metals by the

American Industrial Hygiene Association (AIHA) or a laboratory that demonstrates QA for metals analysis that is equivalent to AIHA accreditation.

Notification of monitoring results—The responsible employer must, within ten working days after receipt of any monitoring results, notify the affected workers of monitoring results in writing.

10 CFR 850. 28, "RESPIRATORY PROTECTION"
The responsible employer must establish a respiratory protection program that complies with the respiratory protection program requirements of 29 CFR 1910.134, "Respiratory Protection."

The responsible employer must provide respirators to, and ensure that they are used by, all workers who

- are exposed to an airborne concentration of beryllium at or above the action level
- are performing tasks for which analyses indicate the potential for exposures at or above the action level

The responsible employer must include in the respiratory protection program any beryllium-associated worker who requests to use a respirator for protection against airborne beryllium, regardless of measured exposure levels.

The responsible employer must select for use by workers

- respirators approved by NIOSH if NIOSH-approved respirators exist for a specific DOE task
- respirators that DOE has accepted under the DOE Respiratory Protection Acceptance Program if NIOSH-approved respirators do not exist for specific DOE tasks

10 CFR 850.29, "PROTECTIVE CLOTHING AND EQUIPMENT"
The responsible employer must provide protective clothing and equipment to beryllium workers and ensure its appropriate use and maintenance, where dispersible forms of beryllium may contact the worker's skin, enter openings in worker's skin, or contact worker's eyes, including the following:

- Exposure monitoring has established that airborne concentrations of beryllium are at or above the action level.
- Surface contamination levels measured or presumed prior to initiating work are above the level prescribed in 10 CFR 850.30, "Housekeeping."
- Surface contamination levels results obtained to confirm housekeeping efforts are above the level prescribed in 10 CFR 850.30.
- Any beryllium-associated worker who requests the use of protective clothing and equipment for protection against airborne beryllium, regardless of measured exposure levels.

The responsible employer must comply with 29 CFR 1910.132, "Personal Protective Equipment General Requirements," when workers use personal protective clothing and equipment.

The responsible employer must establish procedures for donning, doffing, handling, and storing protective clothing and equipment that

- prevent beryllium workers from exiting areas that contain beryllium with contamination on their bodies or their personal clothing
- include beryllium workers exchanging their personal clothing for full-body protective clothing and footwear before they begin work in regulated areas

The responsible employer must ensure that no worker removes beryllium-contaminated protective clothing and equipment from areas that contain beryllium, except for workers authorized to launder, clean, maintain, or dispose of the clothing and equipment.

The responsible employer must prohibit the removal of beryllium from protective clothing and equipment by blowing, shaking, or other means that may disperse beryllium into the air.

The responsible employer must ensure that protective clothing and equipment is cleaned, laundered, repaired, or replaced as needed to maintain effectiveness. The responsible employer must

- ensure that beryllium-contaminated protective clothing and equipment, when removed for laundering, cleaning, maintenance, or disposal, is placed in containers that prevent the dispersion of beryllium dust and that are labeled in accordance with 10 CFR 850.38, “Warning Signs and Labels”; and
- inform organizations that launder or clean DOE beryllium-contaminated protective clothing or equipment that exposure to beryllium is potentially harmful, and that clothing and equipment should be laundered or cleaned in a manner prescribed by the responsible employer to prevent the release of airborne beryllium.

10 CFR 850.30, “HOUSEKEEPING”

Where beryllium is present in operational areas of DOE facilities, the responsible employer must conduct routine surface sampling to determine housekeeping conditions. Surfaces contaminated with beryllium dusts and waste must not exceed a removable contamination level of 3 µg/100 cm^2 during non-operational periods. This sampling would not include the interior of installed closed systems such as enclosures, gloveboxes, chambers, or ventilation systems.

When cleaning floors and surfaces in areas where beryllium is present at DOE facilities, the responsible employer must clean beryllium-contaminated floors and surfaces using a wet method, vacuuming or other cleaning methods, such as sticky tack cloths, that avoid the production of airborne dust. Compressed air or dry methods must not be used for such cleaning.

The responsible employer must equip the portable or mobile vacuum units that are used to clean beryllium-contaminated areas with HEPA filters, and change the filters as often as needed to maintain their capture efficiency.

The responsible employer must ensure that the cleaning equipment that is used to clean beryllium-contaminated surfaces is labeled, controlled, and not used for nonhazardous materials.

10 CFR 850.34, "MEDICAL SURVEILLANCE"
The responsible employer must establish and implement a medical surveillance program for beryllium-associated workers who voluntarily participate in the program.

The responsible employer must designate a site occupational medical director (SOMD) who is responsible for administering the medical surveillance program.

The responsible employer must ensure that the medical evaluations and procedures are performed by, or under the supervision of, a licensed physician who is familiar with the health effects of beryllium.

The responsible employer must establish, and maintain, a list of beryllium-associated workers who may be eligible for protective measures. The list must be

- based on the hazard assessment, exposure records, and other information regarding the identity of beryllium-associated workers; and
- adjusted at regular intervals based on periodic evaluations of beryllium-associated workers.

The responsible employer must provide the SOMD with the information needed to operate and administer the medical surveillance program, including the

- list of beryllium-associated workers;
- baseline inventory;
- hazard assessment and exposure monitoring data;
- identity and nature of activities or operations on the site that are covered under the CBDPP, related duties of beryllium-associated workers; and
- type of PPE used.

The responsible employer must provide the following information to the SOMD and the examining physician:

- A copy of this rule and its preamble
- A description of the worker's duties as they pertain to beryllium exposure
- Records of the worker's beryllium exposure
- A description of the personal protective and respiratory protective equipment used by the worker in the past, present, or anticipated future use

Medical evaluations and procedures—The responsible employer must provide, to beryllium-associated workers who voluntarily participate in the medical surveillance program, the medical evaluations and procedures at no cost and at a time and place that is reasonable and convenient to the worker.

Baseline medical evaluation—The responsible employer must provide a baseline medical evaluation to beryllium-associated workers. This evaluation must include

- a detailed medical and work history with emphasis on past, present, and anticipated future exposure to beryllium;
- a respiratory symptoms questionnaire;
- a physical examination with special emphasis on the respiratory system, skin, and eyes;

- a chest radiograph interpreted by a NIOSH B-reader of pneumoconiosis or a board-certified radiologist;
- spirometry consisting of forced vital capacity and forced expiratory volume at one second;
- a beryllium lymphocyte proliferation test; and
- any other tests deemed appropriate by the examining physician for evaluating beryllium-related health effects.

Periodic evaluation—The responsible employer must provide to beryllium workers a medical evaluation annually, and to other beryllium-associated workers a medical evaluation every three years. The periodic medical evaluation must include

- a detailed medical and work history with emphasis on past, present, and anticipated future exposure to beryllium;
- a respiratory symptoms questionnaire;
- a physical examination with emphasis on the respiratory system;
- a beryllium lymphocyte proliferation test; and
- any other medical evaluations deemed appropriate by the examining physician for evaluating beryllium-related health effects.

The responsible employer must provide to beryllium-associated workers a chest radiograph every five years.

Emergency evaluation—The responsible employer must provide a medical evaluation as soon as possible to any worker who may have been exposed to beryllium because of a beryllium emergency. The medical evaluation must include the requirements of 10 CFR 850.34.

Multiple physician review—The responsible employer must establish a multiple physician review process for beryllium-associated workers that allows for the review of initial medical findings, determinations, or recommendations from any medical evaluation conducted pursuant to 10 CFR 850.34.

If the responsible employer selects the initial physician to conduct any medical examination or consultation provided to a beryllium-associated worker, the worker may designate a second physician to

- review any findings, determinations, or recommendations of the initial physician; and
- conduct such examinations, consultations and laboratory tests, as the second physician deems necessary to facilitate this review.

The responsible employer must promptly notify a beryllium-associated worker in writing of the right to seek a second medical opinion after the initial physician provided by the responsible employer conducts a medical examination or consultation.

The responsible employer may condition its participation in, and payment for, multiple physician review upon the beryllium-associated worker doing the following within fifteen days after receipt of the notice, or receipt of the initial physician's written opinion, whichever is later:

- Informing the responsible employer in writing that he or she intends to seek a second medical opinion
- Initiating steps to make an appointment with a second physician

If the findings, determinations, or recommendations of the second physician differ from those of the initial physician, then the responsible employer and the beryllium-associated worker must make efforts to encourage and assist the two physicians to resolve any disagreement.

If, despite the efforts of the responsible employer and the beryllium-associated worker, the two physicians are unable to resolve their disagreement, then the responsible employer and the worker, through their respective physicians, must designate a third physician to

- review any findings, determinations, or recommendations of the other two physicians; and
- conduct such examinations, consultations, laboratory tests, and consultations with the other two physicians, as the third physician deems necessary to resolve the disagreement among them.

The SOMD must act consistently with the findings, determinations, and recommendations of the third physician, unless the SOMD and the beryllium-associated worker reach an agreement that is consistent with the recommendations of at least one of the other two physicians.

Alternate physician determination—The responsible employer and the beryllium-associated worker or the worker's designated representative may agree upon the use of any alternate form of physician determination in lieu of the multiple physician review process, so long as the alternative is expeditious and at least as protective of the worker.

Written medical opinion and recommendation—Within two weeks of receipt of results, the SOMD must provide to the responsible employer a written, signed medical opinion for each medical evaluation performed on each beryllium-associated worker. The written opinion must take into account the findings, determinations, and recommendations of the other examining physicians who may have examined the beryllium-associated worker. The SOMD's opinion must contain

- the diagnosis of the worker's condition relevant to occupational exposure to beryllium, and any other medical condition that would place the worker at increased risk of material impairment to health from further exposure to beryllium;
- any recommendation for removal of the worker from DOE beryllium activities, or limitation on the worker's activities or duties or use of PPE, such as a respirator; and
- a statement that the SOMD or examining physician has clearly explained to the worker the results of the medical evaluation, including all tests results and any medical condition related to beryllium exposure that requires further evaluation or treatment.

The SOMD's written medical opinion must not reveal specific records, findings, and diagnoses that are not related to medical conditions that may be affected by beryllium exposure.

Information provided to the beryllium-associated worker—The SOMD must provide each beryllium-associated worker with a written medical opinion containing the results of all medical tests or procedures, an explanation of any abnormal findings, and any recommendation that the worker be referred for additional testing for evidence of chronic beryllium disease (CBD), within ten working days after the SOMD's receipt of the results of the medical tests or procedures.

The responsible employer must, within thirty days after a request by a beryllium-associated worker, provide the worker with the information the responsible employer is required to provide the examining physician under paragraph (a)(6) of this section.

Reporting—The responsible employer must report on the applicable OSHA reporting form beryllium sensitization, CBD, or any other abnormal condition or disorder of workers caused or aggravated by occupational exposure to beryllium.

Data analysis—The responsible employer must routinely and systematically analyze medical, job, and exposure data with the aim of identifying individuals or groups of individuals potentially at risk for CBD and working conditions that are contributing to that risk.

The responsible employer must use the results of these analyses to identify additional workers to whom the responsible employer must provide medical surveillance and to determine the need for additional exposure controls.

10 CFR 850.37, "TRAINING AND COUNSELING"
The responsible employer must develop and implement a beryllium training program and ensure participation for

- beryllium-associated workers
- all other individuals who work at a site where beryllium activities are conducted

The training provided for workers must

- be in accordance with 29 CFR 1910.1200
- include the contents of the CBDPP
- include potential health risks to beryllium worker family members and others who may come in contact with beryllium on beryllium workers or beryllium workers' personal clothing or other personal items as the result of a beryllium control failure at a DOE facility

The training provided for workers must consist of general awareness about beryllium hazards and controls.

The responsible employer must provide the training required by this section before or at the time of initial assignment and at least every two years thereafter.

The employer must provide retraining when the employer has reason to believe that a beryllium worker lacks the proficiency, knowledge, or understanding needed to work safely with beryllium, including at least the following situations:

- To address any new beryllium hazards resulting from a change to operations, procedures, or beryllium controls about which the beryllium worker was not previously trained
- If a beryllium worker's performance involving beryllium work indicates that the worker has not retained the requisite proficiency

The responsible employer must develop and implement a counseling program to assist beryllium-associated workers who are diagnosed by the SOMD to be sensitized to beryllium or to have CBD. This counseling program must include communicating with beryllium-associated workers concerning

- the medical surveillance program provisions and procedures;
- medical treatment options;
- medical, psychological, and career counseling;
- medical benefits;
- administrative procedures and workers' rights under applicable workers' compensation laws and regulations;
- work practice procedures limiting beryllium-associated worker exposure to beryllium; and
- the risk of continued beryllium exposure after sensitization.

10 CFR 850.39, "RECORDKEEPING AND USE OF INFORMATION"

The responsible employer must establish and maintain accurate records of all beryllium inventory information, hazard assessments, exposure measurements, exposure controls, and medical surveillance.

Heads of DOE departmental elements must

- designate all record series as required under this rule as agency records and, therefore, subject to all applicable agency records management and access laws; and
- ensure that these record series are retained for a minimum of seventy-five years.

The responsible employer must convey to DOE or its designee all record series required under this rule if the employer ceases to be involved in the CBDPP.

The responsible employer must link data on workplace conditions and health outcomes in order to establish a basis for understanding the beryllium health risk.

The responsible employer must ensure the confidentiality of all work-related records generated under this rule by ensuring that

- all records that are transmitted to other parties do not contain names, social security numbers or any other variables, or combination of variables, that could be used to identify particular individuals; and
- individual medical information generated by the CBDPP is
    - either included as part of the worker's site medical records and maintained by the SOMD, or is maintained by another physician designated by the responsible employer;
    - maintained separately from other records; and
    - used or disclosed by the responsible employer only in conformance with any applicable requirements imposed by the Americans with Disabilities Act, the

Privacy Act of 1974, the Freedom of Information Act, and any other applicable law.

The responsible employer must maintain all records required by this part in current and accessible electronic systems, which include the ability readily to retrieve data in a format that maintains confidentiality.

The responsible employer must transmit all records generated as required by this rule, in a format that protects the confidentiality of individuals, to the DOE chief Health, Safety and Security officer on request.

The responsible employer must semi-annually transmit to the Office of Domestic and International Health Studies, Office of Environment, Health, Safety and Security an electronic registry of beryllium-associated workers that protects confidentiality, and the registry must include, but is not limited to, a unique identifier, date of birth, gender, site, job history, medical screening test results, exposure measurements, and results of referrals for specialized medical evaluations.

10 CFR 851, "Worker Safety and Health Program"

10 CFR 851.21, "HAZARD IDENTIFICATION AND ASSESSMENT"
Contractors must establish procedures to identify existing and potential workplace hazards and assess the risk of associated workers injury and illness. Procedures must include methods to

- assess worker exposure to chemical, physical, biological, or safety workplace hazards through appropriate workplace monitoring;
- document assessment for chemical, physical, biological, and safety workplace hazards using recognized exposure assessment and testing methodologies and using of accredited and certified laboratories;
- record observations, testing, and monitoring results;
- analyze designs of new facilities and modifications to existing facilities and equipment for potential workplace hazards;
- evaluate operations, procedures, and facilities to identify workplace hazards;
- perform routine job activity-level hazard analyses;
- review site safety and health experience information; and
- consider interaction between workplace hazards and other hazards such as radiological hazards.

Contractors must submit to the head of DOE field element a list of closure facility hazards and the established controls within 90 days after identifying such hazards. The head of DOE field element, with concurrence by the CSO, has 90 days to accept the closure facility hazard controls or direct additional actions to either

- achieve technical compliance
- provide additional controls to protect the workers

Contractors must perform the activities identified in 10 CFR 851.21, initially to obtain baseline information and as often thereafter as necessary to ensure compliance with the requirements.

10 CFR 851.25, "TRAINING AND INFORMATION"
Contractors must develop and implement a worker safety and health training and information program to ensure that all workers exposed or potentially exposed to hazards are provided with the training and information on that hazard in order to perform their duties in a safe and healthful manner.

The contractor must provide

- training and information for new workers, before or at the time of initial assignment to a job involving exposure to a hazard;
- periodic training as often as necessary to ensure that workers are adequately trained and informed; and
- additional training when safety and health information or a change in workplace conditions indicates that a new or increased hazard exists.

Contractors must provide training and information to workers who have worker safety and health program responsibilities that is necessary for them to carry out those responsibilities.

10 CFR 851.26, "RECORDKEEPING AND REPORTING"
Contractors must

- establish and maintain complete and accurate records of all hazard inventory information, hazard assessments, exposure measurements, and exposure controls;
- ensure that the work-related injuries and illnesses of its workers and subcontractor workers are recorded and reported accurately;
- comply with the applicable occupational injury and illness recordkeeping and reporting workplace safety and health standards; and
- not conceal or destroy any information concerning noncompliance or potential noncompliance with the requirements.

Reporting and investigation. Contractors must

- report and investigate accidents, injuries and illness; and
- analyze related data for trends and lessons learned.

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.

29 CFR 1910.1200 requires chemical manufacturers or importers to classify the hazards of chemicals that they produce or import, and all employers to provide information to their employees about the hazardous chemicals to which they are exposed, by means of a hazard communication program, labels and other forms of warning, SDSs, and information and training. In addition, 29 CFR 1910.1200 requires distributors to transmit the required information to employers.

29 CFR 1910.1200 applies to any chemical that is known to be present in the workplace in such a manner that employees may be exposed under normal conditions of use or in a foreseeable emergency.

29 CFR 1910.1200 applies to laboratories only as follows:

- Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.
- Employers shall maintain any SDSs that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible during each work shift to laboratory employees when they are in their work areas.
- Employers shall ensure that laboratory employees are provided information and training.
- Laboratory employers who ship hazardous chemicals are considered to be either a chemical manufacturer or a distributor under this rule, and thus must ensure that any containers of hazardous chemicals leaving the laboratory are labeled in accordance with 29 CFR 1910.1200, and that an SDS is provided to distributors and other employers.

In work operations where employees only handle chemicals in sealed containers which are not opened under normal conditions of use (such as are found in marine cargo handling, warehousing, or retail sales), this section applies to these operations only as follows:

- Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.
- Employers shall maintain copies of any SDSs that are received with incoming shipments of the sealed containers of hazardous chemicals, shall obtain a SDS as soon as possible for sealed containers of hazardous chemicals received without a SDS if an employee requests the SDS, and shall ensure that the SDSs are readily accessible during each work shift to employees when they are in their work area(s).
- Employers shall ensure that employees are provided with information and training to the extent necessary to protect them in the event of a spill or leak of a hazardous chemical from a sealed container.

Video 20. Hazard communication program—GHS
https://www.youtube.com/watch?v=71CwaDQ1V3g

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 29 CFR 1910.133.

The employer shall ensure that each affected employee uses appropriate eye or face protection when exposed to eye or face hazards from flying particles, molten metal, liquid chemicals, acids or caustic liquids, chemical gases or vapors, or potentially injurious light radiation.

The employer shall ensure that each affected employee uses eye protection that provides side protection when there is a hazard from flying objects. Detachable side protectors (e.g., clip-on or slide-on side shields) meeting the pertinent requirements of this section are acceptable.

The employer shall ensure that each affected employee who wears prescription lenses while engaged in operations that involve eye hazards wears eye protection that incorporates the prescription in its design, or wears eye protection that can be worn over the prescription lenses without disturbing the proper position of the prescription lenses or the protective lenses.

Eye and face PPE shall be distinctly marked to facilitate identification of the manufacturer.

The employer shall ensure that each affected employee uses equipment with filter lenses that have a shade number appropriate for the work being performed for protection from injurious light radiation.

Ear Protection

The following is taken from U.S. Department of Labor, *Occupational Noise Exposure.*

An effective hearing conservation program must be implemented by employers in general industry whenever worker noise exposure is equal to or greater than 85 dBA for an eight-hour exposure or in the construction industry when exposures exceed 90 dBA for an eight-hour exposure. This program strives to prevent initial occupational hearing loss, preserve and protect remaining hearing, and equip workers with the knowledge and hearing protection devices necessary to protect them. Key elements of an effective hearing conservation program include

- workplace noise sampling, including personal noise monitoring that identifies which employees are at risk from hazardous levels of noise;
- informing workers at risk from hazardous levels of noise exposure of the results of their noise monitoring;
- providing affected workers or their authorized representatives with an opportunity to observe any noise measurements conducted;
- maintaining a worker audiometric testing program (hearing tests) which is a professional evaluation of the health effects of noise upon individual worker's hearing;
- implementing comprehensive hearing protection follow-up procedures for workers who show a loss of hearing (standard threshold shift) after completing baseline (first) and yearly audiometric testing;
- proper selection of hearing protection based on individual fit and manufacturer's quality testing indicating the likely protection that they will provide to a properly trained wearer;
- evaluate the hearing protectors attenuation and effectiveness for the specific workplace noise;
- training and information that ensures the workers are aware of the hazard from excessive noise exposures and how to properly use the protective equipment that has been provided; and

- data management of and worker access to records regarding monitoring and noise sampling.

Protective Clothing/Gloves
The following is taken from 29 CFR 1910.138.

Employers shall select and require employees to use appropriate hand protection when employees' hands are exposed to hazards such as those from skin absorption of harmful substances; severe cuts or lacerations; severe abrasions; punctures; chemical burns; thermal burns; and harmful temperature extremes.

Employers shall base the selection of the appropriate hand protection on an evaluation of the performance characteristics of the hand protection relative to the task(s) to be performed, conditions present, duration of use, and the hazards and potential hazards identified.

Respiratory Protection
The following is taken from 29 CFR 1910.134.

A respirator shall be provided to each employee when such equipment is necessary to protect the health of such employee. The employer shall provide the respirators that are applicable and suitable for the purpose intended. The employer shall be responsible for the establishment and maintenance of a respiratory protection program, which shall include the requirements outlined in 29 CFR 1910.134. The program shall cover each employee required to use a respirator.

29 CFR 1910.134 requires the employer to develop and implement a written respiratory protection program with required worksite-specific procedures and elements for required respirator use. The program must be administered by a suitably trained program administrator. In addition, certain program elements may be required for voluntary use to prevent potential hazards associated with the use of the respirator. The employer shall include in the program the following provisions, as applicable:

- Procedures for selecting respirators for use in the workplace
- Medical evaluations of employees required to use respirators
- Fit testing procedures for tight-fitting respirators
- Procedures for proper use of respirators in routine and reasonably foreseeable emergency situations
- Procedures and schedules for cleaning, disinfecting, storing, inspecting, repairing, discarding, and otherwise maintaining respirators
- Procedures to ensure adequate air quality, quantity, and flow of breathing air for atmosphere-supplying respirators
- Training of employees in the respiratory hazards to which they are potentially exposed during routine and emergency situations
- Training of employees in the proper use of respirators, including putting on and removing them, any limitations on their use, and their maintenance
- Procedures for regularly evaluating the effectiveness of the program

17. Personnel shall demonstrate a familiarity level knowledge of DOE O 422.1, Admin Chg 2, *Conduct of Operations,* and the principles of conduct of operations, and relate these principles to an operational environment.

a. Discuss the purpose of DOE O 422.1, Admin Chg 2*.*

The objective of DOE O 422.1, Admin Chg 2 is to define the requirements for establishing and implementing conduct of operations (CONOPS) programs at DOE/NNSA facilities and projects. A CONOPS program consists of formal documentation, practices, and actions implementing disciplined and structured operations that support mission success and promote worker, public, and environmental protection. The goal is to minimize the likelihood and consequences of human fallibility or technical and organizational system failures. CONOPS is one of the safety management programs recognized in 10 CFR 830, but it also supports safety and mission success for a wide range of hazardous, complex, or mission-critical operations, and some CONOPS attributes can enhance even routine operations. It supports the ISM system by providing concrete techniques and practices to implement the ISM core functions to develop and implement hazard controls and perform work within controls. It may be implemented through facility policies, directives, plans, and SMSs and need not be a stand-alone program.

The term "operations" encompasses the work activities of any facility or organization, from building infrastructure, to print shops and computer centers, to scientific research, and to nuclear facilities. While many hazards can be dealt with through engineered solutions, people still have to perform operations, and they can and do make mistakes. The purpose of this 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.

b. State the eighteen requirement areas in Attachment 2 of DOE O 422.1, Admin Chg 2, and discuss how each requirement contributes to an effective and safe operational environment.

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

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:

- Prompt notification to operating personnel and supervisors of changes in 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

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

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
- AC 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

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 event

Investigation of Abnormal Events, Conditions, and Trends, DOE-STD-1045-93, Chg 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

Notifications, DOE-STD-1045-93, Chg 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

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 (LOTO) for AC of equipment status
- 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

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 LOTO for the protection of personnel:

- Procedures, roles and responsibilities associated with the development, mentation, review, installation, and removal of a LOTO
- Compliance with OSHA rules, 29 CFR 1910 and/or 29 CFR 1926, requirements for the protection of workers using LOTO
- Compliance with NFPA standard 70E electrical safety requirements using LOTO
- Description and control of the tags, locks, lockboxes, chains, and other components utilized for the LOTO program
- Training and qualification in LOTO 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

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:

- SSCs, 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

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

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

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
- Operator training and qualification to understand interrelated processes, to interpret instrument readings, and provide timely corrective action for process-related problems
- Establish lines of communication between operating personnel, process support personnel, and other interrelated process operators for coordination of activities

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

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

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, detail 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 and revisions
- 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)

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
- AC of installed operational aids
- Periodic review for adequacy and correctness

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
- AC 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 231.1B, Chg 1, *Environment, Safety, and Health Reporting***
- **DOE O 433.1B, Admin Chg 1, *Maintenance Management Program for DOE Nuclear Facilities***
- **DOE O 414.1D, Admin Chg 1, *Quality Assurance***

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, Admin Chg 1, 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 for maintenance and the reliable performance of 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 assure themselves of proper equipment operation before authorizing its return to service after maintenance, testing, or emergency/abnormal event.

DOE O 414.1D, Admin Chg 1, 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.

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

The following is taken from Oak Ridge Associated Universities, *Conduct of Operations Training Course,* "Lesson—Investigation and Notifications."

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, Admin Chg 1, *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.

The following is taken for DOE-NE-STD-1004-92.

A root cause is the cause that, if corrected, would prevent recurrence of this and similar occurrences. The root cause does not apply to this occurrence only, but has generic implications to a broad group of possible occurrences, and it is the most fundamental aspect of the cause that can logically be identified and corrected. There may be a series of causes that can be identified, one leading to another.

This series should be pursued until the fundamental, correctable cause has been identified. For example, in the case of a leak, the root cause could be management not ensuring that maintenance is effectively managed and controlled. This cause could have led to the use of improper seal material or missed preventive maintenance on a component, which ultimately led to the leak. In the case of a system misalignment, the root cause could be a problem in the training program, leading to a situation in which operators are not fully familiar with control room procedures and are willing to accept excessive distractions.

Video 21. 5 Whys-root cause analysis
https://www.youtube.com/watch?v=v7M1Gs951Jk

f. Define the term "lessons learned" and explain their importance in operational safety.

The following is taken from DOE Office of Health, Safety, and Security, *DOE Lessons Learned.*

Since the DOE Corporate Lessons Learned Information Services was put into production in 1995, several commercial companies and educational institutions have been very interested in using the DOE system within their own organizations. Companies that have received copies of the lessons learned database include Motorola, Sprint, Marathon Oil, and others. Spokespersons from these organizations indicate there is significant value-added to having a lessons learned program and consider DOE's implementation an excellent starting point for their own systems.

Within DOE, lessons learned programs have been instrumental in aiding training and work planning organizations to improve the knowledge and work performance of DOE workers and managers. Many DOE sites have robust internal lessons learned programs and dedicated lessons learned program managers or advocates. Lessons learned programs are an important component of ISM in that they feed back learned experiences and good practices into the overall work process while warning organizations of adverse work practices or experiences. The results include improved safety performance, reduced worker injuries and exposures, and reduced property damage.

g. Describe stop work authority and the role of personnel in its application.

The following is taken from the *DOE Worker's Right.*

10 CFR 851 states that contractors must establish procedures to permit workers to stop work or decline to perform an assigned task because of a reasonable belief that the task poses an imminent risk of death, serious physical harm, or other serious hazard to workers when the workers believe there is insufficient time to utilize normal procedures.

10 CFR 851 also states that workers have the right, without reprisal, to stop work when the worker discovers employee exposures to imminently dangerous conditions or other serious hazards, provided that any stop work authority must be exercised in a justifiable and responsible manner in accordance with procedures established in the approved worker safety and health program.

h. Describe the key elements of a lockout/tagout system.

The following is taken from DOE O 422.1, Admin Chg 2.

The operator must establish and implement operations practices that address the following elements for the installation and removal of LOTOs for the protection of personnel:

- Procedures, roles and responsibilities associated with the development, documentation, review, installation, and removal of a LOTO
- Compliance with 29 CFR 1910 and/or 29 CFR 1926, requirements for the protection of workers using LOTO
- Compliance with NFPA 70E electrical safety requirements using LOTO
- Description and control of the tags, locks, lockboxes, chains, and other components utilized for the LOTO program
- Training and qualification in LOTO 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

18. Personnel shall demonstrate a familiarity level knowledge of DOE O 231.1B, Chg 1, *Environment, Safety, and Health Reporting,* and DOE O 232.2, Chg 1, *Occurrence Reporting and Processing of Operations Information.*

a. State the purpose of DOE O 231.1B, Chg 1.

The purpose of DOE O 231.1B, Chg 1 is to ensure DOE/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. This will be accomplished through timely collection, reporting, analysis, and dissemination of data pertaining to ES&H issues as required by law, or regulations, or in support of United States political commitments to the AEA.

b. Define the following terms:

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

The following definitions are taken from DOE O 232.2, Chg 1.

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 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, Chg 1.

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, Chg 1.

Facility Representative
For each major facility or group of lesser facilities, an individual or designee assigned responsibility by the head of field element/operations organization 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 (SO)/deputy administrator (NNSA) and head of field element/operations organization for implementing the requirements of DOE O 232.2, Chg 1.

c. Discuss the occurrence-reporting responsibilities of a facility representative.

The following is taken from DOE O 232.2, Chg 1.

Facility representatives 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, Chg 1
- 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 following is taken from DOE O 232.2, Chg 1.

General

Significance categories (SCs) provide a means to reflect perceived risk associated with a given occurrence. Risk determinations take into consideration the potential consequence of an occurrence in terms of health, safety, and security to personnel, the public, the environment, and the operational mission.

Operational emergency (OE) or SC-1 occurrences reflect management's judgment that circumstances pose an immediate or near-term potential for harm unless promptly mitigated or that the occurrence meets reporting thresholds established by other regulatory requirements. Occurrences below OE or SC-1 require assessment and mitigation to prevent or mitigate adverse consequences, but are not as time-sensitive as OEs or SC-1s. Occurrences at the lower levels, SC-3 and SC-4, reflect situations that require analysis and learning to generate measured actions to prevent potential future consequences.

Operational Emergency

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. OEs are the most serious occurrences and require an increased alert status for onsite personnel and, in specified cases, for offsite authorities.

Significance Category 1

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

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
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
Events or circumstances that were mitigated or contained by normal operating practices, but where reporting provides potential learning opportunities for others.

Significance Category R
Recurring 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.

The following is taken from DOE O 232.2, Chg 1.

The ten major groups of categorized occurrences are as follows:
- Group 1—OEs
- 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

19. Personnel shall demonstrate a familiarity level knowledge of 10 CFR 830 Subpart A, "Quality Assurance Requirements," and DOE O 414.1D, Chg 1, *Quality Assurance.*

a. Discuss the objectives and applicability of the DOE quality requirements, including the relationship between 10 CFR 830 Subpart A and DOE O 414.1D, Chg 1, 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 includes the following:
- 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 O 414.1D.

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, “Exclusions.”

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 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 American Society of Mechanical Engineers, (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 414.1D, Chg 1, *Quality Assurance,* including the Federal responsibilities and the 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 10 CFR 830.

A contractor responsible for a nuclear facility must ensure implementation of, and compliance with, the requirements of 10 CFR 830.

The requirements of 10 CFR 830 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 10 CFR 830.

10 CFR 830, Subpart A, "Quality Assurance Requirements"
10 CFR 830, Subpart A establishes QA requirements for contractors conducting activities, including providing items or services, that affect, or may affect, nuclear safety of DOE nuclear facilities.

DOE O 414.1D, Chg 1, Quality Assurance
The purpose of DOE O 414.1D includes the following:

- 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 O 414.1D.

DOE O 414.1D, CHG 1, 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, Chg 1, Attachment 2, as well as the requirements in DOE O 414.1D, Chg 1, Attachment 3, for all facilities, and for nuclear facilities, the requirements in DOE O 414.1D, Chg 1, 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, Chg 1 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-1150-2013, *DOE Standard: Quality Assurance Functional Area Qualification Standard.*

Federal personnel directly responsible for oversight of safety software quality assurance (SSQA) activities of defense nuclear facilities must be qualified in accordance with DOE STD-1172-2011, *DOE Standard: Safety Software Quality Assurance Functional Area Qualification Standard*.

c. Describe, in general terms, the content and objectives of the quality assurance criteria in the following categories, as found in DOE O 414.1D, Chg 1:
- **Management**
- **Performance**
- **Assessment**

The following is taken from DOE G 414.1-2B, Chg 2.

Management

DOE O 414.1D, Chg 1, and 10 CFR 830, Subpart A require that an organization develop, document, implement, and maintain an effective QAP. The goal of the QAP is delivery of safe, reliable products and services that meet or exceed the customer's requirements, needs, and expectations. The QAP is defined as the overall program or management system established to assign responsibilities and authorities, define policies and requirements, and provide for the performance and assessment of work. Defining the proper structure for the organization and the management processes necessary to conduct work within the organization is critical to ensure that work can be controlled and conducted safely. This allows the organization to efficiently conduct work safely, as well as meeting or exceeding applicable requirements and expectations.

Performance

Work should be performed consistent with technical standards, ACs, and hazard controls adopted to meet regulatory or contract requirements using approved instructions, procedures, or other appropriate means. Work processes consist of a series of actions planned and carried out by qualified personnel using approved procedures, instructions, and equipment under administrative, technical, and environmental controls to achieve a result.

Assessment

DOE O 414.1D, Chg 1, and 10 CFR 830, Subpart A require that managers assess their management processes, and identify and correct problems that hinder the organization from achieving its objectives. Assessments should promote continuous improvement and ensure that the organization's performance is acceptable.

d. Discuss the quality requirements in the following attachments (and their supporting implementing guides) of DOE O 414.1D, Chg 1, 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 414.1-2B, Chg 2, *Quality Assurance Program Guide***
- **Attachment 4, "Safety Software Quality Requirements for Nuclear Facilities," 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***

Attachment 3, "Suspect/Counterfeit Items Prevention"

The organization's QAP must address 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 HSS.
- Provide for training and informing managers, supervisors, and workers on S/CI processes and controls.
- Prevent introduction of S/CIs into DOE work.
- Include processes for inspection, identification, evaluation, and disposition of S/CIs that have been installed in safety applications and other applications that create potential hazard—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.
- 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.

DOE G 414.1-2B, Chg 2, Quality Assurance Program Guide

DOE G 414.1-2B, Chg 2 provides information on principles, requirements, and practices used to establish and implement an effective QAP for non-nuclear and nuclear facilities consistent with the requirements of DOE O 414.1D and 10 CFR 830, Subpart A.

An organization may select alternative methods to document and implement its QAP as long as the QA regulatory requirements in 10 CFR 830, Subpart A, and the additional QA requirements in DOE O 414.1D, Chg 1 are satisfied for nuclear facilities, and all QA requirements in DOE O 414.1D, Chg 1 are satisfied for non-nuclear facilities.

The content of the QAP should be based on an organization's unique set of responsibilities, products and services, hazards, and customer expectations.

Throughout DOE G 414.1-2B, Chg 2, when the 10 CFR 830, Subpart A is mentioned, the QA requirements pertain to nuclear facilities/work only. DOE O 414.1D, Chg 1 also contains requirements that are not found in 10 CFR 830, Subpart A (i.e., S/CI and SSQA). The S/CI requirements are applicable to nuclear and non-nuclear work. The SSQA requirements are only applicable to nuclear facilities or nuclear work.

Attachment 4, "Safety Software Quality Requirements for Nuclear Facilities"

Safety software must be acquired, developed and implemented using ASME NQA-1-2008 with the NQA-1a-2009 addenda or other national or international consensus standards that provide an equivalent level of QA requirements as NQA-1-2008. DOE-approved QAPs applicable to safety software based on requirements from DOE O 414.1D are acceptable. The standards used must be specified by the user and approved by the designated DOE approval authority. 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 (including inspection and testing); 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. Grading levels must be submitted to and approved by the responsible DOE approval authority.
- Using the consensus standard selected and the grading levels established and approved, select and implement applicable SSQA work activities.

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

DOE promulgated the safety software requirements and DOE G 414.1-4 to control or eliminate the hazards and associated postulated accidents posed by nuclear operations, including radiological operations. Safety software failures or unintended output can lead to unexpected system or equipment failures and undue risks to the DOE/NNSA mission, the environment, the public, and the workers. Thus, DOE G 414.1-4 has been developed to provide guidance on establishing and implementing effective QA processes tied specifically to nuclear facility safety software applications. DOE also has guidance for the overarching QAP, which includes safety software within its scope. DOE G 414.1-4 includes software application practices covered by appropriate national and international consensus standards and various processes currently in use at DOE facilities. This guidance is also considered to be of sufficient rigor and depth to ensure acceptable reliability of safety software at DOE nuclear facilities.

DOE G 414.1-4 should be used by organizations to help determine and support the steps necessary to address possible design or functional implementation deficiencies that might exist and to reduce operational hazards-related risks to an acceptable level. Attributes such as the facility life-cycle stage and the hazardous nature of each facility's operations should be considered when using DOE G 414.1-4. Alternative methods to those described in DOE G 414.1-4 may be used provided they result in compliance with the requirements of 10 CFR 830, Subpart A and DOE O 414.1D, Chg 1.

Another objective of DOE G 414.1-4 is to encourage robust software quality methods to enable the development of high quality safety applications.

e. Describe the Federal responsibilities for review, approval, and oversight of contractor quality assurance programs developed under 10 CFR 830, Subpart A, and DOE O 414.1D, Chg 1.

The following is taken from 10 CFR 830.121.

The contractor responsible for a DOE nuclear facility must

- 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 quality assurance requirements; and
- conduct work in accordance with the QAP.

The QAP must

- describe how the QA criteria of 10 CFR 830.122, "Quality Assurance Criteria" 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; and
- describe how the contractor responsible for the nuclear facility ensures that subcontractors and suppliers satisfy the criteria of 10 CFR 830.122.

20. Personnel shall demonstrate a familiarity level knowledge of DOE O 151.1C, *Comprehensive Emergency Management System*, and its implementing guides.

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***

- **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"
The following is taken from 10 CFR 830.1.

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.

The following is taken from 10 CFR 830.4.

No person may take or cause to be taken any action inconsistent with the requirements of 10 CFR 830.

A contractor responsible for a nuclear facility must ensure implementation of, and compliance with, the requirements of 10 CFR 830.

The requirements of 10 CFR 830 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 10 CFR 830.

29 CFR 1910.120, "Hazardous Waste Operations and Emergency Response"
29 CFR 1910.120 covers the following operations:

- 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
- 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 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

DOE O 151.1C, Comprehensive Emergency Management
The objectives of DOE 151.1C are to perform the following:

- 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/NNSA.

- Establish requirements for comprehensive planning, preparedness, response, and recovery activities of emergency management programs or for organizations requiring DOE/NNSA assistance.
- Describe an approach to effectively integrate planning, preparedness, response, and recovery activities for a comprehensive, all-emergency management concept.
- Integrate public information and emergency planning to provide accurate, candid, and timely information to site workers and the public during all emergencies.
- 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.
- Ensure that the DOE is ready to respond promptly, efficiently, and effectively to any emergency involving DOE/NNSA facilities, activities, or operations, or requiring DOE/NNSA assistance.
- Integrate applicable policies and requirements, including those promulgated by other Federal agencies (e.g., stockpiling stable iodine for possible distribution as a radiological protective prophylaxis) and interagency emergency plans into the Department's. In compliance with the statutory requirements in 42 USC 7274k, DOE hereby finds that DOE O 151.1C is necessary for the fulfillment of current legal requirements and conduct of critical administrative functions.
- Eliminate duplication of emergency management effort within the Department.

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 that

- the Department can respond effectively and efficiently to operational emergencies 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; and
- reentry activities are properly and safely accomplished, and recovery and post-emergency activities commence properly.

DOE G 151.1-1A, Emergency Management Fundamentals and the Operational Emergency Base Program: Emergency Management Guide

The overall mission of DOE emergency management is to be ready to respond promptly, efficiently, and effectively to any emergency involving or affecting DOE facilities/sites or activities by applying the necessary resources to mitigate the consequences and protect workers, the public, the environment, and national security. The DOE "comprehensive" emergency management system provides a framework within which to address all hazards, from natural phenomena to terrorist attacks, and all of the components of an effective emergency management program. The standard components of a DOE emergency management program are planning, preparedness, readiness assurance, response, and recovery.

The majority of specific requirements related to the release of hazardous materials promulgated in DOE O 151.1C are intentionally non-prescriptive due to the wide variety of operations and activities conducted by DOE/NNSA and its contractors, and the broad range of associated hazards. DOE O 151.1C requires that facility/site or activity emergency management programs be developed commensurate with the hazards at that particular facility/site or activity. To assist facilities/sites and activities in implementing the Order requirements, DOE/NNSA has developed DOE G 151.1-1A.

DOE G 151.1-2, Technical Planning Basis: Emergency Management Guide

The purpose of DOE G 151.1-2 is to assist DOE/NNSA field elements in complying with the DOE O 151.1C requirement that a hazards survey be prepared, maintained, and used for emergency planning purposes. DOE O 151.1C requires that emergency management efforts begin with the identification and qualitative assessment of the facility- or site-specific hazards and the associated emergency conditions that may require response, and that the scope and extent of emergency planning and preparedness at a DOE facility reflect these facility-specific hazards. The first step in the implementation of this “commensurate with hazards” approach to emergency management is a hazards survey.

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 and the potential impacts of such emergencies to be addressed by the DOE comprehensive emergency management system. The hazards survey also identifies key components of the OE base program that provide a foundation of basic emergency management requirements and an integrated framework for response to serious emergency events or conditions. Much of the information to be used in the hazards survey, and included in its documentation, should have already been collected in the course of meeting other DOE, NNSA, and Federal, state, tribal, and local authority requirements. For facilities involved in producing, processing, handling, storing, or transporting hazardous materials that have the potential to pose a serious threat to workers, the public, or the environment, the hazards survey provides a hazardous material screening process for determining whether further analysis of the hazardous materials in an emergency planning hazards assessment is required.

DOE G 151.1-2 is directed at operations and emergency management staff responsible for DOE and NNSA facilities at field offices, service centers, and operating contractor organizations. It is expected that emergency management staff will obtain support from site and facility management and from a variety of scientific and technical disciplines within their respective organizations to conduct and document the analyses described in DOE G 151.1-2. Appendix A provides a recommended screening approach for radioactive and chemical hazardous materials. Appendix B illustrates the application of the suggested hazards survey method to a hypothetical facility and site.

DOE G 151.1-3, Programmatic Elements: Emergency Management Guide

The purpose of DOE G 151.1-3 is to assist DOE/NNSA field elements in complying with the DOE O 151.1C requirement to provide effective organizational management and AC of an emergency management program by establishing and maintaining authorities and resources necessary to plan, develop, implement, and maintain a viable, integrated, and coordinated program. Each manager or administrator of a DOE-, NNSA- and/or 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 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, and coordinate emergency resources. Responsible administrators of emergency management programs should use the guidance in DOE G 151.1-3 to define responsibilities and implement functions to ensure and maintain effective emergency planning, preparedness, readiness assurance, and response activities.

DOE G 151.1-3 is designed primarily for facilities/sites or activities that are required to implement an OE hazardous material program and is directed at operations and emergency management staff at field elements and operating contractor organizations responsible for DOE and NNSA facilities/sites or activities.

DOE G 151.1-4, Response Elements: Emergency Management Guide

The purpose of DOE G 151.1-4 is to assist DOE/NNSA field elements in complying with the DOE O 151.1C requirement to establish and maintain an ERO for each facility/site or activity and to ensure that DOE/NNSA 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. An adequate number of experienced and trained personnel, including designated alternates, should be available on demand for timely and effective performance of ERO functions.

DOE G 151.1-4 is designed primarily for facilities/sites and activities that are required to implement an OE hazardous materials program and is directed at operations and emergency management staff at field elements and operating contractor organizations responsible for DOE and NNSA facilities/sites and activities.

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 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.

b. State what is meant by an operational emergency.

The following is taken from DOE O 232.2, Chg 1.

OEs 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. OEs are the most serious occurrences and require an increased alert status for onsite personnel and, in specified cases, for offsite authorities.

c. Describe the purpose of a facility emergency plan and implementing procedures.

The following is taken from DOE G 151.1-4.

The emergency plan should address the scope and responsibility of the support functions and the equipment and facilities required for performance of the function. Implementing procedures should assign personnel to the various functions required and provide directives and checklists for the performance of those duties. The extent to which support functions are implemented depends on the nature and severity of potential emergencies at a facility/site. Some support functions may not be required at all, while some may be required dependent on the type or classification of emergency. While most generally conform to the NIMS management structure, several functions are unique to DOE/NNSA emergency management programs and are not explicitly encompassed within the NIMS functions.

d. Discuss the requirements for developing the hazards survey and the emergency planning hazards assessment.

The following is taken from DOE G 151.1-1A.

The hazards survey, which is required by DOE O 151.1C for each facility/site or activity, is used to identify the generic emergency events or conditions that define the scope of the emergency management program. The hazards survey is a qualitative examination of the events or conditions specific to the facility/site or activity that may require an emergency response. The description of the potential impacts of such events or conditions (e.g., natural phenomena, wild land fires, hazardous materials releases, malevolent events, etc.) contained in the hazards survey determines the planning and preparedness requirements that apply. These requirements constitute the base program.

The hazards survey is the formal mechanism used to determine the scope and extent of the facility/site or activity base program. If hazardous materials are not present at the facility/site or activity, or are present in quantities less than quantities that are “easily and safely manipulated by one person” (i.e., threshold screening quantities), then the base program appropriately defines the facility/site or activity emergency management program that meets the requirements of DOE O 151.1C.

A facility/site- or activity-specific emergency planning hazards assessment (EPHA) is required by DOE O 151.1C to be conducted for each DOE facility/site or activity where identified hazardous materials are present in quantities exceeding the quantity that can be easily and safely manipulated by one person and whose potential release would cause the impacts and require response activities characteristic of an OE. An EPHA is a quantitative analysis that includes the identification and characterization of hazardous materials specific to a facility/site or activity, analyses of potential accidents or events, and evaluation of potential consequences. The results of the EPHA determine whether an OE hazardous material program is required. If the analysis results indicate that no potential accident events and conditions would be classified as an alert or higher, then the base program constitutes the appropriate emergency management program for the facility/site or activity. If the analysis results associated with a facility/site indicate the potential for an alert, site area emergency, or general emergency, a hazardous material program is required; the analysis results will also provide the technical planning basis for the hazardous materials emergency management program. The base program provides the "base" or foundation for the hazardous material program. The emergency management program that results from the seamless integration and coordination of these sets of requirements ("base" plus hazardous materials) becomes the emergency management program for the facility/site or activity.

Not every conceivable situation can be analyzed and, hence, not every response can be preplanned. However, the development of an adequate hazards survey and EPHA, in combination with effective and integrated emergency planning and preparedness, provides the framework for response to any emergency event or condition.

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 the Federal Emergency Management Agency, *National Incident Management System.*

The NIMS is a systematic, proactive approach to guide departments and agencies at all levels of government, nongovernmental organizations, and the private sector to work together seamlessly and manage incidents involving all threats and hazards—regardless of cause, size, location, or complexity—in order to reduce loss of life, property, and harm to the environment. The NIMS is the essential foundation to the National Preparedness System and provides the template for the management of incidents and operations in support of all five national planning frameworks.

The purpose of the NIMS is to provide a common approach for managing incidents. The concepts contained herein provide for a flexible but standardized set of incident management practices with emphasis on common principles, a consistent approach to operational structures and supporting mechanisms, and an integrated approach to resource management.

Incidents typically begin and end locally, and they are managed daily at the lowest possible geographical, organizational, and jurisdictional level. There are other instances where success depends on the involvement of multiple jurisdictions, levels of government, functional agencies, and/or emergency-responder disciplines. These instances necessitate effective and efficient coordination across this broad spectrum of organizations and activities. By using NIMS, communities are part of a comprehensive national approach that improves the effectiveness of emergency management and response personnel across the full spectrum of potential threats and hazards (including natural hazards, terrorist activities, and other human-caused disasters) regardless of size or complexity.

Video 22. National Incident Management System
https://www.youtube.com/watch?v=d39esZe-NXg

Incident Command System

The following is taken from the Federal Emergency Management Agency, *Incident Command System.*

The incident command system (ICS) is a management system designed to enable effective and efficient domestic incident management by integrating a combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure. ICS is normally structured to facilitate activities in major functional areas: command, operations, planning, logistics, intelligence and investigations, and finance and administration. It is a fundamental form of management, with the purpose of enabling incident managers to identify the key concerns associated with the incident—often under urgent conditions—without sacrificing attention to any component of the command system.

Video 23. Incident command system
https://www.youtube.com/watch?v=kOa8jiEmkIc

Incident Commander

The following is taken from Wikipedia, *Incident Commander*.

The incident commander is the person responsible for all aspects of an emergency response, including quickly developing incident objectives, managing all incident operations, and application of resources as well as responsibility for all persons involved. The incident commander sets priorities and defines the organization of the incident response teams and the overall incident action plan. The role of incident commander may be assumed by senior or higher qualified officers upon their arrival or as the situation dictates. Even if subordinate positions are not assigned, the incident commander position will always be designated or assumed. The incident commander may, at his or her own discretion, assign individuals, who may be from the same agency or from assisting agencies, to subordinate or specific positions for the duration of the emergency.

In the United States, most agencies use an incident commander for the roles and responsibilities as defined under NIMS as a part of the ICS.

Emergency Director

The following is taken from DOE G 151.1-4.

One position in the facility/site contractor ERO, the emergency director 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 (such as fire, medical, security and HAZMAT personnel). 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 thirty days prior to the conduct of the exercise.
  - Evaluation reports for facility and site exercises must be completed within thirty 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 thirty 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.

21. Personnel shall 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 DOE G 424.1-1B, Chg 2.

The USQ process allows contractors to make physical and procedural changes and to conduct tests and experiments without prior DOE approval if the proposed change can be accommodated within the existing safety basis. The contractor must evaluate any proposed change to ensure that it will not affect the safety basis of the facility either explicitly or implicitly.

b. Discuss the reasons for performing a USQ determination (USQD)

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 documented safety analysis (DSA)
- temporary or permanent change in the procedures as described in the existing DSA
- test or experiment not described in the existing DSA
- 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.

Documented Safety Analysis

The following is taken from 10 CFR 830.3.

DSA means a documented analysis of the extent to which a nuclear facility can be operated safely with respect to workers, the public, and the environment, including a description of the conditions, safe boundaries, and hazard controls that provide the basis for ensuring safety.

Technical Safety Requirements

The following is taken from 10 CFR 830.3.

Technical safety requirements (TSRs) means the limits, controls, and related actions that establish the specific parameters and requisite actions for the safe operation of a nuclear facility and include, as appropriate for the work and the hazards identified in the DSA for the facility: safety limits (SLs), operating limits, surveillance requirements (SRs), administrative and management controls, use and application provisions, and design features, as well as a bases appendix.

Unreviewed Safety Question Determination

The following is taken from DOE G 424.1-1B, Admin Chg 2.

The USQD is not a substitute for a safety analysis; it merely serves as a benchmark for whether the safety basis is being preserved. A safety analysis may show that a proposed change is safe, yet the USQD may find that the change creates a USQ and therefore requires DOE approval prior to implementation.

Potential Inadequacy of the Safety Analysis (PISA)

The following is taken from DOE G 424.1-1 B, Admin Chg 2.

A PISA may result from situations that indicate that the safety basis may not be bounding or may be otherwise inadequate; for example, discrepant as-found conditions, operational events, or the discovery of new information. It is appropriate to allow a short period of time to investigate the conditions to confirm that a safety analysis is potentially inadequate before declaring a PISA. The main consideration is that the safety analysis does not match the current physical configuration, or the safety analysis is inappropriate or contains errors. If it is immediately clear that a PISA exists, then the PISA should be declared immediately.

Safety Analysis

The following is taken from DOE-HDBK-1188-2006.

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.

d. Describe the situations that require a USQD.

See CS-21b for an explanation of this KSA.

e. Define the conditions for a USQ.

The following is taken from DOE G 424.1-1B, Admin Chg 2.

Four criteria define a USQ (see CS-21b). Three can be addressed by answering seven questions. The fourth PISA criterion also invokes the seven questions as described 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 USQDs.

The following is taken from DOE G 424.1-1B, Admin Chg 2.

Contractors are expected to provide a detailed procedure on how to perform a USQD. Specific guidance on how to conduct a USQD 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 USQD would not be triggered.

Specific responsibilities of those performing or reviewing USQDs 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 USQD 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.

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 USQD 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.

h. Discuss site actions to be taken for a USQ.

The following is taken from DOE G 424.1-1B, Admin Chg 2.

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 (i.e., when the USQD 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 USQD 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.

The following is taken from DOE G 424.1-1B, Admin Chg 2.

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, 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 shall 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.

a. Define and compare the terms "hazard” and “risk.”

Hazard

The following is taken from DOE-HDBK-1188-2006.

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

The following is taken from DOE-HDBK-1188-2006.

A risk is the quantitative or qualitative expression of possible loss that considers the probability that a hazard will cause harm and the consequences of that event.

Video 24. Understanding hazards and risks
https://www.youtube.com/watch?v=aRvULYpobms

b. Explain and compare the terms “safety basis,” “design basis,” and “authorization basis.”

The following is taken from DOE-HDBK-1188-2006.

Safety Basis

The safety basis is the DSA and hazard controls that provide reasonable assurance that a DOE nuclear facility can be operated safely in a manner that adequately protects workers, the public, and the environment.

Design Basis

The design basis is the set of requirements that bound the design of SSCs within the facility. These design requirements include consideration of safety, plant availability, efficiency, reliability, and maintainability. Some aspects of the design basis are important to safety, although others are not.

Authorization Basis

The authorization basis are those aspects of the facility design basis and operational requirements relied on 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 DSA and other safety analyses; hazard classification documents, the TSRs, DOE-issued safety evaluation reports, and facility-specific commitments made to comply with DOE Orders or policies.

c. Discuss the relationship of DSAs to TSRs.

The following is taken from DOE G 423.1-1B.

The DSA 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

TSRs

The following is taken from 10 CFR 830.205.

A contractor responsible for a hazard category 1, 2, or 3 DOE nuclear facility must

- develop TSRs that are derived from the DSA;
- prior to use, obtain DOE approval of TSRs and any change to TSRs; and
- 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.

A contractor for an environmental restoration activity may follow the provisions of 29 CFR 1910.120 or 1926.65 to develop the appropriate hazard controls, provided the activity involves either

- work not done within a permanent structure; or
- the decommissioning of a facility with only low-level residual fixed radioactivity.

DSAs

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

- 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, CONOPS, emergency preparedness, fire protection, waste management, and radiation protection; and

- with respect to a nonreactor nuclear facility with fissionable material in a form and amount sufficient to pose a potential for criticality, define a criticality safety program that
  - ensures that operations with fissionable material remain subcritical under all normal and credible abnormal conditions;
  - identifies applicable nuclear criticality safety standards; and
  - describes how the program meets applicable nuclear criticality safety standards.

e. Define the following terms and discuss the purpose of each:
- **Safety limit (SL)**
- **Limiting control settings (LCS)**
- **Limiting conditions for operation (LCO)**
- **Surveillance requirements (SR)**

The following definitions are taken from DOE-HDBK-1188-2006.

Safety Limit
The SL is a limit on process variables associated with those physical barriers, generally passive, that are necessary for the intended facility function and which are found to be required to guard against the uncontrolled release of radioactive or other hazardous materials.

Limiting Control Settings
LCSs are the settings on safety systems that control process variables to prevent exceeding an SL.

Limiting Conditions for Operation
LCOs are the limits that represent the lowest functional capability or performance level of SSCs required for safe operations.

Surveillance Requirements
SRs are the requirements relating to test, calibration, or inspection to ensure that the necessary operability and quality of SSCs and their support systems required for safe operations are maintained, that facility operation is within SLs, and the LCS and LCO are met.

f. Discuss the possible source documents that may be used in developing TSRs.

The following is taken from DOE G 423.1-1B.

TSRs can be viewed as a distillation of the DSA’s analytical results for the required performance of safety related SSCs and ACs. TSRs set forth the minimum acceptable limits for operations under normal and specified failure conditions and establish maintenance and SRs. In accordance with 10 CFR 830, all TSRs written by operating contractors, and proposed changes thereto, must be reviewed and approved by DOE before nuclear operations can commence.

Typically, chapter 5 of a facility's DSA identifies needed TSRs and their technical basis. Subsection 5.5, "TSR Derivation," is intended to provide a link between the safety analysis and the list of variables, SSCs, and ACs that are necessary to ensure safety.

In some cases, the DSA may not supply all of the technical details necessary for the development of a TSR. This situation may apply in areas such as maintenance and surveillance frequencies and compensatory measures for systems out of service. In such cases, national and international codes, standards, and guides should be used if available. Where no code, standard, or guide is applicable, other documents such as reliability analyses, instrumentation/equipment uncertainty analyses, failure modes and effects analyses, manufacturer documentation, and data based on operating history may be used, along with engineering judgment.

g. Discuss the conditions that constitute a violation of TSRs.

The following is taken from DOE G 423.1B.

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 failure to comply with an LCO
3. Failure to perform a surveillance within the required time limit
4. Failure to comply with an AC statement

The following are two examples of "failure to comply with an LCO":

1. An operation performed that is prohibited by the mode the facility is in
2. A safety system rendered incapable of performing its safety function (e.g., by maintenance) without entering the applicable LCO

There are two types of violations of "failure to comply with an AC statement":

1. Any single instance of a failure to comply with a requirement in a directive action specific administrative control (SAC)
2. A failure to meet the intent of a referenced safety management program that is significant enough to render the DSA summary invalid

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, is of the same format as a DOE-STD-3009-2014, *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-3009-2014 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 shall demonstrate a familiarity level knowledge of DOE O 420.1C, Chg 1, *Facility Safety.*

a. Discuss the purpose and applicability of DOE O 420.1C, Chg 1.

Purpose

The objective of DOE O 420.1C, Chg 1, is to establish facility and programmatic safety requirements for the DOE/NNSA, for the following:

- Nuclear safety design criteria
- Fire protection
- Criticality safety
- Natural phenomena hazards mitigation
- Cognizant system engineer program

Applicability

DOE O 420.1C, Chg 1, applies to all DOE elements with responsibility for design, construction, management, operation, decontamination, decommissioning, or demolition of government-owned or government-leased facilities and onsite contractor-leased facilities used for DOE mission purposes.

Except for the equivalencies and exemptions the CRD sets forth requirements of DOE O 420.1C, Chg 1 that will apply to contracts that include the CRD. The CRD, or its requirements, must be inserted into all contracts that require design, construction, management, operation, decontamination, decommissioning, or demolition of government-owned and government-leased facilities.

b. Discuss the requirements imposed by DOE O 420.1C on the contractors that operate DOE nuclear facilities.

Regardless of the performer of the work, the contractors are responsible for complying with the requirements of the CRD. The contractors are responsible for flowing down the requirements of the CRD to subcontractors at any tier, to the extent necessary, to ensure the contractors' compliance with the requirements.

Contractors must satisfy the requirements set forth in Attachments 2 and 3 of DOE O 420.1C, Chg 1.

For design and construction activities, contractors must identify the applicable industry codes and standards, including the IBC, and the applicable DOE requirements and technical standards. If approved by the responsible field element manager, state, regional, and local building codes may be used in lieu of the IBC upon contractor submission of a report that demonstrates that implementation of the substituted code for the specific application will meet or exceed the level of protection that would have been provided by the IBC. Additionally, DOE O 413.3B, *Program and Project Management for the Acquisition of Capital Assets*, requires nuclear projects to establish and maintain a code of record early in project design for identifying applicable industry codes and standards.

Contractors must satisfy the requirements in DOE technical standards and industry codes and standards that are identified as applicable unless relief is approved.

When the DOE-STD-3009-2014 methodology is used to satisfy 10 CFR 830 safety basis requirements, DOE-STD-3009-2014 must be used for new DOE non-reactor nuclear facilities and major modifications to existing DOE non-reactor nuclear facilities. Note: For such major modifications to existing non-reactor nuclear facilities, the appropriate SO, with concurrence by the applicable central technical authority (CTA), may approve use of DOE-STD-3009-2014.

DOE-STD-3009-2014 must be used for existing DOE non-reactor nuclear facilities that use the DOE-STD-3009-2014 method to satisfy 10 CFR 830 requirements when those facilities have mitigated offsite dose estimates greater than 25 rem.

c. Discuss, in general terms, the focus and the content of the following sections of DOE O 420.1C, Chg 1:
- **Nuclear safety design criteria**
- **Fire protection**
- **Criticality safety**
- **Natural phenomena hazards mitigation**
- **Cognizant system engineer program**

Nuclear Safety Design Criteria
The objectives of the nuclear safety design criteria is to establish requirements for safety design of DOE hazard category 1, 2, and 3 nuclear facilities to support implementation of DOE P 420.1, *Department of Energy Nuclear Safety Policy*.

The requirements of this chapter support implementation of the requirements for hazard category 1, 2, and 3 nuclear facilities in 10 CFR 830, Subpart B, "Safety Basis Requirements."

Fire Protection

The objective of fire protection is to establish requirements for comprehensive fire protection programs for DOE facilities and EROs to

- minimize the likelihood of occurrence of a fire-related event;
- minimize the consequence of a fire-related event affecting the public, workers, environment, property, and missions; and
- provide a level of safety protection consistent with the "highly protected risk" class of industrial risks.

Criticality Safety

The objective of criticality safety is to establish requirements for developing and implementing nuclear criticality safety programs for nuclear facilities and activities, including materials transportation activities, which provide adequate protection to the public, workers, and the environment.

Natural Phenomena Hazards Mitigation

The objective of natural phenomena hazards mitigation is to establish requirements for DOE facility design, construction, and operations to protect the public, workers, and the environment from the impact of natural phenomena hazards events (e.g., earthquake, wind, flood, lightning, snow, and volcanic eruption).

Cognizant System Engineer Program

The objective of the cognizant system engineer (CSE) program is to establish requirements for a CSE program for hazard category 1, 2, and 3 nuclear facilities and to ensure continued operational readiness of the systems within its scope.

A key element of the CSE program is the designation of CSEs who are responsible for maintaining overall cognizance of assigned systems, providing systems engineering support for operations and maintenance, and technical support of line management safety responsibilities for ensuring continued system operational readiness.

24. Personnel shall demonstrate a familiarity level knowledge of DOE P 226.1B, *Department of Energy Oversight Policy*, and its implementing DOE O 226.1B, *Implementation of Department of Energy Oversight Policy.*

a. Discuss the purpose and scope of DOE P 226.1B.

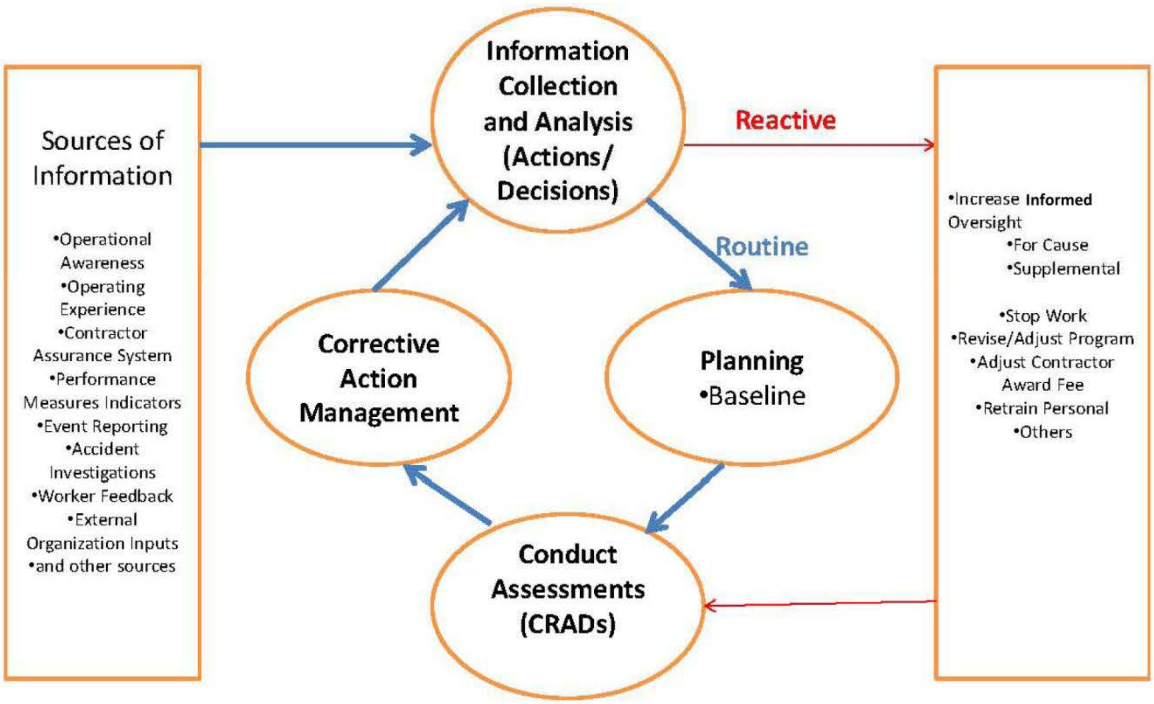
The purpose of DOE P 226.1B is to establish DOE's expectations for the implementation of a comprehensive and robust oversight process that enables the Department's mission to be accomplished effectively and efficiently while maintaining the highest standard of performance for safety and security. As used in DOE P 226.1B, any reference to DOE is also meant to include the NNSA. The scope of DOE P 226.1B covers operational aspects of ES&H; safeguards and security (S&S); cyber security; and emergency management.

b. Discuss DOE's oversight model.

The DOE oversight model was deleted in DOE P 226.1B. The following is taken from DOE G 226.1-2A.

DOE O 226.1B requires that DOE line management perform the following:

- Maintain sufficient technical capability and knowledge of site and contractor activities to make informed decisions about hazards, risks, and resource allocation; provide direction to contractors; and evaluate contractor performance
- Evaluate contractor and DOE programs and management systems, including site assurance systems, for effectiveness of performance, including compliance with requirements using written plans and schedules for planned assessments
- Conduct HQ oversight processes that are focused on the DOE field element activities to determine the effectiveness of line management oversight of the contractors
- Establish an issues management process that is capable of categorizing findings based on risk and priority, ensuring that relevant findings are effectively communicated to the contractors, and ensuring that problems are evaluated and corrected on a timely basis
- Establish and communicate performance expectations to contractors through formal contract mechanisms and establish effective processes for communicating oversight results and other issues in a timely manner.



Source: DOE G 226.1-2A

Figure 14. Overview of DOE Federal line management oversight

Figure 14 shows a generic representation of a DOE line management oversight program. One of the keys to an effective oversight program is a systematic process for continually evaluating information from many sources. This information is used to design a comprehensive oversight program that includes a baseline oversight program (which can be defined as the minimum level of oversight to be conducted regardless of the contractor's performance), as well as oversight in response to the results of processes for determining which areas warrant supplemental oversight commensurate with the hazards of the nuclear facility (i.e., informed oversight).

DOE line management oversight includes field element (tier 2) and program office oversight (tier 3) processes that perform complementary functions and are coordinated to eliminate unnecessary duplication. However, an appropriate degree of overlap is appropriate for oversight of high hazard nuclear facilities. Key attributes of effective DOE line management oversight that apply to DOE field elements and program offices include the following:

- Requirements-based—The baseline set of oversight activities required by DOE directives are rigorously conducted, and the results are relatable to the requirements.
- Efficient in application—To the extent possible, oversight processes appropriately use contractor assurance information to adjust the rigor and frequency of oversight in a particular area. Similarly, HQ (tier 3) and HSS independent oversight processes appropriately utilize DOE line management oversight information to adjust the rigor and frequency of oversight of DOE field elements.

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 (CTAs), Chief of Defense Nuclear Safety (CDNS), and Chief of Nuclear Safety (CNS)

The following is taken from DOE G 226.1-2A.

DOE CTAs in NNSA and the undersecretaries for Energy and Science provide centralized technical expertise and maintain operational awareness to ensure adequate implementation of nuclear safety policy and requirements. The CTAs are supported by the CNS/CDNS technical support organizations. The CNS/CDNS perform oversight activities at DOE organizations and nuclear facilities in support of their respective program offices and CTAs.

DOE Program Office Safety Oversight

The following is taken from DOE G 226.1-2A.

DOE program offices conduct oversight to ensure that the oversight systems for their nuclear facilities are working effectively. Program office oversight processes focus on their field elements, including reviewing contractor activities to the extent necessary to evaluate the effectiveness of their field element's oversight of its contractors. DOE program office safety oversight (tier 3) functions also include

- ensuring that systemic safety issues affecting the DOE complex are identified and addressed
- evaluating areas where the field element has not looked or where performance or vulnerability indicates the need for oversight beyond the scope of that conducted by the field element
- performing self-assessments of their own activities concerning the safety of their nuclear facilities

DOE O 226.1B requires program offices to establish their oversight activities with a planning process. That process includes scheduled assessments and may also include "for cause" reviews and reviews requested by the field element.

DOE Field Element Safety Oversight

The major safety oversight functions performed by DOE field elements (tier 2) include two broad categories: 1) DOE field element oversight of DOE contractor activities, and 2) DOE field element self-assessments of their own activities and functions. Field elements have the most experience with the activities and hazards at their sites and are in the best position to evaluate site status and contractor safety performance. Thus, field elements have primary responsibility for establishing and implementing DOE line management oversight of contractor performance.

Routine DOE field element oversight of DOE contractor activities includes

- maintaining safety-related operational awareness
- identifying and addressing safety vulnerabilities and issues
- confirming contractors' implementation of safety-related contract provisions that are based on safety-related regulations and directives
- reviewing event reports
- observing work
- attending meetings
- reviewing facility representative and safety system oversight (SSO) assessments
- reviewing SME reports

In addition to the above day-to-day oversight activities, field elements perform a wide variety of safety-related activities, including

- establishing and approving the list of safety requirements in contracts
- conducting independent reviews of safety basis documents and providing approval recommendations to the approval authority
- conducting independent reviews of nuclear safety in new or modified operations
- reviewing changes in nuclear safety system designs resulting from a positive USQD
- reviewing the hazard categorization determinations
- participating in readiness reviews
- reviewing (and in some cases approving) safety management programs

Field elements may arrange for additional technical assistance or reviews from outside organizations. Such organizations include their DOE program office's safety organization; the applicable DOE CTAs and their technical support organizations, such as the CNS/CDNS office; HSS; or other field elements.

Facility Representatives and Safety System Oversight Personnel

The following is taken from DOE G 226.1-2A.

The facility representative is typically responsible for oversight of operational controls, such as daily, weekly, and monthly surveillances that verify system operational parameters and SACs. SSO personnel are typically responsible for oversight of less-frequent surveillances, such as quarterly and annual maintenance activities, integrated system testing, and passive design feature inspections.

d. Describe the roles and responsibilities of the DOE's Office of Independent Oversight.

[Note: The Office of Independent Oversight was replaced by the Office of Enforcement and Oversight in May 2011.]

The following is taken from energy.gov, *Office of Enforcement and Oversight.*

The independent oversight program is implemented by two sub-offices: the Office of Security and Cyber Evaluations and the Office of Safety and Emergency Management Evaluations. The program provides DOE line management, congress, and other stakeholders with independent evaluations 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 independent oversight program is designed to ensure maximum value to the Department in completing its missions by identifying gaps and vulnerabilities in safety (worker, nuclear, and facility safety) and physical and cyber security programs and related performance. The staff performs facility, site-specific, and Department-wide performance-based assessments to verify that the Department's S&S interests are protected, particularly SNM and sensitive and classified information in all forms; departmental employees and the public are protected from hazardous operations and materials; and the Department can effectively respond to emergencies. Independent oversight activities are tailored to the unique needs of each DOE program office, considering relative risks and past performance in prioritizing activities. The independent oversight program also provides information and analysis regarding the effectiveness and trends in the Department's safety and security programs and other functions of interest. Information is made available to the secretary, deputy secretary, undersecretaries, congressional committees, and other stakeholders, such as unions and local public interest groups, to provide confidence that the Department's operations are being performed in a safe and secure manner.

e. Describe "assurance systems" as found in DOE P 226.1B.

The following 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.

Effective and properly implemented oversight processes and assurance systems are expected to result in

- DOE HQ and field elements having assurance that site workers, the public, and the environment are protected while mission objectives are met, contract requirements are fulfilled; and operations, facilities, and systems are being effectively run and continuously improved;
- the establishment of metrics and targets for assessing performance and holding managers accountable for achieving their targets; and
- improvements in the efficiency and effectiveness of DOE oversight programs by leveraging, when appropriate, the processes and outcomes of contractors' assurance systems.

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 DOE and the contractors' 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 (CAS), 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 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 enables contractor management to ensure that problems are evaluated and corrected on a timely basis. For issues categorized as higher significance findings, contractor management must ensure the following activities are completed and documented:
        - A thorough analysis of the underlying causal factors is completed.
        - Timely corrective actions that will address the cause(s) of the findings and prevent recurrence are identified and implemented.
        - After completion of a corrective action or a set of corrective actions, an effectiveness review is conducted using trained and qualified personnel that can validate the effectiveness of corrective action/plan implementation and results in preventing recurrence.
        - Documentation of the analysis process and results are described in maintenance and tracking to completion of plans and schedules for the corrective actions and effectiveness reviews.
        - Communicates issues and performance trends or analysis results up the contractor management chain to senior management using a graded approach that considers hazards and risks, and provides sufficient technical basis to allow managers to make informed decisions and correct negative performance/compliance trends before they become significant issues.
- Timely and appropriate communication to the contracting officer, including electronic access of assurance-related information.
- Continuous feedback and improvement, including worker feedback mechanisms (e.g., employee concerns programs, telephone hotlines, employee suggestions forms, labor organization input), improvements in work planning and hazard identification activities, and lessons learned programs.

f. Describe the attributes of effective oversight.

The following is taken from DOE G 226.1-2A.

Attributes of effective oversight of a CAS include the following:

- DOE line management assesses the implementation and effectiveness of CASs for nuclear facility safety and supporting sub-elements by examining
  - assessment methods;
  - whether the process used for selecting assessment topics is structured and appropriately implemented;
  - the frequency, breadth, and depth of self-assessments;
  - line management involvement in self-assessments;
  - evaluators' technical expertise and qualifications;
  - the number and nature of findings identified;
  - the degree of rigor applied to self-assessment; and
  - the application of the CAS by subcontractors and prime contractor oversight of subcontractor safety programs and processes, including self-assessments and issues management processes.
- DOE line management regularly assesses the adequacy and effectiveness of contractor issues management and corrective action processes, lessons-learned processes, and other feedback mechanisms. DOE line management also evaluates contractor processes for communicating information, including safety concerns and dissenting technical opinions, up the management chain. DOE line management validates that contractor corrective actions have been implemented and are effective in resolving deficiencies and preventing recurrence.
- DOE line management regularly assesses the contractor's reporting processes and performance to determine whether contractors meet reporting requirements for events and incidents relevant to nuclear facility safety and takes effective actions to prevent their recurrence.
- For sites where contractors report the results of performance measures to DOE, DOE regularly assesses the effectiveness of processes for collecting, evaluating, and reporting performance data to ascertain the accuracy, completeness, and validity of the performance measures.

g. Discuss the requirements imposed by DOE O 226.1B on the contractors that operate DOE nuclear facilities.

The following is taken from CRD in DOE O 226.1B.

The contractor must establish an assurance system that includes assignment of management responsibilities and accountabilities and provides evidence to assure DOE 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 must submit an initial CAS 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, CAS 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 G 226.1-2A.

Criteria review and approach documents (CRADs) are used to establish the depth and detail of an assessment and to provide clarity and consistent guidance to the assessment team, as well as to the organization being assessed. The quality of these documents significantly impacts the overall quality of the assessment. The criteria delineated within the CRADs should be specific and as objective as possible. The graded approach is applied to the scope of the assessment through the CRADs. Areas that include significant hazards, such as nuclear operations, should be assessed to a greater extent than other areas.

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 shall demonstrate a familiarity level knowledge of DOE O 210.2A, *DOE Corporate Operating Experience Program.*

a. Describe the objectives of DOE O 210.2A.

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.
- to 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; and
- to 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 ISM system, and enhance mission accomplishment, quality assurance, safety and reliability.

b. Describe the types of information that are collected and analyzed.

The following is taken from DOE O 210.2A.

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, the National Aeronautics and Space Administration; the NRC, and the EPA; foreign government and foreign industry experience; and international agencies involved with energy issues such as the International Energy Agency and the AEA. This requirement may be satisfied by regular participation in the review of external events conducted by the operating experience committee.

Each organization's operating experience program, in particular the designated DOE corporate operating experience program lead office, must routinely screen and assess internal and external operating experience to identify significant issues and lessons learned that may be of safety significance or have a bearing on the success of DOE missions and to make them available to the DOE complex.

c. Describe the types of operating experience reports that are developed.

The following is taken from DOE O 210.2A.

Table 6. DOE corporate operating experience program documents

Operating experience document (OED)	Purpose
OED level 1 (OED-1)	To inform the DOE complex of the most significant events or trends of concern to DOE management, including assessments and required actions with closeout verification in a formal response.
OED-2	To inform the DOE complex (or affected sites) of potentially significant safety issues (e.g., CONOPS; S/CI, or defective items). Must include a statement of actions required (or recommended for NNSA) and formal method of feedback.
OED-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 or defective 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 shall demonstrate a familiarity level knowledge of DOE O 225.1B, *Accident Investigations.*

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 accident investigation board (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.

- 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 (JON) 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
  - 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; and
  - 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
  - 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; and
  - 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
    - identify the causes 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 JON is based on objective analysis and application of the core analytical techniques using the facts to develop the root and contributing causes; and
    - 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
    - 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 JON 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 JON.
- 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 JON.
- 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.

Head of HQ Element

Consider the criteria identified in Appendix A, the value of the knowledge to be gained by conducting the investigation, and any other relevant factors, to determine whether an AIB must be appointed.

Serve as the appointing official for AIBs for programs, offices, and facilities under their authority. 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 and conduct the accident investigation.

Maintain a staff of trained and qualified personnel to serve in the capacity of chairperson and DOE accident investigators for AIBs and, upon request, provide them to support other AIBs.

If requested by the AIB chairperson, review the draft AIB report for factual accuracy within the time frame allowed so that comments may be considered for incorporation into the final draft report.

Distribute accident investigation reports to all heads of field elements under their cognizance and direct that extent-of-condition reviews be conducted for issues identified during accident investigations that are applicable to work locations and operations.

As appropriate, require the submittal of corrective action plans to address the JON, approve the implementation of those plans, and track the effective implementation of those plans to closure.

Chief Health, Safety, and Security Officer

Develops and maintains DOE accident investigation policies, procedures, standards, and guidelines, and oversees their implementation.

Consults with the cognizant head of HQ element as the office of primary interest on requests for proposed equivalencies and exemptions to DOE O 225.1B that are processed in accordance with DOE O 251.1C, *Departmental Directives Program*.

Consults with the deputy secretary when it does not concur with the head of the HQ element determination for not appointing an AIB.

Serves as appointing official.

Analyzes accident data to assist in identifying trends and conditions surrounding the initiation or occurrence of accidents. Performs complex-wide analyses of accidents to guide and focus investigative efforts based on analyzed safety impact and DOE-wide significance.

Reviews Federal accident investigation reports and determines whether the conditions identified in the report may have DOE-wide implications. As deemed appropriate, recommend to head of HQ element that they conduct an extent-of-condition review to determine whether similar conditions exist at their sites and, if confirmed, to institute timely compensatory and/or corrective action to prevent recurrence of a similar accident.

Develops and disseminates information on DOE accident investigation techniques and ensures that training is available through the HSS National Training Center for personnel who wish to receive training to serve in the capacity of AIB chairperson or DOE accident investigator.

Maintains a list of qualified AIB chairpersons, DOE accident investigators, and technical SMEs.

Provides investigative and technical subject matter expertise to appointing officials, AIB chairpersons, and points of contact, as requested.

If requested by the heads of HQ elements, reviews and provides comments on draft corrective action plans resulting from an AIB.

Upon request, provides reasonable support to the heads of HQ element in implementing the requirements in DOE O 225.1B.

Reviews, for quality purposes, all accident investigation reports before submittal to the appointing official for acceptance, and provides comments to the AIB chairperson.

Note: This review provides assurance that an objective investigation was conducted, that the AIB employed the core analytical techniques to develop the causal factors, conclusions, and JON, and that the required contents of the investigation report are clearly and concisely addressed. A similarly rigorous assurance review will be applied to accident investigation reports published by other government agencies that exercise statutory or regulatory jurisdiction over DOE or DOE contractor activities. If no causal factors are identified in such a report, HSS will consult with the head of the HQ element on the appropriate course of action to identify appropriate corrective actions to prevent recurrence.

In accordance with DOE O 226.1B, which governs line management oversight, supports and participates in the corrective action management review.

Maintains website library of final accident investigation reports.

Heads of Field Elements

Identify contracts to which the CRD should apply and notify the cognizant contracting officers.

After incorporating DOE O 225.1B into contracts, ensure its implementation and identify to the head of the HQ element and HSS a single point of contact to act as liaison to HQ on matters pertaining to the accident investigation program.

Provide for the necessary onsite support to the AIB, as requested by the chairperson, to facilitate the timely and effective completion of the accident investigation.

Review draft accident investigation reports for factual accuracy within the time frame allowed for the investigation.

As appropriate, develop or provide assistance in developing lessons learned for accident investigations.

As appropriate, require the submittal of contractor corrective action plans to address the JON, approve the implementation of those plans, and track the effective implementation of those plans to closure.

As directed by the head of the HQ element, conduct extent-of-condition reviews for specific issues resulting from accident investigations that might be applicable to work locations or activities under the head of field element's authority, and address applicable lessons learned from investigations conducted at other DOE sites.

Appointing Officials.

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 AIBs 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 Chairpersons

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 CFR and DOE O 225.1B are 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, logistical support, and/or investigative time is needed to produce a high quality investigation and report, notify the when those needs are recognized so that requested support can be acquired early in the investigation.

Contracting Officers

Incorporate the CRD into contracts in a timely fashion upon notification of its applicability.

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 AIB. 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.

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 AIB chairperson.

Data Analysis Techniques

A suite of analytical techniques available to support the accident investigation process is listed in table 7. 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 AIB chairperson, in consultation with board members and advisors/consultants who have expertise in available techniques.

Table 7. 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 SMEs and the AIB 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 (Archived)

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. Conclusions may also address significant concerns arising out of the accident or address unsubstantiated concerns or inconclusive results.

Where appropriate, conclusions may be used to highlight positive aspects of performance revealed during the investigation.

When developing conclusions, the investigator should

- organize conclusions sequentially, preferably in chronological order, or in logical sets;
- 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; and
- keep conclusions as short as possible and, to the extent possible, limit reference citations to one per conclusion.

Judgments of Need

The JON are the AIB's decisions regarding the managerial controls and safety measures necessary to prevent or minimize the probability or severity of a recurrence. JON should also provide the basis for subsequent corrective actions. DOE O 225.1B requires that each accident investigation report contain JON 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. JON 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.

JON should be constructed so they clearly identify the organization that is to implement corrective actions to prevent recurrence of the accident. The AIB should avoid generic statements and focus on processes and systems, not individuals. JON 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 JON may start, "A need exists…" or, "There is a need to…" As an example, a JON 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 JON does not tell management how to do something; instead, it simply identifies the need. Corrective action plans are prepared to address the JON. The resulting corrective actions are the responsibility of line management. If the AIB 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 shall demonstrate a familiarity level knowledge of DOE O 410.1, *Central Technical Authority Responsibility Regarding Nuclear Safety Requirements.*

The information for the KSAs in this competency is taken from DOE O 410.1.

a. State the purpose of DOE O 410.1*.*

The purpose of DOE O 410.1 is to establish CTA and CNS/CDNS responsibilities and requirements directed by the secretary of Energy in the development and issuance of DOE regulations and directives that affect nuclear safety.

- To identify CTA authorities and actions for specific regulations and directives
- To establish related responsibilities and requirements for other departmental elements
- To establish responsibilities and requirements for addressing nuclear safety regulations and directives in contracts

b. Define the following terms:

- **Exception**
- **Exemption**

Exception

An exception is the situation that exists when WWSs, S/RIDS, approved SMS, 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.

CTA concurrence is required on directives included pursuant to 48 CFR 970.5204-2 paragraph (b) and paragraph (c) in all new prime management and operating, management and integration, design, and construction contracts for DOE nuclear facilities.

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 request 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 the 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 of DOE O 410.1 that are applicable to the construction, major modification or new program work were not previously included in the contract.

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.

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 established for the concurrences to exemptions in DOE M 251.1-1B for 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; and
- 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:

- 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.
- 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 of the Chief of Defense Nuclear Safety.

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.

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.

28. Personnel shall demonstrate a familiarity level knowledge of DOE security programs, including DOE O 470.4B, Chg 1, *Safeguards and Security Program,* and its supporting directives.

a. Discuss information security programs, including control of classified materials, as described in DOE O 471.6, Admin Chg 2, *Information Security.*

Classified information in all forms must be protected in accordance with all applicable laws, regulations, policies, directives, and other requirements.

NNSA and DOE program offices must provide direction to Federal personnel, contractors, and any other organizational elements to ensure that all DOE and national policies, objectives, and requirements are implemented and achieved. They must also establish or provide direction for establishing each officially designated Federal security authority (ODFSA) and officially designated security authority (ODSA) necessary to fulfill their respective roles in accordance with all applicable delegations and authorities.

All procedures used to protect classified information must be documented in security plans.

Authorized access to classified information requires appropriate clearance, relevant access approval, and need-to-know.

All classified information must be protected from unauthorized access.

Methods to deter, detect, respond to, and mitigate unauthorized access to classified information must be implemented.

All classified information, including but not limited to that which is generated, received, transmitted, used, stored, reproduced, or permanently placed—until it is destroyed or otherwise no longer classified—must be protected and controlled commensurate with its classification level, category, and caveats (if applicable). All pertinent attributes must be used to determine the degree of protection and control required to prevent unauthorized access to classified information.

b. Discuss physical protection programs, including security areas, intrusion detection, and access controls, as described in DOE O 473.3, *Protection Program Operations.*

The following is taken from DOE O 473.3.

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. The security areas address a graded approach for the protection of S&S interests as well as direction provided through national level standards.

General Access Areas (GAAs)

GAAs may be established to allow access to certain areas with minimum security requirements documented in security plans approved by the ODFSA.

GENERAL REQUIREMENTS

These designated areas are accessible to all personnel including the public. DOE line management should establish security requirements for those areas designated as a GAA.

POSTING OF GENERAL ACCESS AREAS

The designated GAA security requirements must be posted to inform all personnel, including the public, that entry into these areas subjects them to the security requirements. The posting should list the security conditions.

Property Protection Areas (PrPAs)

PrPAs 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.

GENERAL REQUIREMENTS

The requirements for PrPAs 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. The ODSA must designate, describe, and document PrPA protection measures within their site security plan.

SIGNS PROHIBITING TRESPASSING

Warning signs and/or notices must be posted around the perimeter and at entrances to a PrPA.

- Signs listing prohibited articles must be posted at PrPA entrances.
- Warning signs and/or notices must be posted at entrances to areas under electronic surveillance advising that physical protection surveillance equipment is in operation.

VISITOR PROCESSING

Site specific requirements and procedures for receiving visitors must be developed and approved by the ODSA and documented in the site security plan.

LIMITED AREAS (LAs)

LAs 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.

GENERAL REQUIREMENTS

LA boundaries shall be defined by physical barriers encompassing the designated space and access controls to ensure that only authorized personnel are allowed to enter the LA.

ACCESS CONTROL

Access controls must be in place to ensure that only appropriately cleared and authorized personnel are permitted unescorted access to the LA. Access must be based on an individual's need-to-know to perform official duties, validation of the individual's security clearance, and the presentation of a DOE security badge. Access must be controlled when going from one security area into another security area with increased protection requirements. Where practical, automated access control systems must be used in place of protective force or other authorized personnel to validate the identity and clearance level of each person seeking entry to an LA.

- If automated access control equipment is used, a DOE security badge must be used to access the LA.
- Entry control points for vehicle and pedestrian access to LA must provide the same level of protection as that provided at all other points along the security perimeter. Additionally, these entry control points must be constructed in such a manner as to preclude bypass.
- Exits from LAs must satisfy life safety requirements of NFPA 101, *Safety to Life from Fire in Buildings and Structures*. Some exits may be provided for emergency use only.
  - Security area entrances and exits must be equipped with doors, gates, rails, or other movable barriers that direct and control the movement of personnel or vehicles through designated control points.
  - Automated gates must be designed to allow manual operation during power outages or mechanism failures.
  - Site-specific requirements and procedures for receiving visitors must be developed and approved by the ODSA.
  - Information from visitor logs must be retained in accordance with local records management procedures.

PERSONNEL ACCESS

Individuals without a security clearance must be escorted by an authorized person who is to ensure measures are taken to prevent a compromise of classified matter.

- Escort ratios—The ODSA must establish escort-to-visitor ratios in a graded manner for each LA or above security area. This decision must be documented in the SSP.
- Escort responsibilities—Any person permitted to enter a LA or above who does not possess a security clearance at the appropriate level must be escorted at all times by an appropriately cleared and knowledgeable individual trained in local escort procedures:
  - Escorts must ensure measures are taken to prevent compromise of S&S interests.
  - The escort must ensure the visitor has a need-to-know for the security area or the S&S interests.
- Automated access control systems—Automated access control systems may be used if the following requirements are met:
  - Automated access controls used for access to a security area must verify that the security clearance and the DOE security badge are valid. Badges may be validated by means of a personal identification number (PIN) or other approved means as stipulated in the site security plan.
  - When remote, unattended, automated access control system entry control points are used for access to LA and above security areas, the barrier must be resistant to bypass. The unattended entry control point should have closed-circuit television system coverage.
  - Automated control system alarms must be treated as an intrusion alarm for the area being protected.
  - Personnel or other protective measures are required to protect card PINs, card reader access transactions, displays, and keypad devices. The process of inputting

storing, displaying, or recording verification data must ensure the data are protected in accordance with the site security plan.

- The system must record all attempts at access to include unsuccessful, unauthorized, and authorized.
- Door locks opened by badge readers must be designed to relock immediately after the door has closed.
- Transmission lines that carry security clearance and personal identification or verification data between devices/equipment must be protected in accordance with the site security plan.
- Records reflecting active assignments of DOE security badges, PINs, security clearance, and similar system-related records must be maintained. Records of personnel removed from the system must be retained for one year, unless a longer period is specified by other requirements. Personal data must be protected.
- Badge reader boxes, control lines, and junction boxes must have line supervision or tamper indication or be equipped with tamper-resistant devices. Data gathering panels/field processors or multiplexers and other similar equipment must be tamper alarmed or secured by a means that precludes surreptitious tampering with the equipment.
- Uninterruptable power supply or compensatory measures must be provided at installations where continuous operation is required.

VEHICLE ACCESS
Government-owned or -leased vehicles may be admitted only when on official business and only when operated by properly cleared and authorized drivers.

The approval process for nongovernment vehicles, which includes privately owned, to access LAs must be documented in the site security plan.

The site security plan must identify procedures for inspection of, and access by, service and delivery vehicles. Factors to be considered are vehicle identification, identification of owner/operator and provision for various technologies to include vehicle navigation systems, cell phones and back-up cameras.

All personnel within a vehicle are required to produce DOE security badges when accessing an LA and comply with individual LA procedures.

When a remote automated access control system is used for vehicle access control, it must verify that the operator or the escort has a valid DOE security badge. The unattended entry control point should have closed-circuit television system coverage.

Signs—Signs must be posted to convey information on the prohibited and controlled articles; the inspection of vehicles, packages, hand-carried items, and persons entering or exiting the security area; the use of video surveillance equipment; and trespassing. The decision on the signage and posting rests with the ODFSA and the requirements cited in Federal statutes and regulations.

c. Describe how graded security protection is used in safeguards and security planning in accordance with DOE O 473.3, *Program Protection Operations.*

The implementation of graded physical protection programs required by DOE O 473.3 must be systematically planned, executed, evaluated, and documented as described by a site security plan that appropriately addresses all national and DOE requirements.

- Program protection operations elements must be based on DOE O 470.3B, *Graded Security Protection (GSP) Policy*, and used in conjunction with local threat guidance. The GSP applies to all DOE facilities including those that do not possess classified material or SNM.
- Departmental interests must be protected from malevolent acts such as theft, diversion, and sabotage and events such as natural disasters and civil disorder by considering site and regional threats, protection planning strategies, and protection measures.
- SNM must be protected at the higher level when roll up to a higher category can occur within a single security area unless the facility has conducted an analysis that determined roll up was not credible.
- Sites upgrading security measures must consider the benefits provided using security technology by conducting life-cycle cost benefit analyses comparing the effectiveness of security technology to traditional manpower-based methodologies. However, at category I/II facilities various manpower alternatives to include security technologies must be used to allow protective force personnel to concentrate on the primary mission of protecting nuclear weapons, SNM, and designated high value targets.

d. Discuss the basic requirements of material control and accountability per DOE O 474.2, Admin Chg 3, *Nuclear Material Control and Accountability.*

The following are essential to a valid and successful material control and accountability (MC&A) program.

DOE Line Management Requirements

The detection of nuclear materials diversion and theft or unlawful activities by the site or facility operator; and the confirmation of the effectiveness of the MC&A programs.

Line management must assure and assess the performance of DOE MC&A programs in providing accurate nuclear material inventory information; controlling nuclear materials to deter and detect loss or misuse; providing timely and localized detection of unauthorized removals within specified limits; providing assurance that all nuclear materials are accounted for and that theft/diversion has not occurred; and assisting in the detection and deterrence of radiological and/or toxicological sabotage involving nuclear materials that could adversely impact national security, the health and safety of employees, the public, or the environment. Programs must assess performance using the metrics identified in Attachment 3 of DOE O 474.2, Admin Chg 3, unless alternative metrics have been documented in program or site office procedures and in the MC&A plan.

Oversight personnel must review and verify the validity of operator reports of nuclear material storage, processing, and use to the national system of accounting, and must ensure the effective regulatory control of nuclear materials as required by the AEA.

DOE Program Planning and Administration

A comprehensive 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. 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 for each MC&A element.

Program Management Objectives

The program

- ensures that documentation is sufficient to maintain a comprehensive, effective, and cost-efficient program to control and account for nuclear materials;
- defines MC&A system elements with performance goals that reflect consequence of loss or misuse of the material managed by the program;
- must be graded based on the consequence of loss and contain control and accounting mechanisms for nuclear materials;
- establishes and maintains an evaluation program that monitors the effectiveness of the MC&A system;
- responds effectively and efficiently to material loss indicators, anomalous conditions, and degradation of system performance; and
- 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 assure 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 assure 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 for reporting 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 the nuclear materials management and 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, assures 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.

Program Integration

The MC&A program must be integrated with other programs such as S&S program planning and management, physical protection, protective force, information security, personnel security, and response personnel. Additionally, the activities and requirements in the weapons surety, foreign visits and assignments, safety, emergency management, cyber security, intelligence, and counterintelligence programs should also be considered in the implementation of this Order.

DOE to Department of Defense (DoD) SNM Transfers

For DOE to DoD weapons transfers, SNM in weapons must not be transferred to DoD under 42 U.S. Code 2121(b), "Material for Department of Defense Use," until DOE has received direction from the president.

- Require that DOE line management not transfer nuclear material to DoD, or authorize contractor facilities to make such transfers, until it has received written authorization for specific transfers
- Require that DOE line management and the contractor retain written authorization on file for audit purposes
- Maintain memorandum inventory accounts and current inventory records for all transfers of accountable SNM in weapons to DoD by the NNSA Service Center

- Include inventory records for all quantities shipped to DoD, all quantities returned to DOE (based on the receiver's measured quantities), all quantities determined to have been consumed or lost, and inventory and loss data for reports of composition of ending inventory.

e. Discuss the responsibilities of field elements and contractor employees in identifying classified information as defined in DOE O 471.6 Admin Chg 2, *Information Security*.

[DOE O 471.6 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/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/her organization at least once every five 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/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/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.

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