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SUBJECT MATTER AREA: Nuclear Criticality	PREPARER: Joe Hack | Page 1 of 45
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TITLE: NUCLEAR CRITICALITY SAFETY EVALUATIONS AND CALCULATIONS	APPROVED BY/DATE: Arlen Schade 7/6/06 [Approval Signature on File]
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BJC ETTP Classification & Information Control Office Date

REVISION LOG

Revision Number	Description of Changes	Pages Affected
0	Initial Release Intent Change. This document replaces DE-A-1005, *Nuclear Criticality Safety Program Elements*, Rev. 0.	All
1	Non-intent Changes: • Delete "in general" from item A.1. • Record copy should go to the Document Management Center rather than placed in the work control package. • Change "effective" date to "implementation" date. • Numbering instructions deleted. Refer to BJC-OS-1004.	3 7 9 and 28 19
2	Intent Changes: • Revised NCSD approval cycle to match those for NCSEs. • Corrected BJC *Project Calculations* procedure number. • Clarified definitions of Fissile Material, Fissionable Material Operation, and Peer Reviewer. • Incorporation of measurement uncertainties and associated NCS restrictions to be considered in analysis. • Incorporation of verifying FMO is within CAAS if applicable. • Incorporation of Operations staff input into development of credible process changes and associated NCS limits and controls. • Minor editorial changes.	2-4, 7-10, 15, 17-28, 30, 31, 36
3	Intent Changes: • Expanded applicability to all personnel, including subcontractors, that generate NCS documents. • Revised Attachment B for Nuclear Criticality Safety Determinations to incorporate a suggested format that more closely resembles that of an NCSE. • Revised Attachment D for Nuclear Criticality Safety Evaluations to remove 1st and 2nd defense format restrictions. • Minor editorial changes.	All
4	Intent Changes: • Clarified relationship between double contingency and incredibility. Double contingency discussion is not appropriate for documentation that justifies activities without CAAS. Incorporated guidance on criticality incredibility and methods for development of credible accident scenarios. • Described the selection and documentation of NCS controls for the DSA/TSRs. Defined a Nuclear Criticality Safety Report (NCSR).	All
5	Administrative Changes: • Expanded Criticality Accident Incredibility Section to discuss Nature of Process in more detail. • Updated Facility Management procedure number and deleted Project Calculations procedure from Other Documents Needed List. • Removed the Implementation date from the NCSD/E cover sheet. • Made the requirement to use the Attachment D approval cover sheet or equivalent consistent throughout. • Added definition of Nature of Process in Attachment A. • Updated sample revision log to include analyst and tech reviewer identification in Attachment D.	4, 5 3 36 9, 11, 35 23 37

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 (ANSI) standards and and the Baseline List of Required Compliance Documents, and specifies the method of obtaining approval for operations involving fissionable materials. This procedure is not retroactive.

SCOPE

This procedure applies to all personnel [Bechtel Jacobs Company LLC (BJC) or subcontractors] responsible for generating NCS documentation.

OTHER DOCUMENTS NEEDED

- BJC-FS-515, *Facility Management*
- BJC-NS-1003, *Nuclear Criticality Safety Program*
- BJC-OS-1001, *Records Management, Including Document Control*
- BJC-OS-1004, *Document Numbering and Issuance*
- Oak Ridge Accelerated Closure Contract, DE-AC05-98OR22700, Part III, Section J, Appendix E, *Baseline List of Required Compliance Documents*, Latest Revision
- PA-1005, *Paducah Facility Safety Program*
- PORT-5001, *Site Operations Review Committee*
- BJCF-554, Safety Document Worksheet

GENERAL REQUIREMENTS

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

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 of ANSI-8.1. The double contingency principle is as follows:

> *Process designs should incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible.*

To implement this principle, protection (or defenses) shall be provided by either (i) the control of independent process parameters (preferred approach), or (ii) a system of multiple controls on a single process parameter. The number of controls required upon a single controlled process parameter shall be based upon control reliability and any features that mitigate the consequences of a control failure. In all cases, no single credible event or failure shall result in the potential for a criticality accident.

In some cases, Double Contingency is met by having a control over a parameter and by crediting an unlikely, independent, and concurrent change in process conditions as the second control.

An exception to the application of the Double Contingency, where single contingency operations are permissible, is presented in paragraph 5.1 of ANSI/ANS-8.10. This exception applies to operations with shielding and confinement (e.g., hot cells or other shielded facilities). Process designs that do not incorporate the above factors of safety shall be justified and documented, and U.S. Department of Energy (DOE) must approve the analysis.

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 FEM), nuclear criticality safety is a factor in the facility categorization determination. Guidance has been provided by the 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 is adequately defined in DOE-STD-1027. However, the local Department of Energy (DOE) office has provided the following elaboration on the definition of "nature of process," which restricts the use of administrative NCS controls in the categorization of a facility because the categorization is developed on an "unmitigated" basis.

> *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*[1].

[1] DOE letter I-00128-0035, from Lori Fritz (DOE) to Paul Clay (BJC), "Hazard Categorization of Bechtel Jacobs Company LLC Facilities," September 16, 2002.

For waste management facilities, the form of material is often dictated by the waste acceptance criteria. Given the initial waste acceptance criteria are satisfied, criticality accidents are considered precluded by nature of process if physical features inherent to the process prevent criticality after unintentional procedural errors on the part of facility operations. Features "inherent to the process" are systems, structures, and components associated with normal facility operations. "Unintentional procedural errors" include simple operator errors (omission or commission); however, they do not include violation of the initial waste acceptance criteria or errors of number/type resulting from gross neglect or sabotage[2].

The inclusion of the administrative controls outside of the purview of operations (e.g., waste acceptance criteria, safety basis level controls not initiated by NCS) as a part of the nature of a process is based on Sect. 3.1 of DOE-STD-1027 that states:

> "Only facilities which fall below the Category 3 threshold are exempt from the requirements of DOE Order 5480.23. However, these facilities should have administrative controls in place to ensure minimum values are not exceeded through introduction of new material."

b. Criticality accident incredibility determinations for CAAS coverage requirements

For FMOs where it has been shown that a nuclear criticality accident is not credible, 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. An operable CAAS is also required by DOE O 420.1A if the fissionable material mass exceeds ANSI/ANS-8.3 limits, the criticality accident probability exceeds 10^{-6} per year based on qualitative argument from good engineering judgement, and the expected dose exceeds 12 rad in free air. [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.]

DOE Order 420.1 provides requirements relating to the needs for a CAAS and exceptions to the above requirement for a CAAS (see Attachment E). 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); 2) shipping fissionable material packaged in approved shipping containers; or 3) having fissionable material packaged in approved shipping containers awaiting transport provided that no other operation involving fissionable material not so packaged is permitted on the shipping dock or in the shipment area.

[2] ORNL 1997. "Hazard Classification Criteria for ORNL Waste Management and Remedial Action Division Facilities," ORNL/WMRAD/AD-109/R2, Oak Ridge National Laboratory, Lockheed Martin Energy Systems, Inc., June 6, 1997.

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. These means of criticality safety control 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.

B. Nuclear Parameters Important to Nuclear Criticality Safety

Control of one or more of the following nuclear parameters shall be incorporated into the FMO to the extent necessary.

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 Control**. 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. Considering a "Safe Mass" is a simple approach to establishing mass limits. For example, if double-batching is credible, limiting the mass to 45% of the minimum critical mass (MCM) in the controlled environment prevents criticality even if doubling batching occurs. (The controlled environment means the environment provided by the other imposed controls, for example the allowed volume, allowed density or concentration, etc. Full water reflection is usually assumed, unless the environment substantially excludes water. For example, 43.5% for U235 is typically used at Portsmouth.) If double-batching is not credible, a simple limit is 75% of the MCM in the controlled environment. If used in combination with a geometry parameter to determine the minimum critical number of like items, the same 45%/75% criteria should apply to the number of items.

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

4. **Concentration/Density Control.** Concentration/density control is typically used to restrict the permitted concentrations of fissile material dissolved or dispersed in another medium.

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

6. **Reflection Control.** Reflection control restricts the quantity, composition, and configuration of hydrogenous or other effective neutron reflecting materials in proximity to fissile material.

7. **Moderation Control.** 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.

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

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

C. Nuclear Criticality Subcritical Limits

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:

- Reference to national standards that present subcritical limits.

- Reference to widely accepted handbooks on 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.

Examples of calculational methods are Monte Carlo codes such as KENO-Va and discrete ordinates transport theory codes such as XSDRN-PM.

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 an FMOs is begun or an existing FMO is changed it should be determined and documented that the entire process is subcritical under both normal and credible abnormal conditions, or that a criticality is not credible.

NOTE 2: An 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 (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 an NCS determination. 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 supercede any site-specific safety basis document [e.g., Safety Analysis Report (SAR) or Technical Safety Requirement (TSR)] requirements.

NCS Engineer

1. Upon receipt of a request for a NCSE, 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 fissionable equivalent mass [FEM]);
- Fissionable nuclide enrichment;
- Presence of super moderators or super reflectors;
- Form of fissionable material;
- Transportation issues; and
- Change to the assumptions or safety basis arguments (double contingency or incredibility) contained in an existing NCSE.

NOTE 3: If at all possible, do not include classified material in the NCSD.

NOTE 4: Process knowledge may be considered as appropriate, with greater weight being given to information that is written or from multiple sources.

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

3. **IF** generating a new NCSD or a significant revision to an 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 NCS Evaluation is required for the operation and perform an NCS Evaluation per Section B.

5. **IF** NCS controls **are not** required within the FMO, **THEN**
   document the technical basis for reaching this determination, following the guidance in Attachment B for formatting and using an approval cover similar to that in Attachment D.

6. Prepare the draft NCSD for the NCS Peer Reviewer by checking for accuracy and clarity. Attachment F may 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 sign the NCSD when comments are resolved. Attachment F may 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.

Facility Manager, Responsible Manager, NCS Manager or Designees, Workers

9. 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, contingencies considered (if applicable), and acceptability of the NCSD. Include workers in walkdowns or small group discussions to ensure the accuracy and acceptability of the NCSD.

10. **IF** the NCSD is **NOT** acceptable due to an inaccurate or incomplete description, assumptions, technical basis, or contingency analysis, **THEN**
    provide comments on the NCSD to the NCS engineer.

11. **IF** the NCSD description, assumptions, and contingency analysis are acceptable, **THEN**
    sign the NCSD acknowledging understanding of and concurrence with the NCSD and the basis thereof and transmit to the BJC NCS Organization Manager.

BJC NCSO Manager or Designee	**12.** Review and approve the NCSD or provide comments as applicable. **NOTE:** Steps 12 through 17 are for the Portsmouth Site and Paducah Site only. These steps pertain to intent changes to NCSDs that require Portsmouth (PORTS) Site Operations Review Committee (SORC) review and approval or Paducah Gaseous Diffusion Plant (PGDP) Independent Review Committee (IRC) review and approval. Non-intent changes to NCSDs are not required to be approved by the SORC or the IRC.
	13. Forward the new or revised (with intent changes) NCSD to SORC/IRC for approval.
SORC/IRC	**14.** Review and comment on the NCSD.
NCS Engineer, NCS Peer Reviewer	**15.** Resolve and incorporate SORC/IRC comments.
SORC/IRC	**16.** Recommend and document SORC/IRC approval on the NCSD.
BJC NCSO Manager or Designee	**17.** **IF** the FMO covered by the NCSD is to be performed in a facility retained by the DOE but could potentially affect United States Enrichment Corporation (USEC) operations, **THEN** submit the NCSD to the USEC Plant Operating Review Committee (PORC) for information only.
	18. **IF** the NCSD relates to an activity that affects leased facilities, systems, or activities, **THEN** submit the NCSD to the USEC PORC for review and approval.
NCS Engineer	**19.** Initiate the implementation process in accordance with BJC-NS-1003.
	20. Prepare a BJCF-554, Safety Document Worksheet, and transmit the NCSD to the NCSO Manager for signature.
BJC NCSO Manager or Designee	**21.** Complete the BJCF-554, Safety Document Worksheet, and transmit the original, signed NCSD to the BJC Document Management Center for retention and controlled distribution.

B. Developing, Revising, and Approving an NCS Evaluation

NOTE: Before a FMO is begun or an existing FMO is changed it shall be determined and documented that the entire process is subcritical via double contingency analysis under both normal and credible abnormal conditions or that a criticality is incredible.

NCS Engineer

1. Examine the information provided by the Responsible Manager for accuracy, consistency and completeness.

NOTE: If at all possible **DO NOT** include classified material in the NCSE.

2. **IF** the subject matter of the proposed evaluation deals with classified material, **THEN**
   coordinate with Security to ensure that classified matter 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 written or from multiple sources.

4. Establish normal case conditions based on the available information.

NCS Engineer, Responsible Manager, Facility Manager, First Line Supervision, Fissile Material Workers

5. Identify the contingencies (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 contingencies and controls to ensure subcritical operations.

NCS Engineer, Fissile Material Workers

6. NCS Engineer shall involve Fissile Material Workers in walkdowns or small group discussions to ensure contingencies are accurate and controls are acceptable.

NOTE: The format for a prior version of a NCSE (and approval) may not match the format shown in Attachment C. If minor revisions or modifications are being made to the evaluation, the prior format may be used if approved by the BJC NCSO Manager or designee, with the exception of the approval cover sheet. The approval cover sheet in Attachment D or equivalent shall 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 format in Attachment C should be used.

7. Perform the NCSE and document the evaluation in accordance with Attachment C. If calculations are required, see Section C below.

8. Prepare the draft NCSE for the NCS Peer Reviewer by checking for accuracy and clarity. Attachment F may be used as a guide for performing the review.

9. Submit draft NCS evaluation to peer reviewer.

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 peer reviewer, and revise 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, and the Responsible Manager for review.

Facility Manager, Responsible Manager, NCS Manager or Designees, Fissile Material Worker

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 contingency analysis is inaccurate or incomplete, **THEN** provide comments on the NCSE to the NCS engineer.

17. **IF** the NCS requirements, description, assumptions, and contingency analysis are acceptable, **THEN** sign the NCSE acknowledging understanding of and concurrence with the NCS requirements and the basis thereof and transmit to the BJC NCSO manager.

BJC NCSO Manager or Designee

18. Review and approve the NCSE or provide comments as applicable.

NOTE: Steps 19 through 24 are for the Portsmouth Site and Paducah Site. These steps pertain to intent changes to NCSEs and Unreviewed Safety Question Determination (USQD) forms that require PORTS Site Operations Review Committee (SORC) review and approval or PGDP Independent Review Committee (IRC) review and approval. Non-intent changes to NCSEs are not required to be approved by the SORC or the IRC.

	19. Forward the NCSE with intent changes to SORC/IRC for approval.
SORC/IRC	**20.** Review and comment on the NCSE.
NCS Engineer, NCS Peer Reviewer	**21.** Resolve and incorporate SORC/IRC comments.
SORC/IRC	**22.** Recommend and document SORC/IRC approval on the NCSE.
BJC NCSO Manager or Designee	**23.** **IF** the NCSE is to be performed in a facility retained by the DOE but could potentially affect USEC operations, **THEN** submit the NCSE to the USEC PORC for information only.
	24. **IF** the NCSE relates to an activity that affects leased facilities, systems, or activities, **THEN** submit the NCSE to the USEC PORC for review and approval.
NCS Engineer	**25.** Initiate the implementation process in accordance with BJC-NS-1003.

C. Performing NCS Calculations and Generating an NCS Report

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

NCS 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, and • Used on a system installed by Information Technology.
NCS Engineer	**2.** Report NCS calculations in a stand-alone document or include in an NCS evaluation. If the calculation is a stand-alone document, obtain an NCS Report number and prepare a NCS Report (NCSR) or revise an existing NCSR.

3. Document in the report of the NCS calculation the following items:

   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. Computer code input files. In cases where multiple calculations are used to establish trends, only representative inputs are required; and

   j. Calculation Results. Note: 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 Peer Reviewer

4. **IF** the calculation is documented in a separate report from the NCS evaluation (i.e., the calculation is not part of the NCSE), **THEN** perform an independent review of the NCS calculation.

5. Provide comments, if any, to the NCS Engineer.

NCS Engineer

6. Resolve any comments regarding the calculation with the peer reviewer, and revise as necessary.

NCS Engineer and NCS Peer Reviewer

7. Sign the NCS calculation.

8. Forward the calculation to the NCS Manager or Designee for approval.

NCS Manager

9. Review the calculation and approve or provide comments as applicable.

10. Transmit the calculation to the BJC NCSO Manager or Designee for approval.

BJC NCSO Manager or Designee	**11.**	Approve the NCS calculation or provide comments as applicable.
NCS Engineer	**12.**	Prepare a BJCF-554, Safety Document Worksheet, and transmit the approved calculation to the BJC NCSO Manager.
BJC NCSO Manager or Designee	**13.**	Complete the BJCF-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: The installation of any new hardware or software on BJC computers shall be coordinated with the Information Technology Department.

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 replaced,

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.

BJC NCSO Manager, NCS Manager or Designees

2. Assign an NCS Engineer to conduct the V&V and an independent peer reviewer.

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** obtain an Nuclear Criticality Safety Report number and document the following information in a verification report:

- Computer identification number (e.g., serial number)
- Type of computer processor
- Computer operating system and version
- NCS computer code and version
- Date of verification
- Directory listing of the verification input files.

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.

NCS Peer Reviewer

h. Peer review the Verification Report.

NCS Engineer and NCS Peer Reviewer

i. Sign the Verification Report.

NCS Engineer

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.

d. Establish the bias by statistical analysis.

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

f. 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.

NOTE: A validation may be documented in a stand alone report, within an NCSE, or within an NCS calculation document.

5. 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, and 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 NCS Manager for approval.

NCS Manager

8. Review and approve the validation report or provide comments as applicable, and transmit to the BJC NCSO Manager.

BJC NCSO Manager	**9.** Review and approve the validation report or provide comments as applicable.

E. Selection and Documentation of Controls for Documented Safety Analysis (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., K-25, Molten Salt Reactor Experiment). An existing NCSR must be updated/revised as new NCS analyses are performed. Guidance on the content of an 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. Incorporate the information into a new or revised NCSR.
NCS Engineer, Nuclear Safety Engineer, 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 And Nuclear Safety Technical Lead	**4.** Peer review the NCSR and provide comments as applicable.
NCS Engineer and NCS Peer Reviewer	**5.** Sign the NCSR and transmit to the NCS Manager for approval.

NOTE: Steps 6 through 11 pertain to intent changes to NCSRs and USQD forms that require review and approval by the PORTS Site Operations Review Committee (SORC), the PGDP IRC, or the East Tennessee Technology Park (ETTP) Safety Basis Review Board (SBRB). Non-intent changes to NCSRs are not required to be approved by the SORC, the IRC, or the SBRB.

	6. Forward the NCSR with intent changes to SORC/IRC/SBRB for review and approval.
SORC/IRC	**7.** Review and comment on the NCSR.

NCS Engineer, NCS Peer Reviewer	**8.** Resolve and incorporate SORC/IRC/SBRB comments.
SORC/IRC	**9.** Recommend and document SORC/IRC/SBRB approval on the NCSR.
BJC NCSO Manager or Designee	**10. IF** the NCSR is to be performed in a facility retained by the DOE but could potentially affect USEC operations, **THEN** submit the NCSR to the USEC PORC for information only.
	11. IF the NCSR relates to an activity that affects leased facilities, systems, or activities, **THEN** submit the NCSR to the USEC PORC for review and approval.
Facility Manager	**12.** Initiate revision of safety basis documentation (e.g., DSA, TSR), if applicable.
NCS Engineer	**13.** Prepare a BJC-554, Safety Document Worksheet, and transmit the NCSR to the BJC NCSO Manager.
BJC NCSO Manager or Designee	**14.** Complete the BJCF-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 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 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 and obtain approval to write the document based on the scope of the item and its value in support of the NCS program.
BJC 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 a BJC-554, Safety Document Worksheet, and transmit the NCSR to the BJC NCSO Manager.
BJC NCSO Manager or Designee	**5.** Complete the BJCF-554, Safety Document Worksheet, and transmit the approved NCSR to the Document Management Center for retention.

RECORDS

The following NCS records shall be maintained and controlled as quality records in accordance with BJC procedures during the period of their applicability. A completed BJCF-554, Safety Document Worksheet must accompany all NCS Documents to the Document Management Center.

- NCS Evaluations
- NCS Calculations
- NCS Computer Code Verification and Validation Reports
- NCS Document Non-Intent Revision Forms
- NCS Determinations
- NCS Reports

SOURCE DOCUMENTS

- ANSI/ANS-8.1-1998, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors.*
- ANSI/ANS-8.3-1997; R2003, *Criticality Accident Alarm System*
- ANSI/ANS-8.7-1998, *Guide for Nuclear Criticality Safety in the Storage of Fissile Materials*
- ANSI/ANS-8.10-1983; R1999, *Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement*
- ANSI/ANS-8-15-1981; R1995, *Nuclear Criticality Control of Special Actinide Elements*
- ANSI/ANS-8.17-1984; R1997, *Criticality Safety Criteria for Handling, Storage, and Transportation of LWR Fuel Outside Reactors*
- ANSI/ANS-8.19-1996, *Administrative Practices for Nuclear Criticality Safety*
- ANSI/ANS-8.20-1991; R1999, *Nuclear Criticality Safety Training*
- DOE-STD-3007, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities*
- Oak Ridge Accelerated Closure Contract, DE-AC05-98OR22700, Part III, Section J, Appendix E, *Baseline List of Required Compliance Documents*, Latest Revision

Attachment A
DEFINITIONS AND ACRONYMS
Page 1 of 5

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.

Area(s) of Applicability – 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.

BJC – Bechtel Jacobs Company LLC

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

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

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.

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.

Attachment A
DEFINITIONS AND ACRONYMS

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 Bechtel Jacobs Company LLC 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 BJC-FS-515, *Facility Management*.

Fissile 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, and this definition is met by ^{233}U, U enriched in ^{235}U, ^{236}Np, ^{239}Pu, ^{241}Pu, ^{242m}Am, ^{243}Cm, ^{245}Cm, ^{247}Cm, ^{249}Cf and ^{251}Cf. Although they do not meet the strict technical definition of fissile, ^{237}Np, ^{238}Pu, ^{240}Pu, ^{242}Pu, ^{241}Am, ^{243}Am and ^{244}Cm are considered fissile materials for the purposes of the BJC NCS Program. Although both contain ^{235}U, neither natural uranium (any uranium containing the ^{235}U found in the naturally occurring distribution of isotopes) nor depleted uranium (any uranium containing less ^{235}U than the naturally occurring distribution if uranium isotopes) is considered to be fissile material under the conditions expected to be encountered. The presence of any of the above listed nuclides in quantities of 0.1 grams ^{235}U FEM or less per container is not considered to be fissile material. The most common fissile nuclide present at the ETTP, PORTS and PGDP is ^{235}U. The most common fissile nuclide present at the Molten Salt Reactor is ^{233}U.

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 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 a 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 BJC NCSE.

Attachment A
DEFINITIONS AND ACRONYMS
Page 3 of 5

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

Fissionable Material – Any nuclides or material 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, all transuranic nuclides for which critical masses have been measured, and some transuranic nuclides for which critical masses have been inferred from measurements or have been calculated. The terms "fissionable" and "fissile" are sometimes used interchangeably; all fissile nuclides or materials are fissionable, but not all fissionable nuclides or materials are fissile. Where the term "fissile" appears in other definitions, it implies that ^{235}U is the dominant fissionable nuclide.

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 – Bechtel Jacobs Company managed portions of the following five sites: Y-12 Plant, East Tennessee Technology Park, Oak Ridge National Laboratory, Portsmouth Gaseous Diffusion Plant, and Paducah Gaseous Diffusion Plant.

Intent Change – Changes to NCS evaluations 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.

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.

NCSAE – Terminology for some sites resulting as an acronym for Nuclear Criticality Safety Approval Evaluation, or as a combination of NCSA and NCSE because a process had both documents associated with it. Current procedural intent is that FMOs be covered by an NCSE meeting the format specified in Attachment C.

Non-Intent Change – Changes to NCS evaluations 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.

Attachment A
DEFINITIONS AND ACRONYMS
Page 4 of 5

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 Approval (NCSA) – A formal, written approval for a FMO that was formerly used by the BJC. It states the NCS limits for the particular activity.

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

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

Nuclear Criticality Safety Evaluation (NCSE) – The process that demonstrates that a 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. For some sites, this is also referred to as a NCS Approval Evaluation.

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.

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

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

Nuclear Criticality Safety Personnel (BJC 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 that 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).

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 human intervention is not required.

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.

Attachment A
DEFINITIONS AND ACRONYMS

PGDP – Paducah Gaseous Diffusion Plant

PORTS – Portsmouth Gaseous Diffusion Plant

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.

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, e.g., a value of 43.5% for ^{235}U is typically used at Portsmouth based on their particular situation and analyses).

Site NCS Manager – The BJC NCSO Manager for Oak Ridge Sites or designee for Paducah and Portsmouth.

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.

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.

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

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 documented 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 fissile material operations (FMO) 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 NCS determination is not required to be on a specific form. However, the format specified below is recommended. All NCS determinations are considered quality records and shall be numbered as specified in the BJC-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.

Table of Contents
A table of contents and list of tables and figures are optional. If the NCSD is several pages long the NCS engineer should consider their inclusion.

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

Background and/or 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. 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.

Analysis
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.)

Operational Limitations
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 2 of 2

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)
Page 1 of 7

NCSEs shall be assigned a unique number in accordance with BJC-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 subcritical limits

2. Reference to widely accepted handbooks on 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 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.

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 should be addressed in facility safety analyses, so they do not need to be considered again in the NCSE, unless special circumstances warrant. The NCS engineer should ensure that the natural phenomena are addressed either in facility safety authorization basis documents or in an NCSE.

Attachment C
FORMAT AND INSTRUCTIONS FOR COMPLETING A NUCLEAR CRITICALITY SAFETY EVALUATION (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 detectability and correctability. 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, that 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. This is usually determined by engineering judgment; for example, a particular contingency that is unlikely is not expected to occur in the lifetime of the facility. Contingencies shall be independent, that is, not 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.

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.

Attachment C
FORMAT AND INSTRUCTIONS FOR COMPLETING A NUCLEAR CRITICALITY SAFETY EVALUATION (NCSE)
Page 4 of 7

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 double contingency principle should be demonstrated in this section. Control of independent nuclear parameters is the preferred means 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 is allowed. In all cases, no single failure shall result in the potential for a nuclear criticality accident. The Responsible Manager and the BJC 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. Clearly identify any necessary restrictions on the measurement methods such that the double contingency principle analysis is not voided. As applicable, incorporate these restrictions into the NCSE requirements. Controls derived from this evaluation should be cross-referenced in Section 6 that contains all of the final controls for the operation.

5.2 Incredibility Studies
Incredibility studies are generally performed to demonstrate Criticality Accident Alarm System (CAAS) coverage is not warranted. DOE Order 420.1 (see Attachment E, Item 2) states 10^{-6} per year is used as a measure of credibility. For double contingency evaluations, anticipated and unlikely events are identified. Demonstration of criticality probabilities as less than 10^{-6} per year 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.

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

6.0 Design Features and Administrative Limits and Controls

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. It such instances, consideration should be given to providing a local posting in the area where the control is required to assist fire fighters.

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 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.

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

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

NCS postings should supplement written procedures. The following types of information shall be considered for posting requirements:

- Types of fissionable materials present;
- All limits that are subject to procedural criticality control;
- For process areas, only those NCS limits and controls which are observable and controllable by an operator and supplement written procedures, and
- For fissionable material storage arrays:
  - Types of containers permitted,
  - Fissionable material mass limits,
  - Fissionable material enrichment limits,
  - Number of units/containers (when used as a limit or control),
  - Fissionable material concentration/density limits,
  - Volume limits,
  - Moderation limits, and
  - Spacing limits.
- Measurement uncertainties, such that they are unambiguously presented to operators and consistent throughout the process.

7.0 Summary and Conclusions

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

8.0 References

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 Calculation 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
NCSE COVER SHEET AND APPROVAL SHEET
Page 1 of 3

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

BECHTEL
JACOBS
Bechtel Jacobs Company LLC

NUCLEAR CRITICALITY SAFETY EVALUATION

(NCSE#)

(Title)

NCSE Approval

Nuclear Criticality Safety Organization

NCS Engineer - Analyst:	NCS Engineer – Peer Reviewer:	Subcontractor NCS Manager: (n/a when the subcontractor is in direct support of BJC)	BJC NCSO Manager or Designee:
Print Name	Print Name	Print Name	Print Name
Sign/Date	Sign/Date	Sign/Date	Sign/Date

Facility/Operations

Acknowledgment (Operations): I have read, understand, and agree to the limits and conditions stated within.

Facility Manager:	Responsible Manager:
Print Name	Print Name
Sign/Date	Sign/Date

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

Nuclear Criticality Safety Organization
Bechtel Jacobs Company LLC
(Site Location)

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 E
CAAS COVERAGE CRITERIA
Page 1 of 4

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 the CAAS evaluation limit in Table E-1; or
b. Mass quantities of nuclide combinations exceed 700 grams ^{235}U Fissionable Equivalent Mass (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 needs for a CAAS and CDS shall be satisfied by compliance with following:

NOTE: In what follows, 10^{-6} per year frequency is used as a measure of credibility, and does not mean that a probabilistic risk assessment must be performed. Reasonable grounds for incredibility may be presented on the basis of engineering judgment.

Attachment E
CAAS COVERAGE CRITERIA
Page 2 of 4

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 greater than 10^{-6} per year (as documented in a DOE-approved Safety Analysis Report (SAR) or in the supporting analysis for an SAR), 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 greater than 10^{-6} per year, (as documented in a DOE-approved SAR or in the supporting analysis for an SAR), 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 occurrence is determined to be less than 10^{-6} per year (as documented in a DOE-approved Safety Analysis Report (SAR) or in the supporting analysis for an SAR, or in other appropriate documentation such as an NCSE), neither a CAAS nor a CDS is required.

   NOTE: Neither a CAAS nor a CDS is required for fissionable material during shipment when packaged in approved shipping containers, or when packaged in approved shipping containers awaiting transport provided that no other operation involving fissionable material not so packaged is permitted on the shipping dock or in the shipment area.)

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 4

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.

Table E-1 – CAAS Evaluation Limits[3,4,5,6]

Nuclide	CAAS Evaluation Limit (grams)	f_{35} (mass factor for ^{235}U FEM)	Fissile (thermal fission) criticality possible
^{233}U	500[7]	1.40	Yes
^{235}U	700[5, 8]	1.00	Yes
^{236}Np	5	140	Indicated[9]
^{237}Np	20000	0.035	No
^{238}Pu	3000	0.23	No
^{239}Pu	450[5]	1.56	Yes
^{240}Pu	15000	0.047	No
^{241}Pu	200	3.5	Yes
^{242}Pu	40000	0.018	No
^{241}Am	16000	0.044	No
^{242m}Am	13	54	Yes
^{243}Am	25000	0.028	No
^{243}Cm	90	7.8	Yes
^{244}Cm	3000	0.23	No
^{245}Cm	30	23	Yes
^{247}Cm	900	0.78	Yes
^{249}Cf	10	70	Yes
^{251}Cf	5	140	Yes

[3] The CAAS evaluation values are generally on the order of 90% of the critical mass of the particular fissionable nuclide(s) involved: water-moderated and water-reflected if the material is fissile, and unmoderated but reflected by thick stainless steel if not.

[4] *American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, ANSI/ANS-8.1. Available from American Nuclear Society, La Grange Park, Illinois.

[5] *American National Standard for Nuclear Criticality Control of Special Actinide Elements*, ANSI/ANS-8.15. Available from American Nuclear Society, La Grange Park, Illinois.

[6] Most of the numerical quantities in the table have two significant figure precision only.

[7] The CAAS Evaluation Limit for combinations of ^{233}U, ^{235}U, and ^{239}Pu is 450 g; see American National Standard for Criticality Accident Alarm System, ANSI/ANS-8.3, paragraph 4.2.1.

[8] This limit applies to non-metal uranium at greater than 0.96% ^{235}U enrichment (1% for PORTS and PGDP) and to metal uranium greater than 0.93% ^{235}U enrichment.

[9] The physics of neptunium-236 suggests that thermal fission is possible but it has not been determined.

Attachment E
CAAS COVERAGE CRITERIA
Page 4 of 4

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, which 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 2

The following checklist shall be used as a guide for NCS peer reviewers to ensure that the NCSE is complete and thorough.

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 or not, 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 is 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. Are controls for singly contingent operations covered by the Safety Basis Documentation?
15. Does the NCSE adequately account for dimensional tolerances of equipment?
16. 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?
17. If subcritical limits from national standards or accepted references are used, are they appropriate for the types of material involved (including reflectors and moderators)?
18. 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?
19. Are documents from which subcritical limits taken referenced properly?
20. If independent verification of an NCS control is required in the NCSE, are the control steps clearly defined to ensure the desired outcome?
21. 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)?
22. If the operation involves fissile material storage, are storage facilities and structures designed, fabricated, and maintained in accordance with good engineering practices?
23. Does the design of storage structures preclude unacceptable arrangements or configurations, thus reducing the reliance on administrative controls?
24. 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?

Attachment F
PEER REVIEW CHECKLIST
Page 2 of 2

25. 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?
26. 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?
27. 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?
28. Is access to areas where fissionable material is handled, processed, or stored appropriately controlled?
29. If a computer code was used:
    a. Does the model bound the FMO being analyzed?
    b. 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?
    c. Is the code margin of subcriticality adequate for the FMO?
    d. Are the results quoted and used accurately?
30. Was the preferred design approach used where appropriate in the development of controls?
31. Are passive and active engineered features appropriately described?
32. Are references to other NCSEs appropriate? (Use original documents as references and not documents that reference other documents for important information.)
33. Is information from hard-to-find references included in an appendix?
34. Are operator aids (e.g., postings) provided for administrative controls as appropriate?
35. Are measurement uncertainties correctly accounted for in the analysis of both normal and contingent conditions?
36. Are measurement uncertainties unambiguously incorporated into guidance for postings?
37. For measurements credited for fulfilling the double contingency principle 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)?
38. Does the CAAS coverage documentation demonstrate that the FMO is within CAAS coverage (and if not required, the reason shall be included)?

Attachment G
SELECTION OF CONTROLS FOR DSA/TSRs
Page 1 of 1

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 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. The DOE 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 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 double contingency principle does not have to be demonstrated in the DSA. Adherence to the double contingency principle 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. Additional LCOs may be selected as appropriate to add value, but the double contingency principle does not have to be demonstrated in the TSR. Adherence to the double contingency principle 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.

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

NCSRs shall be assigned a unique number in accordance with BJC-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.