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OWNER: Nuclear and Criticality Safety	**PROC-NS-1005**	**REVISION: 4**
SUBJECT MATTER AREA: Nuclear Criticality	**PREPARER: Ryan Smith/Joe Hack**	**Page 1 of 50**
PROCEDURE TYPE: **Administrative** ☒ **Emergency** ☐ **Alarm Response** ☐	**CONCURRENCE/DATE: Karl Klinger 7/27/22 [Approval Signature on File]**	
TITLE: NUCLEAR CRITICALITY SAFETY EVALUATIONS AND CALCULATIONS	**APPROVED BY/DATE: Christie Sudduth 7/26/22 [Approval Signature on File]**	
USQD ☒ **UCD** ☐ **CAT X** ☐ **EXEMPT** ☐	**EFFECTIVE DATE: 8/10/22**	
USQD/UCD/CAT X No: USQD-MS-PROCNS1005-1821	**REQUIRED REVIEW DATE: 8/10/25**	
Exhibit L Mandatory Contractor Procedure No ☐ **Yes** ☒	**If an Interim Procedure, Expiration Date:**	

This document is approved for public release per review by:
Leesa Laymance 7/19/22
UCOR Classification & Information Control Office Date

REVISION LOG

Revision	Effective Date	Description of Changes	Pages Affected
4	8/10/22	Intent change. Update department titles. Add clarification to ensure affected disciplines are involved from an early stage of document preparation. Updated all standards and DOE orders to latest revisions and incorporate any resulting requirements updates.	3-5, 7, 9-11, 14-16, 18, 21, 23, 24, 26-29, 31-35, 39, 41, 42, 45, 48, 49
3	4/28/15	Intent change. Updated DOE Order 420.1B to DOE Order 420.1C. Updated all ANSI/ANS standards to latest revisions. Deleted description of operations being controlled by a single parameter as not meeting double contingency principle.	3, 34, 47
2	6/14/12	Intent change. Change “may” to “should” in steps that reference Attachment F guidance. Added requirements from ANSI/ANS-8.24 Updated Source Document List Added to footnotes of Table E-1 to clarify values are based on single-parameter limits for isolated aqueous mixtures.	10, 12 16, 17 20 42
1	3/22/12	Non-intent change. Added additional information regarding references to other NCSEs (Attachment F #36). Addresses I/CATS Issue I0080156; Action 36469.	46
0	2/10/12	Initial release. Replaces BJC-NS-1005, Rev. 7, *Nuclear Criticality Safety Evaluations and Calculations*	All

PURPOSE

This procedure specifies the requirements for performing Nuclear Criticality Safety (NCS) Evaluations (NCSE) and NCS Determinations (NCSD) for fissile material operations (FMO). In particular, this procedure addresses the requirements in American National Standards Institute/American Nuclear Society (ANSI/ANS) standards and the Baseline List of Required Compliance Documents, and specifies the method of obtaining approval for operations involving fissionable materials.

SCOPE

This procedure applies to all United Cleanup Oak Ridge LLC (UCOR), and subcontractor personnel responsible for generating NCS documentation.

OTHER DOCUMENTS NEEDED

- PROC-FO-515, *Facility Management*
- PROC-IT-6008, *Application Lifecycle Management*
- PROC-NS-1003, *Nuclear Criticality Safety Program*
- PROC-OS-1001, *Records Management, Including Document Control*
- PROC-OS-1004, *Document Numbering and Issuance*
- UCOR-4172, *Nuclear Criticality Safety Program Description*
- Oak Ridge Reservation Cleanup Mission Contract, 89303322DEM000067
- Form-554, Safety Document Worksheet

GENERAL REQUIREMENTS

The following principles and practices shall be used in the NCS of FMOs.

A. General Nuclear Criticality Safety Principles and Practices

1. Double Contingency

Where there is a credible potential for a nuclear criticality accident and the FMO is in an area covered by an operable Criticality Accident Alarm System (CAAS), nuclear criticality prevention shall be based upon the Double Contingency Principle (DCP) of ANSI/ANS-8.1. The DCP is as follows:

> *The DCP, when utilized, is implemented by crediting (or applying) controls such that at least two unlikely, independent, and concurrent changes in process conditions (i.e., contingencies) would have to happen before a criticality accident is possible.* – ANSI/ANS-8.1-2014, Appendix B.

Unless an NCSE documents that a criticality is not credible, the Department of Energy-Oak Ridge Office of Environmental Management (DOE-OREM) must review and approve any FMO that fails to satisfy the DCP. DOE-OREM approval shall be obtained either by (1) submittal to DOE-OREM of an NCS document that summarized the FMO and the justification for deviating from the DCP, or (2) through the safety basis process, i.e., revision to and approval of the subject facility Documented Safety Analysis/Technical Safety Requirements (DSA/TSR). The approval must be documented prior to implementation/use of the NCSE.

In all cases, no single credible event or failure shall result in the potential for a criticality accident.

Events that are outside the scope of the DCP requirements include: (1) single events beyond Design Basis Events (DBEs) for the facility and (2) sabotage, gross negligence, and other willful misconduct.

2. Criticality Accident Incredibility

Criticality may not be credible due to the physical nature of the materials and process, the controls and/or limitations of the process, or a combination of these. There are two independent sets of guidance for criticality accident incredibility determinations, each in place for a specific purpose.

a. Criticality accident incredibility determinations for facility categorization (Nature of Process)

In a facility with sufficient fissionable material inventory such that an unmitigated criticality is possible (i.e., ≥700 g ^{235}U fissile equivalent mass [FEM]), nuclear criticality safety is a factor in the facility categorization determination. Guidance has been provided by the US Department of Energy (DOE) on what is necessary to categorize a facility as radiological, if fissile material is present (DOE-STD-1027). According to DOE-STD-1027, segmentation and "nature of process" are acceptable criteria that can be used. Segmentation and nature of process are adequately defined in DOE-STD-1027.

The inclusion of the administrative controls outside of the purview of operations as a part of the nature of a process is based on Sect. 3.1.6 of DOE-STD-1027. DOE-STD-1027 provides the following examples of "controls" that may exist as part of the nature of process:

- Controls that restrict the types, forms, amounts, chemical properties and/or the distribution of the fissionable material from entering the facility. An example of these controls would be limits on the amount, type, or form of material in a facility or amount of moderators/reflectors that are more effective than water allowed in the facility.
- Limitations on the scope of the facility activities that are permitted, e.g., surveillance/maintenance (no work activities allowed with only surface contamination); storage/staging only (no opening or processing allowed).

DOE-STD-1027 further notes:

Note: Demonstration that the nature of the process or segmentation precludes criticality is not a sufficient justification to eliminate the contractor's criticality safety program. Additionally, the establishment of defense-in-depth controls by criticality safety does not by itself negate the ability to achieve a nature of the process determination.

b. Criticality accident incredibility determinations for CAAS coverage requirements

DOE O 420.1C requires compliance with ANSI/ANS-8.3. ANSI/ANS-8.3 states that the need for criticality alarm systems shall be evaluated for all activities in which the inventory of fissionable materials in individual unrelated areas exceeds 700 g U-235, 500 g U-233, 450 g Pu-239, or 450 g of any combination of these three isotopes.

For FMOs where it has been shown that a nuclear criticality accident is not credible, based on qualitative argument from sound engineering judgment, an operable CAAS is not required. If it is not possible to demonstrate that a criticality accident is not credible, then a double contingency analysis is required, and a CAAS conforming to ANSI/ANS-8.3 shall be provided to cover occupied areas in which personnel would be subject to an excessive radiation dose. Realistically due to cost, if a CAAS is present, only a double contingency analysis will be performed; and if a CAAS is not present, the FMO will be altered as necessary to ensure that a criticality is not credible.

A CAAS is not required when: 1) handling or storing fissionable material with shielding that is adequate to protect personnel (e.g., spent fuel pools, hot cells, or burial grounds); or 2) DOT/DOE/Nuclear Regulatory Commission (NRC)-approved containers and packaging that are specification packages or packaged supported by a safety analysis report for packaging (SARP) loaded onto a transport vehicle.

NOTE: Once the DOT/DOE/NRC-approved packages are loaded onto the vehicle in accordance with the Certificate of Compliance for the package, they are covered by the safety basis supporting transport, e.g., basis supporting 49 CFR (Code of Federal Regulations) or the SARP, and no longer require an explicit UCOR NCSE/NCSD.

3. Hierarchy of Controls

To the extent practical, NCS defenses or protection shall employ passive engineered controls over active engineered controls over administrative controls.

Passive engineered control is the highest ranked means of criticality safety control, involving fixed, passive design features or devices rather than moving parts. Passive engineered controls may have moving parts if the motive force provided to actuate the moving parts would not credibly fail e.g., gravity. These means of criticality safety controls are highly preferred because they provide high reliability, a broad range covering many potential criticality accident scenarios, and require little operational support to maintain effectiveness. Human intervention is not required with passive engineered controls.

Active engineered control is a means of control of intermediate rank, involving add on, active electrical, mechanical, or hydraulic hardware that protects against criticality. These devices act by sensing a process variable important to NCS and providing automatic action to secure the system in a safe condition.

Administrative control is a means of NCS control that relies on the judgment, training, and responsibility of people for implementation. These controls may be action steps or caution steps in a written procedure or steps in a surveillance program. Because they are human-based, and subject to error in application, administrative controls are generally regarded as the least preferred means of control and should be used as the primary control only when no practical design features are available. Therefore, the use of administrative controls should be minimized and, if used, they should be simple, self-consistent, and directly controllable.

4. Acceptable Margin of Subcriticality

Limits shall be set to ensure an adequate margin of subcriticality. Limits are set with a consideration of upset conditions and the sensitivity of the controlled parameters. The limit for each controlled parameter shall be determined with the assumption that the other controlled parameters can reach their specified limits.

5. Conservatism

Evaluation and analysis techniques, associated nuclear data, and descriptions of fissionable materials and associated materials (e.g., container size) are inexact. Typically, many simplifications, approximations, and assumptions are necessary to perform evaluations, perform analyses, or draw conclusions. A reasonable degree of conservatism is applied to ensure that the cumulative effect of simplifying approximations, assumptions, and uncertainties does not invalidate conclusions.

Conservatism is different from and is in addition to setting a minimum margin of subcriticality. When performing calculations, it is customary to perform parametric studies to determine the values of the parameter which yield the highest k_{eff} and use that value to derive controls. It is acceptable if some individual simplifying assumptions decrease reactivity or if the effect on reactivity is indeterminate as long as the evaluation demonstrates the actual margin of safety meets or exceeds the minimum margin necessary to support conclusions. The goal is finding a practical balance between excess conservatism arising from overly simplified limits and the confusion that may arise from having too many exceptions.

B. Nuclear Parameters Important to Nuclear Criticality Safety

The following nuclear parameters shall be considered in the analysis of an FMO.

1. **Geometry -** Geometry control is the limitation of dimension and geometry to provide “geometrically favorable” containers, vessels, drains, and sumps for fissile material.

2. **Mass -** Mass controls restrict the quantity of fissile materials permitted in individual units, in work areas, in a total configuration, or in the total number of units. The use of mass limits shall account for uncertainties in the assay or enrichment used.

   Consideration shall also be given to the potential buildup of fissile material over time. To address the concern of legacy holdup, scanning requirements shall be considered.

3. **Enrichment -** Enrichment controls restrict the maximum weight percent of fissile nuclide for a fissile element.

4. **Concentration/Density -** Concentration/density controls are typically used to restrict the permitted concentrations of fissile material dissolved or dispersed in another medium.

5. **Volume -** Volume controls restrict the fissile material volume, container volume, or vessel volume.

6. **Reflection -** Reflection controls restrict the quantity, composition, and configuration of hydrogenous or other effective neutron reflecting materials in proximity to fissile material. Super-reflectors, such as beryllium and high density concrete, shall be considered for each FMO.

7. **Moderation -** Moderation controls restrict the allowed range of moderating material relative to fissile material in moderator/fissile mixtures or solutions or on the total amount of moderating material allowed.

   If moderators are controlled, designating the area in which the FMO occurs as a moderator-controlled area shall be considered. In particular, moderation controls may include special fire-fighting activities, restricting operations to days when it is not raining, or even requiring closed containers.

   Super-moderators, such as beryllium and oil, shall be considered for each FMO.

8. **Neutron Interaction (Spacing) -** Interaction control restricts neutron interaction by adjusting spacing between units, vessels, containers, and accumulations of fissile material or crediting interstitial shielding.

9. **Neutron Absorption -** Neutron absorption control reduces neutron interaction by increased absorption in a controlling medium such as borosilicate glass.

C. Nuclear Criticality Critical and Subcritical Limits

Critical and subcritical limits shall be based on experimental data, where available, with an adequate allowance for uncertainties in the data. There are five methods for establishing acceptable critical and subcritical values. They are:

- Reference to national standards that present critical and/or subcritical limits.
- Reference to widely accepted and current handbooks on critical and/or subcritical limits.
- Reference to experiments with appropriate adjustments for uncertainties in data to ensure subcriticality.
- Calculational techniques that include a validation with experimental data to establish a calculational upper subcritical limit. The upper subcritical limit shall contain a margin of subcriticality that is sufficient to ensure subcriticality. This margin of subcriticality shall include allowances for the uncertainty in the bias and for uncertainties due to any extensions of the area(s) of applicability.
- Subcritical limits derived from other approved NCS documents.

Examples of calculational methods are Monte Carlo codes such as KENO-Va and discrete ordinates transport theory codes such as XSDRN-PM. Calculations shall be run with code and computers that meet the verification and validation (V&V) requirements and UCOR software quality assurance (SQA) requirements as specified in PROC-IT-6008, *Application Lifecycle Management.*

Hand calculation methods such as limited surface density, density analog, or solid angle methods were developed based on experimental data. If these methods are used, the FMO analyzed must be demonstrated to be within the applicability of the method chosen.

WHAT TO DO

A. Nuclear Criticality Safety Determination

NOTE 1: Before a new FMO is initiated or an existing FMO is changed, the entire process is determined and documented to be subcritical under both normal and credible abnormal conditions, or that a criticality is not credible.

NOTE 2: A NCSD is used to govern certain FMOs wherein NCS controls applied within the FMO are determined unnecessary to preclude a nuclear criticality accident. NCSDs may include operational limitations, assumptions and initial conditions (i.e., controls external to the FMO such as waste acceptance criteria) to ensure the process remains within evaluated boundaries. Caution should be exercised when performing a NCSD. Although general guidance is provided below, operations such as storage of uranium reactor fuels may require a full NCSE even when their enrichments are less than traditional subcritical limits. Additionally, this section does not supersede any site-specific safety basis document [e.g., TSR] requirements.

NOTE 3: Participation by a Criticality Safety Officer (CSO) applies to those projects and facilities that have assigned CSOs.

NCS Engineer

1. Upon receipt of a request for an NCSE or NCSD, determine if NCS controls are required for the described operation(s) by considering items such as:

- Description of the process and equipment
- Fissionable mass (or FEM)
- Fissionable nuclide enrichment
- Presence of super moderators or super reflectors
- Form of fissionable material
- Transportation issues
- Change to the assumptions or safety basis arguments (double contingency or incredibility) contained in an existing NCSE or NCSD.

NOTE 1: If at all possible, do not include Sensitive Government Information (SGI) in the NCSD.

NOTE 2: Process knowledge may be considered as appropriate, with greater weight being given to information that is written or is from multiple sources.

2. **IF** the subject matter of the proposed evaluation deals with SGI, **THEN** coordinate with Security to ensure that SGI protection requirements are met.

3. **IF** generating a new NCSD or a significant revision to a NCSD, **THEN** walk down the process with line supervision and gather information and process knowledge from workers, documents, and other sources as applicable.

4. **IF** NCS controls are determined to be required or may be required within the FMO to conduct the operation, **THEN**
notify the Responsible Manager that an NCSE is required for the operation and perform an NCSE per Section B.

5. **IF** NCS controls **are not** required within the FMO to remain subcritical during normal operations and all credible upset scenarios, including facility design basis and natural phenomena events, **THEN**
document the technical basis for reaching this determination, following the guidance in Attachment B for formatting and using an approval coversheet similar to that in Attachment D.

6. Prepare the draft NCSD for the NCS Peer Reviewer by checking for accuracy and clarity. Attachment F should be used as a guide for performing the review.

7. Submit draft NCS determination to peer reviewer.

NCS Peer Reviewer	**8.**	Perform an independent review of the NCSD for technical accuracy, reasonableness of assumptions, clarity, and consistency with applicable requirements and coordinate signatures with the NCS Engineer when the NCSD comments are resolved. Attachment F shall be used as guidance for performing this review. **IF** the Peer Reviewer concludes that the operation requires NCS controls that are internal (meaning specific to the operation), **THEN** notify the NCS Engineer that an NCSE is required for the operation.
NCS Engineer	**9.**	**IF** NCS controls are determined to be required or may be required within the FMO to conduct the operation, **THEN** notify the Responsible Manager that an NCSE is required for the operation and perform an NCSE per Section B.
Facility Manager, Responsible Manager, CSO (as applicable), Fissile Material Workers, other applicable disciplines	**10.**	Review the draft NCSD, as applicable, to ensure accurate representation and description of the operation or process, validity of operation-based assumptions, completeness of technical basis for no NCS controls, upset scenarios considered (if applicable), and acceptability of the NCSD. Include workers and CSOs (as applicable) in walk downs or small group discussions to ensure the accuracy and acceptability of the NCSD.
	11.	**IF** the NCSD is **NOT** acceptable due to an inaccurate or incomplete description, assumptions, technical basis, or upset analysis, **THEN** provide comments on the NCSD to the NCS Engineer.
	12.	**IF** the NCSD description, operational limitations, assumptions, and upset analysis are acceptable, **THEN** sign the NCSD acknowledging understanding of and concurrence with the NCSD and the basis thereof and transmit to the UCOR NCS Organization (NCSO) Manager or Designee.
UCOR NCSO Manager or Designee	**13.**	Review and approve the NCSD or provide comments as applicable.
NCS Engineer or CSO (as applicable)	**14.**	Conduct the implementation process in accordance with PROC-NS-1003, *Nuclear Criticality Safety Program*.
NCS Engineer	**15.**	Prepare Form-554, Safety Document Worksheet, and transmit the original, signed NCSD to the UCOR Document Management Center for retention and controlled distribution.

B. Developing, Revising, and Approving a Nuclear Criticality Safety Evaluation

NOTE 1: Before a new FMO is initiated or an existing FMO is changed, the entire process is determined and documented to be subcritical under normal and credible abnormal conditions or that a criticality is incredible.

NOTE 2: Participation by a CSO applies to those projects and facilities that have assigned CSOs.

NCS Engineer	**1.** Examine the information provided by the Responsible Manager for accuracy, consistency, and completeness.
	NOTE: If at all possible, do not include SGI in the NCSE.
	2. **IF** the subject matter of the proposed evaluation deals with SGI, **THEN** coordinate with Security to ensure that SGI protection requirements are met.
	3. **IF** generating a new NCSE or a significant revision to an NCSE, **THEN** walk down the process with line supervision and gather information from workers, documents, and other sources, as applicable, for the contingency analysis. Process knowledge may be considered as appropriate, with greater weight being given to information that is documented or from multiple sources.
	4. Establish normal case conditions based on the available information.
NCS Engineer, Responsible Manager, CSO (as applicable), Facility Manager, First Line Supervision, Fissile Material Workers, and other applicable disciplines	**5.** Identify possible upset conditions (i.e., the abnormal conditions for the FMO) and the affected NCS parameters (e.g., mass, enrichment, etc.). The NCS Engineer should facilitate the contributions of pertinent personnel. Identify the upsets and controls to ensure subcritical operations.
NCS Engineer	**6.** Ensure that the credible upset conditions include facility design basis and natural phenomena events.
	7. Involve Fissile Material Workers and CSOs in walk downs or small group discussions to ensure upsets are accurate and controls are acceptable.

NOTE: The format for a prior version of an NCSE may not match the format described in Attachment C. If minor revisions are being made to the evaluation, the prior format may be used if approved by the UCOR NCSO Manager or designee, with the exception of the approval cover sheet. The approval cover sheet (as described in Attachment D) or equivalent is to be used for all new or revised NCSEs that are issued after the implementation date of this procedure. For major revisions to an NCSE or a new NCSE, the approved format (as described in Attachment C) is to be used.

NCS Engineer	**8.** Perform the NCSE and document the evaluation (as described in Attachment C). If calculations are required, see Section C below.
	9. Prepare the draft NCSE for the NCS Peer Reviewer by checking for accuracy and clarity. Attachment F should be used as a guide for performing the review.
NCS Peer Reviewer	**10.** Perform an independent review to examine the NCSE for technical accuracy, reasonableness of methods and assumptions, clarity, and consistency with applicable requirements. Attachment F is a minimum list of items that shall be checked during the peer review.
	11. Provide comments, if any, to the NCS Engineer.
NCS Engineer	**12.** Resolve any comments regarding the NCSE with the NCS Peer Reviewer, and make changes as necessary.
NCS Engineer and NCS Peer Reviewer	**13.** Sign the NCSE.
	14. Transmit the draft NCSE to the NCS Manager or Designee, the Facility Manager, the Responsible Manager, and CSO (as applicable) for review.
Facility Manager, Responsible Manager, CSO (as applicable), Fissile Material Worker, and other applicable disciplines	**15.** Review the draft NCSE, as applicable, to ensure accurate representation and description of the operation or process, validity of operation-based assumptions, completeness of contingencies considered, and acceptability of NCS requirements. Fissile Material Workers shall be included in reviews or small group discussions to ensure accuracy and acceptability of NCS requirements.
	16. **IF** the NCS requirements are NOT acceptable or the description, assumptions, or upset analysis are inaccurate or incomplete, **THEN** provide comments on the NCSE to the NCS Engineer.
NCS Engineer	**17.** Resolve any comments regarding the NCSE, and make changes as necessary.
	18. **IF** the NCS requirements, description, assumptions, and upset analysis are acceptable, **THEN** sign the NCSE acknowledging understanding of and concurrence with the NCS requirements and the basis thereof and transmit to the UCOR NCSO Manager or Designee.
UCOR NCSO Manager or Designee	**19.** Review and approve the NCSE or provide comments as applicable.

NOTE: If the NCSO Manager comments result in intent changes in the NCSE, repeat the review steps above.

NCS Engineer

20. Initiate the implementation process in accordance with PROC-NS-1003.

21. **IF** DSA/TSR changes are identified during implementation, **THEN**
Go to Section E.

22. Prepare Form-554, Safety Document Worksheet, and transmit the original, signed NCSE to the UCOR Document Management Center for retention and controlled distribution.

C. Performing NCS Calculations and Generating an NCS Report (NCSR)

NOTE 1: Only trained, qualified, and authorized personnel shall perform NCS calculations.

NOTE 2: Participation by a CSO applies to those projects and facilities that have assigned CSOs.

NOTE 3: Ensure all software used for NCS calculations meets the UCOR SQA requirements as specified in PROC-IT-6008, *Application Lifecycle Management.*

UCOR NCSO Manager or Designee

1. Ensure that software used for NCS calculations is:

- Quality and configuration controlled
- Used only by personnel who meet the established qualifications
- Used on a system installed by Information Technology (IT).

NCS Engineer

2. Report NCS calculations in a stand-alone document or included in an NCSD/NCSE. If the calculation is a stand-alone document, obtain a NCSR number and prepare the NCSR or revise an existing NCSR.

3. The following items shall be documented in the report of the NCS calculation, as applicable:

a. A general description of the calculational method including a general statement of the applicability of the method to the problem, a summary of the neutronics code validation, and the area of applicability.

b. A clearly stated description of the calculational model.

c. Dimensioned sketches or the specific geometric model input used in the calculation.

d. The identification of materials used in all regions of the model geometry, including, when used, material densities, and/or atomic number densities.

e. Description of any differences between the actual and modeled materials and physical representation.

f. The upper safety limit derived from the validation.

g. A comparison or discussion of the area of applicability relative to the results of the calculation, as necessary.

h. A listing of calculational input parameters.

i. Calculation Results. The actual computer code output file (or files) does not have to be included in the calculation document, but computer results must be traceable to a specific input file.

NCS Engineer	**4.**	**IF** the calculation is documented in a separate report from the NCSE (i.e., the calculation is not part of the NCSE), **THEN** prepare the draft NCSR for the NCS Peer Reviewer by checking for accuracy and clarity. Attachment F should be used as a guide for performing the review.
	5.	Forward the calculation to the NCS Peer Reviewer.
NCS Peer Reviewer	**6.**	Perform an independent review to examine the NCSR for technical accuracy, reasonableness of methods and assumptions, clarity, and consistency with applicable requirements. Attachment F is a minimum list of items that shall be checked during the peer review.
	7.	Provide comments, if any, to the NCS Engineer.
NCS Engineer	**8.**	Resolve any comments regarding the calculation with the NCS Peer Reviewer.
NCS Engineer and NCS Peer Reviewer	**9.**	Approve the NCS calculation by signing the NCSE, NCSD or NCSR, as applicable.
	10.	Forward the calculation to the UCOR NCSO Manager or Designee for approval.
UCOR NCSO Manager or Designee	**11.**	Approve the NCS calculation by signing the NCSE, NCSD or NCSR, as applicable; or provide comments as applicable.
NCS Engineer	**12.**	Prepare Form-554, Safety Document Worksheet, and transmit the approved calculation to the Document Management Center for retention.

D. Verification and Validation (V&V) of NCS Software

NOTE 1: The installation of any new hardware or software on UCOR computers shall be coordinated with the IT Department.

NOTE 2: Ensure all software used for NCS calculations meets the UCOR SQA requirements as specified in PROC-IT-6008, *Application Lifecycle Management.*

NCS Engineer

1. **IF** any of the following changes occur:

- NCS software is modified,
- A new version of the NCS software is installed,
- The area(s) of applicability of the software must be extended, or
- The central processing unit, hard drive, or operating system is modified,

THEN
notify the NCSO Manager or Designee that a V&V needs to be conducted and that an applicable V&V Review Report will need to be developed or revised.

UCOR NCSO Manager or Designee

2. Assign an NCS Engineer to conduct the V&V and an NCS Peer Reviewer to independently review the V&V.

NCS Engineer

3. To perform the verification of the NCS software:

a. Ensure that the NCS software is installed properly.

b. Document a listing of the computer files including the NCS executable programs and cross-section libraries.

c. Compare the listing of computer files obtained from the above step with a listing of the computer files from a configuration controlled version of the NCS computer program. Verify that the files installed on the computer have the same file name and file date as the configuration controlled version.

d. Run a pre-determined set of input files (verification input files) that is designed to test the applicable portions of the NCS software.

e. Compare the results of the verification input files with the results obtained from the configuration controlled version. Ensure that the results match (with exception of non-essential information such as date and time stamps on the output files).

f. **IF** the applicable results match, **THEN**
document the following verification results:

- Computer identification number (e.g., serial number)
- Type of Central Processing Unit (CPU)
- Computer operating system and version
- NCS computer code and version
- Date of verification
- A listing of the test files and output files used for the verification
- A listing of the Computer Code executable files installed
- A listing of the Computer Code data library files installed

g. **IF** the applicable results DO NOT match, **THEN**
examine the results to identify the cause of the "failed" comparison. Make any necessary corrections to obtain satisfactory results.

h. Sign the verification document or form.

4. To perform the validation of the NCS software:

a. Develop or acquire a set of input files to be executed by the computer code.

b. Ensure the input files selected represent the area(s) of applicability for which calculations will be performed.

c. Run the code and evaluate the output to ensure adequate coverage throughout the area(s) of applicability.

NCS Engineer

d. Establish the bias by statistical analysis.

- If a positive bias is used in the determination of the calculational margin, its use shall be justified based on an understanding of the cause(s) of such a bias. Note the sign of the bias is arbitrary. For this step it is defined to be positive when the calculated values exceed the experimental values, but it could be defined otherwise.
- The determination of bias uncertainty shall contain allowances for uncertainties in benchmark physical properties and measurement techniques; uncertainties due to limitations in the geometric, material, or neutronic representations (e.g., cross sections) used in a calculational model; and statistical and convergence uncertainties.
- Individual elements (e.g., bias and bias uncertainty) of the calculational margin need not be computed separately. Methods may be used that combine the elements into the calculational margin.
- While statistical methods are typically used in the determination of the calculational margin, nonstatistical methods may be used where appropriate.
- Trends that arise from comparison of the calculated values with benchmark data may be considered.
- Parameters chosen for trending shall be based on the characteristics of the system or process under consideration.
- Trends in data used for extrapolation or for wide interpolation (e.g., gaps between groups of data) shall be based on an understanding of the causes of such trends.
- Data may be weighted to account for benchmark uncertainties or other indications of benchmark quality (e.g., degree of characterization or degree of applicability).
- Rejection of data outliers shall be based on the inconsistency of the data with known physical behavior or on established statistical rejection methods.

e. The validation applicability shall be established based on the benchmark applicability and may be extended to allow for extrapolation and wide interpolation of the data.

f. Review the validation results to ensure that the area of applicability has been adequately represented.

g. The validation applicability shall not be so large that a subset of the data with a high degree of similarity to the system or process would produce an upper subcritical limit that is lower than that determined for the entire set. This criterion is established to ensure that a subset of data that is closely related to the system or process is not nonconservatively masked by benchmarks that do not match the system as well.

NCS Engineer

h. Determine a minimum subcritical margin to be applied and establish the maximum allowable multiplication factor, k_{sub}, that will ensure subcriticality for the area of applicability.

- An upper subcritical limit shall be established based on the calculational margin and the margin of subcriticality.
- A margin of subcriticality shall be applied that is sufficiently large to ensure that calculated conditions will actually be subcritical. The selection of a margin of subcriticality shall take into account the sensitivity of the system or process to variations in fissile form, geometry, or other physical characteristics. A single margin might not be appropriate over the entire validation applicability.

5. Obtain an NCSR number and draft or modify an applicable Validation Report that contains the following minimum information.

a. Calculational Method – A description of the calculational method, including when applicable, software, nuclear cross-section data sets, computer platform, and configuration control information.

b. Description of Critical Experiments – A description of the critical experiments, or an appropriate reference that describes the experiments, identifying experimental data and listing parameters derived for use in the validation of the method.

c. Calculational Models – All input parameters related to nuclear physics, code options, system geometry, and the materials used for the calculation.

d. Results – Data output relevant to the validation study.

e. Area(s) of Applicability – The ranges of material compositions, material properties, and geometric arrangements within which the bias and upper subcritical limit of a validated calculational method are established.

f. Statistical Analyses – State the statistical analytical methods, the margin of subcriticality, the calculational bias, and the prescribed upper subcritical limit over the area(s) of applicability. State the basis for the margin of subcriticality.

g. Conclusions – Overall conclusions and how the conclusions were applied to evaluated results.

h. References.

i. Input File Listings.

NCS Peer Reviewer

6. Peer review the Validation Report and provide comments as applicable.

NCS Engineer and NCS Peer Reviewer

7. Sign the Validation Report and transmit to the NCSO Manager or Designee for approval.

UCOR NCSO Manager or Designee	**8.**	Review and approve the Validation Report or provide comments as applicable.

E. Selection and Documentation of Controls for DSA/TSRs

NOTE: Selection and documentation of controls for DSA/TSRs must involve consideration of all NCSDs/NCSEs contributing to the safety of the operation. See Attachment G for guidance. Multiple NCS analyses will be summarized in a single NCSR for the project or facility (e.g., Molten Salt Reactor Experiment). An existing NCSR must be updated/revised as new NCS analyses are performed. Guidance on the content of a NCSR for safety basis purposes is contained in Attachment H.

NCS Engineer	**1.**	**IF** a new or revised NCSD or NCSE has been completed, **THEN** prepare NCSR background information and identify previous NCSDs, NCSEs, and NCSRs that describe and govern the operation.
NCS Engineer, Nuclear Safety Engineer, and Facility Manager or Designee	**2.**	Collectively review assumptions that protect workers from a criticality accident. Identify specific controls that are essential and significant in maintaining criticality safety control of an operation (e.g., UF_6 cylinder wall integrity). Select elements for inclusion in the DSA/TSR based on guidance in Attachment G.
NCS Engineer	**3.**	Write a new NCSR or revise an existing NCSR based on the review using guidance provided in Attachment H.
NCS Peer Reviewer, CSO (as applicable), and Nuclear Safety Lead	**4.**	Peer review the NCSR for accuracy, clarity and consistency, and provide comments as applicable.
NCS Engineer and NCS Peer Reviewer	**5.**	Resolve any comments, sign the NCSR and transmit to the NCSO Manager or Designee for approval.
UCOR NCSO Manager or Designee	**6.**	Review and approve the NCSR or provide comments as applicable
Facility Manager	**7.**	Initiate revision of safety basis documentation (e.g., DSA, TSR), if applicable.
NCS Engineer	**8.**	Prepare Form-554, Safety Document Worksheet, and transmit the approved NCSR to the Document Management Center for retention.

F. General Nuclear Criticality Safety Reports

NOTE: NCSRs may be used to document NCS topics other than calculations (as described in Section C) and linkage to DSA/TSR safety basis documents (as described in Section E). Prospective authors should consult the NCSO Manager or Designee early in the process to determine whether the topic is appropriate for a NCSR and to select the appropriate approvals (e.g., the NCSO Manager's or Designee's signature is the minimum approval required).

NCS Engineer, Responsible Manager or Designee	**1.** **IF** a topic or item is believed to be best documented in a NCSR, **THEN** consult the NCSO Manager or Designee and obtain approval to write the document based on the scope of the item and its value in support of the NCS program.
UCOR NCSO Manager or Designee	**2.** Approve the scope and content of the proposed NCSR; define the approval signatures required.
NCS Engineer	**3.** Write the proposed NCSR and obtain required reviews and approvals.
	4. Prepare Form-554, Safety Document Worksheet, and transmit the approved NCSR to the Document Management Center for retention.

RECORDS

Records generated by this procedure and listed below shall be dispositioned in accordance with PROC-OS-1001, *Records Management, Including Document Control*. A completed Form-554, Safety Document Worksheet, must accompany all NCS Documents to the Document Management Center.

- NCS Evaluations (NCSE)
- NCS Determinations (NCSD)
- NCS Reports (NCSR)
- NCS Cancellation (NCAN)
- NCS Clarification Form (NCCF)
- NCS Surveillance Report (NCSV)
- NCS Verification Checklist (NCVC)

SOURCE DOCUMENTS

- ANSI/ANS-8.1-2014; R2018, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*
- ANSI/ANS-8.3-1997; R2017, *Criticality Accident Alarm System*
- ANSI/ANS-8.7-1998; R2017, *Nuclear Criticality Safety in the Storage of Fissile Materials*
- ANSI/ANS-8.15-2014; R2019, *Nuclear Criticality Control of Special Actinide Elements*
- ANSI/ANS-8.17-2004; R2019, *Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors*
- ANSI/ANS-8.19-2014; R2019, *Administrative Practices for Nuclear Criticality Safety*
- ANSI/ANS-8.20-1991; R2020, *Nuclear Criticality Safety Training*
- ANSI/ANS-8.21-1995; R2019, *Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors*
- ANSI/ANS-8.22-1997; R2021, *Nuclear Criticality Safety Based on Limiting and Controlling Moderators*
- ANSI/ANS-8.23-2019, *Nuclear Criticality Accident Emergency Planning and Response*
- ANSI/ANS-8.24-2017, *Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations*
- ANSI/ANS-8.26-2007; R2022, *Criticality Safety Engineer Training and Qualification Program*
- DOE O 420.1C, Chg. 3, *Facility Safety*
- DOE-STD-1027-2018, *Hazard Categorization of DOE Nuclear Facilities*
- DOE-STD-3007-2017 *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities*
- Oak Ridge Reservation Cleanup Mission Contract, 89303322DEM000067

Attachment A
DEFINITIONS AND ACRONYMS

Active Engineered Controls – A means of NCS control of intermediate rank involving add-on, active electrical, mechanical, or hydraulic hardware that sense a change in a process variable important to NCS and provide an automated response to place the system in a safe, subcritical condition.

Administrative Controls – A means of NCS control that relies on human judgment, training, and responsibility. Such controls are usually implemented as action steps in procedures and are the least preferred means of control because they are human-based and subject to error in application.

ANSI/ANS – American National Standards Institute/American Nuclear Society

Area(s) of Applicability (AOA)– The ranges of material compositions and geometric arrangements within which the bias of a calculational method is established.

Bias – A measure of the systematic disagreement between the results calculated by a method and experimental data. The uncertainty in the bias provides a measure of the precision and accuracy of the calculated values and the experimental data. NOTE: Calculated value and experimental data accuracy may not be known or well understood and precision may not be well characterized in the experimental data.

Calculational Method – The mathematical equations, approximations, assumptions, associated numerical parameters (e.g., neutron cross sections), and calculational procedures that yield the calculated results.

CFR – Code of Federal Regulations

Configuration Control – The process of identifying and defining the configuration items in a system, controlling the release and change of these items throughout the system life cycle, and recording and reporting the status of configuration items and change requests.

Contingency – A possible but unlikely change in a condition originally specified as essential to the NCS of a specific operation such that the NCS of the operation is decreased.

Credible – Offers reasonable grounds of being believed.

Criticality Accident Alarm System (CAAS) – A system capable of providing an immediate emergency evacuation alarm signal (usually audible but may be visual) after detecting a criticality accident (usually by the detection of gamma and/or neutron radiation).

Criticality Detection System (CDS) – A system capable of detecting a criticality accident (usually by the detection of gamma and/or neutron radiation). The system does not include annunciation capability.

Criticality Safety Officer (CSO) – An individual assigned by Project or Facility management to serve as a liaison for criticality matters between decontamination and decommissioning (D&D) Personnel (operations) and the NCS Organization.

Attachment A
DEFINITIONS AND ACRONYMS
Page 2 of 6

D&D – Decontamination and Decommissioning

DCP – Double Contingency Principle

DOE – U.S. Department of Energy

DOT – U.S. Department of Transportation

Double Contingency Principle – An approach incorporating sufficient factors of safety into process designs to require at least two unlikely independent and concurrent changes in process conditions before a nuclear criticality accident is possible.

DSA – Documented Safety Analysis

Effective Neutron Multiplication Factor (k_{eff}) – The ratio of the total number of neutrons produced during a time interval (excluding neutrons produced by sources whose strengths are not a function of fission rate) to the total number of neutrons lost by absorption and leakage during the same interval.

Engineered Controls – See Active Engineered Controls and Passive Engineered Controls.

Enriched Uranium – Uranium compounds containing U-235 in a weight percentage greater than 0.71 percent on a total uranium basis.

ETTP – East Tennessee Technology Park

Facility – Any equipment, structure, system, process, or activity that fulfills a specific purpose. The term facility most often refers to buildings and other structures, their functional systems and equipment, and other fixed systems and equipment installed therein to delineate a facility. However, specific operations and processes independent of buildings or other structures (e.g., waste retrieval and processing, waste storage, waste burial, remediation, groundwater or soil decontamination, decommissioning) are also encompassed by this definition.

Facility Manager – An individual designated by UCOR as the responsible person for ensuring that the conduct of activities is in compliance with requirements for all aspects of a facility's functions and uses. See PROC-FO-515, *Facility Management*.

Attachment A
DEFINITIONS AND ACRONYMS
Page 3 of 6

Fissile/Fissionable Material – Any material capable of supporting a self-sustaining neutron chain reaction. The term fissile has strict technical definition related to the energy of a neutron causing fission (thermal energy neutrons), and this definition is met by ^{233}U, U enriched in ^{235}U, ^{232}U, ^{239}Pu, ^{241}Pu, ^{242m}Am, ^{243}Cm, ^{245}Cm, ^{247}Cm, ^{249}Cf and ^{251}Cf. Fissionable nuclides or materials are materials in which a self-sustaining, neutron-induced fission chain reaction can occur, either by fast or thermal energy neutrons. These nuclides include all fissile nuclides. The terms “fissionable” and “fissile” are used interchangeably, but conformance with established terminology used in these definitions is recommended (e.g., Fissile Control Area, Fissionable Equivalent Mass, etc.). The following fissionable nuclides are also controlled in the UCOR NCSP, ^{234}U, ^{237}Np, ^{236}Pu, ^{238}Pu, ^{240}Pu, ^{242}Pu, ^{241}Am, ^{243}Am, ^{242}Cm, ^{244}Cm, and ^{246}Cm. The terms “fissionable” and “fissile” are used interchangeably, but conformance with established terminology used in these definitions is recommended (e.g., Fissile Control Area, Fissionable Equivalent Mass, etc.).

Fissile Material Operation (FMO) – Operations that involve the movement, storage, transfer, mixing, packaging, or configuration control change of non-exempt Fissile Materials. An operation with non-exempt fissile materials sealed in Department of Transportation (DOT)/DOE/ NRC-approved containers and packaging that are specification packages or packages supported by a safety analysis report for packaging (SARP) shall be considered an FMO until the packages are loaded onto a transport vehicle. Once the packages are loaded onto the vehicle in accordance with the Certificate of Compliance for the package, they are covered by the safety basis supporting transport, supporting 49 CFR or the SARP, and no longer require an explicit UCOR NCSE.

Fissionable Equivalent Mass (FEM) – The total mass of any aggregation of fissionable materials expressed in terms of an equivalent ^{235}U mass.

Geometrically Favorable Container – Container in which a nuclear criticality is not possible under stated conditions of use (e.g., with limitations on enrichment, types of materials, etc.).

Incredible – Having likelihood of occurrence less than 10^{-6} per year. The figure 10^{-6} is used as a measure of credibility and does not mean that a probabilistic risk assessment (PRA) has to be performed. Reasonable grounds for incredibility may be presented on the basis of commonly accepted engineering judgment.

Installation – UCOR-managed portions of the following three sites: Y-12 National Security Complex, East Tennessee Technology Park, and Oak Ridge National Laboratory.

Intent Change – Changes to NCSE that result in the deletion or alteration of a previously approved NCS limit or control or the addition of a new NCS limit or control.

Attachment A
DEFINITIONS AND ACRONYMS
Page 4 of 6

IT – Information Technology

LCO – Limiting condition of operation

Minimum Critical Mass (MCM) – The minimum mass of fissile material, at a given enrichment, that can sustain a neutron chain reaction under optimum geometry, moderation, and reflection.

Model – A calculational representation of a physical configuration.

Nature of Process – Nature of process means that the form of material is inherently safe or that facility or process equipment is designed such that the formation of a critical mass for a particular form of fissile material cannot be achieved.

NCS Manager – The individual that is responsible for the management of NCS personnel for a subcontractor organization.

NFS – Nuclear Facility Safety

Non-Intent Change – Changes to NCSEs other than those that can be characterized as intent changes (e.g., correction of typographical or grammatical errors, change to an expiration date, wording change to clarify an NCS limit or control, etc.). Non-intent changes cannot be used to change the intent of NCS requirements.

NRC – Nuclear Regulatory Commission

Nuclear Criticality Accident – An uncontrolled neutron chain reaction in which heat and large, potentially lethal amounts of radiation are emitted.

Nuclear Criticality Safety (NCS) – The practice of taking appropriate actions to prevent a nuclear criticality accident and to mitigate the consequences of the accident, preferably by prevention.

Nuclear Criticality Safety Controls – Rules given in an NCS specification that, if followed, help the operation comply with NCS limits. NCS controls may be grouped as being either administrative controls or engineered controls.

Attachment A
DEFINITIONS AND ACRONYMS
Page 5 of 6

Nuclear Criticality Safety Determination (NCSD) – A formal written document that establishes the basis for not requiring internal operation-specific NCS controls or CAAS coverage for an FMO.

Nuclear Criticality Safety Evaluation (NCSE) – The process that demonstrates that an FMO remains subcritical following any single credible contingency or that documents incredibility using controls internal to the FMO. This document also states the NCS limits and controls for the particular activity.

Nuclear Criticality Safety Limits – The limiting value assigned to a parameter (e.g., mass, volume, etc.) controlled for NCS that results in a subcritical system under specified conditions.

Nuclear Criticality Safety Organization (NCSO) – Personnel responsible for providing NCS support and oversight to UCOR.

Nuclear Criticality Safety Personnel (UCOR or Subcontractor) – Qualified NCS Engineers contracted or assigned to perform NCS responsibilities designated in this procedure.

Nuclear Criticality Safety Report (NCSR) – A report that documents NCS-related information, which is not appropriate for an NCSE or NCSD, and may include NCS calculations and calculational methodology used to support an NCSE or safety basis document, or provide a link between an NCSE (or series of NCSEs) and Safety Basis documentation (such as a Documented Safety Analysis).

OREM – Oak Ridge Office of Environmental Management

Passive Engineered Controls – The highest ranked means of NCS control involving design limits on shape, size, location, etc., or physical limits on chemical processes. Such controls are highly preferred because they provide high reliability, cover many potential accident scenarios, require little operational support to maintain effectiveness, and require no human intervention.

Peer Reviewer – A Senior NCS Engineer *not* directly involved in the development of the document, who examines applicable NCS documents for technical accuracy, reasonableness of method and assumptions, clarity, and consistency with applicable requirements.

Procedure – A document that specifies or describes how an activity is to be performed.

Process – A series of actions that achieve an end result.

Qualification (personnel) – The characteristics or abilities gained through education, training, or experience, as measured against established requirements, such as standards or tests that qualify an individual to perform a required function.

Responsible Manager – An individual with responsibility of a specific program or administrative function that covers the FMO being evaluated.

Attachment A
DEFINITIONS AND ACRONYMS

Safe Mass – An amount of fissile material which, if exceeded, has the potential to create a credible criticality accident scenario. (Often this is an amount of fissile material equal to less than half the minimum critical mass.)

SAR – Safety Analysis Report

SARP – Safety Analysis Report for Packaging

NCS Manager – The UCOR NCSO Manager for Oak Ridge Sites or designee.

SGI – Sensitive Government Information

Shall, Should, May – “Shall” is used to denote a requirement. “Should” is used to denote a recommendation. “May” is used to denote permission, neither a recommendation nor a requirement.

Significant Quantity of Fissionable Material – The aggregate amount of fissionable material for which control of at least one parameter is required to ensure subcriticality under all normal and credible abnormal conditions.

SQA – Software Quality Assurance

SR – Surveillance Requirement

Supermoderator – Refers to moderation by materials whose moderation properties are more effective than those of water, such as heavy water, oil, polyethylene, beryllium, and carbon.

Super-reflectors – Refers to reflection by materials whose reflection properties are more effective than those of water, such as high density concrete and beryllium.

Trend – A series of findings, items, or events that identifies an underlying or prevailing tendency.

TSR – Technical Safety Requirement

UCOR – United Cleanup Oak Ridge LLC

UCOR NCSO Manager – The individual responsible for the management of the UCOR Nuclear Criticality Safety (NCS) Program for both UCOR and subcontractor personnel.

V&V – Verification and Validation

Validation – The practice of developing and documenting bias and bias uncertainty over a defined area of applicability for a computational method.

Verification – The practice of acceptance testing, periodic rerunning of sample problems to determine if exact repeatability can be obtained, and documenting that a computational method is mathematically performing as intended.

Attachment B
NUCLEAR CRITICALITY SAFETY DETERMINATION (NCSD)
Page 1 of 2

An NCSD is used to govern certain FMOs wherein NCS controls internal to the FMO are determined unnecessary to preclude a nuclear criticality accident. The determination shall be documented and independently peer reviewed to ensure that safety is not compromised. The format to record the NCSD is not required to be on a specific form. However, the format specified below is recommended. All NCSDs are considered quality records and shall be numbered as specified in the PROC-OS-1004, *Document Numbering and Issuance.*

NOTE: A title page and approval page, similar to that contained in Attachment D, shall be used for all NCSDs initiated or revised after the implementation date of this procedure.

<u>Table of Contents</u>
A table of contents and a list of tables and figures are optional. If the NCSD is several pages long the NCS Engineer should consider their inclusion.

<u>Introduction/Objective</u>
The purpose and objective of the determination shall be stated in this section.

<u>Background and/or System/Process Description</u>
The system or process description shall contain sufficient detail, clarity, and lack of ambiguity to allow a peer reviewer either to independently evaluate the system/process or to independently assess the adequacy and accuracy of the existing evaluation. Drawings and/or sketches should be provided as needed to provide clarity. Any data used for calculations should be provided or referenced in this section. Any current NCSEs or NCSDs that may cover the operation should be stated in this section.

<u>Evaluation Methodology</u>

To establish that a proposed system or process will be subcritical under normal and credible abnormal conditions, and that a criticality is not a credible event. Acceptable subcritical limits for the operation shall be established. This section of the NCSD documents the acceptable subcritical values.

Subcritical limits shall be based on experimental data, where available, with an adequate allowance for uncertainties in the data. There are four methods for establishing acceptable subcritical values. They are:

1. Reference to national standards that present relevant critical and/or subcritical limits

2. Reference to widely accepted and current handbooks on critical and/or subcritical limits, including hand-calculational methods

3. Reference to experiments with appropriate adjustments for uncertainties in data to ensure subcriticality

4. Calculational techniques that include a validation with experimental data to establish a calculational upper subcritical limit. The upper subcritical limit shall contain a margin of subcriticality that is sufficient to ensure subcriticality. This margin of subcriticality shall include allowances for the uncertainty in the bias and for uncertainties due to any extensions of the area(s) of applicability.

Attachment B
NUCLEAR CRITICALITY SAFETY DETERMINATION (NCSD)
Page 2 of 3

The method used in a given evaluation must be supported in the text of this section. When employing methods 1 or 2, simply provide the reference giving the critical and/or subcritical limit. If hand-calculation methods are involved, reference or describe the method. When employing method 3, provide the references giving the critical parameters, and fully explain your consideration of uncertainty in the reported critical parameters when

determining limits. When employing method 4, indicate the specific methods that were used in the assessment of subcriticality. References to appropriate NCS calculation documents or to an appendix of the NCSD should be provided to allow a reviewer the opportunity to further research the methods used in the evaluation. It is not necessary to describe the theory behind any calculational methods used. It is only necessary to indicate what methods were used.

Examples of calculational methods are: the three-dimensional Monte Carlo code, KENO-Va; the one-dimensional discrete-ordinates transport theory code, XSDRN-PM; and hand calculation methods such as limited surface density, density analog, or solid angle methods.

<u>Analysis</u>
To establish that a proposed system or process will be subcritical under normal and credible abnormal conditions, an analysis should be documented in this section. This section should include, where applicable:

1. Formulas or methodology used,
2. All assumptions,
3. Calculations or reference to calculations,
4. Comparisons of results to subcritical limits, and/or
5. Discussion of why a criticality is not a credible event. (Refer to Attachment C for more discussion regarding contingencies.)
6. External events such as floods, tornadoes, and other natural phenomena shall be addressed in the NCSD.

<u>Operational Limitations/Assumptions</u>
This section contains a description of the conditions necessary for the FMO to remain within the analyzed boundaries.

Attachment B
NUCLEAR CRITICALITY SAFETY DETERMINATION (NCSD)
Page 3 of 3

Conclusion
The overall NCS assessment of the system being analyzed should be summarized in this section.

References
References of external technical information shall be provided so that relevant information can be easily confirmed.

Appendices/Attachments
Appendices/attachments may be attached to the determination to include:

1. Data used for analysis,

2. Calculations,

3. Spreadsheets,

4. Correspondences including memos or e-mails, and/or

5. Other supplemental information as needed so that relevant information can easily be confirmed.

Attachment C
FORMAT AND INSTRUCTIONS FOR COMPLETING A NUCLEAR CRITICALITY SAFETY EVALUATION (NCSE)

NCSEs shall be assigned a unique number in accordance with PROC-OS-1004, *Document Numbering and Issuance*. The format for documenting an NCSE is free form and should contain the following sections as appropriate:

NOTE: The title page and approval page contained in Attachment D, or equivalent, shall be used for all new NCSEs or NCSEs revised after the implementation date of this procedure.

Table of Contents

1.0 Introduction

The purpose and scope of the evaluation shall be stated in this section.

2.0 System/Process Description

The system or process description shall contain sufficient detail, clarity, and lack of ambiguity to allow a peer reviewer either to independently evaluate the system/process or to independently assess the adequacy and accuracy of the existing evaluation. Drawings and/or sketches should be provided as needed to provide clarity.

3.0 Evaluation Methodology

To establish that a proposed system or process will be subcritical under normal and credible abnormal conditions or that a criticality is not a credible event. Acceptable subcritical limits for the operation shall be established. This section of the NCSE documents the acceptable subcritical values.

Subcritical limits shall be based on experimental data, where available, with an adequate allowance for uncertainties in the data. There are four methods for establishing acceptable subcritical values. They are:

1. Reference to national standards that present relevant critical and/or subcritical limits

2. Reference to widely accepted and current handbooks on critical and/or subcritical limits, including hand-calculational methods

3. Reference to experiments with appropriate adjustments for uncertainties in data to ensure subcriticality

4. Calculational techniques that include a validation with experimental data to establish a calculational upper subcritical limit. The upper subcritical limit shall contain a margin of subcriticality that is sufficient to ensure subcriticality. This margin of subcriticality shall include allowances for the uncertainty in the bias and for uncertainties due to any extensions of the area(s) of applicability.

Attachment C
FORMAT AND INSTRUCTIONS FOR COMPLETING
A NUCLEAR CRITICALITY SAFETY EVALUATION (NCSE)
Page 2 of 7

The method used in a given evaluation must be supported in the text of this section. When employing methods 1 or 2, simply provide the reference giving the critical and/or subcritical limit. If hand-calculation methods are involved, reference or describe the method. When employing method 3, provide the references giving the critical parameters, and fully explain your consideration of uncertainty in the reported critical parameters when determining limits. When employing method 4, indicate the specific methods that were used in the assessment of subcriticality. References to appropriate NCS calculation documents or to an appendix of the NCSE should be provided to allow a reviewer the opportunity to further research the methods used in the evaluation. It is not necessary to describe the theory behind any calculational methods used. It is only necessary to indicate what methods were used.

Examples of calculational methods are: the three-dimensional Monte Carlo code, KENO-Va; the one-dimensional discrete-ordinates transport theory code, XSDRN-PM; and hand calculation methods such as limited surface density, density analog, or solid angle methods.

4.0 Discussion of Normal Operations

This section presents the basis for the normal operation being subcritical. For all measurements used to support the basis for normal operations, measurement uncertainties shall be considered in the analysis.

As a first priority, reliance shall be placed on geometry control to ensure subcriticality. Where geometry control is not feasible, the preferred order of controls is other passive engineering controls, active engineering controls, and administrative controls.

5.0 Nuclear Criticality Parameters & Contingency Analysis

This section of the NCSE presents the main technical discussion of the evaluation which supports the conclusion that double contingency is assured or that criticality is incredible. The double contingency analysis should be organized by nuclear parameter. Attachment F contains several technical practices or guidelines that should be considered during the contingency analysis. The evaluator shall develop a comprehensive list of credible scenarios and shall state what method (What If, HAZOPS, etc.) was used to develop those scenarios. A summary of the nuclear criticality parameters, contingencies, controls, and bounding assumptions may be provided at the beginning of this section, if desired. The following information by NCS parameter (e.g., mass, enrichment, etc.) is to be presented:

- **Nuclear Parameter Discussion -** Identify the credible range of values for each parameter as applicable. If the parameter does not affect the fissile material operation (FMO), provide a short justification for excluding the parameter from evaluation.

Attachment C
FORMAT AND INSTRUCTIONS FOR COMPLETING A NUCLEAR CRITICALITY SAFETY EVALUATION (NCSE)

5.1 Contingencies

For each nuclear parameter, identify credible events arising from items such as human error, procedural error, and processes that would affect the nuclear criticality parameter. If a contingency affects more than one parameter, it should be addressed once under the parameter affected the most. External events such as floods, tornadoes, and other natural phenomena shall be addressed in the NCSE.

Credible accident scenarios should be developed through the use of parameter checklists (What If checklists), HAZOPS, Fault Tree Analysis, Event Tree Analysis, Failure Modes and Effects Analysis (FMEA), or other formal hazards assessment techniques as appropriate. The analyst shall state the basis for the approach selected. The hazards analysis should include input from existing hazard assessments or other guidance documents describing contingencies (e.g., maximum credible flood depth in the facility). Upset scenarios should be developed through discussion with the operating organization, engineering, or other disciplines, and should consider the ability to detect and correct the upset. For example, if the maximum credible flood depth is two feet above floor level in a given facility, fissionable material located more than two feet off the floor may not be flooded. Account for any incidental moderation and reflection of other objects that may occur because of the upset.

The combinations of contingent and anticipated abnormal conditions that must remain subcritical should be discussed. This analysis must consider the impact that parameters have on one another. For example, high-density material may be more reactive as single units. Larger, less dense items may be more reactive in a spaced array, especially with interspersed moderation. Measurement uncertainty and parameter variability should be considered in selecting normal, upset, and contingent conditions.

Anticipated abnormal conditions, which are expected to arise as a result of the legacy conditions at the site, should be bounded by the normal operations considered in the limit and control set (i.e., expected conditions that may not be typical of normal operations should be accommodated within the analysis as an allowed normal condition).

Contingencies shall be at least unlikely. A particular contingency that is unlikely is improbable based on commonly-accepted engineering judgement. Contingencies shall be independent; that is, they should not be the result of common mode failures. Evaluations that credit the sampling of solution need to ensure that both analyzed contingencies do not credit the same sample result. Contingencies shall not occur concurrently; that is, the second contingency must be unlikely to occur before the effects of the first are corrected or compensated for, and the second contingency must be unlikely to occur at the same time and place as the first. The concurrence criterion must be considered in establishing the acceptable frequency to meet the unlikely requirement.

Attachment C
FORMAT AND INSTRUCTIONS FOR COMPLETING
A NUCLEAR CRITICALITY SAFETY EVALUATION (NCSE)

For closed facilities or shutdown operations, engineering judgment will frequently be utilized to address the likelihood of occurrence for upsets in facilities rather than a calculated probability. This engineering judgment must be an engineering component of an analysis having a logical technical basis. Judgment is required in determining whether two events are related and consequently whether they actually represent two contingencies or a single contingency. For example, exceeding storage limits and then flooding an area would constitute two independent events; however, fire followed by flooding from an automatic sprinkler system could be considered a single event. Include sufficient detail to support any engineering judgment used. Engineering judgment shall always be subject to peer and management review.

For each contingency, justification that the FMO remains subcritical shall be provided. For all measurements used in the analysis of contingent conditions, measurement uncertainties shall be considered in the analysis (e.g., mass and enrichment). For double contingency discussions, compliance with the DCP should be demonstrated in this section. Control of independent nuclear parameters is required to demonstrate double contingency protection.

If control of independent nuclear parameters is not possible, then a system of multiple controls on a single nuclear parameter may be developed. If an NCSE does not document either that a criticality is not credible, or that the FMO satisfies the DCP, the evaluated FMO must be reviewed and approved by DOE-OREM. DOE-OREM approval shall be obtained either by (1) submittal to DOE-OREM of an NCS document that summarized the FMO and the justification for deviating from the DCP, or (2) through the safety basis process, i.e., revision to and approval of the subject facility DSA/TSR. The approval must be documented prior to implementation/use of the NCSE.

In all cases, no single failure shall result in the potential for a nuclear criticality accident. The Responsible Manager and the UCOR NCSO shall be notified immediately if an existing or planned operation is determined to be singly contingent. NCS controls are to arise directly from the evaluations of double contingency or incredibility. Clearly identify any necessary restrictions on the measurement methods such that the DCP analysis is not voided. As applicable, incorporate these restrictions into the NCSE controls. Controls derived from this evaluation should be cross-referenced in Section 6 of the NCSE, which contains all of the final controls for the operation.

Attachment C
FORMAT AND INSTRUCTIONS FOR COMPLETING
A NUCLEAR CRITICALITY SAFETY EVALUATION (NCSE)
Page 5 of 7

5.2 Incredibility Studies

Incredibility studies are generally performed to demonstrate CAAS coverage is not warranted. For incredibility evaluations, anticipated and unlikely events are identified. Demonstration of criticality probabilities as qualitatively not credible can therefore include multiple concurrent events that are at least unlikely, or demonstration that a minimum critical mass cannot be accumulated. On occasion it may be more appropriate to use multiple concurrent events that individually are more frequent than unlikely, but together are extremely unlikely or incredible. Incredibility evaluations should not be fundamentally different than a double contingency evaluation. The major difference is incredibility evaluations must demonstrate a much lower probability of a criticality accident for the entire operation/facility (not just per scenario). In doing so, the analyst must be more comprehensive when performing the analysis. This should drive the evaluation to cover things (e.g., facility characterization, operating history, etc.) in a more exhaustive manner than is done in a standard double contingency evaluation. For incredibility evaluations, the defense in depth items that may not be credited in double contingency arguments may need to be credited and controlled. In addition, the physical nature of the process might be such that criticality is not credible.

5.3 Documented Safety Analysis Crosswalk

For either method chosen (contingency analyses or incredibility studies), the Nuclear Criticality Safety Program requirements of the Documented Safety Analysis (DSA) shall be discussed and compared to the requirements of the criticality safety evaluation to ensure that the DSA requirements are satisfied. This comparison will include the accidents considered in the DSA, the overall Safety Management Program (SMP), credited bulleted elements of the SMP, and any technical safety requirements (e.g., pertaining to the CAAS). If there is an indication that new controls (i.e., in the form of credited bullets of the SMP or TSRs) are potentially needed, or that all of the requirements of the current DSA are potentially not satisfied, a revision to the NCSR and a USQD should be initiated.

6.0 <u>Design Features and Administrative Limits and Controls</u>

Design features (passive and active) and administratively controlled limits and requirements for the purpose of preventing or reducing the probability of a nuclear criticality accident should be stated in this section. This section should address the six items below. In each section where controls are specified, the basis for the control from the contingency analysis in Section 5 must be referenced.

6.1 Nuclear Criticality Safety Fire Protection Requirements

Determine the need for any limitations or controls on fire fighting. These controls may include, for example, direction to minimize the use of water or guidance on spraying mists from above rather than a direct high-pressure stream that might relocate and concentrate fissile materials. In such instances, consideration should be given to providing a local posting in the area, a moderator-controlled area, where the control is required to assist fire fighters.

Attachment C
FORMAT AND INSTRUCTIONS FOR COMPLETING
A NUCLEAR CRITICALITY SAFETY EVALUATION (NCSE)

6.2 Criticality Accident Alarm System Coverage Requirements

Determine the need for CAAS coverage and associated requirements. Using Attachment E as guidance, document that the associated FMO is within the effective coverage area of the CAAS. If criticality is demonstrated to be incredible, either Section 5 or 6.2 of the NCSE should include discussion of common mode failures.

6.3 Passive Design Features Relied Upon for Nuclear Criticality Safety

Determine the need for passive design features to provide criticality safety controls. These controls may include, for example, container dimensions and designs inspected by Quality representatives upon receipt and prior to use, or engineered storage arrays constructed and inspected to specifications of the evaluation.

6.4 Active Design Features Relied Upon for Nuclear Criticality Safety

Determine the need for any active systems that provide criticality safety control. These systems may include, for example, active sensors (e.g., pressure transducers, liquid level instruments, or scales) that transmit a signal to a system to shut off a pump, a transfer process, etc., to prevent the accumulation of too much fissile material and a criticality accident. These systems may have uninterruptible power supplies or fail-safe configurations. Operator intervention is not necessary for the system to respond.

6.5 Administratively Controlled Limits and Conditions (Administrative controls are required to be in written procedures)

Determine the need for any administratively controlled limits and conditions that provide criticality safety control. These are parameters over which the operator has control during the operation or work activity (mass of material, number of items, spacing of containers, etc.). Steps to comply and verify compliance with these parameters are required to be in procedures.

6.6 Administrative Aids (e.g., Postings, labeling, etc.)

The NCSE may specify the need for a NCS posting. The development of the NCS posting is part of the NCSE implementation process defined in PROC-NS-1003.

7.0 <u>Summary and Conclusions</u>

The overall NCS of the system being analyzed should be summarized in this section.

8.0 <u>References</u>

References of external technical information shall be provided so that relevant information can easily be confirmed.

Attachment C
FORMAT AND INSTRUCTIONS FOR COMPLETING
A NUCLEAR CRITICALITY SAFETY EVALUATION (NCSE)
Page 7 of 7

Appendices

Appendices shall be included to provide technical information as needed. Examples of information to be included in appendices are:

- NCS Calculations (that are not in an NCS Report) with the following information:
  - ➢ A general description of the calculational method;
  - ➢ A clearly stated description of the calculational model;
  - ➢ Dimensioned sketches or the specific geometric model input used in the calculation;
  - ➢ The identification of materials used in all regions of the model geometry, including, when used, material densities, and/or atomic number densities;
  - ➢ Description of any differences between the actual and modeled materials and physical representation;
  - ➢ A listing of calculational input parameters or input listings of computer models. In cases where multiple calculations are used to establish trends, only representative inputs are required;
  - ➢ Summary of the neutronics code validation and the area of applicability; and
  - ➢ Calculation results.
- Operations staff input into the development of credible process changes and associated NCS limits and controls, including process knowledge where appropriate. Information may take any number of forms, including interview records, comment sheets, memos, original data, etc.
- Other appendices providing supplemental information as needed.

Attachment D
NCSD/NCSE COVER SHEET AND APPROVAL SHEET
Page 1 of 4

The following three pages contain the NCSE and NCSD Approval Sheet and the revision log. The NCSE or NCSD Approval Sheet, or equivalent shall be used on all new NCSEs/NCSDs and all NCSEs/NCSDs revised since the implementation date of this procedure. The revision log is recommended so that the purpose of the revision will be documented.

Attachment D
NCSD/NCSE COVER SHEET AND APPROVAL SHEET
Page 2 of 4

UCOR
United Cleanup Oak Ridge LLC

NUCLEAR CRITICALITY SAFETY EVALUATION

NCSE and Revision #
NCSE Title

NCSE Approval

Nuclear Criticality Safety Organization
NCS Engineer - Analyst: Print Name/Sign/Date
NCS Engineer – Peer Reviewer: Print Name/Sign/Date
NCSO Manager or Designee: Print Name/Sign/Date
Facility/Operations Acknowledgment (Operations): I have read, understand, and agree to the limits and conditions stated within.
Facility Manager: Print Name/Sign/Date
Responsible Manager: Print Name/Sign/Date

The implementation requirements of PROC-NS-1003 shall be completed prior to starting a fissionable material operation governed by this NCSE.

Attachment D
NCSD/NCSE COVER SHEET AND APPROVAL SHEET
Page 3 of 4

(NCSE Title)

NCSE#, Revision YY
Page 2 of XX

REVISION LOG			
Revision Number	Description of Changes	Analyst/ Date	Reviewer/ Date
0	Initial Release		
1	Brief summary of change (e.g., non-intent clarification of controls, revised FMO process, etc.)		

Attachment D
NCSD/NCSE COVER SHEET AND APPROVAL SHEET
Page 4 of 4

UCOR
United Cleanup Oak Ridge LLC

NUCLEAR CRITICALITY SAFETY DETERMINATION

NCSD and Revision #
NCSD Title

NCSD Approval
Nuclear Criticality Safety Organization
NCS Engineer - Analyst: Print Name/Sign/Date
NCS Engineer – Peer Reviewer: Print Name/Sign/Date
NCSO Manager or Designee: Print Name/Sign/Date
Facility/Operations Acknowledgment (Operations): I have read, understand, and agree to the limits and conditions stated within.
Facility Manager: Print Name/Sign/Date
Responsible Manager: Print Name/Sign/Date
The implementation requirements of PROC-NS-1003 shall be completed prior to starting a fissionable material operation governed by this NCSD.

Attachment E

CAAS COVERAGE CRITERIA
Page 1 of 3

Requirements relating to the need for a Criticality Accident Alarm System (CAAS) and/or a Criticality Detection System (CDS) shall be satisfied by compliance with Item 1 or Item 2:

Item 1: Requirements Relating to the Need for CAAS/CDS (ANSI/ANS-8.3, ¶ 4.2.1)

1.) The need for a CAAS shall be evaluated for all FMO in which the inventory of fissionable materials in individual unrelated areas exceeds 700 grams of ^{235}U, 500 grams of ^{233}U, 450 grams of ^{239}Pu, or 450 grams of any combination of these three nuclides.

2.) For other fissionable nuclides, this evaluation shall be made whenever:

   a. Mass quantities of individual nuclides exceed two times the FMCL presented in PROC-NS-1003, *Nuclear Criticality Safety Program*; or
   b. Mass quantities of nuclide combinations exceed 700 grams ^{235}U FEM.

3.) Also, this evaluation shall be made for all processes in which neutron moderators or reflectors more effective than water are present, or unique material configurations exist such that critical mass requirements may be less than the typical subcritical mass limits noted above.

4.) For this evaluation, individual areas may be considered unrelated when the boundaries between them are such that:

   a. there can be no uncontrolled transfer of materials between areas;
   b. the minimum separation between material in adjacent areas is 10 cm; and
   c. the area density of fissionable material averaged over each individual area is less than 50 grams/m^2 for ^{233}U, ^{235}U, ^{239}Pu, or any combination of these three nuclides.

Item 2: Alternative Determination of Requirements for Criticality Accident Alarm System and Criticality Detection System (CDS)

Requirements relating to the need for a CAAS and a CDS shall be satisfied by compliance with following:

NOTE: In what follows, to determine credibility, a probabilistic risk assessment is not required. Reasonable grounds for incredibility may be presented on the basis of engineering judgment.

Attachment E
CAAS COVERAGE CRITERIA
Page 2 of 3

1.) In those facilities where the mass of ^{235}U FEM material exceeds the limits established in paragraph 4.2.1 of ANSI/ANS-8.3 and the probability of a criticality accident is not documented as being incredible, a CAAS conforming to ANSI/ANS-8.3 shall be provided to cover occupied areas in which the expected dose exceeds 12 rads in free air, where a CAAS is defined to include a criticality accident detection device and a personnel evacuation alarm. An unoccupied area is one for which the combination of physical barriers and administrative controls prevents lawful entry.

2.) In those facilities where the mass of ^{235}U FEM material exceeds the limits established in paragraph 4.2.1 of ANSI/ANS-8.3 and the probability of a criticality accident is not documented as being incredible, but there are no occupied areas in which the expected dose exceeds 12 rads in free air, a CDS shall be provided, where a CDS is defined to be an appropriate criticality accident detection device but without an immediate evacuation alarm. The CDS response time should be sufficient to allow for appropriate process-related mitigation and recovery actions. Appropriate response guidance to minimize personnel exposure shall be provided by the contractor.

3.) In those facilities where the mass of ^{235}U FEM material exceeds the limits established in paragraph 4.2.1 of ANSI/ANS-8.3, but a criticality accident is determined to be impossible due to the physical form of the fissionable material, or the probability of a criticality accident is documented as being incredible, neither a CAAS nor a CDS is required.

NOTE: An operation with non-exempt fissionable materials sealed in DOT/DOE/NRC-approved containers and packaging that are specification packages or packages supported by a SARP shall be considered an FMO until the packages are loaded onto a transport vehicle. Once the packages are loaded onto the vehicle in accordance with the Certificate of Compliance for the package, they are covered by the safety basis supporting transport (in the Code of Federal Regulations or the SARP) and no longer require an explicit UCOR NCSE.

4.) If a criticality accident is possible wherein a slow (i.e., quasi-static) increase in reactivity could occur leading from subcriticality to supercriticality to self-shutdown without setting off emplaced criticality alarms, then a CAAS might not be adequate for protection against the consequences of such an accident.

NOTE: To aid in protecting workers against the consequences of slow criticality accidents in facilities where analysis has shown that slow criticality accidents are credible, CAASs should be supplemented by warning devices such as audible personnel dosimeters (e.g., pocket chirpers/flashers, or their equivalents), area radiation monitors, area dosimeters, or integrating CAASs. If these devices are used solely as criticality warning devices, they shall meet the requirements for monitoring instruments of 10 CFR 835.401.

Attachment E
CAAS COVERAGE CRITERIA
Page 3 of 3

5.) Neither a CAAS nor a CDS is required to be installed for handling or storage of fissionable material when sufficient shielding exists that is adequate to protect personnel (e.g., spent fuel pools, hot cells, or burial grounds); however, a means to detect fission product gasses or other volatile fission products should be provided in occupied areas immediately adjacent to such shielded areas, except for systems where no fission products are likely to be released.

Basis for Incredibility

The first choice for demonstrating that criticality is not credible is the physical nature of the process or facility. That is, does justification exist that a critical fissile configuration cannot be assembled, due to insufficient mass or less than optimal configuration? This method can utilize known process parameters such as fissile enrichment, geometry, moderation, neutron poisons, etc. Any parameters that reduce reactivity should only be credited to the extent that their presence or configuration can be assured. Justification must be provided for credit given these parameters. Care should be exercised when crediting large reactivity reductions to a single parameter, such as neutron poisons.

An important part of a strong incredibility argument is a thorough facility characterization detailing the quantity, form, and distribution of fissionable material in the facility. In order to support an incredibility assertion, the potential holdup in a facility needs to be addressed. New facilities that previously have not processed or handled fissionable materials obviously have no holdup. But holdup in older facilities must be addressed. Utilization of operating personnel or facility experts with direct knowledge of operations spanning the full life cycle of the facility is important. When personnel with direct knowledge of past operations are not available, documentation relevant to the facility operations and off-normal events must be used. A thorough characterization includes:

- Description of the operating history of the facility sufficient to support conclusions about the presence or absence of fissionable materials in various locations.
- Description of accidents or process upsets, particularly those that might have left significant quantities of fissionable materials in unexpected locations (e.g., fires, floods, spills, etc.).
- Description of current material inventories, including all accountable fissionable material, inventory differences, and comprehensive fissionable material assays. The characterization should also include brief description of assay methods used, their accuracy, potential weaknesses, comprehensiveness of the assays, and the meaning of any stated uncertainties.

When the process alone does not prevent criticality, engineered features or administrative controls may be credited in a manner similar to contingency evaluations. Engineering judgment should be used in crafting an argument that concludes that criticality is not credible based on multiple, defense-in-depth controls. Caution should be exercised to assure failure of the controls is adequately addressed. Extreme care must be applied when using this alternative.

Attachment F
PEER REVIEW CHECKLIST
Page 1 of 3

The following checklist shall be used as a guide for NCS Peer Reviewers to ensure that the NCSE/NCSD/NCSR is complete and thorough. Comments shall be documented either on a comment review sheet or in the electronic draft copy of the respective NCS document along with the analyst's proposed resolutions to the comments. Note that many of the items in this checklist are worded specifically for NCSE peer reviews and judgement should be made on the applicability to NCSDs and NCSRs depending on the complexity and content of those documents.

1. Is the process description accurate and does it adequately describe all phases of the operation?
2. Is process knowledge, if used, considered appropriately (e.g., uncertainties are discussed and considered, weight is given to multiple sources)?
3. Is all equipment applicable to the NCS aspects of the operation adequately described?
4. Is there extraneous information that can be deleted?
5. Is the Fissile Nuclide Percent appropriate per Safety Basis Documentation?
6. Is the area covered by a CAAS?
    a. If not, has the operation been evaluated as to whether a CAAS is required, and is the basis documented?
    b. If a CAAS is required and the area is not covered, has an exclusion been requested?
7. Are all credible process upsets/contingencies that could lead to a criticality identified?
8. Are independent controls and/or unlikely events clearly identified for all credible contingencies?
9. If "unlikely events" are used as a basis for controls, are they adequately justified in the NCSE?
10. For each contingency in a double contingency evaluation, is it adequately demonstrated that a second credible independent and concurrent contingency required before criticality is possible?
11. For analyses demonstrating criticality is incredible, is it adequately demonstrated that credible combinations of events are subcritical?
12. Are common mode failures considered and adequately addressed?
13. Have all necessary controls been transcribed into clear, unambiguous statements in the Limits and Controls section of the NCSE, and has the basis for the control from Section 5 been noted in Section 6 with the control?
14. Has the possibility of untoward holdup been addressed? If fissile material can accumulate over time, is there a need to have a requirement for periodic scanning?
15. Are controls for singly contingent operations covered by the Safety Basis Documentation?
16. Does the NCSE adequately account for dimensional tolerances of equipment?
17. If credit is taken for neutron absorbers or neutron absorption properties of materials to ensure subcriticality, are there any controls necessary to ensure the absorber material remains properly distributed and in appropriate concentration?
18. If subcritical limits from national standards or accepted references are used, are they appropriate for the types of material involved (including reflectors and moderators)?
19. If subcritical limits from national standards or accepted references are used, are they appropriate for the credible configuration (heterogeneous vs. homogeneous) of the material involved?
20. Are documents from which subcritical limits taken referenced properly?
21. If independent verification of an NCS control is required in the NCSE, are the control steps clearly defined to ensure the desired outcome?
22. Did the evaluation consider the possibility of interaction with uranium bearing material outside the area being analyzed (e.g., on the other side of the wall)?

Attachment F
PEER REVIEW CHECKLIST
Page 2 of 3

23. If the operation involves fissile material storage, are storage facilities and structures designed, fabricated, and maintained in accordance with good engineering practices?
24. Does the design of storage structures preclude unacceptable arrangements or configurations, thus reducing the reliance on administrative controls?
25. Does the FMO restrict the presence of moderators, and if so:
    a. Should the area in which the FMO occurs be designated a moderator-controlled area (through procedures and administrative aids)?
    b. Does the evaluation credit barriers to protect the area?
    c. Did the evaluation consider potential penetrations through barriers (such as a pipe or ductwork) which could allow for the entry of moderators?
    d. Should combustibles in the area be controlled? If so, was the use of non-combustible or fire-resistant materials considered?
    e. Does the evaluation consider the property of materials, e.g., is the material hygroscopic, absorptive, etc.?
    f. Is sampling or monitoring required to protect credited values?
    g. Has tolerance in the physical/chemical properties been considered in the evaluation?
    h. Has consideration been given to moderation both internal to the fissile matrix as well as between units?
    i. Has container integrity been considered?
    j. Can moderators be introduced during maintenance, decontamination, or other non-operational activities?
    k. Is there consideration for any active engineered feature that could detect or measure the presence of moderators?
26. If the operation involves a fissile material storage area where a sprinkler system(s) is involved, was the possibility of a nuclear criticality occurring from accumulation of runoff water considered?
27. If the operation involves a fissile material storage area where a sprinkler system(s) is involved, are the containers designed to prevent the accumulation of water if moderation control is relied upon?
28. If the storage of fissionable materials requires the use of a significant quantity of combustible material (e.g., storage of combustible scrap), is a fire protection system installed?
29. If shelving is relied upon for the storage of fissionable materials, is the shelving structurally sound to support the materials (i.e., sturdy) and made of non-combustible material?
30. Is access to areas where fissionable material is handled, processed, or stored appropriately controlled?
31. If a computer code was used:
    a. Do the code and computer used for the calculations meet the V&V requirements?
    b. Does the model bound the FMO being analyzed?
    c. Is the system analyzed within the area of applicability of the code validation? If the system is beyond the area of applicability, has justification been provided?
    d. Is the code margin of subcriticality adequate for the FMO?
    e. Are the results quoted and used accurately?
32. Was the preferred design approach used where appropriate in the development of controls?
33. Are passive and active engineered features appropriately described?
34. Are operator aids (e.g., postings) required as appropriate?

Attachment F
PEER REVIEW CHECKLIST
Page 3 of 3

35. Are measurement uncertainties correctly accounted for in the analysis of both normal and contingent conditions?
36. Are references to other NCSEs appropriate? (Use original documents as references and not documents that reference other documents for important information. Do not credit controls from other NCSEs as being implemented, unless that assumption is protected within the NCSE being reviewed.)
37. Is information from hard-to-find references included in an appendix?
38. Are measurement uncertainties unambiguously incorporated into guidance for postings?
39. For measurements credited for fulfilling the DCP or supporting an incredibility argument, is the measurement process clearly defined and incorporated into the requirements of the NCSE (e.g., if independent measurements are required, does the NCSE define what constitutes an independent measurement and is this definition stated in the NCSE requirements)?
40. Does the CAAS coverage documentation demonstrate that the FMO is within CAAS coverage (and if not required, the reason shall be included)?
41. Does the NCSE document any scenario in which a single upset can lead to a criticality? If an NCSE does not document either that a criticality is not credible, or that the FMO satisfies the DCP, the evaluated FMO must be reviewed and approved by DOE-OREM. DOE-OREM approval shall be obtained either by (1) submittal to DOE-OREM of an NCS document that summarizes the FMO and the justification for deviating from the DCP, or (2) through the safety basis process, i.e., revision to and approval of the subject facility DSA/TSR. The approval must be documented prior to implementation/use of the NCSE.

Attachment G
SELECTION OF CONTROLS FOR DSAs/TSRs

Key Differences between the DSA and the NCSE

DSAs and NCSEs are prepared according to different guidance and reference material. The DSAs analyze hazards, identify controls to prevent or mitigate those hazards, and get the U.S. Department of Energy (DOE) concurrence on the identified controls. As a lower tier document, the NCSE evaluates credible scenarios, establishes a set of NCS controls, and obtains Facility Operations concurrence on the set of controls. Although DOE-OREM may have to approve the use of an NCSE, i.e., an NCSE that documents a scenario in which a criticality could occur due to the credible failure of a control or set of controls of a single parameter, it does not approve NCSEs.

Guidelines for Incorporating NCS Controls and Limits into the DSA

Since there are significant differences between the DSA and the NCSE in terminology and in development, blindly incorporating NCS controls from the NCSE into the DSA may not meet the regulatory requirements for the DSA. Nevertheless, NCSEs can be support documents for the DSA; however, careful interpretation of the two documents must be made before NCS requirements can be identified in the DSA. This section provides guidance for establishing the NCS requirements in a DSA.

1. The selection of NCS controls for the DSA should be performed using a team of criticality safety, nuclear safety, and operations personnel.
2. The consequence of criticality should be examined to determine if the Evaluation Guideline of 25 rem to the public is challenged, for the purpose of establishing safety class or safety significant items.
3. The NCSE(s) that cover(s) the fissionable material operations addressed by the DSA should be examined to ensure that bounding assumptions or analysis conditions are considered as potential DSA controls.
4. All passive engineered features credited in the NCSE should be considered for selection as a DSA design feature. If the nuclear criticality safety of the fissionable material operation relies upon a single nuclear parameter to ensure subcriticality, and a passive engineered feature is credited as a control for that process parameter, the engineered feature shall be selected as a DSA design feature. The initial selection of engineered features should focus on the minimum, most reliable control set that covers the most scenarios to keep the system subcritical. Additional controls may be selected as appropriate to add value, but the DCP does not have to be demonstrated in the DSA. Adherence to the DCP is performed through the NCS program.
5. All active engineered features credited in the NCSE should be considered for selection as a TSR control with a Limiting Condition of Operation (LCO) and an associated Surveillance Requirement (SR). The initial selection of engineered features should focus on the minimum, most reliable control set that covers the most scenarios to keep the system subcritical. If an active engineered feature is credited for protecting the only nuclear parameter relied upon to ensure criticality, the active engineered feature shall be included in the DSA as a Safety Significant (SS) Structure, System and Component (SSC) and be controlled in the Configuration Management Plan (CMP). Additional LCOs may be selected as appropriate to add value, but the DCP does not have to be demonstrated in the TSR. Adherence to the DCP is performed through the NCS program.
6. If all of the credible scenarios are shown to be subcritical by engineered features, then specific NCS administrative controls are not required to be contained in the DSA.
7. In general, administrative controls in the NCSE should not be explicitly contained in the DSA. These controls are administered by the NCS program, which may be an administrative program credited in the DSA. General reference to the nuclear parameters being controlled by NCS administrative controls may be made. In some cases, administrative controls may be identified as specific credited elements in the TSRs based on their importance to safety.
8. NCS limits are not the same as DSA safety limits, and should not, in general, be included in the DSA.

SELECTION OF CONTROLS FOR DSA/TSRs
Page 2 of 2

Conclusions from the discussion above are summarized in Table 1.

Table 1. Criteria for Control Selection

Question	Answer	
1. Does a single nuclear criticality parameter ensure subcriticality, and is a passive engineered feature credited as a control for that process parameter?	YES Feature becomes DSA design feature and is controlled in the CMP	NO No impact on DSA or TSR
2. Does a single nuclear criticality parameter ensure subcriticality with no passive engineered features credited?	YES One or more controls should be evaluated for inclusion as SAC(s)	NO No impact on DSA or TSR
3. Is there an engineered feature that protects multiple nuclear criticality parameters (e.g., mass, concentration, geometry, interaction, moderation)? (If the engineered feature is not easily degraded during its lifetime and environment, answer NO.)	YES Passive feature becomes DSA design feature Active feature becomes TSR LCO with SR	NO No impact on DSA or TSR
4. Is there an active engineered feature credited for protecting the only nuclear parameter relied upon to ensure subcriticality?	YES Active feature becomes DSA design feature Active feature becomes TSR LCO with SR Active feature becomes Safety Significant Structure, System and Component (SSC) Active feature is controlled in the CMP	NO ALL ACTIVE ENGINEERED FEATURES BECOME TSR LCO with SR
5. Are there no engineered features, and is there an administrative control where a single or few operator failures can lead to an inadvertent nuclear criticality accident?	YES One or more controls should be evaluated for inclusion as SAC(s)	NO No impact on DSA or TSR

Attachment H
FORMAT AND INSTRUCTIONS FOR COMPLETING
A NUCLEAR CRITICALITY SAFETY REPORT
Page 1 of 1

NCSRs shall be assigned a unique number in accordance with PROC-OS-1004, *Document Numbering and Issuance.* The format for documenting an NCSR is free form and should contain the following sections as appropriate:

NOTE: The title page and approval page contained in Attachment D or equivalent shall be used for all new NCSRs or NCSRs revised after the implementation date of this procedure.

Table of Contents

1.0 Introduction

The purpose and scope of the report shall be stated in this section. Background information on the facility and its NCSDs and NCSEs should be outlined.

2.0 Evaluation of Facility Systems/Area

Current surveillance, maintenance, and project activities should be summarized. The system or process descriptions shall contain sufficient detail, clarity, and lack of ambiguity to determine the essential criticality safety features. Information from each NCS analysis should include, as applicable:

- A summary description of the activity or operation;
- Drawings and/or sketches (for clarity);
- Assumptions and initial conditions from the NCS analysis;
- Interfaces with Safety Management Programs;
- Passive features;
- Active features; and
- Administrative controls.

3.0 Documented Safety Analysis

Passive and active design features, NCS administrative controls, assumptions and initial conditions, interfaces with Safety Management Programs, and other essential factors are integrated and reviewed. Primary contributors preventing the occurrence of a criticality are identified for incorporation into the NCS section of the Documented Safety Analysis.

4.0 Conclusion

Essential controls, if any, are identified for inclusion in the DSA/TSR. The need for CAAS coverage is identified.