October 4, 2010

To: J. N. McKamy Manager, NCSP
From: C. M. Hopper *Calvin M. Hopper* CSSG

Subject: **CSSG Response to Tasking 2009-05**

In response to Tasking 2009-05 a subgroup of the Criticality Safety Support Group (CSSG), in collaboration with Mr. Jerry Hicks (DOE AL), was organized to prepare a Criticality Safety Qualification Standard Reference Guide 2010 for use with DOE-STD 1173-2009, CRITICALITY SAFETY FUNCTIONAL AREA QUALIFICATION STANDARD.

The core response team consisted of the following members

Jerry Hicks (DOE-AL) Lead
Ivon Fergus (CSSG Ex-Officio)
Adolf Garcia (CSSG)
Jim Morman (CSSG)

The Guide was reviewed by the entire CSSG and comments were incorporated into the version that is attached. This version represents a consensus position by the entire CSSG.

cc: CSSG Members
J. Felty
N. Ellis
L. Scott

Criticality Safety Qualification Standard Reference Guide 2010

For use with DOE-STD 1173-2009, *CRITICALITY SAFETY FUNCTIONAL AREA QUALIFICATION STANDARD*

PURPOSE

The purpose of this reference guide is to provide a document that contains the information required for a National Nuclear Security Administration (NNSA) technical employee to successfully complete the Criticality Safety Functional Area Qualification Standard. In some cases, information essential to meeting the qualification requirements is provided. Some competency statements require extensive knowledge or skill development. Reproducing all the required information for the competency statements was judged by the expert group to be incorrect. In most instances, references are included to guide the candidate to additional resources.

SCOPE

This reference guide has been developed to address the competency statements in DOE-STD-1173-2009, Criticality Safety Functional Area Qualification Standard. 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. The qualification standard for criticality safety contains 40 competency statements. This reference guide will addresses all 40 statements.

Every effort has been made to provide the most current information and references available as of June 2010. However, the candidate is advised to verify the applicability of the information provided. As a parallel effort, references that are not easily obtainable have been collected, and will be placed on the DOE Nuclear Criticality Safety Program Website. Federal Nuclear Criticality Safety personnel should also be aware that the qualification standard requires that the incumbents maintain awareness of the latest revisions to the applicable DOE directives and ANSI/ANS Standards.

This guide may used for development of test questions for qualification of federal criticality safety candidates only by DOE Senior Nuclear Criticality Staff and members of the Criticality Safety Support Group. However, test material will address the competencies in the qualification standard, and is not limited to the content of this guide.

Please direct your questions or comments related to this document to one of the following:

- The NNSA Service Center Safety Department criticality safety staff;
- NNSA HQ criticality safety staff
- The Chair of the Criticality Safety Support Group (CSSG);
- The DOE NCSP Program manager.

1. Criticality safety personnel must demonstrate a working-level knowledge of the fission process.

a. Define the following terms:

- Excitation energy
- Cross section
- Fissile material
- Fissionable material
- Fertile material

See:
Modules 1 and 2 on the DOE/NCSP Website. http://ncsp.llnl.gov/ncset/Module1.pdf, http://ncsp.llnl.gov/ncset/Module2.pdf

See:
DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, DOE-HNDBK-1019/1-93, Module 1, Nuclear Fission section
http://www.hss.doe.gov/nuclearsafety/ns/techstds/standard/hdbk1019/h1019v1.pdf

b. Sketch the fission cross section for both U-235 and Pu-239 as a function of neutron energy. Label each significant energy region and explain the implications of the shape of the curves for criticality safety.

See:
DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, DOE-HNDBK-1019/1-93, Module 2, Nuclear Cross Sections section

http://www.hss.doe.gov/nuclearsafety/ns/techstds/standard/hdbk1019/h1019v1.pdf

Cross section data are available from these web sites.
http://www.nndc.bnl.gov/sigma/index.jsp
http://atom.kaeri.re.kr/cgi-bin/endfplot.pl

Cross sections can also be plotted from SCALE and MCNP.

c. Explain why only the heaviest nuclei are easily fissioned.

See:
DOE-HDBK-1019-93 DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory Module 1, Nuclear Fission section
LA-14098, *Modern Fission Theory for Criticality,* Lynn, February 2004.

d. Explain why uranium-235 fissions with thermal neutrons and uranium-238 fissions only with fast neutrons.

See:

DOE-HDBK-1019-93, DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory Module 1, Nuclear Fission section

e. Characterize the fission products in terms of mass groupings and radioactivity.

See:
DOE-HDBK-1019-93 DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, Module 1, Energy Release from Fission section

f. Define sub-critical, critical, super-critical, reproduction factor, prompt neutron fraction, and delayed neutron fraction.

See:
DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, DOE-HNDBK-1019/2-93 Module 3, Neutron Life Cycle section

http://www.hss.doe.gov/nuclearsafety/ns/techstds/standard/hdbk1019/h1019v2.pdf

g. Discuss isotopes other than U-235 and Pu-239 that are fissionable.

See:
ANSI/ANS 8.1, ANSI/ANS 8.15,
Nuclear Safety Guide, TID 7016 Rev 2 Appendix

2. Criticality safety personnel must demonstrate a working-level knowledge of the various types of radiation interaction with matter.

a. Describe the interactions of the following with matter:

- Alpha particle
- Beta particle
- Positron
- Neutron

See:
DOE-HDBK-1019-93, DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory Module 1, Interaction of Radiation with Matter section

b. Describe the following ways that gamma radiation interacts with matter:

- Compton scattering
- Photoelectric effect
- Pair production

See:
DOE-HDBK-1019-93, DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory Module 1, Interaction of Radiation with Matter section

3. Criticality safety personnel must demonstrate a working-level knowledge of criticality control and safety parameters.

a. Discuss the effects and applications of the following factors relevant to criticality safety of operations:

- Mass
- Interaction
- Geometry
- Moderation
- Reflection
- Concentration
- Volume
- Neutron absorbers
- Enrichment

See:
Modules 1, 2, 3, 4, 5, on the DOE/NCSP Website.
http://ncsp.llnl.gov/trainingMain.html
Nuclear Criticality Safety, Theory and Practice, R. A. Knief, American Nuclear Society, 1985

b. Discuss the influence of the presence of non-fissionable materials mixed with, or in contact with, fissionable material on nuclear criticality safety. Include a discussion of the effects of mild absorbers (e.g. some absorption, but mostly scattering), and materials that behave as almost pure elastic scatterers, either with or without significant moderation per collision (e.g., describe the effect of diluting plutonium oxide with either wet or dry silica, contrast the two, and explain the effects from an interaction viewpoint.).

See:
TID 7016, Rev 2, Nuclear Safety Guide, June 1978, § 2.21 & 2.22

The candidate should prepare or reference a chart showing the critical mass vs. the concentration for fissile material and water compared to fissile material and a common diluent such as silica. The concentration ranges should be from approximately the minimum critical concentration to full density metal (i.e. no dilution). The effect of water and diluent should also be illustrated. Previous work by the candidate may be used.

c. Discuss the effects of Density, Heterogeneity, and Enrichment with respect to resonance escape and lumped fuel.

See:
DOE Fundamentals Handbook, Nuclear Physics and Reactor Theory, DOE-HNDBK-1019/2-93, Module 3, Neutron Life Cycle section
http://www.hss.doe.gov/nuclearsafety/ns/techstds/standard/hdbk1019/h1019v2.pdf

Introduction to Nuclear Reactor Theory, J. LaMarsh, Addison Wesley, 1966 & 1972, now available from ANS.

d. Discuss the effects of mixtures of different fissionable nuclides and the appropriate applications of the "rule of fractions" and "fissionable equivalent mass" concepts.

See: WSRC-TR-94-0366, Equivalence Relations for the 9972-9975 SARP (U), Niemer & Frost, Westinghouse Savannah River Company, October 1994

The candidate should prepare or reference charts showing the actual critical mass vs the critical mass estimated by fraction critical for mixtures of two common fissile isotopes. The charts should include at least one for pure metal, and one at near optimum moderation. Previous work by the candidate may be used.

e. Discuss the concept of contingencies for checking the validity of criticality safety limits.

See:
LA-2063, *Nuclear Safety Guide,* 1956
LA-3366, Criticality Control in Operations with Fissile Material
ANSI/ANS 8.1 § 4.1.2 & 4.2.1

4. Criticality safety personnel must demonstrate a working-level knowledge of alarm systems for criticality accidents.

a. Define the following terms:

- Criticality accident
- Minimum accident of concern
- Process area

See:
ANSI/ANS 8.3, Criticality Accident Alarm System.
Nuclear Criticality Safety Theory and Practice, Appendix E, R. A. Knief, 1991 (Available from ANS)

b. Discuss the general principles associated with the use of criticality alarm systems including the following:

- Installation
- Coverage
- Detection
- Alarms
- Dependability
- Removal

See:
ANSI/ANS 8.3, Criticality Accident Alarm System
DOE STD 3007 § III.A

Nuclear Criticality Safety Theory and Practice, Appendix E, R. A. Knief, 1991 (Available from ANS)

c. Discuss the requirements for testing the criticality alarm system.

See:
ANSI/ANS 8.3, Criticality Accident Alarm System.

5. Criticality safety personnel must demonstrate a working-level knowledge of neutron absorbers.

a. Describe the use of neutron poisons.

See:
competency 19, ANSI/ANS 8.14 and 8.21)
DOE Handbook 1019 Module 3, Neutron Poisons
ANSI/ANS 8.14
ANSI/ANS 8.21
Nuclear Criticality Safety Theory and Practice, Chapters 1 & 4, R. A. Knief, 1991 (Available from ANS)

b. Explain the absorption characteristics of the following elements in terms of their cross sections.

- cadmium
- boron
- chlorine
- hydrogen

See:
Cross section publication websites:
http://www.nndc.bnl.gov/sigma/index.jsp
http://atom.kaeri.re.kr/cgi-bin/endfplot.pl
The MCNP code and the SCALE code package can also plot cross sections.
NCSET Module 2
DOE Handbook 1019 Module 2, Cross Sections
DOE Handbook 1019 Module 3, Neutron Poisons

c. Explain the purpose and use of Raschig rings as a neutron poison. (See competency 19, ANSI/ANS 8.5)

The detailed requirements for the use of borosilicate-glass Raschig rings are found in ANSI/ANS-8.5-1996.

6. Criticality Safety Personnel must demonstrate a familiarity level knowledge of the functional interfaces between safety system software and control components and the system level design and function.

a. Identify how system level requirements are developed. Explain how these requirements are incorporated into an engineered system. Describe the

methods a quality organization should use to verify that the as installed system meets the system level requirements as defined.

See:
Safety Software Guide for use with 10 CFR 830 Subpart A, *Quality Assurance Requirements, and DOE O 414.1C, Quality Assurance,* DOE G 414.1-4, Section 5.2
NUREG/CR-6263 MTR 94W0000114, Vol. 2, High Integrity Software for nuclear power Plants, Candidate Guidelines, Technical Basis and Research Needs, Main Report, Section 9.0 Software Safety Analysis.
Institute of Electrical and Electronics Engineers (IEEE) Std 830-1998, *IEEE Recommended Practice for Software Requirements Specifications,* IEEE, 1998, sections 4.4, 5.2.5, and 5.3.
IEEE 1228, *IEEE Standard for Software Safety Plans, IEEE, 1994*

b. Describe and discuss the advantages and disadvantages of the following automation approaches:

- Analog control systems
- Hard wired relay logic
- Programmable Logic Controller (PLC) based systems.
- Computer control systems

See:
Perry's Chemical Engineers' Handbook. (Chapter 22 in the 6th Edition)

c. Discuss the limitations and pitfalls of automation as it relates to criticality safety. Identify areas that are appropriate to automate and areas where automation might be a detriment to safety.

See:
Perry's Chemical Engineers' Handbook. (Chapter 22 in the 6th Edition)

d. Describe the effect of the following on control of a process or experimental system:

- sensing elements, (e.g. thermocouples, position sensors, level sensors, flow sensors, pressure sensors, power level sensors)
- control logic element (e.g. the hardware and/or software that actuates the control action elements)
- control action element and control action (e.g. induction furnace power, resistance furnace voltage, cooling coil flow control, refrigeration unit, modulating valve position, block valve position, pump speed, control rod position, scram system action)
- controlled system response to control action (e.g. change in temperature, position, level, flow, pressure, power level)

See:
Perry's Chemical Engineers' Handbook. (Chapter 22 in the 6th Edition)

e. Discuss the effects of time dependence in sensing and control systems in relation to the system dynamics. A possible example is a shock driven safety block in a fast burst reactor, as compared to a thermocouple sensor with motor driven reactivity removal in such a reactor.

See:
Perry's Chemical Engineers' Handbook. (Chapter 22 in the 6th Edition)

7. Nuclear Criticality Safety Personnel must demonstrate a familiarity level knowledge of Non-Destructive Assay Techniques for quantification of fissile and fissionable materials.

See for Items a through g:
Passive Nondestructive Assay Manual (PANDA) manual and associated reports, downloadable from http://www.lanl.gov/orgs/n/n1/panda/index.shtml

a. For the following types of stationary assay equipment:

- Calorimeter
- Gamma Spectrometer
- Segmented gamma scanner
- Package gamma scanner or 'package counter'
- Passive Neutron Counter
- High Efficiency Neutron counter
- Passive/Active Neutron Counter

1. Briefly describe each type of assay machine.
2. Describe the strengths and weaknesses of each type of machine.
3. Identify the types of materials that will grossly bias the assay, both high and low.

b. Discuss the various types of detectors used, and the strengths and weaknesses of each. (e.g. NaI, GeLi, HPGe, Geiger-Mueller, ^{3}He, BF_3)

c. Discuss the physics and mathematics that relate count time, amount of material, and precision of the assay.

d. Discuss the types of Non-destructive assay equipment used for in-situ measurements.

e. Discuss the types of equipment and limitations of assay when the material of interest is

- Shielded by containers or process equipment
- Low activity
- High activity

- Characteristic radiations are low energy
- Characteristic radiations are High energy

f. Briefly discuss how to derive detection criteria and select the appropriate NDA methods for stationary and in-situ applications.

g. Briefly discuss how the geometry models for detector and source material affect the interpretation of raw NDA data. (e.g. generalized geometry, plane source, point source, line source)

8. Criticality Safety Personnel must demonstrate a familiarity level knowledge of the relationship between human factors, human performance, and implementation of criticality safety controls

See for items a-e:
INPO 06-002, *Human Performance Tools for Workers*, April 2006 and
Principles for a Strong Nuclear Safety Culture, INPO, November 2004
Principles for a Strong Nuclear Safety Culture, INPO, November 2004
Department of Energy Action Plan - Lessons Learned from the Columbia Space Shuttle Accident and Davis-Besse Reactor Pressure-Vessel Head Corrosion Event , USDOE, July 2005
DOE HDBK-1028-2009, Human Performance Improvement Handbook, June 2009

a. Identify and discuss aspects of person-machine interface that can degrade or enhance the safety performance of personnel.

NUREG-0700 Rev.2, "Human-System Interface Design Review Guidelines, 2002 (HFE design guidelines for human-machine interface);
IEEE Std 1023-2004 IEEE Recommended Practice for the Application of Human Factors Engineering to Systems, Equipment, and Facilities of Nuclear Power Generating Stations and Other Nuclear Facilities (integrated HFE design process)
DOE-HDBK-1140-2001, Human Factor/Ergonomics Handbook for the Design for Ease of Maintenance;

b. Identify and discuss how written procedures are conducive to reliable or unreliable performance of activities important to safety.

DOE-STD-1029-92 (CN1), Writer's Guide for Technical Procedures, December 1998;
DOE-HDBK-1076-94 Table-Top Job Analysis, December 1994

c. Identify and discuss how personnel training programs can be conducive to safety or prone to error.

DOE-HDBK-1078-94, Training Program Handbook: A Systematic Approach to Training, August 1994
DOE-HDBK-1076-94 Table-Top Job Analysis, December 1994

d. Identify and discuss how staffing and qualification of operational personnel are conducive to safe versus unsafe operations.

DOE G 423.1-1, Implementation Guide for Use in Developing Technical Safety Requirements

e. Identify and discuss the influence of management and organizational factors upon safety of operations.

DOE G 423.1-1, Implementation Guide for Use in Developing Technical Safety Requirements

f. Identify and discuss the methods used to estimate the probability of significant mistakes made by personnel and the relationship to probabilistic risk assessment.

See
NUREG/CR-6883 [INL/EXT-05-00509] *The SPAR-H Human Reliability Analysis Method*, Idaho National Laboratory for U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research Washington, DC 20555-0001, D. Gertman, H. Blackman, J. Marble, J. Byers, C. Smith, August 2005
IEEE Std 1082, IEEE Guide for Incorporating Human Action Reliability Analysis for Nuclear Power Generating Stations
ANSI/ANS 58.8, Time-response Design Criteria for Safety Related Operator Actions

g. Identify and discuss the methods for assessing the reliability of administrative controls in maintaining criticality safety.

See
NUREG/CR-6883 [INL/EXT-05-00509] *The SPAR-H Human Reliability Analysis Method*, Idaho National Laboratory for U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research Washington, DC 20555-0001, D. Gertman, H. Blackman, J. Marble, J. Byers, C. Smith, August 2005
DOE-STD-1186-2004, Specific Administrative Controls
DOE-STD-3007-2007, Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities

9. Criticality safety personnel must demonstrate a working-level knowledge of calculational methods used in criticality safety evaluations, and must have demonstrated the ability to use such methods.

a. Identify and discuss the application of several common hand calculation methods (e.g., buckling method, solid angle method, surface density, and density analog).

See:
LA-14244, *Hand Calculation Methods for Criticality Safety – A Primer*, Bowen and Busch, November 2006.

Knief, *Nuclear Criticality Safety Theory and Practice*, Ch. 8 and sample problems in Appendices B, C and D.

b. Prepare an example using each one of the hand calculational methods listed in 9.a above.

The qualifying official should suggest example problems that relate to the candidate's site.

This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

10. Criticality safety personnel must demonstrate a working-level knowledge of critical and sub-critical experiments.

a. Describe the types of data derived from critical experiments and its use in criticality safety.

Reference:
Knief, *Nuclear Criticality Safety Theory and Practice*, Ch. 5, and the International Handbook Criticality Benchmark Experiments

b. Discuss the physics of critical experiments including fundamental concepts associated with critical experiments (e.g., six factor formula, approach to critical, reactivity insertion, multiplication, reactor kinetics, reactivity changes, etc.).

Reference DOE Handbook 1019, Volume 2, Module 4, pages 1-33

c. Participate in a criticality experiment demonstration.

This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

11. Criticality safety personnel must demonstrate a working-level knowledge of computer codes used in criticality safety evaluations, and must have demonstrated the ability to use such methods.

a. Develop input model for one Monte Carlo and one deterministic code (e.g., MONK, VIM, SCALE/KENO, MCNP, PARTISN, SCALE/XSDRN, COG).

This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

See:
ORNL/TM-2005/135, KENO V.a Primer.
LA-12827-M, Criticality Calculations with MCNP, A Primer

SCALE Manual if using a SCALE deterministic code.

b. Describe how cross section data impact Monte Carlo and deterministic codes.

Cross section data are the fundamental physical data on which Monte Carlo and deterministic codes rest. The cross section is the probability of a particular interaction between a particular nucleus and a neutron of a particular energy. The basis of the physical model in Monte Carlo is converting this data to probability density functions and collecting the tallies to form the solution to the integral equations. The cross section data are also fundamental to the deterministic codes. Although they use a different mathematical algorithm and do not use the stochastic methods, the neutron-nuclei interactions are still the basis of the code.

c. Discuss the advantages and disadvantages of point-wise continuous and multi-group cross section data.

See the MCNP5 Manual, Chapter 2, § III

Point-wise continuous cross sections can most accurately calculate the interaction effect of the various cross sections of the materials of concern. This is particularly important in the resonance regions of the cross sections. However, calculations with multi-group cross-section sets require much less computer memory and are much quicker.

d. Briefly discuss the effect of geometry and spectral assumptions on the development of multi-group cross sections.

All multi-group cross section sets are developed by collapsing larger sets of data by using simplifying assumptions. These assumptions include geometry and spectral effects. If the assumed spectrum, geometry, and spatial effects are incorrect for the system being calculated, significant errors can occur.

e. Describe the importance of validation of computer codes and how it is accomplished. (See competency 19, ANSI/ANS 8.1 & 8.24)

See the referenced standards.

The codes are only theoretical without validation. Validation is the comparison of the code results to known conditions. It is accomplished by modeling known critical conditions, known in validation practice as benchmarks. The results of the code vs. the benchmarks are compared, the variances in the differences are analyzed, and trends are searched out. Typical parameters are main fissile isotope, main diluent, reflectors, and some measure of energy range. Bias, variance in the bias, experimental uncertainties, and code variance are also considered. This work is often reduced to a maximum acceptable K-effective, or preferably a maximum acceptable K-effective for each type of system likely to be analyzed by the validator (person or organization). When this is done, the proper goal is to have a maximum acceptable K-effective such that the validator (and user, if different) are highly confident that the maximum acceptable K-effective is subcritical. This applies over an applicable range of parameters and that the bias may not be a single value.

f. Describe the methodology supporting Monte Carlo codes and deterministic codes.

Reference NCSE Training Modules 6 and 7

g. Describe advantages and pitfalls of Monte Carlo calculations and deterministic codes.

Deterministic codes are much faster than Monte Carlo, due to the fewer number of calculations required to iterate to a solution. They are limited by the approximations of spatial mesh, directional grouping, and energy grouping. Properly validated, they can be useful for a wide range of single unit problems. They can be misleading if the group structure of the cross sections has not been properly derived for the energy spectrum of the system being calculated. The limitation on energy spectrum is somewhat (but not entirely) mitigated by using a large number of groups.

Monte Carlo codes have the advantage of being able to handle almost any geometry. Some codes also use pointwise continuous cross section data, avoiding the need to derive the group structures for an energy spectrum. Their disadvantages are that they can be treated like a black box, and some understanding of statistics is necessary to understand the output. Further, systems can be modeled which the code may calculate incorrectly, especially if important regions are not sampled with particles. This can be detected only by correctly designing the input to provide some output check of the source sampling of each important region. Also, if review is done by reviewing the input deck, errors in geometry and material descriptions are easy to miss.

h. The diffusion theory model is not strictly valid for treating fissile systems in which neutron absorption, voids, and/or material boundaries are present. In the context of these limitations, identify a fissile system for which a diffusion theory solution would be adequate.

See:
LA-14244-M *Hand Calculation Methods for Criticality Safety – A Primer,* Bowen and Busch, November 2006

i. Discuss the International Handbook of Evaluated Criticality Safety Benchmark Experiments, including its purpose, accessibility, and application to computer code validation.

See:
The introductory material to the handbook.

The ICSBEP Handbook contains descriptions of hundreds of critical experiments and a few subcritical experiments, with detailed geometry and material data. The handbook alone can often provide an adequate set of benchmarks for validation, but it is not to be considered the only source. Of course, the experiments in the handbook can be used for evaluation of an application system by direct comparison to experiment also. The handbook contains a few experiments that it states are not suitable for benchmark use that may be used for comparison to application problems.

Many of the experiments also have associated model decks, which are sometimes useful for understanding the geometry. The included decks should not be used for validation unless a thorough QA check is done to assure that the model is the same as the user would have modeled the system.

12. Criticality safety personnel must demonstrate both a working-level knowledge of development of criticality safety evaluations and the ability to develop such evaluations.

a. Prepare two criticality safety evaluations for two different applications selected from those listed in h., i., and k. below.

This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

b. Describe development of contingency analysis and controls.

See:
DOE-STD-3007-2007
NCSET Module 12
LA-3366
LA-2063

c. Describe practical ways to minimize the use of administrative controls, and discuss of how to evaluate whether the evaluation develops a proper mix of engineered and administrative controls.

See:
NCSET Module 12

d. Give an example of a practical method for controlling each of the following parameters:

- Mass
- Absorption
- Geometry
- Interaction
- Concentration
- Moderation
- Enrichment
- Reflection
- **Volume**

See:
NCSET Module 12

ANSI/ANS-8.1-1998, Appendix A

e. Describe key personnel in preparation of criticality safety evaluations and determination of process upsets.

See:
NCSET Module 12
ANSI/ANS-8.19-2005
ANSI/ANS-8.26-2007

f. Describe how sub-critical margins and limits are determined.

See:
DOE-STD-3007-2007
NCSET Module 12
ANSI/ANS-8.1-1998
ANSI/ANS-8.24-2007

g. Describe when validation and bias estimates must be considered, and when they may be disregarded.

See:
DOE-STD-3007-2007
ANSI/ANS-8.1-1998
ANSI/ANS-8.24-2007

h. Describe considerations when evaluating various fissile processes, including common process upsets, for the following process types:

- **Aqueous**
- **Metal**
- **Recovery**
- **Fabrication/Foundry**
- **Mixed waste**

See:
DOE-STD-3007-2007
NCSET Module 12
ANSI/ANS-8.1-1998 Appendix A
NCSET Modules 10 & 11

i. Describe considerations for evaluating material storage:

- Pits
- Waste
- Fuel elements
- Solutions
- Metal parts

See:
DOE-STD-3007-2007
NCSET Module 12
ANSI/ANS-8.7-1998
NCSET Modules 10 & 11
The candidate should also consult with qualifying officials with experience in these areas. Mentoring will be necessary.

j. Discuss elements of the following industry reference material:

- LA-10860-MS, Critical Dimensions of Systems Containing U235, Pu239, and U233, 1986
- LA-12808, Nuclear Criticality Safety Guide, 1996
- BNWL-SA-4868 or successor PNL-SA-4868, Anomalies of Criticality
- LA-11627-MS, Glossary of Nuclear Criticality Terms

k. Describe elements to consider when preparing a safety analysis report for packaging (SARP).

See:
10 CFR 71
49 CFR 173

l. Describe considerations for evaluating storage of DOE/DOT/NRC certified shipping containers and non-certified shipping containers.

See:
10 CFR 71
49 CFR 173
TID-7016 Chapter IV

13. Criticality safety personnel must demonstrate a working level knowledge of the requirements in Department of Energy (DOE) Technical Standard DOE-STD-3007-2007, Guidelines for Preparing Criticality Safety Evaluations at DOE Non-Reactor Nuclear Facilities.

a. Describe the documentation requirements for a criticality safety evaluation conforming to this standard.

See:
DOE-STD-3007-2007
NCSET Module 12

b. Discuss the role of this standard in establishing appropriate analytical techniques for criticality safety evaluations.

See:
DOE-STD-3007-2007
NCSET Module 12

c. Discuss the relationship between DOE-STD-3007-2007, Guidelines for Preparing Criticality Safety Evaluations at DOE Non-Reactor Nuclear Facilities, and DOE Order 420.1b, Facility Safety.

See:
DOE-STD-3007-2007
NCSET Module 12

d. Discuss the proper relationship between criticality analyses and controls, the Documented Safety Analysis, and TSR Controls, and design features documented in the DSA and TSRs.

See:
(DOE-STD-3007-2007, 10CFR830, ANSI/ANS 8.26 § 7.7, DOE G 421.1-2, DOE G 423.1-1, DOE STD 3009-94 CN 3)

14. Criticality safety personnel must demonstrate a working-level knowledge of the guidance provided in DOE Technical Standard DOE-STD-1134-99, *Review Guide for Criticality Safety Evaluations*.

a. Describe the purpose and general structure of the guide.

Reference:
DOE-STD-3007-2007
DOE-STD-1134-99

b. Using the guide as a reference, discuss the guidelines provided for use by DOE criticality safety personnel when reviewing criticality safety evaluations produced by a Contractor.

This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

15. Criticality safety personnel must demonstrate a working level knowledge of previous criticality accidents and their causal factors.

a. Discuss with some detail three (3) historic accidents described in LA-13638 and the lessons learned from each.

Reference
LA-13638, McLaughlin, Monahan, & Pruvost, *A Review of Criticality Accidents,* May 2000.
Nuclear Criticality Safety Theory and Practice, Chapter 3, R. A. Knief, 1991 (Available from ANS)

b. Discuss generic precursors to criticality accidents, and lessons learned from criticality accident history, as described in LA-13638, Section 1C.

See:
LA-13638, McLaughlin, Monahan, & Pruvost, *A Review of Criticality Accidents,* May 2000.
NCSET Module 14

16. Criticality safety personnel must demonstrate a familiarity level knowledge of problem analysis principles and the techniques necessary to identify Department problems, potential causes, and corrective action(s) associated with criticality safety issues.

It is recommended that CS Federal Personnel attend a one-week Accident Investigation training course early in their career. Numerous commercially available techniques have been used in the DOE complex.

INPO Good Practice OE-907 (INPO 90-004 “Root Cause Analysis”;
NUREG/CR-5455 “Development of the NRC’s Human Performance Investigative Process”

a. Describe and explain the application of problem analysis techniques including the following:

- **Root cause analysis**
- **Causal factor analysis**
- **Change analysis**
- **Barrier analysis**
- **Management oversight risk tree analysis**

See:
DOE G 225.1A-1, Implementation Guide for use with DOE Order 225.1A, Accident Investigations
DOE Workbook, Conducting Accident Investigations,
http://www.hss.energy.gov/CSA/CSP/AIP/workbook/index.html

b. Describe the following types of investigations and discuss an example of the application of each of the following:

- **Type A**
- **Type B**

See DOE O 225.1a, Accident Investigations

c. Compare and contrast immediate, short term, and long-term actions taken as the result of a problem identification or an occurrence.

Immediate actions are to put the system or process into a safe and stable condition. Short term actions are generally recovery actions to allow other nearby processes or systems to return to operation, or to return unaffected portions of the same process to operation. Short term actions may also be appropriate if only a few items are involved in the occurrence, and the correction path can be readily determined. They are likely to involve things such as shift orders, standing orders, and temporary modifications. Short term actions usually do not deal with recurrence control, or may have expensive compensatory actions for recurrence control. Long term actions may involve engineered solutions and more deliberately revised procedures and training, and usually are undertaken to ensure recurrence control.

d. Given event and/or occurrence data, apply problem analysis techniques and identify the problems and how they might have been avoided.

This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

e. Describe various data gathering techniques and the use of trending/history when analyzing problems.

See:
DOE G 225.1A-1, Implementation Guide for use with DOE Order 225.1A, Accident Investigations
DOE Workbook, Conducting Accident Investigations,
http://www.hss.energy.gov/CSA/CSP/AIP/workbook/index.html

Criticality Safety Oversight (Competencies 17 - 22)

17. Criticality safety personnel must demonstrate a working level knowledge of DOE O 420.1B, *Facility Safety,* with respect to its impact on the Department's criticality safety.

Mentoring will be required for this competency.
See:
DOE O 420.1B
ANSI/ANS 8 Series Standards
DOE O 460.1B, *Packaging and Transportation Safety*
DOE STD 3007-2007

a. Discuss the purpose and objectives of the nuclear criticality safety requirements of DOE O 420.1B.

b. Discuss the following concepts associated with the nuclear criticality safety program:

- **Criticality safety program description document**
- **Qualification requirements of nuclear criticality safety staff**
- **Acceptable preparation methodologies for nuclear criticality safety evaluations**
- **Acceptable review methodologies for nuclear criticality safety evaluations**

- **Proper treatment of the requirements and recommendations from the**
- **ANSI/ANS 8-series standards**
- **Proper treatment of the double contingency principle recommendation and deviations from the principle**
- **Single failure vulnerability**
- **Preferred order of criticality safety controls**
- **Fissionable material accumulation**
- **Firefighting guidelines**

c. Discuss the contractor's responsibilities with respect to the implementation of the requirements of DOE O 420.1B.

d. Discuss the Management and Operating (M&O) contractor responsibilities for the following in relation to criticality safety activities:

- **Criticality safety evaluations**
- **Monitoring**
- **Surveillance**
- **Transportation**
- **Storage**

e. Discuss the role of Department criticality safety personnel with respect to the implementation of the requirements of DOE O 420.1B.

18. Criticality safety personnel must demonstrate a familiarity level knowledge of historical criticality safety-related requirements.

See:
The cited documents

a. Describe the history of criticality safety standards, and inconsistencies between DOE Orders and those standards, including regulatory lessons learned.

References
LA-3366
ANSI N16.1
ANSI/ANS-8.1, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors,* prior and current versions
DOE O 6430.1A, *General Design Criteria, §* 1300-4
DOE O 5480.5, *Safety of Nuclear Facilities*
DOE O 5480.24, *Nuclear Criticality Safety*
DOE O 420.1, 420.1A, and 420.1B, *Facility Safety*
DOE-STD-1189-2008, *Integration of Safety Into the Design Process,* § 7.5 and Table 7-2

LA-2063
TID-7016

Also, review the Los Alamos and Oak Ridge Heritage Videos.

19. Criticality safety personnel must demonstrate a working level knowledge of the following criticality safety-related ANSI/ANS standards:

- **ANSI/ANS-8.1-1998, Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors**
- **ANSI/ANS-8.3-1997, (ANSI N-16.2), Criticality Accident Alarm System**
- **ANSI/ANS-8.5-1996, (ANSI N-16.4), Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material**
- **ANSI/ANS-8.7-1998, Guide for Nuclear Criticality Safety in the Storage of Fissile Materials**
- **ANS-8.14-2004, Use of Soluble Absorbers in Nuclear Facilities Outside of Reactors**
- **ANSI/ANS-8.15-1981, Nuclear Criticality Control of Special Actinide Elements**
- **ANSI/ANS-8.19-2005, Administrative Practices for Nuclear Criticality Safety**
- **ANSI/ANS-8.20-1991, Nuclear Criticality Safety Training**
- **ANSI/ANS-8.21-1995, Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors**
- **ANSI/ANS-8.22-1997, Nuclear Criticality Safety Based on Limiting and Controlling Moderators**
- **ANSI/ANS-8.23-2007, Nuclear Criticality Accident Emergency Planning and Response**
- **ANSI/ANS-8.24-2007, Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations**
- **ANSI/ANS-8.26-2007, Criticality Safety Engineer Training and Qualification Program**

a. Describe the contents, requirements, and relationships among the above ANSI/ANS standards.

See:
The cited standards.

b. Discuss the applicability of the above ANSI/ANS standards to the Department facilities and processes.

Reference:
DOE O 420.1b.

c. Discuss the role of the Department's criticality safety personnel in implementing the requirements of these standards.

See:
DOE O 226.1a

and the following CFRs.
48 CFR 17.604 Identifying management and operating contracts.
48 CFR 970, §970.0370 Management Controls and Improvements, §970.0370–1 Policy.
48 CFR 970, §970.5203–2 Performance improvement and collaboration.

These sections require collaboration from the contractor. Collaboration cannot, by its nature, be a unilateral obligation.

The federal criticality safety oversight includes both assessments and cooperative guidance and leadership of the site criticality safety program. Professional collaboration with the site criticality safety management and operations is essential to a successful program.

20. Criticality safety personnel must demonstrate a familiarity level knowledge of the following criticality safety-related ANSI/ANS standards:

- **ANSI/ANS-8.6, Safety in Conducting Subcritical Neutron-Multiplication Measurements In Situ**
- **ANSI/ANS-8.10-1987, Criteria for Nuclear Criticality Safety Controls in Operations With Shielding and Confinement**
- **ANSI/ANS-8.12, Nuclear Criticality Control and Safety of Plutonium-**
- **Uranium Fuel Mixtures Outside Reactors**
- **ANSI/ANS-8.17-2004, Criticality Safety Criteria for the Handling, Storage and Transportation of LWR Fuel Outside Reactors**
- **ANSI/ANS-8.27-2008, Burnup Credit for LWR Fuel**

a. Describe the contents, requirements, and relationships between the above Orders and Technical Standards.

See:
The listed standards.

b. Describe the role of criticality safety personnel with respect to the requirements in these standards.

See:
DOE O 420.1b and DOE O 226.1a,
and the following CFRs
48 CFR 17.604 Identifying management and operating contracts.
48 CFR 970, §970.0370 Management Controls and Improvements, §970.0370–1 Policy.
48 CFR 970, §970.5203–2 Performance improvement and collaboration.

These sections require collaboration from the contractor. Collaboration cannot, by its nature, be a unilateral obligation.

The federal criticality safety oversight includes both assessments and cooperative guidance and leadership of the site criticality safety program. Professional collaboration with the site criticality safety management and operations is essential to a successful program.

21. Criticality safety personnel must demonstrate a familiarity level knowledge of the following criticality safety experiment related ANSI/ANS standards:

- **ANSI/ANS-1-2000, Conduct of Critical Experiments**
- **ANSI/ANS-14.1-2004, Operation of Fast Pulse Reactors**

a. Discuss when ANS 1 is applicable in a critical experiments facility and when these standards (ANS-1 or ANS 14.1) become the governing criteria as opposed to ANS 8.1.

Mentoring is required for this competency

b. Discuss the similarities between ANS 1-2000 and ANS 8.6-1983.

See:
The cited standards

c. Discuss the differences in safety device actions between operations governed by ANS 1 and ANS 14.1.

See:
The cited standards

d. Discuss the similarities in management practices among ANS 1, ANS 8.1, and ANS 14.1.

See:
The cited standards

e. State the multiplication criteria limits that should be applied to manually performed criticality experiments.

See:
The cited standards

f. Give a brief explanation of the physics reason(s) for ANS-1-2000, § 4.4.

See:
DOE Handbook 1019, Module 4, § 3

22. Criticality safety personnel must demonstrate a working level knowledge of assessment techniques (such as the planning and use of observations, interviews, and document reviews) to assess facility performance, report

results of assessments, and follow up on actions taken as the result of assessments.

See:
DOE O 226.1a, NNSA Manual 226.1 for this competency. It is recommended that the candidate participate in several assessments as a team member.

Mentoring is required for this competency

a. Describe the role of criticality safety personnel in the assessment of Government Owned Contractor Operated (GOCO) and Government Owned Government Operated (GOGO) facilities.

b. Describe how DOE-STD-1158-2002, Self-Assessment Standard for DOE Contractor Criticality Safety Programs, should be used in assessments.

c. Describe the assessment requirements and limitations associated with the interface with contractor employees.

d. Discuss the essential elements of a performance-based assessment including the following:

- **Investigation**
- **Fact-finding**
- **Exit interview**
- **Reporting (Including review for factual accuracy)**
- **Follow-up**
- **Closure**

e. Describe the following assessment methods and the advantages or limitations of each method:

- **Document review**
- **Observation**
- **Interview**

f. Describe the action to be taken if the contractor challenges the assessment findings and explain how such challenges can be avoided.

23. Criticality safety personnel must demonstrate a working level knowledge of DOE O 231.1A Chg 1, Environment, Safety, and Health Reporting, and DOE M 231.1-2, Occurrence Reporting and Processing of Operations Information, with respect to their impact on Department nuclear safety.

Supporting Knowledge and/or Skills:

a. State the purpose of DOE O 231.1A and DOE M 231.1-2.

See:
The referenced Order and Manual

b. Define the following terms:

- **Event**

See:
Manual 231.1-2 § 13

- **Condition**

See:
Manual 231.1-2 § 13

- **Facility**

See:
Manual 231.1-2 § 13

- **Notification report**

See:
Manual 231.1-2 § 13

- **Occurrence report**

See:
Manual 231.1-2 § 13

See:
Manual 231.1-2 § 13 and § 6

c. Discuss the Department's policy regarding the reporting of occurrences as outlined in DOE O 231.1A, Environment, Safety and Health Reporting.

See:
Manual 231.1-2. The Department's policy regarding the reporting of occurrences is now outlined in DOE M 231.1-2.

d. State the different categories of reportable occurrences and discuss each.

See:
Manual 231.1-2 § 6

e. Discuss the categorization, notification, and timeliness requirements associated with the following:

- **Notification report**

See:
Manual 231.1-2 § 5

- **Final report**

See:
Manual 231.1-2 § 5

- **Closing out and verifying occurrence reports**

See:
Manual 231.1-2 § 5

- **Contractor occurrence reporting procedures**

See:
Manual 231.1-2, Attachment 2

g. Using DOE O 231.1A, discuss the role of criticality safety personnel in nuclear safety-related reportable occurrences.

See the order and manual cited in the sub-sections above.

h. Given an occurrence report, determine the following:

- **The adequacy of the review process used**
- **That causes were appropriately defined**
- **That corrective actions addressed causes**
- **That the lessons learned were appropriate**
- **That corrective actions have been completed**

This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

i. Using an occurrence report involving criticality safety activities, identify and discuss the factors contributing to the occurrence.

This is a performance-based competency. The qualifying official will evaluate the completion of this competency.

24. Criticality safety personnel must demonstrate a familiarity level knowledge of DOE O 413.3A Chg 1, *Program and Project Management for the Acquisition of Capital Assets*, and DOE-STD-1189-2008, *Integration of Safety into the Design Process*.

See:
The referenced order and standard, DOE-STD-1186-2004, DOE STD 3007, especially Table 7-1 of DOE-STD-1189

a. Identify the four project phases and four major decision points in an acquisition project.

b. Identify the safety documents and the DOE response documents [e.g. Safety Evaluation Report (SER)] associated with each critical decision.

c. Discuss the criticality guidance provided in DOE-STD-1189, Section 7.5, Table 7-2, Appendix H, and Appendix I. Also, discuss the type of evaluations that should be provided at each critical decision point as identified in DOE-STD-1189, Table 7-1.

25. Criticality safety personnel shall demonstrate a familiarity-level knowledge of DOE O 425.1D, Start-up and Restart of Nuclear Facilities, with respect to nuclear safety issues.

See:
The referenced Order,
DOE STD 3006-2010, *Planning and Conducting Readiness Reviews (ORR)*, DOE HNDK 3012-2003, *Guide to Good Practices for Operational Readiness Reviews (ORR) Team Leader's Guide*

a. Discuss the purpose, scope, and applicability sections of DOE Order 425.1D.

c. Discuss the responsibilities and authorities section of DOE Order 425.1D, with respect to implementation.

d. Define the following terms as they relate to DOE Order 425.1D, and nuclear safety:

- **Facility shutdown**
- **Operational Readiness Review (ORR)**
- **ORR implementation plan**

- **ORR scope**
- **Plan-of-action**
- **Prestart finding**
- **Readiness assessment**
- **Unplanned Shutdown**

e. Discuss M&O contractor responsibilities for implementing DOE Order 425.1D.

f. Discuss the role of Department criticality safety personnel in implementing the requirements of DOE O 425.1D.

Mentoring is required for this competency

26. Criticality safety personnel must demonstrate a familiarity level knowledge of the following DOE Orders, Technical Standards, Notice, and Nuclear Regulatory Commission (NRC) Regulatory Guide:

- **DOE O 5400.5 Chg 2, Radiation Protection of the Public and the Environment**
- **DOE-STD-3011-2002, Guidance for Preparation of Basis for Interim Operation (BIO) Documents**
- **Secretary of Energy Notice (SEN) SEN-35-91, Nuclear Safety Policy**
- **DOE-STD-3009-94-CN3, Preparation Guide for U.S. Department of Energy Nonreactor Nuclear Facility Safety Analysis Reports**
- **DOE-HDBK-3010-94, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities**
- **Regulatory Guide 3.71, (Rev 1, October 2005) Nuclear Criticality Safety Standards for Fuels and Material Facilities**
- **DOE-STD-5506-2007, Preparation of Safety Basis Documents for Transuranic (TRU) Waste Facilities**
- **DOE O 410.1, Central Technical Authority Responsibilities Regarding Nuclear Safety Requirements**
- **DOE O 460.1B, Packaging and Transportation Safety**

See:
The cited documents

a. Describe the contents, requirements, and relationships between the above Orders, Technical Standards, and SEN.

b. Describe the role of criticality safety personnel with respect to the requirements in these Orders, Standards, and SEN.

c. Discuss the DOE criticality safety interest in NRC Regulatory Guide 3.71.

27. Criticality safety personnel must demonstrate a familiarity level knowledge of the following oversight related DOE Orders and Technical Standards:

- **DOE O 224.3, Audit Resolution and Follow-up Program**
- **DOE O 224.2A, Auditing of Programs and Operations**
- **DOE O 226.1A, Implementation of Department of Energy Oversight Policy**
- **DOE P 226.1A, Department of Energy Oversight Policy**
- **DOE M 470.4-6 Chg. 1, Nuclear Material Control and Accountability**
- **DOE P 450.4, Safety Management System Policy**
- **DOE M 450.4-1, Integrated Safety Management System Manual**
- **DOE-STD-3006-2000, Planning and Conduct of Operational Readiness Reviews (ORR)**

See:
DOE-STD-3006-2010, Planning and Conduct of Operational Readiness Reviews (ORR)

a. Describe the contents, requirements, and relationships between the above Orders and Technical Standard.

b. Describe the role of criticality safety personnel with respect to the requirements in these Orders and standard.

28. Criticality safety personnel must demonstrate a familiarity level knowledge of the Price-Anderson Amendments Act of 1988 and its impact on DOE criticality safety activities.

See 42 USC 2210

See the following position statement: http://www.ans.org/pi/ps/docs/ps54-bi.pdf
http://www.gc.energy.gov/documents/paa-appb.pdf
http://www.gpoaccess.gov/uscode/index.html
http://www.gpoaccess.gov/uscode/browse.html

Select title 42

http://frwebgate.access.gpo.gov/cgi-bin/usc.cgi?ACTION=BROWSE&title=42usc&PDFS=YES

select chapter 23

http://frwebgate.access.gpo.gov/cgi-bin/usc.cgi?ACTION=BROWSE&TITLE=42USCC23&PDFS=YES

PAAA is in section 2210

http://frwebgate.access.gpo.gov/cgi-bin/usc.cgi?ACTION=RETRIEVE&FILE=$$xa$$busc42.pt2.wais&start=812454&SIZE=125869&TYPE=PDF

a. Describe the purpose and scope of the Price-Anderson Amendments Act.

b. Discuss the Act's applicability to the Department criticality safety activities.

c. Discuss the civil and criminal penalties imposed on the Department, M&O contractors, and subcontractors as the result of a violation of applicable rules and regulations related to criticality safety.

d. Discuss the requirements associated with the topics below, as they are affected by the rule-making aspect of the Price-Anderson Amendments Act:

- **Safety analysis reports**
- **Unreviewed Safety Questions (USQs)**
- **Quality assurance requirements**
- **Defect identification and reporting**
- **Conduct of operations at DOE nuclear facilities**
- **TSR**
- **Training and certification**
- **Maintenance management**
- **Categorization, notification, reporting, and processing of operational occurrences at DOE nuclear facilities**

e. Discuss the role of Department criticality safety personnel with respect to implementing the requirements of the Price-Anderson Amendments Act in accordance with the following:

- **10 CFR 820, Procedural Rules for DOE Nuclear Activities**
- **10 CFR 830, Nuclear Safety Management**
- **10 CFR 835, Occupational Radiation Protection**
- **DOE-STD-1083, Requesting and Granting Exemptions to Nuclear Safety Rules**
- **Office of Enforcement and Investigation procedure, "Enforcement of DOE Nuclear Safety Requirements under Price-Anderson Amendments Act of 1988"**
- **Office of Enforcement and Investigation procedure, "Identifying, Reporting, and Tracking Nuclear Safety Noncompliance under Price-Anderson Amendments Act of 1988"**

29. Criticality safety system personnel must demonstrate a familiarity-level knowledge of communications (both oral and written) when working or

interacting with the contractor, stakeholders, and other internal and external organizations.

Mentoring or demonstrated ability is required to meet this competency.

DOE Headquarters staff
DOE Field Office staff
DOE Site Office staff
ANS Nuclear Criticality Safety Division officers and members
ANS-8 standards working groups
DOE NCSP groups: CSCT, CSSG, NDAG
Local site safety basis group members
Local site contractor management

Letters, email, memos, telephone, meetings.

30. Criticality safety personnel shall demonstrate a familiarity level knowledge of nuclear safety-related data and information management requirements in accordance with the requirements of the following DOE Orders:

- DOE O 200.1A, Information Technology Management
- DOE O 241.1A, Scientific and Technical Information Management
- DOE G 241.1-1A, Guide to the Management of Scientific and Technical Information
- DOE O 243.1, Records Management Program
- DOE O 243.2, Vital Records
- DOE O 414.1C, Quality Assurance

See:
The cited documents

a. Describe the authorized disposition requirements for criticality safety-related records in DOE O 200.1, Information Management Program.

Reference: DOE O 200.1A, Information Technology Management

b. Describe the requirements for documents and records in DOE O 414.1C, Quality Assurance.

Reference: DOE O 414.1C, Quality Assurance

c. Describe the purpose, scope, contents, and requirements in these Orders.

d. Discuss the applicability of the above Orders to the Department criticality safety activities and processes.

e. Discuss the role of the Department criticality safety personnel in implementing the requirements of these Orders.

31. Criticality safety personnel shall demonstrate a familiarity level knowledge of the following DOE safeguards, security, and nuclear material accountability Orders for nuclear safety-related issues:

- **DOE Order 452.6A, Nuclear Weapon Surety Interface with the Department of Defense**
- **DOE O 470.4A, Safeguards and Security Program**
- **DOE P 470.1, Integrated Safeguards and Security Management (ISSM) Policy**
- **DOE M 470.4-2A, Physical Protection**
- **DOE M 470.4-6 Chg 1, Nuclear Material Control and Accountability**
- **DOE O 471.1A, Identification and Protection of Unclassified Controlled Nuclear Information**
- **DOE O 475.2, Identifying Classified Information**
- **DOE M 470.4-4 Chg 1, Information Security**
- **DOE M470.4-1 Chg. 1, Safeguards and Security Program Planning and Management**
- **DOE M 470.4-7, Safeguards and Security Program References**
- **DOE Order 410.2, Management of Nuclear Materials**

a. Describe the purpose, scope, contents, and requirements of these Orders.

See:
The cited documents.

b. Discuss the applicability of the listed Orders to the Department criticality safety activities and processes.

See:
list above.

c. Discuss the role of the Department criticality safety personnel in implementing the requirements of these Orders.

See:
The cited documents.

32. Criticality safety personnel must demonstrate a working level knowledge of the DOE/facility contract provisions necessary to provide oversight of a contractor's operations.

Mentoring or demonstrated ability is required to meet this competency.

a. Describe the role of criticality safety personnel in contractor oversight.

b. Compare and contrast the following:

- **DOE's expectations of a M&O contractor**
- **A M&O contractor's expectations of the DOE**

c. Identify the key elements and features of an effective DOE and M&O contractor relationship.

d. Describe the responsibility criticality safety personnel have associated with contractor compliance under the Price-Anderson Amendments Act.

e. Describe the role of criticality safety personnel in the performance measure process.

f. Explain the responsibilities of criticality safety personnel for DOE O 442.1A, Department of Energy Employee Concerns Program, and the identification, reporting, reviewing, and documentation of employee concerns.

Interface with Safety Basis and Nuclear Safety (Competencies 33 - 40)

33. Criticality safety personnel must demonstrate a familiarity level of knowledge of the terminology used in nuclear safety analysis.

DOE-HDBK-1188-2006 is a glossary containing most of these terms; however, where possible the references below are to specific pages and sections of Orders and other DOE documents that not only define the respective terms but also use them in context. Since this competency refers to nuclear safety analysis, directives and standards relating to nuclear safety are used where possible.

a. Define the following accident related terms:

• **Accident**	See DOE-STD-3009-94, p. xviii.
• **Safety basis**	See DOE-STD-3009-94, p. xxi
• **Beyond design basis accident**	See DOE-STD-3009-94, p. xviii
• **Design basis**	See DOE-STD-3009-94, p. xviii
• **Design basis accidents**	See item #140 on p. 25 of DOE-HDBK-1188-2006 and the Definitions Section of DOE STD 3009.
• **Evaluation guidelines**	See the Definitions Section of DOE STD 3009.

b. Define the following hazard related terms:

- **Hazard** — See the Definitions Section of DOE STD 3009
- **Hazard classification** — See the definition of Hazard categorization in the Definitions Section of DOE STD 3009
- **Hazard Category 1** — See the Definitions Section of DOE STD 3009
- **Hazard Category 2** — See the Definitions Section of DOE STD 3009
- **Hazard Category 3** — See the Definitions Section of DOE STD 3009
- **Hazardous material** — See the Definitions Section of DOE STD 3009

c. Define the following safety limit related terms:

- **Limiting conditions for operations** — See the Definitions Section of DOE STD 3009
- **Limiting control settings** — See the Definitions Section of DOE STD 3009
- **Risk** — See the Definitions Section of DOE STD 3009
- **Safety analysis** — See the Definitions Section of DOE STD 3009
- **Safety basis** — See the Definitions Section of DOE STD 3009
- **Safety limits** — See the Definitions Section of DOE STD 3009
- **Criticality safety limits** — See ANSI/ANS 8.1 § 4.1.3 & 4.2.1, ANSI/ANS 8.19 § 7.2, and LA-12808, § I.B.2, I.B.3, & III.F.1

d. Differentiate between the following categories of individuals who might be affected by an accident at a Department nuclear facility:

- **Off-site individual** — See DOE-STD-3009-94, Appendix A, § A.2
- **On-site individual** — See the Definitions Section of DOE STD 3009 for Site Boundary.
- **Public** — See the Definitions Section of DOE STD 3009
- **Worker, including collocated worker** — See 10CFR851.3, DOE-STD-1189-2008 Appendix A § A.1 & A2.2, DOE-STD-5506 § 5.1

e. Differentiate between the function of structures, systems, and components in the following classifications:

- **Safety-class structures, systems, and components** — See DOE-STD-3009-94, p. xxi
- **Safety-significant structures, systems, and components** — See DOE-STD-3009-94, p. xxi
-

f. Differentiate between the function and contents of the following documents:

- **TSR** — See DOE-STD-3009-94, pp. xxii – xxiii for a definition of TSR.
- **DSA** — See DOE-STD-3009-94, p. xxi for a definition of Safety Analysis and pp. 1, 4, and the 2nd ¶ on p. 8 for an introduction discussing the basic functions of DSAs and

	TSRs. See also Table of Contents (pp. ix – xvii) for a list of contents of DSA indicating the topics to be covered. Additionally, regarding documenting assumptions for each TSR in the DSA, see for example, sections 4.3.X.5 (p. 59) and 4.5.X.5 (p. 64). Also see 1st ¶. on p. 1 of DOE G 423.1-1 for more information about the function of TSRs.
• **Unreviewed Safety Question Determination (USQD)**	See DOE G 424.1-1B, Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements, pp. 2-6 for an overview of the function and contents for USQDs performed for different reasons.
• **Safety design strategy**	See p. 8-10 of DOE-STD-1189-2008.
• **Conceptual safety design report**	See pp. 27 – 28 of DOE O 413.3A, Ch. 1.
• **Preliminary safety design report**	See DOE O 413.3A, Ch. 1, p. 28
• **Preliminary documented safety analysis**	See DOE O 413.3A, Ch. 1., p. 28. Also, see DOE-STD-3009-94, 2nd par. of Purpose Section (pp. 1-2).

g. Differentiate between the plant/facility features that have the following designations:

• **Mitigating features**	See DOE-STD-3009-94, p. xx
• **Preventive features**	See DOE-STD-3009-94 p. xxi. For more information about differentiating between these feature types, see DOE-STD-3009-94 p. 10. Additionally, see § I.A.1 of LA-12808, Nuclear Criticality Safety Guide

h. Differentiate between the following types of facilities:

• **Nuclear facility**	See 10 CFR 830.3
• **Non-reactor nuclear facility**	See 10 CFR 830.3

34. Criticality safety personnel must demonstrate a familiarity level knowledge of nuclear accident analysis techniques.

a. Identify and discuss essential elements of deterministic and PRA techniques.

See:
DOE G 420.1-2, Appendix B, for rough definitions of probabilistic and deterministic.
DOE-STD-3009-94, § 3.4 for a discussion of the most common deterministic methods used in the DOE.
NUREG-0492 *Fault Tree Handbook* for fault tree methodology. Fault trees can be used for probabilistic or deterministic analysis. Chapters X and XI deal with probabilistic methods.

b. Identify and discuss the methods used to determine and analyze failure modes.

See:
NUREG-0492, Chapter II, § 3 & 4, and DOE-STD-3009-94, § 3.4
The Albuquerque Operations Office Problem Analysis and Risk Assessment training materials, http://www.orau.gov/tdd/QualPrgm/learningmaterials/OccSafety/os1-02.pdf

c. Discuss the methods used in the calculation of criticality safety, source term, environmental transport, and dose assessment activities, including commonly used computer models.

See
SCALE ORIGEN manual
DOE-STD-3009, Appendix A, § A.3.2 & A.3.3
DOE-HDBK-3010-94, § 6
NUREG/CR-6504 [ORNL/TM-13322] *An Updated Nuclear Criticality Slide Rule,* Broadhead, Hopper, Childs, and Tang, Oak Ridge National Laboratory, April 1997, available from RSICC http://www-rsicc.ornl.gov/index.html
Modified Quasi-Steady-State Method to Evaluate the Mean Power Profiles of Nuclear Excursions in Fissile Solution, Nakajima, Yamamoto, & Miyoshi, Nuclear Science and Technology, Vol.39, No. 11, P. 1162-1168 (November 2002)
T. P. McLaughlin, "*Process Criticality Accident Likelihoods, Consequences, and Emergency Planning*," Nuclear Energy, 31, No. 2, 143-147 (1992) Included in the LA-12808 Reference Set

d. Discuss the methods used to identify and categorize the hazards associated with Department nuclear systems.

See:
DOE-STD-1027-92, section 3, and Table 3.1 (p. 7),
DOE-STD-1027-92 section 4
DOE-STD-1027-92, Attachment 1
DOE-STD-3009-94, § 3.3.2.2

e. Identify and discuss the role and use of human factors techniques in hazard and accident analysis.

See
DOE-STD-3009-94, Ch. 13, (~p. 95).
DOE-STD-3009-94, Ch. 132nd par. on p. 96 as well as section 13.3 (pp. 96 -97).
DOE-HDBK-1100-2004 section 3.2.6 (p. 18) and Table 3.4 (p. 21).]
NUREG/CR-6883 [INL/EXT-05-00509] *The SPAR-H Human Reliability Analysis Method*, Idaho National Laboratory for U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research Washington, DC 20555-0001, D. Gertman, H. Blackman, J. Marble, J. Byers, C. Smith, August 2005

35. Criticality safety personnel must demonstrate a familiarity level knowledge of terminology associated with PRA techniques.

a. Define the following terms with respect to PRA:

See the references given for each bulleted item.

• **Probability**	NUREG-0492, p. VI-3.
• **Reliability**	NUREG-0492, Pp. XI-8, XI-14; II-12, X-20
• **Availability**	NUREG-0492, p. XI-11
• **Unavailability**	NUREG-0492, Pp. XI-11, XI-15
• **Risk**	NUREG-1150, p. iii, 1st ¶, WASH-1400, Section 2.4, 1st p¶ (p. 5).
• **Safety**	51 FR 28044, 1st bullet, pp. 1 -2 (as corrected in 51 FR 30028)
• **Accident sequence**	NUREG-1150, p. A-9, 1st par. under heading Accident Sequence Event Tree Analysis
• **Dominant contributors**	NPR 8705.5, Ch. 2, section 2.10
• **Minimal cut set**	NUREG-0492, p. XI-2, section 2(a)

b. Define the following terms and differentiate between the associated processes:

See: NUREG-0492, *Fault Tree Handbook,* pages as referenced.

- **Event tree** Pp. I-8, 2nd ¶. VII-4, section 2, 1st par.
- **Fault tree** p. IV-1, 1st ¶

c. Discuss the concept of "credible" as used in criticality safety process evaluations as compared to the terms "not credible" or "beyond extremely unlikely" as used in DSAs.

See:
DOE-STD-3007-2007, p. v, 3rd definition
DOE-STD-1120-2005/Vol. 2, Table 2.
DOE-STD-3009, § 3.3.2.3, Table 3-4

36. Criticality safety personnel must demonstrate a working level knowledge of the 10 CFR 830, *Nuclear Safety Management*, requirements related to USQs and the associated DOE Guide 424.1-1A, *Implementation Guide for Use in Addressing Unreviewed Safety Question Requirements*.

a. Discuss the reasons for performing an USQD.

See Guide § 1 and 3.3.

b. Define the following terms:

See 10 CFR 830.3.

- **Accident analyses**
  Also see DOE-STD-3009-94, p. xviii.
- **Safety analysis**
  Also see DOE-STD-3009-94, p. xxi.
- **TSR**
  Also see DOE-STD-3009-94, p. xxii – xxiii.

c. Describe the situations for which a criticality safety evaluation is required to be performed.

See DOE-STD-3007-2007, pp. iii, v, and 11.

d. Define the conditions for an USQ.

See Guide final par. of § 2, as well as § 2.1 - 2.4.

e. Describe the responsibilities of contractors authorized to operate DOE nuclear facilities for the performance of safety evaluations.

See DOE-STD-3009-94, especially pp. 4 - 6 in the section on DSA Preparation Conceptual Basis And Process.

f. Describe the actions to be taken by a contractor upon identifying information that indicates a potential inadequacy of previous safety analyses or a possible reduction in the margin of safety as defined in the TSR.

See Guide, § 2.4.

g. Discuss the actions to be taken if it is determined that an USQ is involved.

See Guide, § 2.4.

h. Discuss the following terms as they apply to USQs:

- **Margin of safety**
  See Guide § 3.3, esp. p. 12, last bullet, as well as p. 13.
- **Important to safety**
  See Guide § 1, p. 1, 1st bullet as well as final paragraph on p. 1 (continues on to p. 2).
- **Safety basis**
  See DOE-STD-3009-94, p. xxi for definition of safety basis as well as final par. of Guide § 1 on p. 2.

37. Criticality safety personnel must demonstrate a working level knowledge of the 10 CFR 830, *Nuclear Safety Management*, requirements related to TSRs and the associated DOE Guide 423.1-1, *Implementation Guide for Use in Developing Technical Safety Requirements*.

a. Discuss the purpose of TSRs.

See DOE G 423.1-1, § 1, p. 1, 1st par., as well as DOE-STD-3009-94, p. xxii and xxiii.

b. Describe the responsibilities of contractors authorized to operate DOE nuclear facilities for TSRs.

See DOE G 423.1-1, § 3, p. 2 and par. that continues on to p. 3. Also, see § 4, especially p. 3, 4, and § 4.1 – 4.9 on pp. 4 - 7.

c. Define the following terms and discuss the purpose of each:

- **Safety limit**
  See DOE-STD-3009-94, p. xxi as well as DOE G 423.1-1, § 4.10.1.1.
- **Limiting control settings**
  See DOE-STD-3009-94, p. xx as well as DOE G 423.1-1, § 4.10.1.2.
- **Limiting conditions for operation**
  See DOE-STD-3009-94, p. xx as well as DOE G 423.1-1, § 4.10.1.3.
- **Surveillance requirements**
  See DOE-STD-3009-94, p. xxi and § 5.5.X.2 as well as DOE G 423.1-1, § 4.10.6.

d. Describe the general content of each of the following sections of the TSR:

- **Use and application**
  See DOE G 423.1-1, § 4.8, 1st 3 sentences as well as § 5.2.1, esp. p. 21, 1st par. on p. 22 and 2nd par. on p. 23.

- **Safety limits**
  See DOE G 423.1-1, § 4.8, 5th sentence as well as § 5.2.2, 1st par. and associated Mode Applicability and Action Statements that they should contain as discussed in § 5.2.2.2 and § 5.2.2.3, respectively, as well as Limiting Control Settings discussed in § 5.2.3.1, 1st par.

- **Operating limits**
  See DOE G 423.1-1, § 4.8, 6th sentence as well as § 5.2.3.2 and associated Mode Applicability and Action Statements that they should contain discussed in § 5.2.3.3 and § 5.2.2.4, respectively.

- **Surveillance requirements**

See DOE G 423.1-1, § 4.8, final clause of 6th sentence as well as § 5.2.3, 2nd sentence and § 5.2.3.5.

- **Administrative controls**
  See DOE G 423.1-1, § 4.8, 7th sentence as well as § 5.2.4, 1st sentence, § 5.2.4.1, 1st sentence, § 5.2.4.2, 1st sentence, § 5.2.4.3, 1st sentence, § 5.2.4.4, 1st sentence, § 5.2.4.5 1st sentence, § 5.2.4.6, 1st sentence, § 5.2.4.7, § 5.2.4.8, § 5.2.4.9, 1st sentence, and § 5.2.4.10.

- **Basis**
  See DOE G 423.1-1, p.3, last par., 1st two sentences, as well as § 4.18, 1st sentence and example shown in Fig. 21 (last page before Appendix A).

- **Design features**
  See DOE G 423.1-1, § 4.8, final sentence as well as § 5.2.5, 2nd sentence. For more detail, see items 1 and 2 following 3rd sentence.

e. Discuss the conditions that constitute a violation of the TSRs, and state the reporting requirements should a violation occur.

Violation: See DOE G 423.1-1, § 4.11, 1st two paragraphs.
Reporting: See DOE G 423.1-1, § 4.20 1st thru 3rd sentence (note typo: the 2nd "the" in the 3rd sentence should be "they") as well as § 4.10.7, 2nd sentence. For more details see DOE O 232.1A, § 1.b(1) and § 4.f – k.

f. Discuss the requirements for administrative control of the TSRs.

See DOE G 423.1-1, § 4.5.

g. Discuss the possible source documents that may be used in developing TSRs.

See DOE –STD-3009-94, Ch. 5, Derivation of Technical Safety Requirements, esp. § 5.5 on pp. 67 **-69,** G 423.1-1, § 4.5, §4.10.5, regarding Fire Hazards Analyses, §4.13 regarding Criticality Safety Evaluations, §4.14, regarding Transportation Safety Documents, and Appendix C, 1st par., regarding Hazard Analysis Reports for Nuclear Explosive Operations.

h. Discuss the requirements for emergency actions that depart from the approved TSRs.

See DOE G 423.1-1, § 4.4.

38. Criticality safety personnel must demonstrate a familiarity level knowledge of DOE-STD-1186-2004, *Specific Administrative Controls* (SACs), with respect to its impact on criticality safety.

a. Discuss how SACs are identified.

See DOE-STD-1186-2004, § 1.6.4 as well as § 2.1.

b. Discuss the position of SACs in the preferred hierarchy of hazard controls.

See for background information DOE G 421.1-2, § 5.3 and DOE-STD-1186-2004, § 1.1, 1st par. See also DOE-STD-1186-2004, § 1.6.2, 3rd par., § 2.2 and 3rd par., 3rd sentence.

c. Describe how SACs are treated in DSAs and TSRs.

See DOE-STD-1186-2004, § 4, § 4.2, § 4.3, 1st par., last sentence, 2nd par., 1st thru 4th sentences, 3rd par. 1st thru 3rd sentences, and § 4.4.

d. Discuss how SACs are implemented and maintained.

See DOE-STD-1186-2004, § 2.3, except final par.

e. Describe measures used to ensure the dependability of SACs.

See DOE-STD-1186-2004, § 3, § 3.1, §3.2, §3.2.1, 1st par., §3.22, 1st par., §3.3, §3.4, §3.4.2, 3rd thru 6th par., and §3.5, 1st par.

39. Criticality safety personnel must demonstrate a working level knowledge of DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Reports,* with respect to their impact on the Department's criticality safety.

a. Discuss the differences between the hazard categorization for dose to the public, and hazard categorization when criticality risks exist.

(Category 1 implies the potential for a dose to the public. Criticality accidents are a local risk and Category 2 applies.) See STD-1027-92.

b. Describe the requirements for a facility to remain hazard category 3 or below if a criticality program or criticality controls exist.

(If the facility fissile inventory could exceed the minimum values specifies in the STD, then a program is present to ensure that "segmentation" or "nature of process" conditions remain viable.) See STD-1027-92

c. Discuss the role of criticality safety personnel in implementation of DOE-STD-1027-92.

(If the facility fissile inventory could exceed the minimum values specifies in the STD, then a program is present to ensure that "segmentation" or "nature of process" conditions remain viable.) See STD-1027-92

40. Criticality safety personnel must demonstrate a working level knowledge of 10 CFR 830, *Nuclear Safety Management,* requirements related to DSAs and

the associated DOE G 421.1-2, *Implementation Guide in Developing Documented Safety Analysis to Meet Subpart B of 10 CFR 830*.

a. Discuss the four basic purposes and objectives of DSAs.

See 10CFR830.204b and G 421.1-2, section 4.1

b. Describe the responsibilities of contractors authorized to operate DOE nuclear facilities for the development and maintenance of a DSA.

See 10CFR830.204a and G 421.1-2

c. Define the following terms and discuss the purpose of each:

- **Design basis**

The design basis is the set of requirements that bound the design of systems, structures, and components within the facility. These design requirements include consideration of safety, plant availability, efficiency, reliability, and maintainability. Some aspects of the design basis are important to safety, although others are not.

Information that identifies the specific functions to be performed by a structure, system, or component of a facility, and the specific values or range of values chosen for controlling parameters as reference bounds of design. These values may be

- restraints derived from generally accepted "state of the art" practices for achieving functional goals, or
- requirements derived from analyses (based on calculations and/or experiments) of the effects of a postulated accident for which a structure, system, or component must meet its functional goals. [10 CFR 50.2]

The purpose of the design basis is to set the functional and performance parameters that the system being designed must meet.

- **Engineered safety features**

Engineered safety features are passive or active physical SSCs (e.g. hardware, control systems, and buildings) that are used to prevent or mitigate accidents.

- **Safety analysis**

Safety analysis means an 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. The purpose of safety analysis is to identify the potential accidents from the defined mission activity, and develop preventive and mitigative features to protect workers and the public.

d. Describe the requirements for the scope and content of a DSA, and discuss the general content of each of the required sections of the report.

See G 421.1-2 and DOE-STD-3009-94

e. Discuss the approval requirements for the DSA for new facilities and subsequent changes.

See 10 CFR 830.204 (b)

f. Define who approves facility operations prior to achieving DSA upgrade approval.

See 10 CFR 830.204 and 207; and G 421.1-2, section 4.3. The approving authority is the DOE official who has been delegated the authority to approve facility safety documents,

g. Discuss the requirements for the contractor to maintain the DSA current.

See G 421.1-2, section 3.