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GN470072 - NUCLEAR CRITICALITY SAFETY

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*Indicates a substantive change

Change History

1.0 APPLICABILITY

This supplement to the *ES&H Manual* CPR400.1.1/MN471001 establishes the Nuclear Criticality Safety (NCS) Program at Sandia National Laboratories (SNL). This NCS Program, CPR400.1.1.11/GN470072 shall be employed by Members of the Workforce to ensure the safety of all Sandia fissile material operations with the exceptions of reactor operations and critical experiments in Technical Area V (TA-V). Safety for reactor operations and the TA-V critical experiments is addressed by Documented Safety Analyses (DSAs) in which criticality is considered as normal. Criticality safety outside of the critical operations including fuel handling and fissile storage is subject to the SNL NCS Program.

This NCS Program is documented to ensure that NCS hazards are evaluated and controls are established and implemented. The program establishes responsibilities for NCS to prevent potential unsafe accumulations of fissile materials. The program thereby ensures that operations will remain safely subcritical under both normal and credible abnormal conditions.

This NCS Program fulfills the requirements of 10 CFR 830 for nuclear safety management and DOE Orders, including DOE O 420.1B*, Facility Safety,* chapter III NCS. This NCS Program document shall be approved by DOE in accordance with DOE O 420.1B, and any exceptions to the order shall also be approved by DOE. Additionally, this NCS Program directs the implementation of the ANSI/ANS-8 Standards that are in effect as required by DOE O 420.1B. All recommendations within the ANSI/ANS-8 Standards are to be implemented under this NCS Program, unless explanation is provided within this document. This NCS Program also directs implementation of numerous DOE standards, including DOE-STD-1134-99, DOE-STD-1135-99, DOE-STD-1158-2002, and DOE-STD-3007-2007.

This NCS Program incorporates recent guidance in DOE-STD-3007-2007 for preparing Criticality Safety Assessments (CSAs), but there is no requirement to reissue or revise existing CSAs that are compliant with the applicable ANSI/ANS-8 Standards solely to meet this DOE guidance.

The NCS Program is an integral part of Sandia's Integrated Safety Management System (ISMS) as stated in Chapter 2, on "Cross-Cutting ISMS Elements" of the ES&H Manual. The ISMS also applies to all Sandia operations involving fissile material and is a safety component within Sandia's overall Integrated Laboratory Management System.

2.0 DEFINITIONS AND ACRONYMS

This document differentiates between requirements, recommendations and acceptable practices by using the words "shall, should, and may", respectively, as is often the practice [ANSI/ANS-8.1-1998, *ES&H Manual*].

- ANSI/ANS - American National Standards Institute/American Nuclear Society
- CFR - Code of Federal Regulations
- Contingency
- Credible
- CAAS - Criticality Accident Alarm System
- Criticality Safety Assessment (CSA)
- Criticality Safety Index (CSI)
- Criticality Safety Officer (CSO)
- Documented Safety Analyses (DSA)
- Double-Contingency Principle
- Facility managers
- Fissile material
- Fissile Material Operation (FMO)
- FMO supervisors
- FMO workers
- Local Area Network Material Accountability System (LANMAS)
- Material Balance Area (MBA)

- Material Control and Accountability (MC&A)
- Members of the Workforce
- Minimum Margin of Subcriticality (Δk_{MMS})
- Nuclear Accident Dosimetry (NAD)
- Nuclear Criticality Safety (NCS)
- Nuclear Criticality Safety Engineer (NCSE)
- Nuclear Facility
- Primary Hazard Screening (PHS)
- Potentially Inadequate Safety Analysis (PISA)
- Radiological and Criticality Safety Committee (RCSC)
- Sandia Nuclear Criticality Safety Committee (SNCSC)

3.0 NCS RESPONSIBILITIES

3.1 The Responsible Individual

The Director of the Radiation Sciences Center (01300) is the Responsible Individual for the NCS Program at SNL and shall be responsible for:

- Formulating Sandia NCS policy.
- Communicating such policy to Members of the Workforce involved in operations with fissile material.
- Periodically participating in reviews of the overall effectiveness of Sandia's NCS Program, including participation in NCS committee meetings, which review the NCS Program.
- Appointing the SNCSC chair.
- Appointing the CSO and, if needed, a deputy CSO to assist.
- Ensuring that NCS personnel are independent of facility operations to the extent practicable.

3.2 Facility Managers

The NCS responsibilities for facility managers are determined by the fissile inventories within their facilities. The responsibilities of the facility managers are detailed in the remaining sections of this document. As primary responsibilities, managers of facilities with fissile inventories shall establish the criticality safety of their operations by:

- Ensuring that before any operation involving fissile material commences or is changed, requirements are fulfilled, as appropriate, under the work control and Unreviewed Safety Question (CPR400.1.1.14/ GN470080) processes.
- Ensuring that before any operation involving fissile material commences or is changed, the requirements under this NCS Program document are fulfilled (see Section 4.0 for more requirements detail).
- Ensuring that NCS controls are implemented and changed only in accordance with this NCS Program.
- Ensuring that operations involving fissile materials are surveilled and reviewed in accordance with this NCS Program.
- Being cognizant of other safety requirements applicable to operations involving fissile materials, such as those referenced in Section 9.0. Such non-NCS safety requirements are not discussed in detail in this document.

Facility managers and others who have NCS concerns should contact the CSO or an NCSE or should use the CSO's website.

Table 1 is a guide for the facility managers to see the documentation requirements for the type of fissile material operation (FMO) with additional details identified throughout this document.

Table 1 - Guidance for Activities and Documentation

Type of Fissile Material Operation	Documentation Requirements
Active use of fissile material (experiments/ measurements) and/or Geometric-Spaced Storage Array	CSA and Technical Work Documents are required.
CSI Storage Array	CSA establishing CSI Array, Technical Work Documents for implementation of requirements, and CSI container assignments.

3.3 NCS Committees

The NCS committees that oversee fissile material operations are the:

- Radiological and Criticality Safety Committee (RCSC) for Technical Area V operations.
- Sandia Nuclear Criticality Safety Committee (SNCSC) for all Sandia operations except those in Technical Area V.

These NCS committees, within their purview, shall be responsible for:

- Providing oversight and review of operations involving NCS.
- Advising the facility managers of operations involving fissile materials.
- Reviewing and approving CSAs, as described in Section 5.2.

These NCS committees have additional nuclear facility safety responsibilities as documented in their charters beyond those addressed in this document.

The NCS committee charters require that they perform annual surveillances of facilities with FMOs to ensure compliance with the NCS Program. The SNCSC charter requires triennial assessment of the NCS Program.

3.4 CSO

The CSO or deputy CSO shall be responsible for:

- Fulfilling the responsibilities as an NCSE as listed in Section 3.5.
- Ensuring that operations are identified, to determine if they are FMOs through review of the LANMAS/ MC&A and/or PHS databases.
- Ensuring that CSAs for FMOs are prepared and reviewed following the NCS Procedure for Preparing CSAs.
- Ensuring that CSI calculations are prepared and reviewed following the NCS Procedure for Using the CSI Method .
- Periodically summarizing the CSI calculations for review by the SNCSC.
- Maintaining familiarity with the CSAs and FMOs at SNL.
- Maintaining familiarity with NCS standards, guides, and codes.
- Reviewing notices from DOE and other agencies to determine if there are lessons to be learned involving NCS that are applicable at SNL.
- Communicating appropriate NCS information and lessons learned.
- Serving as the Sandia representative on applicable DOE NCS working groups or ANSI/ANS-8-series standards committees.
- Serving as a member of the RCSC and the SNCSC.
- Serving as a point of contact for NCS audits.

- Managing corrective actions associated with NCS noncompliances.
- Administering the NCSE qualification program under which the NCSEs are qualified in accordance with DOE-STD-1135-99 , including triennial refresher training.
- Maintaining the CSO's website, including a list of qualified NCSEs on the website.
- Reviewing and updating this NCS Program document and supporting procedures.
- Ensuring that records are maintained in accordance with Section 8.2.
- Evaluating the NCS Program and developing performance measures.

3.5 NCSEs

Under Sandia's qualification program, NCSEs are qualified in accordance with DOE-STD-1135-99. NCSEs are identified on the CSO's website. NCSEs, as directed by management, shall be responsible for:

- Maintaining qualification under the NCSE qualification program, including any required triennial refresher training.
- Maintaining FMO-specific knowledge of the facilities they support, by direct interaction with facility managers, FMO supervisors, and FMO workers.
- Preparing or reviewing CSAs following the NCS Procedure for Preparing CSAs.
- Performing or reviewing CSI calculations following the NCS Procedure for Using the CSI Method.
- Performing walkdowns, audits, surveillances, or other NCS evaluations for FMOs.
- Assisting or concurring with CSA implementation and periodic CSA surveillance as may be implemented by completing CSA Review, Implementation & Surveillance Checklists.
- Assisting in evaluating and recording NCS noncompliances, as described in Section 7.2.
- Assisting or concurring with equipment and process design and changes that affect NCS.
- Assisting or concurring with the development and review of procedures that affect NCS.
- Assisting or concurring with NCS training for FMO workers and other staff.

3.6 FMO Supervisors

FMO supervisors shall be responsible for:

- Fulfilling the responsibilities of FMO workers as listed in Section 3.7, including any training requirements.

- Ensuring that criticality safety is maintained with the same level of importance as other functions, such as production, development, research, etc.

- Seeking support from NCSEs and facility management when changes are needed to FMOs or NCS-related documents, configurations, or processes.

3.7 FMO Workers

FMO workers shall be responsible for:

- Completing FMO worker training in accordance with Section 6.0.

- Understanding and complying with the NCS controls for the FMO, as noncompliances are serious and require NCS Noncompliance Reports.

- Carrying out the required actions of Section 7.2.

- Participating when requested to identify potential upset or contingent conditions and the necessary NCS controls for an FMO, as discussed in the NCS Procedure for Preparing CSAs .

4.0 REQUIREMENTS FOR FACILITIES WITH FISSILE INVENTORIES

The applicable requirements for ensuring the criticality safety of Sandia facilities are determined by the fissile inventories within the facilities. Table 2 lists the Threshold Limits for Fissile Inventories which are used to determine the applicable NCS Program requirements. DOE O 420.1B is applicable to facilities or activities that involve or potentially involve fissile inventories exceeding these threshold limits.

The fissile nuclides of primary NCS concern at SNL are U-235 and Pu-239. These nuclides and their threshold limits are indicated in large, bold typeface in Table 2 . The other nuclides in Table 2 are not typically present at SNL and have limits derived from a different standard or extracted from analysis at another DOE facility [UCRL-AM-133867]. Depleted and natural uranium are typical in Sandia activities but are not generally criticality concerns. However, threshold limits for these nuclides are documented in Table 2.

Facility managers shall be responsible for complying with the NCS requirements determined by the fissile inventories involved in their operations by ensuring that:

- A PHS is completed that assesses the potential NCS hazards within the facility. The NCS section of the PHS implements the Table 2 threshold limits that determine the applicable NCS requirements under this NCS Program.

- Section 4.1 is used to determine if an operation exceeds the threshold limits of Table 2.

- Activities that use fissile material inventories that do not exceed the Table 2 threshold limits fulfill the requirements of Section 4.2.

- Activities that use fissile material inventories that exceed or potentially exceed the Table 2 threshold limits fulfill the requirements of Section 4.3.

Compliance with the thresholds limits at SNL/NM is monitored independent of the line organizations using the LANMAS/MC&A database, which tracks fissile inventories in all MBA and provides an alert when a planned fissile material movement into an MBA would cause a threshold limit to be exceeded.

Table 2 - Threshold Limits for Fissile Inventories †

Element	Nuclide	Threshold Mass Limits (g)
Protactinium (Pa)	Pa-231**	350,000
Uranium (U)	U-232‡	500
	U-233*	500
	U-234‡	500
	U-235*	**700**
	Natural or Depleted U‡	18,000,000
Neptunium (Np)	Np-237**	12,000
Plutonium (Pu)	Pu-238**	1,800
	Pu-239*	**450**
	Pu-240‡	10,000
	Pu-241*	200
	Pu-242**	24,000
Americium (Am)	Am-241‡	10,000
	Am-242m**	7
	Am-243**	15,000
Curium (Cm)	Cm-243**	54
	Cm-244**	1,800
	Cm-245*	18
	Cm-246‡	500
	Cm-247**	540
Californium (Cf)	Cf-249**	6
	Cf-250‡	500
	Cf-251**	3
	Cf-252‡	500

† When applying this table, the Section 4.1 requirements shall be fulfilled.

* Limits from ANSI/ANS-8.1-1998

** Limits based on 60% of the ANSI/ANS-8.15-R2005 values.

‡ Limits consistent with analysis from another DOE facility [UCRL-AM-133867].

4.1 APPLYING THRESHOLD LIMITS

When applying the Table 2 to determine compliance with the threshold limits, ensure the following:

1. If the facility's fissile inventory potentially exceeds the threshold limits, an NCSE should be contacted for assistance in applying Table 2 and these requirements.

2. The threshold limits shall be applied regardless of the particular form of the fissile materials, such as gaseous, liquid, or solid.

3. For natural or depleted U, the threshold limit for natural or depleted U, rather than U-235, should be applied.

4. If uranium is present with enrichment between natural and 0.93 weight percent , then an NCSE may be contacted to determine the appropriate threshold limits, but otherwise the 700 g threshold limit shall be applied.

5. The U-235 threshold limit may be applied to mixtures with U-234, U-236, or U-238, provided that U-234 is considered to be U-235 in computing mass.

6. The Pu-239 threshold limit may be applied to mixtures of Pu isotopes, provided that the concentration of Pu-240 exceeds that of Pu-241 and provided that Pu-241 is considered to be Pu-239 in computing the mass.

7. If the facility has a mixture of fissile nuclides, then

    - The lowest of the threshold limits for the nuclides present may be applied (ANSI/ANS-8.1-1998). For example, a 450 g threshold limit may be applied to the sum total of the U-235, Pu-239, and U-233 mass within a facility, OR

    - A "sum-of-fractions" calculation using the fractional portion of the threshold limits for each nuclide present from Table 2 may be applied, but an NCSE shall perform or review the calculation.

8. A facility may maintain their fissile inventories below the threshold limits of Table 2 by segmentation that establishes operations with fissile materials in several different and secured locations. An NCSE shall evaluate the inventories, process, and interaction in the segmented facility to ensure each segmented area is maintained below the threshold limits.

4.2 Fissile Inventories Below Threshold Limits

A facility manager for an operation with fissile inventory below the threshold limits of Table 2 shall be responsible for ensuring that:

- Administrative controls are established to ensure that threshold limits are not exceeded. These controls should be implemented in facility procedures. These controls may be implemented on postings that remind workers of the limits and may include procedural compliance monitoring of the limits by the MBA custodian.
- If the fissile inventory could exceed 25% of the threshold limits of Table 2, then the workers and supervisors involved shall have the NCS120 and NCS220 training, as appropriate. This training is provided by Corporate Learning & Professional Development and further described in Section 6.0.
- Facility or emergency procedures implement appropriate responses for events in which a threshold limit is exceeded.
- Records are maintained showing the fissile inventory.
- Self-assessments are performed to ensure the activities remain below the threshold limits.

4.3 Fissile Inventories Above the Threshold Limit

Facility managers for an FMO with a fissile inventory above the threshold limits in Table 2 shall be responsible for ensuring that:

- Before any FMO commences or any FMO or NCS controls are changed, the requirements of Section 5.0 are fulfilled.
- Workers and supervisors involved shall be trained as FMO workers in accordance with Section 6.0.
- The FMO is compliant with the requirements of Section 7.0, during operation.
- Records are maintained in accordance with Section 8.0.

5.0 CRITICALITY SAFETY ASSESSMENTS

The requirements of this section are applicable when preparing or significantly revising Criticality Safety Assessments (CSAs). However, existing CSAs, if compliant with the applicable ANSI/ANS-8 series standards, do not require revision or reissue solely to meet these requirements.

DOE O 420.1B directs compliance with the requirements of the ANSI/ANS-8 series standards for NCS and implementation of all recommendations from those standards, unless an explanation is provided in this NCS Program document for the recommendation that is not implemented.

5.1 CSA Preparation

The facility manager of an FMO shall be responsible for ensuring that a CSA is prepared:

- By an NCSE qualified in accordance with Section 3.5. A non-qualified analyst may be used, if a qualified NCSE provides oversight.
- Consistently with the facility's authorization basis, including any outcomes of the Unreviewed Safety Question Process for a nuclear facility.
- In compliance with the NCS Procedure for Preparing CSAs and, if appropriate, the NCS Procedure for Using the CSI Method which implement DOE requirements and standards [DOE O 420.1B, DOE-STD-3007-2007, DOE-STD-1158-2002]. As implemented in the NCS Procedure for Preparing CSAs, the CSA shall:
  - Use a minimum margin of subcriticality (Δk_{MMS}) of at least 5%, unless a lower margin is justified in the CSA.
  - Use computation methods that are verified and validated.
  - Use, to the extent practical, 1) passive engineered features, 2) active engineered features, followed by 3) administrative controls as the preferred hierarchy for NCS controls.
  - Establish fulfillment of the Double Contingency Principle or establish that criticality is not a credible event for the FMO as a determinant in decisions on the need for CAAS and NAD (See Section 5.4).
- In compliance with:
  - ANSI/ANS-8.5-R2002 standard, if the FMO uses borosilicate-glass Raschig rings as neutron absorbers in fissile solutions.
  - ANSI/ANS-8.6-R2001 standard, if the FMO conducts subcritical neutron-multiplication measurements.
  - ANSI/ANS-8.7-1998 standard, if the FMO stores large numbers of fissile material items outside of shipping containers.
  - ANSI/ANS-8.12-R2002 standard, if the FMO operates with Pu-U oxide fuel mixtures in significant non-containerized masses.
  - ANSI/ANS-8.14-2004 standard, if the FMO uses soluble neutron absorbers for criticality control.
  - ANSI/ANS-8.17-R2004 standard, if the FMO handles, stores, or transports light water reactor fuel rods and units outside reactor cores.
  - ANSI/ANS-8.21-R2001 standard, if the FMO achieves criticality safety by relying on fixed neutron absorbers.
  - ANSI/ANS-8.22-1997 standard, if the FMO achieves criticality safety by relying primarily on

moderator controls or limits.

5.2 CSA Review and Approval

The facility manager for an FMO shall be responsible for ensuring that the CSA is reviewed and approved by the:

- **NCSE peer reviewer** who verifies compliance with the NCS Procedure for Preparing CSAs. The review should include use of the CSA Review, Implementation & Surveillance Checklist, which implements requirements for the CSA from various sources, including DOE-STD-1134-99 and DOE-STD-1158-2002. However, the checklist is not intended to serve as a template for performing a complete peer review of the technical adequacy of a CSA.
    - As an alternative, the NCS committee review, as described below, may serve as the NCSE peer review, in which case a qualified NCSE shall prepare the CSA and another NCSE shall attend the meeting when the NCS committee approves the CSA. Due to the difficulty in meeting the thoroughness of a DOE-STD-1134-99 review, this alternative will be used infrequently.
- **NCS committee**, as identified in Section 3.3.
- **Facility manager**.
- **DOE,** if the CSA:
    - is for a nuclear facility where the Unreviewed Safety Question process [GN470080] determines that DOE approval is required,
    - is developed and evaluated using methodology other than as prescribed in DOE-STD-3007-2007 and DOE-STD-1134-99, respectively,
    - is for an FMO that requires shielding and confinement to mitigate the consequence of a criticality so that, under the ANSI/ANS-8.10-R2005 standard, operation not fulfilling the Double Contingency Principle is allowed, or
    - establishes criticality safety by fulfillment of the Double Contingency Principle and controls on only one parameter. DOE-STD-3007 Draft This requirement and the parameters important to NCS are discussed further in the NCS Procedure for Preparing CSAs.

5.3 CSA Implementation

The facility manager shall be responsible for ensuring CSA implementation in the FMO by verifying:

- **NCS controls** are implemented in FMO procedures, as directed by the CSA.
- **Passive and active engineered features** are present, functional, and effective, as directed by the CSA.

- **Administrative aids** are provided, such as postings and labels, as directed by the CSA.
- **NCS fire protection requirements** from the CSA are implemented in facility fire plans, which shall be submitted to Sandia's Incident Command System for incorporation into the system.
- **NCS emergency planning requirements** from the CSA are implemented in facility emergency plans, which shall be submitted to Sandia's Incident Command System for incorporation into the system.
- **Surveillance programs** are established, as directed by the CSA.
- **Emergency instructions** are posted on signs or other devices, as the facility manager deems appropriate, at strategic locations to address subjects such as interpretation of and responses to alarms, evacuation routes, and fire protection plans.
- **FMO worker training** is completed as required by Section 6.0, including appropriate FMO-specific training that covers the NCS controls from the CSA.
- **FMO access** is controlled.

The NCS committee:

- Shall review FMO procedures that implement NCS controls from the CSA.
- May review and concur with the CSA Review, Implementation & Surveillance Checklist.
- May review and concur with the proposed FMO or other safety aspects within the facility's authorization basis.

The facility manager should review and approve the CSA Review, Implementation & Surveillance Checklist as verification that the CSA is prepared and implemented in compliance with DOE requirements.

5.4 The Need for CAAS or NAD

If the CSA determines that criticality is not credible for an FMO, the CAAS and NAD are not required.

If the CSA determines that criticality is credible for an FMO, the facility manager shall be responsible for ensuring that:

- A CAAS is installed in accordance with ANSI/ANS-8.3-R2003, if personnel could be subject to excessive radiation dose. Attachment A, "Installing Criticality Accident Alarm Systems" provides more details for establishing compliance with the requirements of ANSI/ANS-8.3-R2003. Excessive radiation dose is any dose to personnel corresponding to an absorbed dose from neutrons and gamma rays equal to or greater than 0.12 Gray (12 rad) in free air. If a CAAS is installed, any additional requirements from ANSI/ANS-8.23-R2005 for emergency plans and procedures shall be fulfilled.
- NAD is provided in accordance with 10 CFR 835.1304.

- The personal NAD complies with requirements in CPR400.1.1.32/MN4710016, Chapter 4, “Radiation Dosimetry,” if personal NAD is used to establish compliance with 10 CFR 835.1304.The additional requirements from ANSI/ANS-8.23-R2005 for emergency plans and procedures that apply, if the facility is required to have a CAAS installed.

5.5 CSA Cancellation

When an FMO is no longer active, the applicable CSA should be canceled with documentation:

- Prepared or reviewed by an NCSE, which identifies the CSA, the FMO, and all actions required to terminate the CSA safely, such as removal of residual fissile materials, and
- That the facility manager approves after all actions required to terminate the CSA are complete.

6.0 FMO WORKER TRAINING

Training for FMO workers, consistent with ANSI/ANS 8.20-R2005, is completed to ensure that they understand the NCS controls, such as those implemented in FMO procedures and postings. Additionally, FMO workers need to understand safety guidance and emergency procedures so that they can work safely. Corporate Learning & Professional Development . Identified weaknesses **shall** be addressed with additional training.

Facility managers shall ensure that training requirements are met, prior to commencing work. This includes the following:

- **NCS120 training** – This is general “all-hands” NCS training. The NCS120 training (or any equivalent training that is subsequently developed) shall be completed biennially by FMO workers, FMO supervisors, and others directly involved in the FMO. Non-supervisory FMO workers may be exempted from the NCS120 training, under the condition of FMO limited tasks, such as moving containerized fissile items. The CSO shall review and the facility manager shall approve the exemption. Additionally, the FMO supervisor shall complete NCS220 training as described below. and
- **NCS220 training** – NCS220 is training supplemental to NCS120, which is a prerequisite. The NCS220 training shall be completed biennially by FMO supervisors and managers who support the FMO. The NCS220 training should be completed biennially by technical support staff with NCS responsibilities.
- **FMO-Specific training** – This training:
    - Shall be completed biennially by FMO workers, FMO supervisors, and others directly involved in the FMO.
    - Shall be developed with the assistance of or reviewed by an NCSE.
    - Shall discuss procedures that pertain to NCS, including NCS controls and emergency procedures.

- Shall explain the proper use of checklists, sign-offs, and documentation in the execution of procedures that pertain to NCS.
- Shall use predetermined performance criteria, such as written, oral or operational examinations, as required by ANSI/ANS-8.20-R2005.
- Shall be conducted by a person knowledgeable in the NCS aspects of the FMO.
- Shall, at a minimum, provide an understanding of the NCS controls from the CSA, and the bases for those controls.
- Should, in a graded approach, address the topics of:
  - NCS basics,
  - FMO and emergency procedures,
  - Facility operating characteristics,
  - Radiological control, and
  - Safety and emergency systems.

- **Fissile Material Handler training** – This training shall be completed biennially by FMO workers, FMO supervisors, and others directly involved in the FMO. The training shall be provided, if the FMO inventory involves significant quantities of fissile material. Significant quantities are those inventories that exceed the threshold limits in Table 2 and for which NCS controls are necessary to ensure criticality safety. An NCSE should be contacted to assist with determining if a fissile inventory that exceeds the threshold limits, needs to be considered a significant quantity. The Fissile Material Handler training requirements as a qualified or certified position are designated in the Documented Safety Analysis at nuclear facilities.
- **Emergency procedure training** – This training shall be completed by FMO workers and supervisors and shall cover all procedures for handling abnormal facility conditions and emergencies relative to assigned responsibilities. The training shall be completed annually by FMO workers and supervisors, if the facility is required to have an installed CAAS, otherwise the training shall be completed biennially .
- **Complete training records** – NCS120 and NCS220 are to be maintained by Sandia's Training & Employee Development System.

7.0 FISSILE MATERIAL OPERATIONS

Facility managers shall be responsible for ensuring that:

- FMO workers understand and comply with the NCS controls.

- Fissile materials are stored in accordance with MC&A requirements and the *Radiological Protection Procedures Manual*.

7.1 Surveillances

Facility managers shall ensure that a documented surveillance is performed annually to assess compliance with the CSA and NCS Program for their FMO. The surveillance:

- Shall be conducted, in consultation with operating personnel, by individuals knowledgeable of NCS and who, to the extent practicable, are not immediately responsible for the FMO.
- Shall use criteria from the ANSI/ANS-8 series standards, such as ANSI/ANS-8.19-2005.
- Should use criteria from the DOE standards, such as DOE-STD-1158-2002.
- Should address whether facility procedures and records are current and adequate to manage the operational risks, including the potential for an accidental criticality.
- May involve an NCSE other than the one who prepared the CSA.
- May use the CSA Review, Implementation & Surveillance Checklist that has surveillance requirements from various sources.
- May be performed with assistance from a center or an NCS committee.
- May have a frequency adjusted from annual, if the FMO is in extended shutdown. The adjusted frequency shall be as deemed appropriate by the facility manager and shall be documented.

Facility managers shall be responsible for ensuring surveillance of any passive or active engineered features as required and scheduled by a CSA.

The NCS committee charters require that they perform annual surveillances of the facilities to ensure compliance with the NCS Program. The NCS Program shall be assessed triennially.

7.2 If an NCS Noncompliance is Discovered

If an NCS noncompliance (Levels 1-5 in Table 3) is identified, the actions shall be to:

1. Stop work immediately, **without** attempting to correct the noncompliance.
2. Evacuate the work area immediately while warning coworkers.
3. Report the noncompliance to a facility manager.

The facility manager shall then:

1. Initiate an evacuation alarm, if deemed appropriate or if required, such as by facility procedures.

2. Establish isolation of any affected area, if deemed appropriate. A zone of 100-foot radius may be considered adequate isolation.

3. Make the notifications, investigations, and reports as required by *ES&H Manual*, Chapter 18, section on "Identifying Reporting, And Correcting Nuclear Safety Nonconformances."

4. Determine USQD and Potentially Inadequate Safety Analysis (PISA) requirements, if applicable, per ES&H Manual Supplement, CPR4001.1.14/GN470080, *Implementing the Unreviewed Safety Question (USQ) Process for Nuclear Facilities*.

5. Ensure that a NCS Noncompliance Report is prepared in a timely manner that contains:

    a. A description of the NCS noncompliance.

    b. A description of the causes of the NCS noncompliance.

    c. The level of the NCS noncompliance based on Table 3.

    d. Delineated recovery and corrective actions.

    e. Approval of an NCSE and the facility manager.

    f. Approval of the appropriate NCS committee, if the level is 1 through 5.

6. Not allow resumption of the FMO, until after the recovery and corrective actions have been addressed as required by the NCS Noncompliance Report.

The facility manager should request the assistance of an NCSE in preparing an NCS Noncompliance Report.

NCS Noncompliance Reports provide the required reporting and tracking of any noncompliance. The reports also provide information for trending and metrics to aid in preventing recurrence. Table 3 describes the assigned levels for NCS noncompliances.

Facility managers should avail themselves of information useful in continually improving the safety of FMOs. Such information provides root causes for understanding NCS noncompliances at other DOE sites. This information may be accessed by using the references in Section 10.0 and especially the "Links to Additional Information" in Section 10.6.

Table 3 NCS Noncompliance Levels

Barriers to Criticality	Level	NCS Noncompliance Description	Reporting Category & Tracking System
None	1	A nuclear criticality accident occurs.	Emergency in Occurrence Reporting & Processing System (ORPS)

No barriers remain	2	All barriers violated such that none are available to prevent criticality (No criticality occurred).	Occurrence in ORPS
Only 1 barrier remains	3	Barriers are violated such that criticality is possible with loss of a single remaining barrier.	
A barrier is violated	4	A TSR affecting NCS is violated, but double contingency or incredibility barriers are maintained with no realistic potential for criticality	
		A CSA control is violated, but double contingency or incredibility barriers are maintained with no realistic potential for criticality.	
Barriers not identified	5	An unanalyzed credible contingency is discovered which does not have appropriate barriers.	
		An approved CSA does not exist for an ongoing FMO.*	
All barriers remain in place	6	NCS Program requirement that affects NCS is violated, but no TSR or CSA control is violated.	Lessons Learned in the Action Item Tracking System within TAVIMS
		Administrative errors, such as in FMO procedures, postings, labels, physical barriers, etc.	
		Abnormal facility conditions, for example water entry that may be inconsistent with the CSA description, but not violate NCS controls.	
*Exception: Activities involved in transition to DOE O 420.1B listed in the SNL Criticality Safety Program Implementation Plan.			

8.0 RECORDS

8.1 Facility Managers

Facility managers shall ensure that the following records are maintained for two years after termination of any FMO or as required by the Sandia Records Retention Schedule:

- Fissile inventory records consistent with Material Control & Accountability requirements.
- Records of NCS audits of FMOs.
- Procedures for FMOs.
- CSAs and CSI Calculations.

8.2 CSO

The CSO shall ensure that these records are maintained:

- A current library of CSAs and CSI calculations at SNL.
- Analyses of the need for CAAS.
- Meeting minutes from the RCSC and SNCSC pertaining to criticality safety.

9.0 RELATED HAZARDS AND ACTIVITIES

Numerous other Sandia documents have safety requirements for operations involving fissile materials that are related to NCS activities. Such safety requirements are not specifically addressed in this NCS Program document, but those performing or overseeing operations involving fissile materials should be cognizant of these other safety requirements.

Safety requirements for activities involving fissile materials are given in several chapters and sections of the *ES&H Manual,*CPR400.1.1/MN471001, including:

- Chapter 2, “Cross-Cutting ISMS Elements.”
- Chapter 5, “Fire Protection.”
- Chapter 8, “Occupational Radiation Protection.”
- Chapter 12, “Packaging and Transportation of Hazardous Materials.”
- Chapter 13, “Hazards Identification, Analysis, and Management.”
- Chapter 15, “ Emergency Preparedness and Management. ”
- Chapter 18, section on “Identifying, Reporting, And Correcting Nuclear Safety Nonconformances.”

Safety requirements for activities involving fissile materials are also given in several other Sandia documents, including:

- CPR400.1.1.14/ GN470080, *Implementing the Unreviewed Safety Question (USQ) Process for Nuclear Facilities*.
- CPR400.1.1.21/ GN470089, *Startup and Restart Process for Sandia Nuclear Facilities/Activities*.
- CPR400.1.1.32/MN471016, *Radiological Protection Procedures Manual*.

- CPR400.1.1.38/GN470101, *Preparation and Review of Documented Safety Analyses (DSAs) and Technical Safety Requirements (TSRs) to Meet 10 CFR 830, Subpart B.*

10.0 REFERENCES

10.1 Requirements Source Documents

10 CFR 71.59, *Standards for Arrays of Fissile Material Packages*.

10 CFR 830, *Nuclear Safety Management*.

10 CFR 835.1304, *Nuclear Accident Dosimetry*.

DOE G 421.1-1, *Criticality Safety Good Practices Program Guide for DOE Nonreactor Nuclear Facilities*.

DOE M 231.1-2, *Occurrence Reporting and Processing of Operations Information*.

DOE M 231.1A,chg 1, *Environment, Safety, and Health Reporting.*

DOE O 420.1B, *Facility Safety*.

DOE O 5480.20A,chg 1, *Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities.*

10.2 DOE Requirements Documents

DOE-STD-1027-92 CH-1, *Hazard Categorization and Accident Analysis Techniques for Compliance With DOE Order 5480.23, Nuclear Safety Analysis Reports.*

DOE-STD-1134-99, *Review Guide for Criticality Safety Evaluations.*

DOE-STD-1135-99, *Guidance for Nuclear Criticality Safety Engineer Training and Qualification.*

DOE-STD-1158-2002, *Self-Assessment Standard for DOE Contractor Criticality Safety Programs.*

DOE-STD-3007-2007, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities.*

10.3 ANSI/ANS-8 Standards

ANSI/ANS-8.1-1998, *Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors.*

ANSI/ANS-8.3-R2003, *Criticality Accident Alarm System.*

ANSI/ANS-8.5-R2002, *Use of Borosilicate-glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material.*

ANSI/ANS-8.6-R2001, *Safety in Conducting Subcritical Neutron-Multiplication Measurements In Situ.*

ANSI/ANS-8.7-1998, *Guide for Nuclear Criticality Safety in the Storage of Fissile Materials.*

ANSI/ANS-8.9-R1995, *Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials.*

ANSI/ANS-8.10-R2005, *Criteria for Nuclear NCS controls in Operations with Shielding and Confinement.*

ANSI/ANS-8.12-R2002, *Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors.*

ANSI/ANS-8.14-2004, *Use of Soluble Neutron Absorbers in Nuclear Facilities Outside Reactors.*

ANSI/ANS-8.15-R2005, *Nuclear Criticality Control of Special Actinide Elements.*

ANSI/ANS-8.17-R2004, *Criticality Safety Criteria for Handling, Storage, and Transportation of LWR Fuel Outside Reactors.*

ANSI/ANS-8.19-2005, *Administrative Practices for Nuclear Criticality Safety.*

ANSI/ANS-8.20-R2005, *Nuclear Criticality Safety Training.*

ANSI/ANS-8.21-R2001, *Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors.*

ANSI/ANS-8.22-1997; *R2006 Nuclear Criticality Based on Limiting and Controlling Moderators.*

ANSI/ANS-8.23-R2005, *Nuclear Criticality Accident Emergency Planning And Response.*

ANSI/ANS-8.24 Draft, *Validation of Neutron Transport Methods for Nuclear Criticality Safety Calculations.*

10.4 Implementing Documents

NCS-AP-001, *NCS Procedure for Preparing CSAs.*

NCS-AP-002, *NCS Procedure for Using the CSI Method.*

SNL, CPR400.1.1/MN471001, *ES&H Manual.*

SNL, CPR400.1.1.14/GN470080, *Implementing the Unreviewed Safety Question (USQ) Process for Nuclear Facilities.*

SNL, CPR400.1.1.21/GN470089, *Startup and Restart Process for Sandia Nuclear Facilities/Activities.*

SNL, CPR400.1.1.32/MN471016, *Radiological Protection Procedures Manual.*

SNL, CPR400.1.1.38/GN470101, *Preparation and Review of Documented Safety Analyses (DSAs) and Technical Safety Requirements (TSRs) to Meet 10 CFR 830, Subpart B.*

10.5 Related Documents

SNL, Radiological and Criticality Safety Committee (RCSC).

SNL, Sandia Nuclear Criticality Safety Committee (SNCSC).

SNL, SNL/NM Emergency Plan.

SNL, CPR400.3.14, *Management of Accountable Nuclear Material.*

UCRL-AM-133867, *Criticality Safety*, ES&H Manual, Lawrence Livermore National Laboratory, Document 20.6, Rev. 4.

10.6 Links to Additional Information

American Nuclear Society NCS Division

ANSI/ANS Standards from the ANS

ANSI/ANS Standards from SNL

Code of Federal Regulations

DOE Directives, Orders, Standards

DOE NCS Information – Recommended as the best overall site for NCS information.

DOE NCS Program, Headquarters site

DOE NCS Program, LLNL site

DOE Nuclear and Facility Safety

SNL Criticality Safety Officer's website

SNL ES&H Lessons Learned Program

SNL TA-V Integrated Management System (TAVIMS)

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CHANGE HISTORY
GN470072, *Nuclear Criticality Safety*

March 26, 2007

Note: An asterisk (*) indicates a substantive change.

- *This document has been altered by greater than 75% and should be read in its entirety. The NCS Program in the GN470072 document was significantly revised to:
  - ***Update:** Requirements and guidance based on DOE O 420.1B and DOE-STD-3007-2007.
  - ***Move:** Requirements and guidance for developing CSAs from the NCS Program document to the NCS Procedure for Preparing CSAs. This change includes moving the information in Attachments A and C.
  - ***Move:** Requirements and guidance for developing CSI calculations from the NCS Program document to the NCS Procedure for Using the CSI Method.
  - ***Add:** Definitions and Acronyms within Section 2.0.
  - ***Update:** The “Responsibilities” now within Section 3.0. For example, specifically discuss responsibilities for FMO workers and supervisors.
  - ***Update:** The “Requirements for facilities with fissile inventories” now within Section 4.0. The list of threshold limits is significantly expanded.
  - ***Update:** The directions for “Criticality Safety Assessments” now within Section 5.0.
  - ***Update:** The directions for “FMO Worker Training” now within Section 6.0.
  - ***Update:** The directions for “Fissile Material Operations” now within Section

7.0.

- ❍ ***Delete:** Attachments A, “Format and Content of Criticality Safety Assessments” and C, “Sample Nuclear Criticality Safety Posting.”

- **Add:** A review date to the header to indicate that an ES&H Manual Self Assessment (SA) checklist was completed on this supplement.

ES&H Manual Glossary:

- ***Add:ANSI/ANS** - American National Standards Institute/ American Nuclear Society.

- ***Add: Contingency** - An unlikely change in a process condition important to the criticality safety of a FMO. A contingency is an undesired, upset condition.

- ***Add: Credible** - The attribute of being believable on the basis of commonly acceptable engineering judgment. Due to the general lack of statistically reliable data, assigning numerical probabilities to events is not justifiable and when used should be backed up with references (DOE-STD-3007-2007).

- ***Delete: Critical mass** – The smallest mass of fissile material that will support a self-sustaining chain reaction under specified conditions.

- ***Add:** Criticality Accident Alarm System (CAAS) - an alarm system that warns of a nuclear criticality accident and meets requirements such as in the ANSI/ANS-8.3 standard.

- ***Change:Criticality Safety Assessment (CSA)** from “ A documented process that establishes the technical basis for nuclear criticality safety and provides subcritical operating values” **to** “Criticality Safety Assessments may required by the NCS Program to establish the fact that proposed fissile material operations will remain safely subcritical under all normal conditions and postulated credible process upset or contingent conditions (contingencies). This is done by considering the amounts, forms, and types of fissile material used in the system or process, establishing parameters that affect NCS, and setting limits or controls on those parameters.”

- ***Change: Criticality Safety Evaluation (CSE)** from “ A documented process that

demonstrates, by establishing and providing subcritical operating values, the nuclear criticality safety of any part of, or process in, a nonreactor nuclear facility that contains fissionable material. The evaluation provides sufficient descriptions of the facility equipment, fissionable material processes, and operational controls to identify the normal and contingent abnormal operating conditions of the facility. The evaluation contains the technical computational or comparative nuclear criticality safety analysis information that provides the bases of subcritical operating values for the normal and abnormal (contingent) conditions of facility operations or processes. Guidelines for preparing CSEs are discussed in DOE-STD-3007-93" **to** "See Criticality Safety Assessment (CSA) for Sandia applications."

- ***Change: Criticality Index (CI)** from, " The criticality-based component of the transportation index (TI) as described in 10 CFR 71.59, and can be calculated for storage/transportation containers. The index value depends on the mass and type of fissionable material, the container dimensions, and the nuclear properties and arrangement of other material in the container. Values range from 0.0 to 10.0. (See GN470072, *Nuclear Criticality Safety*, "CRITICALITY INDEX (CI) CONTROLS," for nuclear criticality safety control parameters in a CI array)" **to** " Synonymous with Criticality Safety Index (CSI), which is the preferred term at Sandia."

- ***Add:Criticality Safety Index (CSI) -** The CSI is a parameter used within the NCS Program to establish the criticality safety of packaged fissile materials during transport or storage. The CSI is the NCS-based component of the transport index as described in 10 CFR 71.59. The CSI depends on various characteristics, such as the fissile mass, moderation and container dimensions and construction.

- ***Add: Criticality Safety Officer (CSO)** - An officer with responsibilities for NCS under the NCS Program. The CSO may be contacted via the ES&H Direct Access Services List or the CSO's website.

- ***Add: Double-contingency principle -** An NCS principle stating that process designs shall incorporate sufficient factors of safety to require at least two unlikely, independent, and concurrent changes in process conditions before a criticality accident is possible [ANSI/ANS-8.1-1998].

- ***Delete:Fissile classification** – The categorization of fissile material packages into one of three classes according to the controls needed to provide nuclear

criticality safety during storage and transportation.

- ***Change:Fissile material** from “Any material that contains nuclides capable of undergoing fission by interaction with slow neutrons, such that the thermal neutron production cross section exceeds the thermal neutron absorption cross section. At SNL, fissile material is usually plutonium, principally the 239 isotope, or uranium enriched in the 235 isotope”

  to

  “Materials which have nuclides that can undergo fission to create a neutron chain reaction and thereby present NCS concerns. At SNL, U-235 and Pu-239 are the fissile nuclides of primary NCS concern. The NCS Program document provides a more detailed list of nuclides that may be NCS concerns. Many nuclides on this list are more properly called fissionable, but the term “fissile” is used because fissile nuclides are the predominate NCS concerns. This choice to use the term “fissile", rather than “fissionable” is consistent with the approach used in the ANSI/ANS-8.19-1984 standard.

  Operations involving fissile materials are controlled under the NCS Program and persons needing assistance with NCS concerns should contact the Criticality Safety Officer.”

- ***Add: Fissile Material Operation (FMO)** - Any facility, system, or activity that involves or potentially involves fissile material inventories exceeding the Threshold Limits defined in the NCS Program. Activities which are FMOs include tests, transport, movement, receipt, loading, unloading, inspection, handling, processing, collocating, disposal, or storage that involves fissile material.”

- ***Change: Fissionable material** from “A broader term referring to all material capable of fissioning, but if the material is nonfissile, conditions for supporting a chain reaction require higher energy neutrons and highly specialized conditions. These later conditions are not generally encountered at SNL” **to** “ A broader term than “fissile material” that refers to all nuclides capable of fissioning, whether or not the fissionable material will support a chain reaction. Np-237 and Pu-238 are examples of fissionable materials that are non-fissile.”

- ***Add: FMO supervisors -** Members of the workforce who are supervisors or managers directly involved in overseeing a Fissile Material Operation.

- ***Add: FMO workers** - Members of the workforce involved in Fissile Material Operations, including facility managers or supervisors who are directly and immediate involved in overseeing the FMO.

- ***Delete: Geometric-spaced array** – A structured storage array containing fissile material in each unit cell. There is a specified, regular center-to-center spacing between unit cells, and a specified maximum fissile mass per cell as well as an overall limit on the number of unit cells in the array. Geometric-spaced arrays are also referred to as "fissile arrays." (See GN470072, *Nuclear Criticality Safety*, "GEOMETRY CONTROLS," for nuclear criticality safety control parameters in a geometric-spaced array).

- ***Add: Local Area Network Material Accountability System (LANMAS)** - The MC&A database used at Sandia and elsewhere within the DOE complex.

- ***Add: Minimum Margin of Subcriticality (Δk MMS)** - An administrate allowance prescribed in the NCS Program and applied to the effective neutron multiplication factor beyond that necessary to account for calculational bias to ensure subcriticality.

- ***Add: Nuclear Accident Dosimetry (NAD) –** radiation dosimetry that responds to nuclear criticality accidents and meets specifications such as in 10 CFR 835.1304.

- ***Add: Nuclear Criticality Safety (NCS**) - Described in the NCS Program.

- ***Add: NCS Engineer (NCSE) -** Engineers with responsibilities for NCS under the NCS Program. NCSEs may be contacted by using the CSO's website.

- ***Add: Nuclear criticality accident** - An accident in which fissile material accumulations produce a self-sustaining neutron chain reaction leading to a high potential for excessive radiation doses.

- ***Delete:Nuclear criticality event** – A situation in which a fissile system accidentally produces a self-sustaining or divergent neutron chain reaction. Such an event results from the mass accumulation of fissile material (certain isotopes of plutonium, typically Pu-239, or uranium, typically U-235), in a configuration such that a fission-neutron chain reaction occurs.

- ***Delete:Safe mass** – An amount of a fissile material that is subcritical for all conditions to which it could reasonably be expected to be exposed, including processing, handling, storing, and procedural uncertainties.

- ***Add: Supermoderators -** In the NCS Program, materials that can, in certain environments, provide neutron moderation or slowing down that is more effective than water. Supermoderators include materials such as polyethylene, oil, heavy water, beryllium, and carbon.

- ***Change: Transport index** from, " The dimensionless number (rounded up the first decimal place) placed on the label of a package or radioactive material to designate the degree of control to be exercised by the carrier during transportation. The transport index is determined by one of the following:

  - The number expressing the maximum radiation level in millirem per hour at 1 meter (3.3 feet) from the external surface or the package.

  - For fissile class II packages, or packages in fissile class III shipment, the number expressing the maximum radiation level at 1 meter (3.3 feet) from the external surface of the package, or the number obtained by dividing 50 by the allowable number of packages that may be transported together whichever is larger."

    to

    "The dimensionless number (rounded up to the next tenth) placed on the label of a package of radioactive or fissile material to designate the degree of control to be exercised by the carrier during transportation as defined in 10 CFR 71.4. The transport index is determined as the larger of the maximum radiation level in milli-rem per hour at one meter from the external surface of the package or the Criticality Safety Index (CSI) that is obtained as described in 10 CFR 71.59. The number of packages allowed on a single shipment is generally limited to those whose sum of TI values is less than 50."

- ***Change: Transportation index** from, "**Transportation Index (TI)** – An index assigned to packages containing radioactive and/or special fissile material prior to shipment on public roads. The TI is the larger of a radioactive measurement value (in mrem/hr @ 1m) and the criticality index (CI) as defined in 10 CFR 71.59. The

number of packages allowed on a single shipment is generally limited to those whose sum of TI values is less than 50" **to** " Synonymous with Transport Index (TI)."

November 16, 2005
Administrative Changes Only

This document was administratively revised:

In GN470072 and Attachments A, B, and C:

- **Change.** The SME from Jeff Philbin to Norm Schwers.
- **Change.** The Contributors from Ron Knief and Norm Schwers to Ron Knief and Jeff Philbin.
- Under the topic, "Responsibilities:"
  - **Change.** Responsible individual (RI) for nuclear criticality safety at Sandia from Director of the Nuclear Energy Technology Center (6400) to Director of the ES&H and Emergency Management Center (10300).
  - **Change.** The title of Center 10300 from "Integrated Safety and Security Center" to "ES&H and Emergency Management Center."
  - **Change.** Person who appoints the Sandia criticality safety officer from Director of the Nuclear Energy Technology Center (6400) to Director of the Radiation Sciences Center (1300).
- Under the topic, "Quantities of Fissile Material Above the Threshold Limit":
  - **Change.** "Preliminary hazard screening" to "primary hazard screening."

June 29, 2005
Administrative Changes Only

This document was administratively revised to:

Change: Executive Policy Sponsor from Les Shephard to Frank Figueroa

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March 31, 2003

Note: This document has been reformatted to clearly distinguish "requirements" from "guidance" and to indicate who is responsible for what activities. Sections 1.0 and 2.0 do **not** contain requirements, but are presented for information only. Requirements and guidance begin in Section 3.0. In addition to the reformat, this document was revised to:

- **Add.** To many sections, numerous links to documents, organizations, and job positions.

- **Change.** Divide the text of the previous Section 1.0, "Applicability," into sections 1.0, "Applicability," 2.0, "Responsibilities," 4.1, "Threshold Limits," 4.1.1, "Exemptions," 4.2, "Quantities of Fissile Material Above the Threshold Limit," and 4.3, "Quantities of Fissile Material Below the Threshold Limit."

- **Change.** Throughout the document, delete the "Step x" numbering system and organize the text into mil-spec numbered sections. This changed the organization of information, but did not change content. Content changes were applied as a separate activity to the renumbered sections.

- **Add.** To Section 3.0, Training," the requirements for facility managers to ensure that NCSE personnel receive refresher training triennially. (This text was moved from the previous Section 6.0, "Training.")

- **Add.** Section 5.2.4, "Volume Controls" as a control option.

- **Add.** To Table 2, "Safe Operational Mass Guidelines," volume as a control.

- **Add.** To Table 2, "Safe Operational Mass Guidelines," to the safe operational mass for a batch of fissile materials consists of a mixture of fissionable nuclides. (For example: Pu-239, U-235, U-233, Np-237, and Cm-244) the clarification"with a safety margin applied as justified in a CSA."

- **Add.** To Table 2, Safe Operational Mass Guidelines," a clarification that the safe

operational mass value shall be below the subcritical limit by a margin that is justified in a CSA or other reference.

- **Change.** In Table 3, "Rules for Demonstrating Nuclear Criticality Safety," clarify the meaning of "safety margin" as the difference between the subcritical limit (k_{eff} < or = 0.95 - epsilon as the subcritical limit) and the "safe operational value" as used in this document.

- **Delete**. From Table 4, "Criticality Alarm and NADs Determination," "Under the USQD option, the USQD will be positive and DOE must approve the new operation (either with or without a CAS)."

- **Add.** To Section 6.3, "Changing Posted Limits at Storage Locations," a requirement for facility managers to ensure that the k_{eff} is shown to be <0.95 with allowances for errors.

- **Add.** To Section 8.0, "Complying With Nuclear Criticality Safety During Operations," the requirement for the MBA custodian to develop **a CSA and** a criticality safety procedure when the MBA inventory is expected to exceed the threshold limits.

- **Add.** To Section 9.0, "Records," requirements for the Criticality Safety Officer to maintain a current library of nuclear criticality safety assessments (CSAs) for projects and facilities and records of analyses of the need for nuclear criticality accident alarms. criticality safety assessments (CSAs).

- **Change.**Move from the previous Section 11.0, Additional Guidance," to Section 8.0, "Complying with Nuclear Criticality Safety During Operations" as guidance.

- **Add.** Attachment C, "Sample Nuclear Criticality Safety Posting."

January 28, 1998

This document was revised to:

- **Reorganize** information.

- **Delete** the following sections:
    - Summary (redundant to "Planning Section:")
    - Basis for requirements
    - Interfaces
- **Add** information about related hazards and activities.
- **Move** information on "Installing Alarms" to Attachment A.
- **Move** "Records" to "Complying With NCS During Operations."
- **Address** requirements added by DOE 0 420.1.
- **Update** reference citations.


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ATTACHMENT A – INSTALLING CRITICALITY ACCIDENT ALARMS

Subject Matter Expert: Norm Schwers; CA Counterpart: N/A
Contributors: Ronald Knief and Jeff Philbin
GN470072, Issue E
Revision Date: March 26, 2007; Replaces Document Dated: March 31, 2003
Review Date: March 26, 2007

A criticality accident alarm detects either neutron or gamma radiation that impinges on its sensors. Such an alarm must be designed to detect nuclear criticality accidents, but minimize false signals that may cause severe operational impacts.

Currently at SNL, gamma detectors are used for criticality accident alarms. In areas with a high gamma background, the use of neutron detectors may be appropriate. Determine the most likely neutron-to-gamma ratio for a criticality accident in the operation to help decide whether to use gamma or neutron detectors.

Note: The Instrumentation and Dosimetry Department 103211 purchases (charged to the SNL organization), inspects, fabricates, calibrates, and maintains criticality accident alarms. This department installs the instrumentation at the locations indicated by SNL organizations and also works with SNL organizations in determining the number and location of nuclear accident dosimeters (NADs) required for radiation protection purposes.

Factors to Consider When Installing Criticality Accident Alarms

When installing criticality accident alarms, consider the following factors:

- A determination should be made of the maximum credible fission yield for each area where a criticality alarm is needed. Consideration of the shielding and geometry then may be used to limit the area needing evacuation to a manageable

level.

- Detectors in the alarm system need to be able to detect an absorbed dose in free air of 20 rads of combined neutron and gamma radiation from the fissile material delivered in 60 seconds. (See paragraph 5.6 of ANSI/ANS-8.3.)

- The alarm radiation dose rate should be set as high as practicable to detect a criticality accident but no other initiating event. (Do not use criticality radiation detection instrumentation for routine operational radiation monitoring.) The level must be set low enough to detect the minimum accident of concern.

- The alarm signal must be distinctive so that it will be interpreted as requiring immediate evacuation. For detailed specifications on audio properties, see ANSI/ANS-8.3. After initiation, the signal must continue to sound as required by emergency procedures, even though the radiation falls below the alarm point. The alarm signal must be for immediate evacuation purposes **only** and of sufficient volume and coverage to be heard in all areas that are to be evacuated.

- If the calculated duration of the criticality accident is less than 60 seconds, contact the Instrumentation and Dosimetry Department 103211 for assistance in determining the means of calibrating the alarm system. The decision concerning the method of calibration may influence whether to choose a gamma or a neutron detector.

Alarm Location

The dose rate measured by an alarm will depend on how far it is from the radiation source and any shielding of the detectors:

- The alarm may be located farther away from the potential criticality accident as the alarm-initiating dose-rate level is lowered. This allows a single alarm to cover a larger area, in turn reducing the total number of alarms needed for a facility. A desire to reduce the total number of alarms by making alarms more sensitive competes with the desire to minimize the number of false alarms by making alarms less sensitive.

- Air absorption and interposed shielding may reduce the coverage of the alarm. The detectors should be located so that shielding is minimized.

- For specifications on alarm dependability and design criteria, see ANSI/ANS-8.3.

Alarm System Testing

Initial tests, inspections, and checks of the system must verify that the fabrication and installation were made in accordance with design plans and specifications. Following significant modification or repair to a system, there must be tests and checks equivalent to the initial installation tests. System response to radiation must be measured periodically to confirm continuing instrument performance. Records of tests must be maintained. The entire alarm system must be tested periodically. Field observations must establish that the signal is audible above background throughout all areas to be evacuated. All personnel in affected areas must be notified in advance of an audible test.

When tests reveal inadequate performance, corrective action must be taken without unnecessary delay. Procedures must be formulated to minimize false alarms that may be caused by testing and to return the system to normal operation immediately following the test. All tests and corrective actions must be recorded in a logbook maintained for each alarm system.

Back to Supplements

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