海外出張報告書

臨界安全技術プロジェクトワークショップ(NCTSP)

(会議報告)

2000年7月

核燃料サイクル開発機構
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海外出張報告書
臨界安全技術プロジェクトワークショップ(NCTSP)
(会議報告)

須藤俊幸*

要旨

2000年3月末に米国ニューメキシコ州アルバカーキ市で開かれた米国エネルギー省(DOE)の臨界安全技術プロジェクトワークショップ(NCTSP)に参加したので報告する。

NCTSPは、DOE関係者の臨界安全に関わる者が、DOEの臨界安全プログラム(NCSP)の一環として情報交換や業務遂行上の改善点について議論の場をもつもので、毎年1回開催しているものである。参加人数は約100名強である。NCTSPの後には臨界安全に関するANS-8基準の更新、改訂、新規策定のための委員会会合が行われた。これらの会合への自由なコメントを歓迎するという立場から、外部の者も自由な参加ができる。

NCSPは7つのタスク(臨界実験、ベンチマーキング、核データ、解析手法、データの適用範囲及び限界、情報保存と普及、トレーニングと資格制度)があり、それぞれの活動状況について報告された。また、東海村のJCO臨界事故に対するDOE、NRC及びその所管施設の対応、DOEのガイド(G)／オーダー(O)の改訂内容についての説明と議論などがなされた。

会場の雰囲気はDOE臨界関係者の内輪の会議といったものであり、発表内容や議論については、組織、規則等の体系、プログラム・プロジェクトの名称やその計画等の背景情報が分からないと把握するのがむずかしい面があった。しかし、DOEといういくつもの核物質取扱施設を有する巨大な組織が、総体として臨界安全安全確保の維持と向上に努力を示す態度、継続的かつ体系的、実用的なプログラム活動には敬服させられるものがある。

本ワークショップに関する背景情報やレポート類のほとんどがウェブサイトを通して公開されており、情報の共有化が図られている。本報告では、これらの関連内容も盛り込むとともに、参考として関連ウェブサイトのアドレスをできる限り記載した。

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Nuclear Criticality Technology Safety Project Workshop (NCTSP)

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Abstract

This paper reports the Nuclear Criticality Technology Safety Project Workshop (NCTSP) hold by the U.S. Department of Energy (DOE) in Albuquerque, New Mexico U.S.A. in the end of March 2000. NCTSP is hold every year as a part of activities of the DOE Nuclear Criticality Safety Program (NCSP) in which the persons concerned make information exchange and have discussion about improvement in ensuring criticality safety. The number of participants was 100 and more. After the workshop, the ANS-8 standards committee meeting on the nuclear criticality safety was hold for maintenance, revision of the standards or new development. People outside the DOE family can participate freely from the standpoint of welcoming any comments to NCSP.

NCSP consists of seven tasks which are critical experiments, benchmarking, nuclear data, analytical methods, application range of the data and limit, information preservation and dissemination, training and qualification. The activity condition of each task was presented at the workshop. Other presentations are responses from DOE, NRC and the facilities under their control to the Tokaimura criticality accident in Japan, revision plans of DOE guide(G)/order(O) and so on.

The workshop seems the conference of the DOE family on criticality safety. Some contents of presentation and discussion are difficult to understand without background information such as structure of organizations and rules, names of programs/projects and their implementation plans.

It is admirable that the DOE, a enormous organization with a lot of nuclear material handling facilities, is making continuous efforts systematically and practically to retain the capabilities and expertise in nuclear criticality safety and improve the availability and use of criticality safety information, tools and guidance throughout the DOE complex.

Most of the background information and reports related to this workshop are open to the public through Internet web sites. The use of such an Internet technology can enable the DOE family to share information widely and speedily. The addresses of the related web sites are described within this paper as references.

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海外出張報告書
米国臨界安全技術プロジェクトワークショップ(NCTSP)

1. ワークショップ概要

本ワークショップは米国エネルギー省(DOE)関係者(DOE, 原子力委員会(NRC), DOE サイト, サイト運営契約者等)の臨界安全関係者約 100 名強が、臨界安全プログラム(NCSP)の一環として情報交換や業務遂行上の改善点について議論の場をもつものである。ANS の臨界安全のトピカルミーティングやその他のテクニカルミーティングとは性質を異にし、研究成果発表の場というより、むしろ、より実際的、具体的な活動の報告の場である。これと合わせて、ワークショップ終了後には臨界安全に関する ANS-8 スタンダードの更新、改訂、新規策定のための委員会会合が行われた。日程の概要を以下に示す。

3 月 27 日　　臨界安全プログラム(NCSP)レビュー
3 月 28, 29 日　NCTSP セッション
3 月 30, 31 日　ANS-8 委員会会合、ライティンググループ会合

会場は、米国ニューメキシコ州アルバカーキ市にある DOE の Energy Training Complex である。

27～29 日での発表は、NCSP の7つのタスクに関する報告(臨界実験、ベンチマーキング、核データ、解析手法、データの適用範囲及び限界、情報保存と普及、トレーニングと資格制度)、東海村の JCO 臨界事故の概要説明と NRC、DOE 及びその所管施設の対応、臨界安全に係る違反と傾向、臨界警報装置及び DOE のガイド(G)／オーダー(O)の改訂内容についての説明と議論である。

初日は、アドホックミーティングとして DOE の臨界安全プログラム(NCSP)レビュー、午後からはこれと並行して、ANS-8.22(Nuclear Criticality Safety Based on Limiting and Controlling Moderators)の作業グループミーティングとエンドユーザーミティングが行なわれた。このうち、DOE の NCS プログラムレビューを聴講した。アドホックのせいか、初日の参加者は全体の約半分(50～60 人)であった。28,29 日は本会議といったところであり、約 120 人が出席していた。30 日は、臨界安全関連基準(ANSI/ANS-8)に関する米国原子力学会(ANS)の基準第8小委員会の全体会合、その後、各基準毎にライティングGrミーティングが行われた。参加者は約 50 名である。

いずれの会合においても、外部の者の参加はウェルカムであり、自由なコメントを歓迎するという立場であり、自由な参加ができる。

本ワークショップの特徴は以下のようである。

・形式張らないプレゼンテーション
・最近の話題に重点を置く
・柔軟なプログラム編成
・自由な質問、議論に十分時間を割く
・発表者の負担軽減のためか、事前のフルペーパーのプロシーディングはなく、OHP 等の発表資料のコピーをたばねて、かなり後に配布あるいはウェブサイトから公開されるようである。

会場の雰囲気はDOE臨界関係者の内輪の会議といったものであり、参加者同士が皆顔見知りでファーストネイムで呼び合い、部外者は私とORNL留学中で参加した清水氏(サイクル機構)だけであった。なかなか落ち着けない緊張した出席となった。

発表内容や議論については、ネイティブ同士の英語であり、かつ、NRC、DOE、及びDOEサイトの組織、規則・基準等の体系、プログラム・プロジェクトの名称やその計画等の背景情報が分からないと把握するのがかなりむずかしく、多くをその場で理解することはできなかった。しかし、会議の雰囲気は、オープンで活発な遠慮のない、かつ、議論を発散させるのではなく、少しでもよりよい方向に持っていこうという前向きな議論がなされており、また、DOE対サイト側の対立めいた議論の場合もあったりで印象的であった。

会場では、飲料を持ち込み、あるいは好きな果物を持ち込みながらの半ばインフォーマルな雰囲気であった。各セッションのチェアマンあるいはプレゼンテーターは最初にジョークを飛ばす場合が多く、和やかなものであった。

100人以上の出席者の中で居眠りする人が皆無で皆熱心に聞いていたのは、専門家と関係者集団の会議であり、かつ、直接自らの業務に密着しているということを割り引いても関心させられた。

NRC, DOE及びDOEサイトとサイト運営の契約者の集まりであるこの専門家会議は、日本で例えれば、原子力安全委員会と科学技術庁とサイクル機構、原研などの臨界専門家及び関係者の情報交換会議といったものに相当することになるが、このような自由でインフォーマルな会議を通して、意思の疎通が図られ、情報の共有が促進されるようなものが日本にないと思われ、少々残念に思う。

また、ほとんどの情報がウェブサイトを通して公開されており、情報の共有化が図られていることに感心した。本報告の中でも、参照できるように関連ウェブサイトのアドレスをできる限り記載した。なお、記載したアドレスは執筆時点のもので(2000年7月)、古くなった情報は移動されたり削除されたりする場合があるので注意されたい。

さて、前述の通り理解不十分なところもあり、断片の記録のような面があるが、以下に会議内容の概略を報告する。報告は、議事日程に沿った形ではなく、後日調査した内容も加えてテーマ毎に整理して記載した。発表内容について筆者の理解不十分なものについては、メモ程度の記載しかできなかったものもあるがご容赦願いたい。また、各種の固有名称(プログラム名、組織名称など)の一部の日本語訳などは著者の知識の範囲での暫定的な訳であり、必ずしも通常使用されている訳と異なる場合があるかもしれない。また元の意味を日本語の単語で置き換えることが正確でないと思われる場合にはカタカナ標記としたところも多々あるので了解願いたい。

2. アジェンダ

ワークショップ及び初日のNCSプログラム・レビューと最後のANS-8サブコミッティー会合のアジェンダを添付資料1に示す。また初日3月27日のプレゼンテーションのOHP集を添付資料2にまとめた。なお、このOHP集は下記のウェブサイトにおいても提供されている。

http://ncsc.llnl.gov:8080/ncspreview/ncspreview.html

3. 臨界安全プログラム(NCSP)

DOE の NCSP の目的は、臨界安全に関する基本的な基盤を維持・整備し、DOE の臨界安全に関する専門技術と能力を維持することにあり、関係者の技術的知識を発展させ、DOE 施設関連情報、ツール、ガイダンスの整備とその利用の改善と促進を図っていくことである。

本プログラムは、米国防衛核施設安全委員会(DNFSB)が DOE に対して施設運営の安全性及び生産性に対して有害な影響をもたらすような状況を改善するために出した 97-2 勧告(97年 5 月)に対応して策定し、1998 年 1 月より開始されたものである。その実施は、1999 年 8 月に発行した NCSP 5ヶ年計画に従って行われており、以下の7つのタスクより構成されている。

・臨界実験:臨界安全解析を支援する計算手法の検証のための実験データの提供
・ベンチマーキング:臨界安全解析を支援するためのベンチマークデータを調査し、評価し、利用可能にする
・核データ:廃棄物の処理・処分運転におけるフィッサイル物質に混合されている他の物質の効果(影響)について計算コードを用いて検討するために必要な核データの提供
・解析手法:臨界安全解析で使用する計算コードの支援と強化
・限界線(Bounding Curves)およびデータの適用範囲:既存データを内外挿する手法の開発
・情報の保存と普及:臨界安全に係る情報を収集し、保存し、十分に利用可能なものとする
・トレーニングと資格制度:臨界安全プラクティショナーのトレーニングの維持、改善と、DOE と契約者(民間)の資格標準の制定

DNFSB の 97-2 勧告の経緯とその内容並びにそれに対する DOE の実施計画については、臨界安全に関する米国の状況と臨界安全確保に向けての真摯な態度が伺え非常に興味深いものと思われるので、関連文書の全文を添付した。(別冊 別添資料1)

参考として、NCSP の各タスクの予算計画と進捗状況を下表に示す。その詳細については別冊の別添資料1を参照されたい。実施計画にある 30 の実施項目のうち、27 項目は既に完了している。遅延している残り3項目についての回復計画についても別添資料1を参照されたい。

Table 1 NCSP Funding by Program Task and Subtask

Program Task or Subtask	Laboratory (Point of Contact)	FY 2000 & Beyond Budget ($k)
NCSP Management	DP-10/EM-66	170
Critical Experiments	LANL LACEF (Rick Anderson)	3,950
Benchmarking	INEEL, LANL, LLNL, ORNL, Y-12, ANL, SRS (Blair Briggs)	1,500
Nuclear Data	ORNL, LANL, & ANL (Bob Roussin)	2,217
Analytical Methods	ORNL, LANL, & ANL (Mike Westfall)	1,303
Applicable Ranges of Bounding Curves And Data (AROBCAD)	ORNL (Calvin Hopper)	700
Information Preservation and Dissemination	LANL (Tom McLaughlin) LLNL (Song Huang)	110
Training, Development & Qualification	LANL (Tom McLaughlin) ANL (Jim Morman)	250(1)
TOTAL		10,200

(1) Supplemented by ~ $84k from tuition collection

Table 2 IP COMMITMENT AND DELIVERABLE/MILESTONE STATUS

Commitment	Deliverable/Milestone	Due Date	Status
6.1 Assess critical experiments program	1.Assessment report of criticality research program	March 1998	Completed
6.2.1 Perform CSIRC pilot program	1. Identify an experiment to archive	November 1997	Completed
	2. Archive logbook(s) and calculation(s) for that experiment	December1997	Completed
	3. Videotape original experimenters	January 1998	Completed
	4. Digitize data and calculations	February 1998	Completed
	5. Publish data and calculations	April 1998	Completed
6.2.2 Continue to implement the CSIRC program	1. Collocate logbooks(copies or originals) from all U.S. critical mass laboratories	December 1998	Completed
	2. Screen existing logbooks with original author/experimenter	December 1998	Completed
	3. CSIRC program plan	December 1998	Completed
6.3 Continue and expand work on ORNL sensitivity methods development	1. Technical program plan	July 1998	Completed
	2. Document initiation of priority tasks from the program plan in the quarterly report to the Board	January 1999	Completed
6.4 Make available evaluations, calculational studies, and data by establishing searchable databases accessible through a DOE Internet web site	1. DOE criticality safety web site	March 1998	Completed
	2. Y-12 evaluations on DOE web site	June 1998	Completed
	3. Calculations compiled by the Parameter Study Work Group on DOE web site	September 1998	Completed
	4. Nuclear Criticality Information System Database on DOE web site	March 1999	Completed
6.5.1 Revise and reissue DOE-STD-3007-93	1. Revise DOE-STD-3007-93	September 1998	Completed
6,5.2 Issue a guide for the review of criticality safety evaluations	1. Departmental guide for reviewing criticality safety evaluations	May 1999	Completed

Table: IP COMMITMENT AND DELIVERABLE/MILESTONE STATUS (continued)

Commitment	Deliverable/Milestone	Due Date	Status
6.6.1 Expand training course at LACEF	1. Expanded LACEF training course	July 1998	Completed: February 2000
6.6.2 Investigate existing additional curricula in criticality safety	1. Assessment of additional training needs and review of available supplementary curricula	June 1998	Completed
	2. Initiate a program which addresses identified needs	December 1998	Completed
6.6.3 Survey existing contractor site specific qualification programs	1. Report on the review of site-qualification programs	June 1998	Completed
	2. Guidance for site-specific criticality safety training and qualification programs	September 1998	Completed
	3. Guidance to procurement officials specifying quarification criteria for contractor criticality safety practitioners	September 1998	Overdue: Expected completion date is September 2000-
	4. DOE Field will provide line management dates upon which contractors will have implemented guidance in Deliverable #2, above	March 1999	Overdue: Expected completion date is March 2001
6.6.4 Federal staff directly performing criticality safety oversight will be qualified	1. Qualification program for Departmental criticality safety personnel	December 1998	Completed
	2. DOE criticality safety personnel qualified	December 1999	Overdue: Expected completion date is December 2000
6.7 Each site will conduct surveys to assess line ownership of criticality safety	1. Individual sites issue report of findings	June 1998	Completed
6.8 The Department will form a group of criticality safety experts	1. Charter for Criticality Safety Support Group approved by the NCSPMT	January 1998	Completed
6.9 Create NCSPMT charter and program plan	1. NCSPMT charter	January 1998	Completed
	2. NCSPMT program plan	June 1998	Completed

NCSP プログラムの最近の達成事項と今後の課題の主要事項を以下に示す。

主要な達成事項

・LANL の LACEF 臨界実験施設における教育訓練コースとして、新規に5日間アドバンス・コースの追加
・ZEUS(Graphite/HEU 臨界実験装置)の初臨界(4/26/99)
・臨界技術者の資格基準(Qualification Standard)の新規策定(DOE 及び運営契約者)
・臨界安全支援グループ(CSSG)による技術的支援
・ウェブサイトの充実
・教育資料として、7つの資料の作成(NCSET:Nuclear Criticality Safety Engineer Training)

主要な課題

・安定した予算獲得
・NCSP プログラムのサポート
・LANL Technical Area(TA)-18 の移転の可能性
  TA-18 は臨界実験施設 LACEF のあるエリアである。本ワークショップ後の 4 月 11 日に、DOE 長官が移転の決定をアナウンスしている。
・プログラム実施計画マイルストーンの達成
・限られた(人的、予算的)資源での、臨界安全コミュニティのニーズへの対応

本プログラムの活動について現在プログラム・リビューが行われており、会場では、各内容の有効性、重要性等に関するプログラム・ユーザー(臨界安全関係者)の意識調査(アンケート調査)書が配布され、内容の説明が行われた。アンケートでは、それぞれのタスク毎に

・活動内容の重要性、活動項目の優先順位の妥当性
・ニーズとそれに答えているかどうか(有効性)
・データ・情報が取得できるようになっているか、利用しているデータ・情報

について、3～4段階からの選択またはコメントをするようになっている。意識調査書は下記ウェブサイトにも掲載されており、誰でも回答することができる。この最初のページを別冊の別添資料2に示す。

http://ncsc.llnl.gov:8080/survey/NCSPsurvey.html

3.1 臨界実験 (LANL, Sandia における臨界実験プログラム)

(1) LANL の臨界実験施設(LACEF)での臨界実験活動

a) 優先順位

次表に、臨界実験の優先順位を示す。

Table 3 Revised Recommendations for Priority of Critical Experiments

Priority	Description
1	Intermediate-energy reactivity-worth and dosimetry experiments for non-fissile matrix materials (ZEUS)
2	Intermediate- and thermal-energy experiments with fissile material (^{233}U, ^{235}U, Pu) in specified waste matrices (e.g., Yucca Mountain tuff)
3	Measurement of worth of CERES fission-product samples for support of burnup credit (in SHEBA-II)
4	Single-unit and array experiments for pit storage and transportation (W-82, etc.), including experiments to simulate flooding/dissolution accidents
5	Experiments to determine effects of special moderators (e.g., beryllium, graphite, D2O, high-density polyethylene) and absorbers (e.g., chlorine) on fissile materials in homogeneous and heterogeneous systems
6	Lattice experiments with MOX fuel pins, including replacement measurements for various materials
7	Criticality Accident Alarm System testing with SHEBA-II and Godiva
8	Verification of positive moderator temperature coefficient for dilute systems with nearly-pure ^{239}Pu
9	Extension of NIST neutron slowing-down experiments in water to larger spheres of water
10	Source jerk / pulsed neutron measurements for subcritical systems

このうちの活動が進められているトップ3の概要を以下に記す。

① 非核分裂性物質を用いた中間エネルギー領域の断面積、反応度価値、線量測定実験

ZEUS(非均質 Graphite/HEU, 4/26/99 初臨界)

対象; ^{235}U(その後に ^{239}Pu、^{233}U)及び Si, Fe, Al, Cl 等

需要;

高濃縮 U／兵器級 Pu＋Si／セラミック媒体(SRS)

フィッサイル物質を含む廃棄物溶液／スラッジへの Fe の添加(Hanford 廃棄物タンク)

兵器級核物質、使用済燃料の地層処分(ユッカ・マウンテン)

兵器級核物質の利用(MOX 炉、加速器、燃焼炉)

廃棄物ドラムの貯蔵と輸送(RFETS)

^{235}U、^{233}U の処分(ORNL)

② 廃棄物媒体中のフィッサイル物質体系の中間及び熱エネルギー領域での実験

Planet (非均質 ^{235}U-ポリエチレン-廃棄体媒体混合系)

実験データの無い廃棄物媒体に対する①の熱エネルギー領域までの拡張実験。廃棄物の充填材として使用される各種物質(SiO_2, MgO, Al_2O_3, CaO など)の断面積測定。^{235}U 終了後 Pu 実験へ移行予定。

③ バーンナップ・クレジット支援活動として CERES の FP サンプルの反応度価値測定

SHEBA-II (Nitrate Solution?)

初期実験終了(解像度 1-2 セント)、高解像度測定の開発中(解像度 0.1 セント)

b) その他の情報

① Time Dependent Benchmark Experiments

・中性子寿命や時間依存の計算に対するベンチマークデータが少ない

・時間依存計算は難しい輸送問題

・GODIVA のパルス炉を利用して実験

② Equivalent Fundamental Mode Source Method for Validating Spontaneous Fission Rates

③ LACEF Future Operations

・臨界実験実施能力確保の必要性

基本データの資源

臨界に関する教育訓練(基本・応用コース、シミュレータ)としての資源

予想外の事象・問題に対処するための資源

・LACEF での活動目標

設備能力の維持

DOE 関係利用者との密接な調整

他の機関との強力

・NCSP へのサポート拡大の提案

Pu 溶液の正の温度係数測定

使用済燃料を用いた臨界安全実験(with SNL)

低温での臨界質量 (NASA)

MOX の計算＆実験装置

臨界のシミュレータ開発

拡大臨界事故研究 (with 日本、ロシア)

臨界のドシメトリ・センター

外部機関との協力

(2) SNL のバーンナップ・クレジット実験プログラム

① NERI (Nuclear Energy Research Initiative)により 3 年間の予算

② SFSX(燃料置換実験)を利用してバーンナップクレジットに関する臨界実験計画

SFSX は安全評価が承認され、燃料が製造されるところまでいったが、いままで実験が行われることはなかったものである。

周囲に未照射燃料、中心に照射燃料を配置し、中心の燃料棒の有無の状態に対する反応度測定

3. 2 ベンチマーク・プログラム

(http://icsbep.inel.gov/icsbep/, 最初のページを別冊の別添資料3 に示す)

(1) 国際臨界安全ベンチマーク評価プロジェクト(ICSBEP)

1992 年、DOE はディフェンス・プログラムの一環として臨界安全ベンチマーク評価プロジェクト(CSBEP)を INEEL で開始し、1994 年には、国際臨界安全ベンチマーク評価プロジェクト(ICSBEP; International Criticality Safety Benchmark Evaluation Project)として発展させ、

OECD-NEAの公式活動として受け入れられた。1997年からは、ICSBEPはNCSPのベンチマーク・タスクとなって活動が続けられており、INEEL がプロジェクト管理を行っている。2000 年度予算は1500k$である。

ICSBEPプロジェクトの目的を以下にまとめる。

1. 総合的な臨界ベンチマーク・データの収集、確認、評価の実施
2. オリジナル・データのレビュー、その結果に基づく関連文書の改訂、さらに、実験者あるいは実験者に親しい者や実験施設に詳しい者とのインタビューにより、可能な限り実験データの検証の実施
3. データを標準化したフォーマットに編集すること
4. 各実験データに対して、標準の臨界計算コードを用いた計算の実施
5. 作業結果を、検証済み臨界ベンチマーク・データとして公式文書化すること

これらの作業により、実験値と計算値との(核データや、近似計算等による計算モデルに起因する)誤差の同定やデータが不十分な領域の同定も可能となる。

現在までに288件の臨界実験シリーズの評価が行われており、約2500個の実験データがまとめられている。2000年版は9月に、26個のベンチマーク実験を追加して公開予定。2000年版では、NUPEC, JAERI/STACYの日本の実験データが11件収録される予定。

今後の予定では、未臨界実験データ、臨界警報装置／遮蔽ベンチマークデータの調査が上げられている。

なお、ICSBEP の作業結果は「国際臨界安全ベンチマーク実験ハンドブック」(NEA/NSC/DOC(95)03)として、CD-ROMにて提供されており、また、ウェブサイトからも閲覧できる。

ICSBEPワーキンググループ・ミーティングが2000年6月末にロシアのセント・ペテルスブルクで予定されており、モスクワのクルチャトフ研究所とオブニンスクの IPPE の臨界実験施設のテクニカルツアーも予定されている。米国、英国、ロシア、仏国、日本、ユーゴスラビア、スペイン、イスラエル、中国及びOECDからの参加が予定されている。

(2) 未臨界測定技術

・未臨界実験の利点は以下のとおり。
  ・臨界実験よりも低コスト
  ・現状の臨界ベンチマーク実験の間のギャップを満たすために利用できる
  ・既存の臨界実験施設で実験できる
・OECD/NEAにてコーディネートされている
・将来予定の実験候補

JAERI: TCA, STACY
LANL : Rossi-α
ORNL : Pulse-n
Valduc: Feynman-α
AEA : ?

これらの結果はICSBEPに盛り込まれることになる。

3.3 アナリティカル・メソッド(解析評価方法)

(1) タスクの目的

DOEのfissile物質を扱うシステムに対して適用できる最新技術を活用した臨界評価方法を提供すること。ベンチマークや解析評価の検証作業に対する独立した、複数の手段を提供すること。さらに既存の評価手法の欠点を克服し、また、より複雑なシステムを扱えるように改良していくこと。このタスクは以下の4つのサブタスクからなる。

- ・KENO/SCALE (ORNL)
- ・MCNP&関連ソフトウェア (LANL)
- ・VIM&関連ソフトウェア (ANL)
- ・ソフトウェアのパッケージング&配布 (RSICC/ORNL)

(2) 必要な改良項目

・ORNL

SCALE/CENTRM シーケンス: 分離共鳴吸収断面積処理

MOX に対する検証レポートが発行されている(ORNL/TM-1999/299)。

複数の燃料領域がある場合の共鳴吸収断面積処理のための設計作業が進められている。

KENO3D for KENO-VI: KENO 形状入力の3次元グラフィックイメージ処理

・LANL

MCNP: 確率テーブルを用いた非分離共鳴断面積処理

JUSTINE: グラフィック&インウットプロセッサ、CAD

自動形状チェック機能, ユーザー・ワーニングの充実, など

・ANL

核分裂ソース収束のための階層サンプリング技術の調査

VIM 用 GUI など

(3) 今後の予定

・新規実験データ、断面積データ、不確かさデータを用いての検証作業の継続

・AROBCAD(後述)感度解析・最適化研究結果に基づく改良輸送モデリング

(4) 改良余地

KENO & MCNP の摂動論の機能

KENO 連続エネルギー版

VIM の最適化、問題依存の断面積作成機能

本タスクの予算計画を次表に示す。

Table 3 Schedule and Budget for the Analytical Methods Task of the NCSP

Tasks by Laboratory	Deliverables and Budget*		
	FY 2000 ($k)	FY 2001 ($k)	FY 2002 ($k)
Oak Ridge National Laboratory Subtask 1 KENO/SCALE software - capability maintenance, training and user assistance, administrative and technical support Needed improvements – documentation and release of SCALE/CENTRM sequence; compatibility of KENO3D graphics with KENO-VI geometry; determination and utilization of material region and zone volumes in KENO.	426 (continuing)	426 (continuing)	426 (continuing)
Subtask 4 RSICC collection, packaging and dissemination of criticality safety software (codes and cross-section libraries)	200 (continuing)	200 (continuing)	200 (continuing)
Los Alamos National Laboratory Subtask-2 MCNP and associated software – capability maintenance, training and user assistance, management support Needed improvements – JUSTINE graphics and input processing including repeated structures, CAD.	384 (continuing)	384 (continuing)	384 (continuing)
Argonne National Laboratory Subtask-3 VIM and associated software – capability maintenance, training and user assistance, management support Needed improvements – completion of stratified sampling, graphics and GUIs for VIM	293 (continuing)	293 (continuing)	293 (continuing)
Task Total	1303	1303	1303

* Budget amounts listed in constant FY 1997 dollars.

3.4 核データ

(1) 核データの測定、解析・評価の実施

新たな燃料のハンドリングや処理技術開発のために様々な物質の核データが必要となる。ユーザーからは評価の過程、計算結果の改善対応としていくつかのデータの不十分さが指摘・報告されている。

Be, Al, Si, Ca, Ti, Cr, Mn, Fe, Zn, Sr-90, Cs-137, Bi-223, Ra-226, Ac225, U-234,235,236,238, Np-237, Pu-238,239,240,241,242, Am-241, Cm-243,245,247,250, Cf-252 等

(2) 中間エネルギー領域

これまでは原子炉での評価に利用することを主眼に速-、熱-中性子のエネルギー領域に焦点が当てられていたが、現在では様々な形態での燃料利用により、中間エネルギー範囲でのデータの改善の重要性が増してきている。

(3) 1999 年度活動例

ORELA(Oak Ridge Electron Linear Accelerator)測定

600keV までの ^{27}Al、Si の捕獲断面積測定(Si は廃棄物体のコンクリート成分として)

400keV までの Cl の transmission 測定(Cl 廃棄物体の PVC 成分として)

SAMMY を用いた評価; ^{27}Al、^{16}O、^{233}U、^{235}U

これらの物質の各データ需要は、主に廃棄物処理・処分活動によるものである。一部のものについて新データを用いた計算結果の改善効果が確認されている。

3.5 トレーニング／資格制度

(1) LANL/LACEF でのトレーニングコース

(http://crit-safety.lanl.gov/ncs/index.htm 参照)

3-,5-Day ベーシックコース

HEU フォイルの積み上げによる臨界実験(1/M アプローチ)

Flaptop または SHEBA を用いたフリーラン

など

5-day アドバンストコース(新規コース)

SHEBA フリーラン

BeRPu(金属)球を用いたデモ

不均質分布を模擬したプレート臨界実験(PLANET)

など

(2) NCSET (Nuclear Criticality Safety Engineer Training)モジュール

(http://ncsc.llnl.gov:8080/ncset/ncset.html 参照、

最初のページを別冊の別添資料4 に示す)

このモジュールは、臨界に関する教育資料であり、現在7つが作成されている。そのタイトルを以下に示す。タイトルからも分かる通り、その内容は一般(運転員)向けではなく、臨界技術者向けのものである。

Module 1: 臨界の物理概論

Module 2: 中性子と物質の相互作用

Module 3: 核分裂連鎖反応

Module 4: 中性子の散乱と減速

Module 5: 臨界安全制限値

Module 6: 拡散理論

Module 7: モンテカルロ計算手法

今後の追加予定

臨界事故の評価計算、手計算による手法など

(3) DOE-STD-1135-99 (DOE Standard for the training and qualification of contractor NCS engineers)策定など

(http://tis.eh.doe.gov/techstds/standard/appframe.html 参照)

3.6 情報保存とその普及

(1) CSIRC (Criticality Safety Information Resource Center、臨界安全情報センター)

(http://crit-safety.lanl.gov/ncs/index.htm または http://www.csirc.net/ 参照、最初のページを別冊の別添資料5に示す)

CSIRC は LANL 内に設置されており、その目的は、(過去の)消失しやすく掛け替えのない情報を保存し活用できるようにすることである。CSIRC は歴史的な臨界安全実験情報を保存し、トレーサビリティを確保できるようにしている。未刊行の情報には、臨界実験者のログブックや他の主要な記録類などがある。CSIRC 主要な活動を以下に述べる。

① ORNL,LANL 等で過去に行われた臨界実験のログ・ブックなどの収集・保存
スキャナーでスキャンし、電子ファイルとして保存。
2000 年 9 月には"ビデオテープ会議"が LANL で予定されている。これは、ORNL と LANL の臨界安全・実験のパイオニアたる人達が一同に会し、臨界安全に関する彼らの長年の作業や臨界実験の個人的な記憶について、ビデオテープに記録するというものである。

② LA-10860 (Critical Dimensions of Systems Containing ^{235}U, ^{239}Pu, and ^{233}U, 1986 Revision, 1987)レファレンス・セット
ウェブサイトにて標記の臨界データ文献及びその参照文献の全てを参照できる。また、CD-ROM(3 枚セット)も提供されている。TID-7016, AHSB(S), CEA-R3114, ARH-600 などの過去の有名な臨界ハンドブックや Y-CDC-12 や臨界実験文献など 195 件が収録されている貴重な情報源となっている。参照文献リストを別冊の別添資料6に示す。

③ LA-12808 (Nuclear Criticality Safety Guide, 1997)
TID-7016 Revision 2, 1978 に続く TID-7016 Revision 3 に相当するもの。

④ "A Review of Criticality Accident", LA-13638, 2000
これまでの世界の臨界事故についてのレビューであり、昨年公開される予定であったが、日本の JCO 臨界事故により、これを含めるべく公開が延びていたものだが、4月に作業を終え、5月末に公開された。本文献も下記ウェブサイトから参照できる。
http://ncsc.llnl.gov:8080/ または
http://www.csirc.net/10_Library/00_Reports/index.html

③及びその参考文献(147 件)及び④の参考文献(約 200 件)について、現在、電子フォーマットとしてスキャン作業中である。これらもウェブサイトで閲覧できる予定であるが、現時点ではまだ準備中である。

(2) NCSP のウェブサイト

(http://ncsc.llnl.gov:8080、別冊の別添資料7 参照)

NCSP プログラムの情報共有化の中心サイトとしてウェブサイトが構築されている。以下にその特徴を記す。

・主な臨界安全関連のウェブサイトへのリンク

・臨界安全専門家のためのサポート情報
・文献、ガイド、スタンダード、実験情報等の集積
・種々の臨界安全に関するワーキンググループ、メンバー、組織のリスト
・ニュース、トピック等
・運転経験、教訓
・計算コード／データ
・Q&A 集
・その他

基本的には、ここのウェブサイトから、DOE の臨界関連情報のほとんどがリンクされており、臨界安全関係者にとっては非常に有用なサイトである。

3. 7 AROBCAD プログラム

AROBCAD (Applicable Ranges Of Bounding Curves And Data)プログラムの目的は、ベンチマーク臨界実験に基づく計算コードの検証や未臨界限度(bounding margin)の設定に対する適用範囲(条件)を決定するための、より客観的で技術的に妥当な方法を、標準化されたユーザーフレンドリーな評価方法としてユーザーや規制側へ提供すること、具体的には既存の計算結果やデータを、臨界安全評価で設定される種々の物理的条件の関数として内挿あるいは外挿するための有効なガイダンスを提供することである。

また、プログラムの成果により、必要な臨界実験や核データの同定やベンチマーク計算と測定との不確かさの比較が可能となる。

本タスクは、1999 年より開始され、感度解析、不確かさ解析、最適化手法の計算評価理論について開発評価中であり、2006年にツールとして完成予定である。タスクチームにはORNL、ANL、LANL、UC-Berkley が参画している。

現在、SCALE に対しては SWAN シーケンスとして SEN1(for XSDRN)、SEN2(for NEWT)、SAMS(for KENO-V.a)モジュールを準備している。このユーザーマニュアルはドラフトのレビュー段階であり、2000 年の第 3 四半期末に印刷予定であるが、コードの公開は 2001 年以降になる見込みである。

AROBCAD についての参考資料として以下がある。

・NUREG-5593
・ANS Annual Meeting, Boston, Massachusetts, 1999
・ANS NCSD(Nuclear Criticality Safety Division) Topical Meeting, p.181, 1997

3. 8 東海村臨界事故、米国にとっての教訓

(1) 事故の概要報告

・発表者である Valerie L.Putman(INEEL)は、JCO の事故当初から多くのニュースソースから情報を集めて積極的に発信してきた人で、昨年 11 月はじめにはそれを整理したものをレポート(INEEL/MIS-1999-1139)として公開している。

(http://www.bazley.net/jco/990930sum.htm 参照)

・ワークショップでの発表内容は事故の原因と経過が主で、退避や被ばく線量についての紹介まではなかった。事故調査委員会の 12 月の最終報告書の英訳版(http://www.sta.go.jp/genan/jco/jco-e00119.html)を入手しているため、紹介された内容は正確なものであった。

・臨界警報装置の有無、臨界訓練について、退避のみか処置対応まであるか、また退避距離等について関心が高かった。

(2) US 調査チームからの報告

・DOE の調査チームが 10 月 18,19 に来日した際の調査報告。

(3) DOE 本部(DOE-HQ)の対応

東海村臨界事故後、大統領より、核燃料取扱施設の運転のレビューを含む Specific Action の指示が出されている。これはそれに対する DOE の対応であり、(4)では NRC の対応について述べる。

(a) DOE Nuclear Criticality Self-Improvement Initiative

DOE ではこれまでも、安全な長期貯蔵のためのフィッサイル物質の安定化、臨界実験を含む臨界解析技術の向上、臨界安全専門家の養成と維持方法の開発、及び教育訓練施設の確保などの臨界安全プログラムの改善、拡張を図る活動を行ってきている。昨年 8 月には、新たな Self-Improvement Initiative 活動を開始していたが、東海村の臨界事故により活動内容が一層強化された。この活動は以下の5項目よりなる。

① 臨界安全エキスパート・チーム(7、8 人)が以下の主要施設に対して運転管理の観点からの High-level アセスメントを実施。これらの施設は、フィッサイル溶液を処理することで選択されたものである。

ORNL/Y-12
LANL/TA-55(Pu 施設)
SRS/FG-line&H-area
Hanford/PFP(Pu Finishing Plant)
RFETS/Build.371

本アセスメント・ツール(文書)として以下が用意された。

・Self-Assessment for DOE Criticality Safety Programs (8/2/99)
・Review Plan for DOE Contractor Criticality Safety Programs (8/2/99)

アセスメントの判断基準は、基本的に以下の2つに基づいている。

・DOE P 450.5, Line Environment, Safety and Health Oversight ("P"は Policy の意)
・ANSI/ANS-8.19, Administrative Practice for Nuclear Criticality Safety

以上の詳細は以下のウェブサイトで見ることができる。(別冊の別添資料8 参照)

http://tis.eh.doe.gov/criticality/archive.html

② DOE field elements, DOE operating contractors による Self-Assessment の実施
③ EH(the Office of Environment, Safety and Health)によるアセス結果の解析
④ DOE Field Elements による Performance Metrics の作成
⑤ LANL/LACEF に対する Option Study

LANL TA-18 にある臨界実験施設 LACEF の移設あるいは新設に関する検討

①のレビュー結果の概要

各施設のレビュー報告書及び総括報告書が以下のウェブサイトで公開されている。

http://tis.eh.doe.gov/criticality/reviews/reviews.html、(別冊の別添資料8 参照)

5施設のレビューは、1999 年 11 月から2000年1月の間にそれぞれ3～4日間かけて実施された。

東海村臨界事故についてDOEが日本政府と行った情報交換についてのDOEレポート(2000年2月29日発行)では、事故の教訓として以下を確実にすることとしている。

・臨界と臨界事故の結果について、あらゆるレベルの関係者の基礎的な理解
・作業者の管理の重要性の理解とその遵守
・管理・監督者及び規制者による運転の十分な監督とモニタリング

これらの教訓は過去の臨界事故で得られた教訓と同様であり、かつ、既に(ANSI/ANS)スタンダードに盛り込まれているものであるため、サイト・レビューでは、特別に東海村臨界事故の教訓に焦点を絞るのではなく、(ANSI/ANS)スタンダードへの対応状況について調査することとし、臨界安全の基本要素として以下の4つに焦点を当てて実施された。

・臨界安全評価と管理
・作業管理
・変更管理(change control)
・ライン・マネジメントの監督

各施設の個別レビュー報告書では、以下の5項目について述べられている。

・Noteworthy Practice; 安全管理システムの改善に効果的な注目に値する優れた活動
・Positive Attribute; 効果的な改善、活動
・Safety Issue; 有害な影響をもたらしうる懸念される状態。これに対しては、DOE オーダーに基づき公式の対策とライン・マネジメントによるフォローが要求される
・Weakness; 管理システム、プロセス、作業上のウィークポイント。管理上の注意や対応策が必要であるが、公式の対応計画までは要求されないもの。
・Opportunity of Improvement; レビューチームによる改善提案

レビューの結果、緊急に是正しなければならないような臨界安全上のハザードは見出されなかった。一部の、あるいはほとんどのサイトで見出された前記5項目の主な内容を以下に示す。

(i) Noteworthy Practice

LANL では、環境・安全・保健部門(ESH-6)のスタッフと核物質技術(NMT)スタッフとの作業エリアでの交流(インタラクション)は模範とすべきものであった。

(ii) Positive Attribute

・組織として臨界安全担当の配置
・臨界安全管理に対する運転員、監督者の理解
・臨界安全スタッフと運転員との交流(インタラクション)
・DOE の現地事務所(Operation Office, Site Office)の担当者がかなりの時間、施設に

滞在し、定期的なプログラム・アセスメントを実施していること

など

(iii) Safety Issue

見出されたSafety Issueの中で重要なものとして、Y-12では以下の2つが指摘され、公式の改善計画が必要とされた。

・核物質の移動に関する管理の不十分さ

・臨界安全管理の運転上の遵守状況のサイトレビューの不十分さ

(iv) Weakness

いくつかのサイトウィークポイントとして以下が上げられていた。

・臨界安全管理方法が複雑で運転員が理解するのが難しい場合がある

・臨界安全スタッフが、施設、工程を理解するため、あるいは運転員へ役立つ情報を提供する機械としての運転員との交流(インタラクション)が不十分。

・運転員の十分な関与がないままに管理方法が定められ、運転員が必ずしも臨界安全制限値や管理方法に対する技術的根拠を理解していない場合がある。

・臨界安全評価の技術的根拠が十分文書化されていない場合がある。

・運転契約者側の臨界安全プログラム・レビューが十分に包括的なものでなかったり、臨界安全の実務を良く知った熟練した者が参加していない場合がある。

・DOE フィールド・オフィスには、十分な臨界安全専門家がおらず、また、運転管理契約者側に対する十分な監督を行うために必要な正式のプログラムがない。

・DOE では臨界安全スタッフのトレーニングと資格のためのガイダンスを策定しているが、(DOE-STD-1135-99, Guidance for Nuclear Criticality Safety Engineer Training and Qualification)、このガイダンスを適用させるための規定をまだ制定していない。DNFSB の 97-2 勧告に対する DOE の実施計画には、このガイダンスに適合させることを運転契約上の要求事項として制定することが含まれているが、既に計画の期限は過ぎており、未だ実施されていない状態である。

など

(v) Opportunities for Improvement

・臨界管理とそれらの技術的根拠が理解されていることの確保

・手順と管理の確実な遵守の確保

・フィードバック及び改良プロセス(システム)の改善

・ANSI/ANS 基準との矛盾を解消するための DOE オーダー及びガイダンスの改訂

・DOE field office の臨界安全プログラムの強化

Self-Assessment の結果、見いだされたウィークポイントに対する対応計画の立案・実施に関するガイドラインとして、以下が発行されている。

・Memorandum: Corrective Action Plans for Identified Self-Assessments (3/17/2000)

(別冊 別添資料8)

(4) NRC の対応

(a) NRC Temporary Instruction 2600/005 (10/12/99)

"Criticality Safety Programs at Fuel Cycle Facilities"

(http://www.nrc.gov/NRC/IM/2600_005.html#_1_12 、別冊の別添資料9 参照)

これは、カテゴリ1の加工施設(高濃縮ウラン取扱施設)及び2つのガス拡散プラントの駐在検査官に対して、臨界安全に関する補足的な検査要求の指示である。その概要を以下に記す。

・中・高濃縮ウランが低濃縮ウランに混合されることがないことの確認

・中・高濃縮ウランのマニュアルによる移送や処理を含む作業について NRC の要求と施設の規則・手順を遵守していることの確認。特に運転管理の実施状況に着目。操作員との議論により、安全要求事項と異常が生じた場合のとるべき行動について理解していることの確認。操作員が適切にトレーニングされ、担当の操作・運転に対し資格認定されていることの確認。

・新規プロセスの運転開始あるいは1年以上の運転停止後の運転再開に先立って、中・高濃縮ウランを取り込む前に、運転スタッフが最新の運転手順、安全制限等についてトレーニングを受けてきていることを保証するための適切な管理が成されていることの確認。

・臨界事故の際の緊急時対応手順のレビュー。最後に対応訓練を実施した日が基準・規定を満足していることの確認。訓練で見出された改善点の措置状況のレビュー。

・臨界安全上重要なシステム、機器、計器の試験、校正、保守が適切に実施されていることの確認。

(b) NRC Information Notice No.99-31 (11/17/99)

"Operational Controls to Guard against Inadvertent Nuclear Criticality"

(http://www.nrc.gov/NRC/GENACT/GC/IN/1999/in99031.html、別冊の別添資料9 参照)

東海村臨界事故に対応して、各施設に活用できる情報のレビューと同様の事象を防止するために適切な対応を求めたものである。その確認事項の概要を以下に記す。

・ HEU と LEU の混合の可能性について考慮され、HEU が LEU に混合されることのないよう厳密な管理が制定されていること。

・ 特殊核物質(SNM; Special Nuclear Material)の取扱いを認められた操作員が臨界安全規則に関して適切なトレーニング及び再トレーニングを受け、運転制限値の重要性とそれお超えた場合の取るべき対応について理解していること。

・ 運転操作及び運転(組織)管理が承認された運転手順に従って実施されていること。

・ 新プロセスの開始及び長期停止後の再開時には、それが現行の安全評価で考慮されていること。SNM の受入れ前に、全ての管理が確立し実施されており、運転員のトレーニング及び再トレーニングが終了していること

・ 緊急時対応計画には、サイト内外の緊急対応者が施設の臨界安全面について知らされており、緊急対応時には適切な防護措置を受けることを確実にするよう、適切な準備が含まれていること。

・プラントの安全プログラムが効果的に実施され期待に添うものであることを確実にするために、マネジメントが高いリスクを伴う操作に対して適切なレベルの監視・監督を行って

いること。

(c) Industry Initiative

NEI (Nuclear Energy Institute) では、東海村臨界事故の対応として、前記(b)に呼応して商業用ウラン処理施設のレビューを実施した。そのレビュー報告は以下のウェブサイトに公開されている。

(http://www.bazley.net/NEIreport.html、別冊の別添資料9 参照)

レビュー対象を以下に示す。

・5つの加工施設(LEU)　　・2つの燃料施設(HEU)

・2つのガス拡散プラント　　・1つのウラン転換施設

レビューでは、以下に示す東海村臨界事故に至らしめた9つの影響因子(contributing factors)に着目して施設当たり15-20時間を費やして行われた。

① コスト削減やスケジュール優先という圧力により、許可された手順からの逸脱を許容する文化

② 無許可の手順の明白な存在と、公式の手順から逸脱してよいという定常的な傾向による手順上の逸脱に対する暗黙の了解

③ 不十分な臨界安全プログラム、二重偶発性の原則の適切な適用及び(人的管理、運転管理ではなく)工学的管理の最大限の適用の不十分さ、

④変更管理(change control)、めったに行われない運転・操作の開始／再開の手順、及び機器配置管理(configuration management)を含む運転管理、組織管理の不十分さ

⑤ 臨界の可能性、臨界事故の重大性及び手順の遵守についての作業員のトレーニングの不十分さ

⑥特に未熟な作業員や通常と異なる操作に関して、監視、監督、臨界に関する自己評価(self-assessment)の不十分さ

⑦ 臨界の可能性や放射線状況をモニタする機器の不十分さ

⑧ 特に、長期継続事象の終息、タイムリーな通知、被ばく者のケアに関して、緊急時対策計画十分さ

⑨ 規制側の監視・監督の不十分さ

その結果、緊急に対策が必要となるような状況は見出されなかった。一部では、実際の行動がマネジメントの期待やスタンダードに達していない場合も見られたが、その場合にには、レビュー・チームが、考慮すべき事項、対応が必要な事項として指摘した。また、レビュー・チームは良好事例(Best Practice)も抽出している。全体を総括して、施設の安全を損なうような規則・手順からの逸脱、行動あるいは状況はなかった。

また、規制側、マネジャー、エンジニア、及び運転員が臨界事故の可能性はあり、そして事故は「ここで」起こり得るという共通認識をもっており、これが安全の継続に有効な寄与を成している。

3. 9 臨界安全の手順違反とその傾向

(Procedure Violations and Infraction Tracking and Trending)

・View from DOE-HQ/EH

DOE Site do it differently - That's OK

DOE-wide Guidance - Focus on Process

Pursuing a "Perfect Process", "Perfect Procedure"

Replace or Augment Procedural Control

- Whenever practical
- To minimize risk for $$$$ spent

・各施設から、作業手順上の違反の種類と件数の推移等について報告された。

違反例の具体的内容については別冊の別添資料10(Operating Experience Weekly Summary、仮訳)参照。これらの違反例は、事象報告処理システム(ORPS;Occurrence Reporting and Processing System)から臨界に関するものを抽出したものである。なお、ORPS は、DOE 施設で発生した、作業員、公衆の安全、環境、核物質の保障措置、防護措置、施設の運転機能、あるいはDOEの評判などに対して有害な影響を与えるまたはその恐れのある事象についての報告システムであり、報告内容はデータベース化されている。かなり軽微な内容まで報告されているものもある。ORPS については、http://tis.eh.doe.gov/web/oeaf/orps/orps.html を参照。

発生した異常事象は、データベース化されており、それらの臨界安全に関する統計結果が示された報告もあったが、この中で7割～8割は、マネジャーか運転員に原因があると報告されていた。

・臨界安全に関わる異常事象のカテゴライゼイション

(http://drambuie.lanl.gov/~esh7/matrix/ 参照)

臨界安全に関わる異常事象に対して、安全余裕の喪失の程度による"unusual","off normal"、及び(not reportable)の簡単な分類方法の説明がなされた。1つは、通常時に有していた安全確保上のバリアがどれだけ失われたかによるもの、1つは、keff(通常時)とkeff(異常時)との差△keffの(1-keff(通常時))に対する相対割合によるものである。

3. 10 臨界警報装置の設置と廃止の基準

・ANSI/ANS-8.3 (Criticality Accident Alarm System)の議論、解釈の議論

・各サイトの臨界警報装置(CASs; Criticality Alarm Systems)の使用経験の報告

SRS では、ミッションの変化により、使用しない設備は deinventorized & cleaned されている。サイト NIM 委員会が CAS の設置／廃止の許可を与えている。CAS の台数の変遷を以下に示す。

年	94	95	96	97	98	99
台数	199	188	147	152?	92	91

RFFO からは、種々のタイプの CAS を臨界事故を模擬した照射場で試験し、どのような条件で使用可能か調査した報告があった。イオンチャンバーがアクセプタブルということであった。

3. 11 規制活動状況 (Regulatory Activity Status)

The Guide (DOE G 421.1-1) and the Order (DOE O 420.1; the Rule (10 CFR part 70) and the NRC SRP (Chapter 5 of NUREG 1520)

3. 8節で述べた"DOE Nuclear Criticality Self-Improvement Initiative"活動の一環として実施された臨界安全エキスパート・チームによる DOE の主要施設に対するレビュー結果として以下の指摘が成された。

DOE では臨界安全スタッフのトレーニングと資格のためのガイダンスを策定しているが(DOE-STD-1135-99, Guidance for Nuclear Criticality Safety Engineer Training and Qualification)、このガイダンスを適用させるための規定をまだ制定していない。DNFSB の 97-2 勧告に対する DOE の実施計画には、このガイダンスに適合させることを運転契約上の要求事項として制定することが含まれているが、既に計画の期限は過ぎており、未だ実施されていない状態である。

この指摘に対応して、DOE では、"DOE O 420.1, Facility Safety"の改訂作業を行っており、臨界安全技術者のトレーニングと資格プログラムの計画の策定と提出をサイト側に要求することとしている。

(1) DOE O 420.1, Section 4.3(臨界安全)の変更事項(案) (別冊の別添資料11 参照)

変更は臨界安全技術者のトレーニング／資格プログラムの実施を要求するものである。このプログラムの要求は、DNFSB の 97-2 勧告(臨界安全)に対する DOE の実施計画における誓約を満足させるものである。

現状、変更は臨界安全技術者のトレーニング／資格プログラムは、その正式さの程度や厳密さにおいて幅広い異なりを示している。DOE は 97-2 実施計画において、臨界安全技術者のトレーニング／資格認定で用いる基準を改善するためのガイダンスの策定とその適用を誓約している。今回の変更案は、その誓約を満足させるものであり、臨界安全スタッフが十分な知識をもち。臨界安全の概念、方法及び実践(実務)について熟知していることを確実にするものである。

変更案は、最初、"DOE N 420.1, 臨界安全技術者のトレーニング／資格"として 2000 年 2 月 28 日に Field Manager Council(FMC)へ提出されたが、レビューした結果、これを DOE O 420.1 の中に入れることがより適切であると決定されたものである。

DOE O 420.1、4.3.3 のｌ、トレーニング／資格(案)の記述を以下に示す。

臨界安全スタッフのトレーニング／資格プログラムが実施されなければならない。DOE-STD-1135-99,"Guidance for Nuclear Criticality Safety Engineer Training and Qualification"は、DOE との契約者がこのこの要求を満たすため

にプログラムを策定する場合のガイダンスとなる。トレーニング／資格プログラムはグレイド・アプローチ(graded approach)を用いて実施すべきである。このグレイド・アプローチは、臨界安全技術者個々の義務と責任に基づくべきで、さらに、臨界安全をあらゆる観点で保証するために適切な優先度を制定すべきである。

変更案が承認された場合の、その後の予定は以下のようになる。

a. 改訂の施行日より 60 日以内に、臨界安全技術者のトレーニングと資格制度についてのプログラム計画を策定し、DOE Field Elements のレビューと承認のために提出すること
b. 計画には、適切な臨界安全スタッフが資格認定を終了する予定日を含めること
c. DOE Field Elements は承認した計画のコピーを Lead Program Secretarial Officers と臨界安全に関するDOEの97-2実施計画の責任者(研究開発、シミュレーション局(DP-10)の Assistant Deputy Administrator)へ提出すること
d. トレーニング／資格制度のプログラム計画は総括トレーニングプログラムの一部として制定されたスケジュールに従って更新していくこと

(2) その他

・DOE-STD-3007-93(CH-1); Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities
(http://tis.eh.doe.gov/techstds/standard/appframe.html 参照)

・Regulatory Activity Status of the Rule (10 CFR Part 70) & the U.S. NRC Draft Standard Review Plan (SRS) (NUREG 1520) (別冊の別添資料 11)

"Proposed Rule for Nuclear Fuel Fabrication Facilities, 10CFR Part 70 Subpart H"
(http://ruleforum.llnl.gov/cgi-bin/rulemak 参照)

"Standard Review Plan (SRP) , Structure"
(http://teckconf.llnl.gov/cgi-bin/topics 参照)

4. 米国原子力学会(ANS)の基準第8小委員会会合、ライティングGrミーティング

4.1 全体会合

3月30日、NCTSPを開催した大部屋から、1/4くらいの中部屋へ移動してロの字形に囲むような配置で開催された。スペースが足らず、テーブルの後ろに椅子を持ち込んで座る人が20名くらいいた。私は部外者ながら、早めに入ったせいもあり、議長であるLANLのT.McLaughlinの一人おいた隣に座ることになってしまい恐縮した。

全体会合では、まず、全員の自己紹介(名前と所属のみ)から始まり、昨年11月18日にワシントンで行われた前回会合の議事録の承認、のうち、交代した議長のあいさつ(ANS-8.16のCalvin Hopper、ANS-8.23がLANLのJ,S,Baker)、その後ANS-8.1から8.25までの各ライティングGr議長よりの改訂あるいはメンテナンス作業の進捗状況報告が行われた。

この中でBNFLのMOXのデータ偽造問題の話がで、BNFLの参加者より安全上の問題ではなくQA上の問題であると述べていたのは英国NIIの調査報告書と同じ立場であった。

ANS-8の各基準の現行の承認バージョン及び作業状況を次表に示す。

(http://www.wxsms.com/ans/Products/projects.htm 参照)

Table 4 ANS-8 Products and Status

Standard	Title	ANSI Approval	Status	Chairman
ANS-8.1	Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors	1998	M (03)	A.S.Garcia
ANS-8.3	Criticality Accident Alarm System	1997	M(02)	D.A.Reed
ANS.8.5	Use of Borosilicate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material	1996	M(01)	N.Ketzlach
ANS-8.6	Safety in Conducting Subcritical Neutron-Multiplication Measurements In Situ	1983; Rf 9/12/95	M(00)	T.E.Valentine
ANS-8.7	Guide for Nuclear Criticality Safety in the Storage of Fissile Materials	1998	M(03)	C.M.Hopper
ANS-8.9	Nuclear Criticality Safety Criteria for Steel-Pipe Intersections Containing Aqueous Solutions of Fissile Materials	1987; Rf 6/12/95	M(00)	F.M.Alcorn
ANS-8.10	Criteria for Nuclear Criticality Safety Controls in Operations with Shielding and Confinement	1983; Rf 2/4/99	M(04)	B.L.Lee
ANS-8.12	Nuclear Criticality Control and Safety of Plutonium-Uranium Fuel Mixtures Outside Reactors	1987; Rf 2/17/93	R(01)Xtn Revision in progress	M.K.Sheaffer
ANS-8.14	Use of Soluble Poisons		N Exp. data being analyzed, draft revised	T.A.Reilly
ANS-8.15	Nuclear Criticality Control of Special Actinide Elements	1981; Rf 9/12/95	Rv(00) WG convened	N.L.Pruvost
ANS-8.17	Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors	1984; Rf 3/20/97	M(02	B.O.Kidd
ANS-8.19	Administrative Practices for Nuclear Criticality Safety	1996	M(01)	R.W.Carson,Jr
ANS-8.20	Nuclear Criticality Safety Training	1991	M(96)Xtn Bal. for Rf	M.R.Crowell
ANS-8.21	Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors	1995	M(00)	H.Toffer
ANS-8.22	Nuclear Criticality Safety Based on Limiting and Controlling Moderators	1997	M(02)	J.S.Bullington
ANS-8.23	Nuclear Criticality Accident Emergency Planning and Response	1997	M(02)	J.S.Baker
ANS-8.24	Verification and Validation		N	R.D.Busch
ANS-8.25	Postings		N	J.R.Davis

Legend: M = Maintenance; N = New; Rf = Reaffirmation; Rv = Revision; Xtn = Extension

4. 2 ライティングGrミーティング

全体会合の後に個別のライティングGrミーティングが行われた。ANS-8 の中でも基本となる基準のANS-8.1のミーティングが午後からとなったので、午前中の残りの時間の30分程度だけ新規基準であるANS-8.24のほうへ出席し、午後からはANS-8.1の方へ出席した。

ライティングGrミーティングは、いずれも小部屋に10人程度集まって行われる。一人はノートパソコンで記録をとっていた。

(1) ANS-8.24: Validation of Calculational Methods for Nuclear Criticality Safety

Chairman, R.D.Bush (UNM)

新設の基準の作成作業にかかっているところである。現状の進捗状況についてよく把握できなかったが、おそらく Forward の部分と思われる文章の以下の修正案が作成されていた。議長が文章を提案し、一人がホワイトボードに書き込み、メンバーがいろいろ修文をコメントしてその場で確認していた。

> This Standard provides guidelines for Validation including establishing applicability of neutron transport calculational methods used in determining critical or sub critical Conditions for NCS analysis.

また、Extended Needs として、以下が提案された。

- Area of Applicability
- Guidance on using bias & uncertainty
- Guidance on using bias (determining bias)
- Increased importance of validation due to need for optimization & increased flexibility in Ops(?)
- Reduced number of Experiments

(2) ANS-8.1: Nuclear Criticality safety in Operations with Fissionable Material Outside Reactors

Chairman, Adolf Garcia (DOE-ID)

メンテナンス作業を行っている。恐らく本文の確認は終わっているようで、各種の臨界制限値見直しの計算作業を開始しようとしているところのようであった。議長がメンバーの使用できる計算コード、データ等を確認し、作業分担を決めていた。

均質、非均質についてどうするかの議論があったようだが、結論には至らなかった。また、既にある臨界ハンドブックとの ANS-8.1 の表との位置づけ、違いについての議論もあった。議長はDOEの人であるが、臨界計算そのものについては詳しいわけではないらしく、個別の詳細は E-mail でやりとりすることとなった。

計算コード;

- MCNP4XU, ENDF/B-VI ライブラリ
- SCALE4.4/KENO-V.a, 238Gr ライブラリ

・MONC8, JEF2.2 ライブラリ
・ONEDANT/TWODANT

物質;

Pu-239, U-235, U-233

UF_4, UF_6, UO_2, UO_3, U_3O_8, UH_3, UCO_3, U_3Si_2, UAl_x, UO_2F_2, $UO_2(NO_3)_2$,
PuF_3, PuF_4, PuO_2, $PuCF_2$, $Pu(NO_3)_4$,

U 濃縮度 5～10%、 (30%、100%)

計算対象;

質量、球半径、円柱直径、平板厚、面積密度、濃度

また、基準にする際のデータの出所を明らかにするために、基準化する前に Nucl.Technol.や Nucl,Sci.Eng.などのジャーナルで公開する必要があることが議長より話があった。これには時間を要することになる。

作業はボランティアのようで、メンバーが計算作業を行うことは結構な作業量となるため、作業の位置づけを明確にするために、議長よりメンバーに対して必要であれば ANS-8 より(依頼の)レターを出すが、どのようなレターがよいかなどと配慮がなされていた。

また、ミーティング参加費等の予算の問題もあり、集まって行う会合を ANS ミーティング(年2回)に会わす等の話し合いなどももたれた。

5. あとがき

今回、臨界安全技術プロジェクトワークショップ(NCTSP)に始めて参加した。これまでこのワークショップに参加した人はサイクル機構内では、95 年に1名、99 年に1名、機構外でもごく少数である。これは、はじめににも述べた通り、このワークショップが学会のような研究開発発表会ではなく、DOE の臨界安全に関する連絡会的性格のものであること、つまり、公開のワークショップであり外部参加者からの自由なコメントを歓迎するという立場ではあるが、実質 DOE の内部連絡会であり、当然 DOE 自身を対象とした話題が主体であり、組織、基準等の体系やプログラム・プロジェクトの名称、内容等の背景情報や情勢が分からないと内容を把握するのがむずかしいことが上げられる。

しかしながら、DOE といういくつもの核物質取扱施設を有する巨大な組織が、総体として臨界安全安全確保の維持と向上に努力を示す態度、すなわち継続的かつ体系的、実用的なプログラム活動は、感銘させられることが多かった。1企業や1機構が DOE の活動をそのまま適用できるものではないと思われるが、臨界安全技術者としてその精神は大いに鼓舞されるものである。このような活動の根底には、DOE では高濃縮ウランや多量のプルトニウムの取扱量が多いため、なにかミスを犯したらそれだけ臨界事故に繋がる可能性が高まり、事故は起こり得るという環境と、その認識の高さがあり、それ故の活動レベルの高さがあるのではないかと個人的に感じた。

また、NCSP の中で、情報保存と普及のためのデジタル保存やウェブサイトの活用、臨界安全技術者のトレーニング／資格認定制度などは考慮に値すべき活動と考える。

今回、単にワークショップに参加したのみでは、前述したような状況のために内容を十分把

握するの無理なところもあるが、ほとんどの背景情報やレポート類はウェブサイトで公開されており、これらを調査することにより十分フォローできるものである。本報告書でも後日の調査によりかなりの部分を補強したつもりである。

本報告書が、DOE の臨界安全活動の把握の一助に、また、サイクル機構の臨界安全確保の向上に繋がれば幸いである。また、このようなワークショップの存在を知り、今後、参加される方の背景情報として役に立てば幸いである。

6. 謝辞

本ワークショップの参加を認めて下さった山内再処理センター長ならびに小形技術主席、出張事務手続きをして下さった方々に感謝いたします。

また、3．9 項の別添資料9(Operating Experience Weekly Summary)は内田技術主務にお願いして翻訳していただいた。改めて感謝いたします。

添付資料1　　議事日程(アジェンダ)

NUCLEAR CRITICALITY TECHNOLOGY SAFETY PROJECT WORKSHOP

Albuquerque, New Mexico **March 27 - 31, 2000**

AGENDA OVERVIEW

Monday, March 27, 2000 --- *ad hoc* Meetings; Registration.

0800 - 1200 --- Registration.

0800 - 1700 --- *ad hoc* Meetings.

1300 - 1600 --- Registration.

Tuesday, March 28, 2000 --- NCTSP Sessions; Registration.

0800 - 1200 --- Registration.
0830 - 0845 --- Introduction and Opening Remarks.
0845 - 0900 --- The View from DOE.
0900 - 1000 --- Session I.
Break
1020 - 1130 --- Session II.

Lunch

1300 - 1600 --- Registration.
1300 - 1440 --- Session III.
Break
1500 - 1645 --- Session IV.
1645 - 1745 --- Session V.

Wednesday, March 29, 2000 --- NCTSP Sessions; Registration.

0800 - 1200 --- Registration.
0800 - 0940 --- Session VI.
Break
1000 - 1130 --- Session VII.

Lunch

1300 - 1330 --- Session VIII.
1330 - 1530 --- Session IX.

Thursday, March 30, 2000 --- Committees and Writing Groups.

0800 - 1030 --- ANS-8 Committee.

1030 - 1700 --- ANS-8 Writing Groups.

Friday, March 31, 2000 --- Writing Groups.

0800 - 1200 --- ANS-8 Writing Group.

NUCLEAR CRITICALITY TECHNOLOGY SAFETY PROJECT WORKSHOP

Albuquerque, New Mexico **March 27 - 31, 2000**

AGENDA GUIDE

***

NCTSP ad hoc Meetings
March 27, 2000

Registration: 0800 - 1200 and 1300 - 1600

Activity	Chairperson	Room	Time
DOE NCS Program Review	James Felty (SAIC)	Acoma	0830 - 1500
ANS-8.22 Nuclear Criticality Safety Based on Limiting and Controlling Moderators	Jack Bullington (WSMS)	Jemez	1400 - 1700
Endusers Group Meeting	Kevin Carroll (Y-12)	Acoma	1500 - 1700

***

Nuclear Criticality Technology Safety Project Workshop
NCTSP Technical Paper and Discussion Sessions
March 28 - 29, 2000
Acoma Room

Registration: 0800 - 1200 and 1300 - 1600 (March 28, only)

Nine Technical Sessions. See pages 3 through 9 for a detailed agenda.

***

ANS-8 Standards Committee and Writing Groups
March 30 - 31, 2000

ANS-8 Committee (Thomas McLaughlin (LANL), Chairman; John Schlesser (WSMS), Secretary) and **ANS-8.n [n = 1, 12, 14, 21, 24] Writing Groups** will meet.

See page 10 for further details.

PRELIMINARY AGENDA
NUCLEAR CRITICALITY SAFETY PROGRAM REVIEW
DOE ENERGY TRAINING COMPLEX
ACOMA ROOM
ALBUQUERQUE, NM
MARCH 27, 2000

8:30 Greeting and Administrative Announcements (Jim Felty)

8:45 Opening Remarks (Roger Dintaman and Hoyt Johnson)

9:00 Critical Experiments (Steve Clement)

9:40 Benchmarking (Blair Briggs)

10:20 Break

10:40 Analytical Methods (Mike Westfall)

11:20 Nuclear Data (Luiz Leal)

12:00 Lunch

1:30 Training and Qualification (Tom McLaughlin and Jim Morman)

2:10 Information Preservation and Dissemination (Tom McLaughlin and Song Huang)

2:50 Break

3:10 Applicable Ranges of Bounding Curves and Data (Calvin Hopper)

3:50 DNFSB Perspective (Joe Roarty)

4:00 Closing Remarks (Roger Dintaman)

4:10 Adjourn

NOTE: Each of the 7 program task areas will be presented as follows: 20 minute presentation by the task manager followed by a 20 minute question/answer period.

(Related ad hoc meetings may be conducted following the NCSP Review. The only constraint is that all must exit the DOE Energy Training Center by 5:30 PM.)

AGENDA

Nuclear Criticality Technology Safety Project Workshop
NCTSP Technical Paper Sessions
March 28 - 29, 2000
Acoma Room

NCTSP Agenda, Tuesday, March 28, 2000	Time
Registration	**0800 - 1200** **1300 - 1600**
Introduction and Opening Remarks: Burton Rothleder (DOE-HQ/EH)	0830 - 0845
The View from DOE: Burton Rothleder (DOE-HQ/EH)	0845 - 0900
Session I.	**0900 - 1000**
DNFSB Recommendation 97-2 Response Status	
Chairperson -- Adolf Garcia (DOE-ID)	
1. Nuclear Criticality Safety Program -- Introduction Roger Dintaman (DOE-HQ/DP)	0900 - 0910
2. Program Structure and Overview Jerry McKamy (DOE-HQ/EH), Calvin Hopper (ORNL <LMER>), and James Morman (ANL)	0910 - 0920
3. Nuclear Criticality Safety Program Training Thomas McLaughlin (LANL), William Casson (LANL/LACEF), and James Morman (ANL)	0920 - 0930
4. Nuclear Criticality Safety Qualification James Morman (ANL) and Jerry McKamy (DOE-HQ/EH)	0930 - 0940
5. Information Preservation Barbara Henderson (LANL), Norman Pruvost (Galaxy), and Roger Meade (LANL)	0940 - 0950
6. Nuclear Criticality Safety Program Web Site Song Huang (LLNL)	0950 - 1000
Announcements and Break	**1000 - 1020**

NCTSP Agenda, Tuesday, March 28, 2000

	Time
Session II.	**1020 - 1130**
Critical Experiment Programs at LANL and Sandia	
Chairperson -- Charlene Cappiello (LANL/LACEF)	
1. Nuclear Energy Research Initiative (NERI) Burnup Credit Experiment Program Gary Harms (SNL)	1020 - 1035
2. Waste Matrices Experiments Rene Sanchez (LANL/LACEF)	1035 - 1050
3. Time Dependent Benchmark Experiments Richard Paternoster (LANL/LACEF)	1050 - 1105
4. Equivalent Fundamental Mode Source Method for Validating Spontaneous Fission Rates Joetta Goda (LANL/LACEF)	1105 - 1120
5. LACEF Future Operations Richard Anderson (LANL/LACEF) and James Felty (SAIC)	1120 - 1130
Announcements and Lunch	**1130 - 1300**

NCTSP Agenda, Tuesday, March 28, 2000

	Time
Session III.	**1300 - 1440**
Tokaimura Criticality Accident: Lessons-Learned for the U.S.	
Chairpersons -- Thomas McLaughlin (LANL) and Robert Wilson (DOE-RFFO)	
1. Factual Overview of the Event Valerie Putman (INEEL <LMIT>)	1300 - 1330
2. Report from the U.S. Team Thomas McLaughlin (LANL)	1330 - 1350
3. Response from DOE-HQ Ivon Fergus (DOE-HQ/EH)	1350 - 1405
4. Response from NRC Dennis Morey (NRC)	1405 - 1420
5. Response from Various DOE Sites: Hanford, Y-12, INEEL, RFETS Robert Wilson (DOE-RFFO)	1420 - 1440
Announcements and Break	**1440 - 1500**

NCTSP Agenda, Tuesday, March 28, 2000

	Time
Session IV.	**1500 - 1645**
Criticality Safety Procedure Violations and Infraction Tracking and Trending	
Chairpersons -- Hans Toffer (Hanford <FFS>) and Thomas Reilly (WSMS)	
1. Procedure Violations and Infraction Tracking and Trending: The View from DOE-HQ/EH Ivon Fergus (DOE-HQ/EH)	1500 - 1515
2. Procedure Violations and Infraction Tracking and Trending: at the Y-12 Plant Kevin Carroll (Y-12 <LMES>)	1515 - 1530
3. Procedure Violations and Infraction Tracking and Trending: at the Savannah River Site David Dolin (SRS)	1530 - 1545
4. Procedure Violations and Infraction Tracking and Trending: at Lawrence Livermore National Laboratory John Pearson (LLNL)	1545 - 1600
5. Procedure Violations and Infraction Tracking and Trending: at the Hanford Site Alan Ramble (Hanford <FFS>), Blaise Mo (Hanford <FFS>), and Robert Richard (Hanford <FFS>)	1600 - 1615
6. Procedure Violations and Infraction Tracking and Trending: at the Los Alamos National Laboratory Stuart Vessard (LANL)	1615 - 1630
7. Procedure Violations and Infraction Tracking and Trending: at the Rocky Flats Environmental Technology Site Robert Wilson (DOE-RFFO)	1630 - 1645
Session V. Open Discussion	**1645 - 1745**
Recurring Scenarios in Criticality Safety Violations and Criticality Accidents	
Moderator -- Burton Rothleder (DOE-HQ/EH)	

NCTSP Agenda, Wednesday, March 29, 2000

	Time
Registration	**0800 - 1200**
Session VI.	**0800 - 0940**

Code Development, Nuclear Data, and Benchmarking

Chairperson -- R. Mike Westfall (ORNL <LMER>)

1. Analytical Methods R. Mike Westfall (ORNL <LMER>), Robert Little (LANL), Lester Petrie (ORNL <LMER>), and Roger Blomquist (ANL)	0800 - 0820
2. Nuclear Data Luiz Leal (ORNL <LMER>), Robert Roussin (ORNL <LMER>), Robert Little (LANL), and Donald Smith (ANL)	0820 - 0840
3. Applicable Ranges of Bounding Curves and Data Calvin Hopper (ORNL <LMER>), Bryan Broadhead (ORNL <LMER>), and Cecil Parks (ORNL <LMER>)	0840 - 0900
4. Benchmarking and ICSBEP Overview Blair Briggs (INEEL <LMIT>), Russell Mosteller (LANL/LACEF), and Richard McKnight (ANL)	0900 - 0920
5. Subcritical Measurements Technology Timothy Valentine (ORNL <LMER>) and Jim Gulliford (AEA Tech.)	0920 - 0930
6. Margins of Subcriticality for Safety Jim Gulliford (AEA Tech.)	0930 - 0940
Announcements and Break	**0940 - 1000**

NCTSP Agenda, Wednesday, March 29, 2000

	Time
Session VII.	**1000 - 1130**
Criteria for Inclusion or Exclusion of Criticality Alarm Systems (CASs)	
Chairperson -- Valerie Putman (INEEL <LMIT>)	
1. Introduction: The Effectiveness of ANSI/ANS-8.3 in Specifying When and Where CASs Are Needed Valerie Putman (INEEL <LMIT>)	1000 - 1015
2. The Logic of the Modifications to ANSI/ANS-8.3 in the DOE Criticality Safety Order Burton Rothleder (DOE-HQ/EH)	1015 - 1030
3. Experience with CAS Inclusion or Exclusion Decisions at Savannah River Site ~~Kenneth Yates~~ Debbie Briggs (WSMS <SRS>)	1030 - 1045
4. Experience with CAS Inclusion or Exclusion Decisions at Rocky Flats Robert Wilson (DOE-RFFO)	1045 - 1100
5. Experience with CAS Inclusion or Exclusion Decisions at Hanford Hans Toffer (Hanford <FFS>)	1100 - 1115
6. Experience with CAS Inclusion or Exclusion Decisions at Y-12 Kevin Carroll (Y-12 <LMES>)	1115 - 1130
Announcements and Lunch	**1130 - 1300**

NCTSP Agenda, Wednesday, March 29, 2000

	Time
Session VIII.	**1300 - 1330**

Regulatory Activity Status: The Guide (DOE G 421.1-1) and the Order (DOE O 420.1; the Rule (10 CFR Part 70) and the NRC SRP (Chapter 5 of NUREG 1520)

Chairperson -- Burton Rothleder (DOE-HQ/EH)

1. Revision Plans for the Good Practices Guide and the Order Burton Rothleder (DOE-HQ/EH-31)	1300 - 1315
2. The Status of the Rule and of Chapter 5 of the SRP Harry Felsher (NRC)	1315 - 1330

Session IX. Open Discussion	**1330 - 1530**

Current Effectiveness in Preventing Criticality Safety Violations and Criticality Accidents as Governed by the Following Factors:

Technology
- Critical and Subcritical Experiments
- Methodology and Computer Code Modeling
- Nuclear Data
- Benchmarking and Applications Data
- Loss of Technological Infrastructure

Competency
- Retention of Nuclear Criticality Safety Professionals
- Education of Nuclear Criticality Safety Professionals
- Training for Professionals and Technicians
- Education of, and Training for, Managers

Accountability
- M&O, M&I, and Commercial Advantage
- Work-Smart Standards
- Privatization
- Safeguards and Security

Regulation
- Standards, Orders, and Guides; Procedures and Postings
- Work-Smart Standards
- Integrated Safety Management
- Oversight
- Safeguards and Security
- Departmental Mission and Organization

Moderator -- Burton Rothleder (DOE-HQ/EH)

ADJOURMENT	**1530**

NCTSP Agenda, Thursday, March 30, 2000

	Room	Time
ANS-8: Standards Committee and Writing Groups		
ANS-8 Standards Committee Thomas McLaughlin (LANL), Chairperson and John Schlesser (WSMS), Secretary	Zuni	0800 - 1030
ANS-8.1 Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors Adolf Garcia (DOE-ID), Chairperson	Jemez	1030 - 1700
ANS-8.12 Nuclear Criticality Control and Safety of Pu-U Fuel Mixtures Outside Reactors Stewart Keeton (LLNL), Acting Chairperson Michael Sheaffer (LLNL), Chairperson	Nambe (1)	1030 - 1700
ANS-8.14 Use of Soluble Poisons Tom Reilly (WSMS), Chairperson	Nambe (2)	1030 - 1700
ANS-8.21 Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reacrors Hans Toffer (Hanford <FFS>), Chairperson	Pecos (1)	1030 - 1700
ANS-8.24 Validation of Calculational Methods for Nuclear Criticality Safety Robert Busch (UNM), Chairperson	Pecos (2)	1030 - 1700

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NCTSP Agenda, Friday, March 31, 2000

	Room	Time
ANS-8: Writing Groups		
ANS-8.1 (continued) Nuclear Criticality Safety in Operations with Fissionable Material Outside Reactors Adolf Garcia (DOE-ID), Chairperson	Jemez	0800 - 1200

NCTSP Agenda, March 27 - 31, 2000

Organizational Acronyms

Acronym	Organization
AEA Tech.	AEA Technology
ANL	Argonne National Laboratory
BWXT	BWX Technologies, Inc.
DOE	U.S. Department of Energy
-HQ	-Headquarters
/DP	/Defense Programs
/EH	/Environment, Safety and Health
-ID	-Idaho Field Office
-RFFO	-Rocky Flats Field Office
FFS	Fluor Federal Services
Galaxy	Galaxy Computer Services, Inc.
INEEL	Idaho National Engineering and Environm'tal Laboratory
LACEF	Los Alamos Critical Experiments Facility
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
LMER	Lockheed-Martin Energy Research
LMIT	Lockheed-Martin Idaho Technologies
NCTSP	Nuclear Criticality Technology Safety Project
NRC	U.S. Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
RFETS	Rocky Flats Environmental Technology Site
SAIC	Science Applications International Corp.
SNL	Sandia National Laboratory
SRS	Savannah River Site
UNM	University of New Mexico
WSMS	Westinghouse Safety Management Solutions

AMERICAN NUCLEAR SOCIETY STANDARDS COMMITTEE SUBCOMMITTEE 8 – AGENDA

U. S. DOE Energy Training Complex
Albuquerque, New Mexico
March 30-31, 2000

1. Welcome, discussion of agenda
2. Approval of ANS-8 meeting minutes, November 18, 1999, Washington, D. C.
3. Standards Activity Report – C. M. Hopper
4. Report of representatives of Other Standards Groups:
   a. ISO Activities – C. M. Hopper
   b. FUSCO Activities –
5. Reports from Work Groups:
   a. ANS-8.1 (Revision), Generic Criticality, A. S. Garcia
   b. ANS-8.3 (Maintenance), Alarm System, D. A. Reed
   c. ANS-8.5 (Maintenance), Raschig Rings, N. Ketzlach
   d. ANS-8.6 (Maintenance), In Situ Measurements, T. E. Valentine
   e. ANS-8.7 (Maintenance), Storage of Fissile Materials, C. M. Hopper
   f. ANS-8.9 (Maintenance), Pipe Intersections, F. M. Alcorn
   g. ANS-8.10 (Maintenance), B. L. Lee
   h. ANS-8.12 (Maintenance), Mixed Oxides, M. K. Sheaffer
   i. Proposed ANS-8.14, Use of Soluble Poisons, T. A. Reilly
   j. ANS-8.15 (Revision), Actinides, N. L. Pruvost
   k. ANS-8.17 (Maintenance), Fuel Element Safety, B. O. Kidd
   l. ANS-8.19 (Maintenance), Administrative Practices, R. W. Carson, Jr.
   m. ANS-8.20 (Maintenance), Training, M. R. Crowell
   n. ANS-8.21 (Maintenance), Fixed Absorbers, H. Toffer
   o. ANS-8.22 (Maintenance), Moderators, J. S. Bullington
   p. ANS-8.23 (Maintenance), Emergency Response, J. S. Baker
   q. Proposed ANS-8.24, V & V, R. D. Busch
   r. Proposed ANS-8.25, Postings, J. R. Davis
6. Old Business
7. New Business
8. Individual Work Group meetings – 1000-1800, Thursday, March 30, 2000
9. Progress reports and assistance – 0830-0930, Friday, March 31, 2000
10. Individual Work Group meetings – 0930-1600, Friday, March 31, 2000
11. Summary of Work Group progress – 1600-1800, Friday, March 31, 2000
12. Closing

添付資料2　発表 OHP 集

(March 27, 2000)

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U.S. Department of Energy
Nuclear Criticality Safety Program

NUCLEAR CRITICALITY SAFETY PROGRAM

PROGRAM REVIEW

ALBUQUERQUE, NM

MARCH 27, 2000

Presentation Slides

Opening Remarks (Roger Dintaman and Hoyt Johnson) *27kb*

NCSP Budget (Jim Felty) *16 kb*

Critical Experiments (Steve Clement) *2.8 Mb*

Benchmarking (Blair Briggs) *1.2 Mb*

Analytical Methods (Mike Westfall) *387 kb*

Nuclear Data (Luiz Leal) *80 kb*

Training (Tom McLaughlin)

Qualification (Jim Morman) *14 kb*

Information Preservation and Dissemination (Tom McLaughlin) *30 kb*

NCSP Web Site (Song Huang) *36 kb*

Applicable Ranges of Bounding Curves and Data (Calvin Hopper) *336 kb*

THE DEPARTMENT OF ENERGY NUCLEAR CRITICALITY SAFETY PROGRAM

- The Department of Energy (DOE) Nuclear Criticality Safety Program (NCSP) is focused on maintaining fundamental infrastructure that enables retention of DOE capabilities and expertise in nuclear criticality safety necessary to support line criticality safety personnel and improving the availability and use of criticality safety information, tools and guidance throughout the DOE complex.

Roger Dintaman, DP-17 March 2000

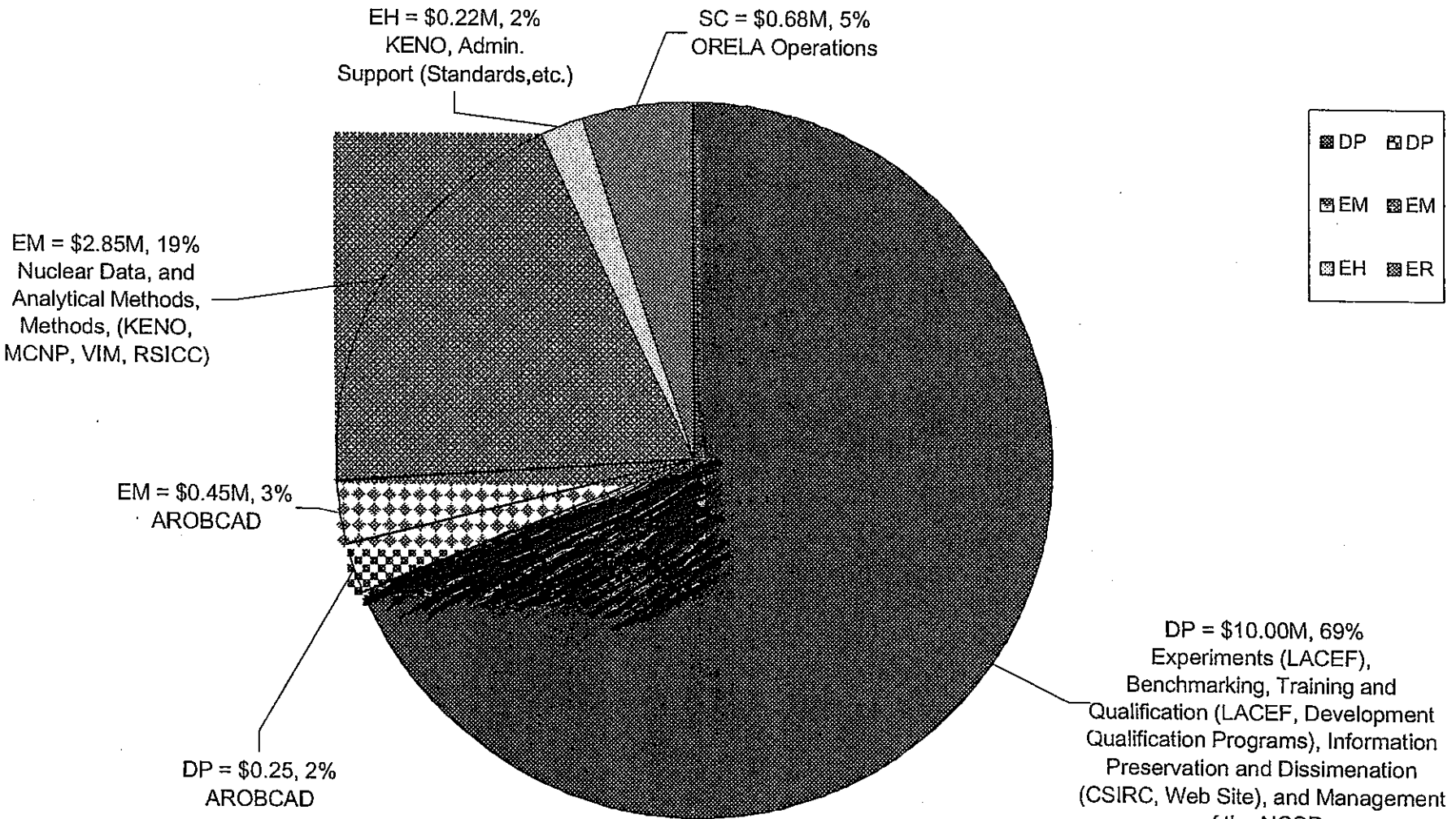
KEY ACCOMPLISHMENTS

- New 5-day Advanced Course at LACEF
- ZEUS First Critical - April 26, 1999
- New Qualification Standards (Federal and Contractor)
- CSSG Support
- Web Site Enhancements
- 7 NCSET Modules

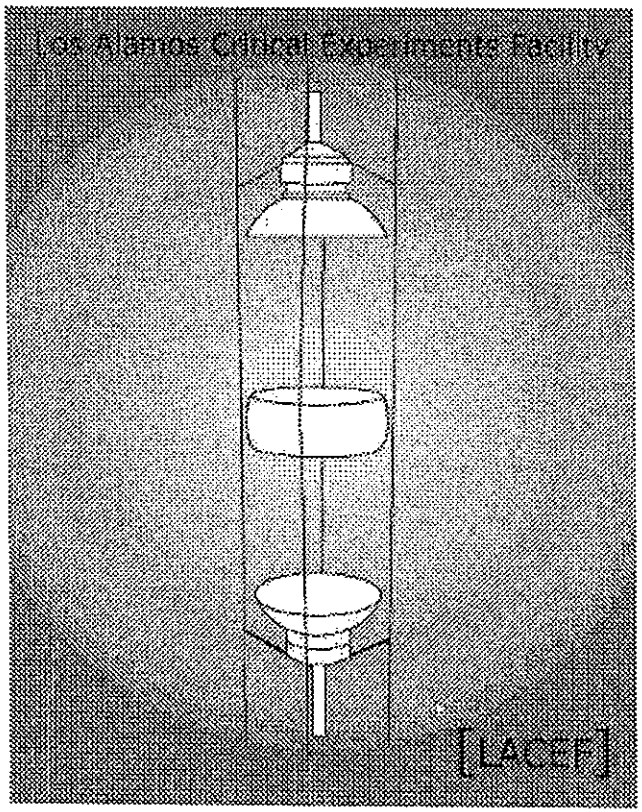
CHALLENGES

- Funding Stability
- Support for the Program
- Potential Relocation of TA-18
- Completion of Implementation Plan Milestones
- Meeting CS Community needs with limited resources

FY 2000 FUNDING FOR NCSP BY DOE OFFICE



Nuclear Criticality Safety Program Review



27 March 2000

Charlene Cappiello
William Casson
Steven Clement
Peter Jaegers
Rene Sanchez

Advanced Nuclear Technology, NIS-6

LA-UR-00-1389
Slide 1

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LACEF Support for NCSP

- Critical Experiments (LACEF)
- Criticality Safety Training (hands on)
  - Basic
  - Advanced
- Benchmarking
- Nuclear Data
- Code Development/Operations

Current LACEF Priorities

• Maintenance of capability	15%	1 FTE
– Training, maintenance, AB, etc.		
• Criticality safety courses	25%	1 FTE
– 2-, 3-, and 5-day courses		
• 97-2 experiments	60%	2 FTEs
– Intermediate energy spectrum		
– Waste matrices		
– CERES		
– etc.		

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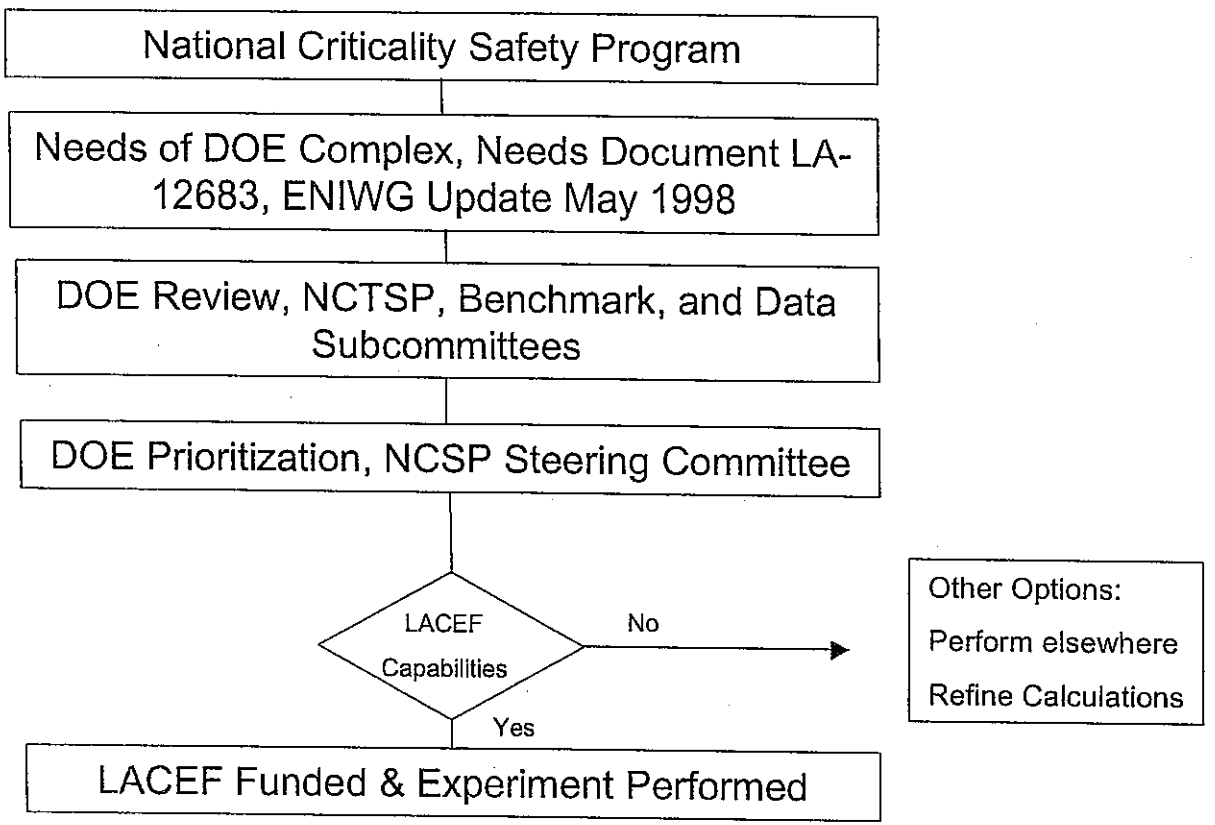
Critical Experiments National Consensus Process



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Critical Experiments Supporting DNFSB Recommendation 97-2

(From May 1998 Update)

Priority	Experiment Description
1	Intermediate-energy reactivity-worth and dosimetry experiments for non-fissile matrix materials. Zeus
2	Intermediate- and thermal-energy experiments with fissile material in specified waste matrices (e.g., Yucca Mountain tuff). Planet
3	Measurement of worth of CERES fission-product samples for support of burn-up credit. SHEBA
4	Single-unit and array experiments for pit storage and transportation, including experiments to simulate flooding/dissolution accidents.
5	Criticality accident simulation. Equipment and methodology qualification.
6	Critical mass measurements and neutron parameters for actinide isotopes.
7	Lattice experiments with MOX fuel pins.

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LACEF Experiments Currently Being Performed in Support of DNFSB Recommendation 97-2

- Experiments to support the top three priority 97-2 recommendations are underway
  - Zeus Intermediate Energy Spectrum Experiment
    - Initial graphite/HEU configuration complete
    - Many additional configurations and interstitial materials remain to be characterized
  - Planet waste matrix material experiments
    - SiO_2, Al, and MgO matrix materials complete
    - 12 additional matrix materials remain to be characterized with HEU before switching to Pu
  - SHEBA reactivity and replacement measurements
    - Initial replacement measurements complete (1-2 cent resolution)
    - Enhanced resolution of a sinusoidal actuator being developed (0.1 cent resolution)

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Slide 6

Other Ongoing Activities in Support of 97-2

- Fabrication of actinide materials for experiments
- Acquisition of CERES samples from the French
- Acquisition of Pu from Argonne West

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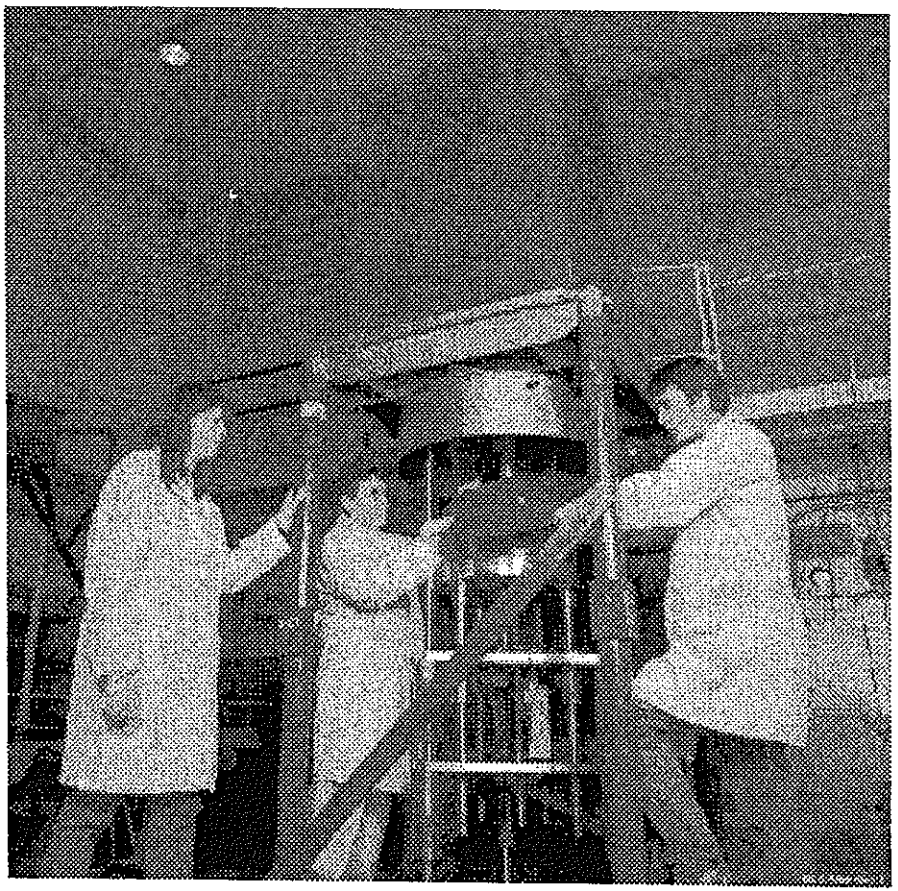
Zeus Experiment



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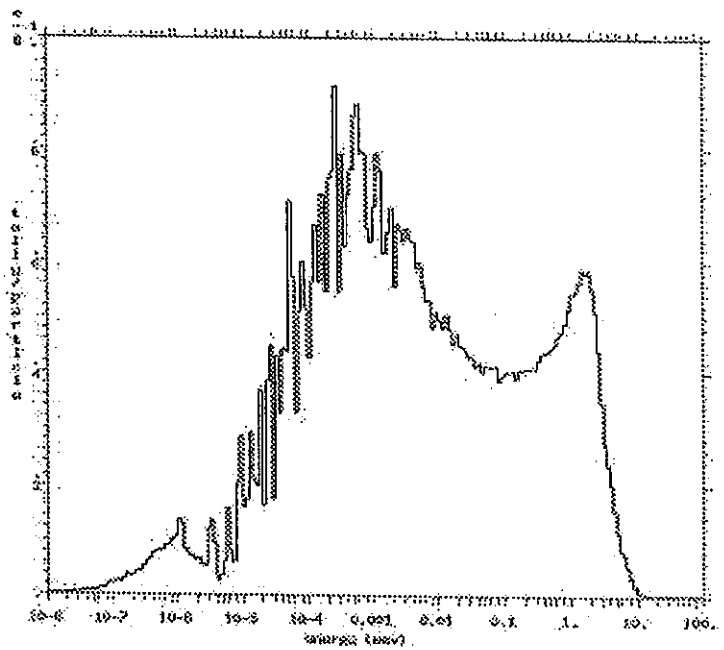
Preliminary Results from Zeus

- First Critical April 27, 2000
  - Benchmark Quality Predicted K_{eff} = 1.005 (Rel. 4, ENDF/B-VI)
- Other Measurements Performed
  - Sub-critical Rossi-alpha
  - Proton recoil neutron spectral measurements – internal and leakage
  - Reaction rate data using ^{239}Pu, ^{235}U, ^{233}U, In, Au Cu, Sc, Ti, Al, Mg, Zr, Fe, Rh, Ni, and V
- Planned Measurements
  - Super-critical Rossi-alpha
  - Critical position based on super-critical inverse period

Predicted Fission Rate Spectrum



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Slide 9

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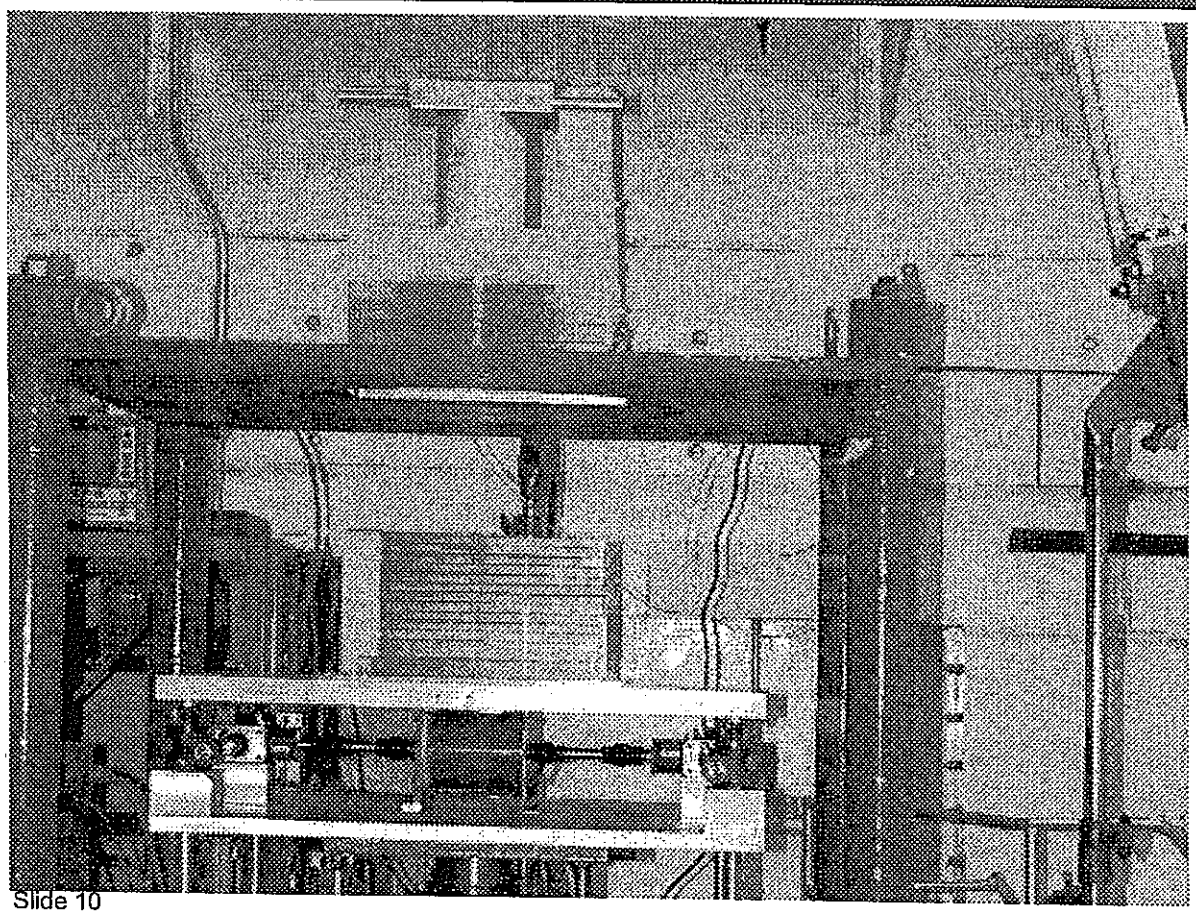
JNC TN8200 2000-006 (1/2)

Planet Assembly



Slide 10

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Preliminary Results from Planet

Diluent	X/^{235}U, H/^{235}U	Extrapolated Critical Mass	Predicted K_{eff}
SiO_2/ Polyethylene	Si/^{235}U = 21 H/^{235}U = 156	2285.3 g	1.02
Al/Polyethylene	Al/^{235}U = 60 H/^{235}U = 159	2609.1 g	?
MgO/Polyethylene	Mg/^{235}U = 18 H/^{235}U = 160	2950.8 g	?
Future Experiments SiO_2/Polyethylene	Si/^{235}U = 41 H/^{235}U = 89	?	?

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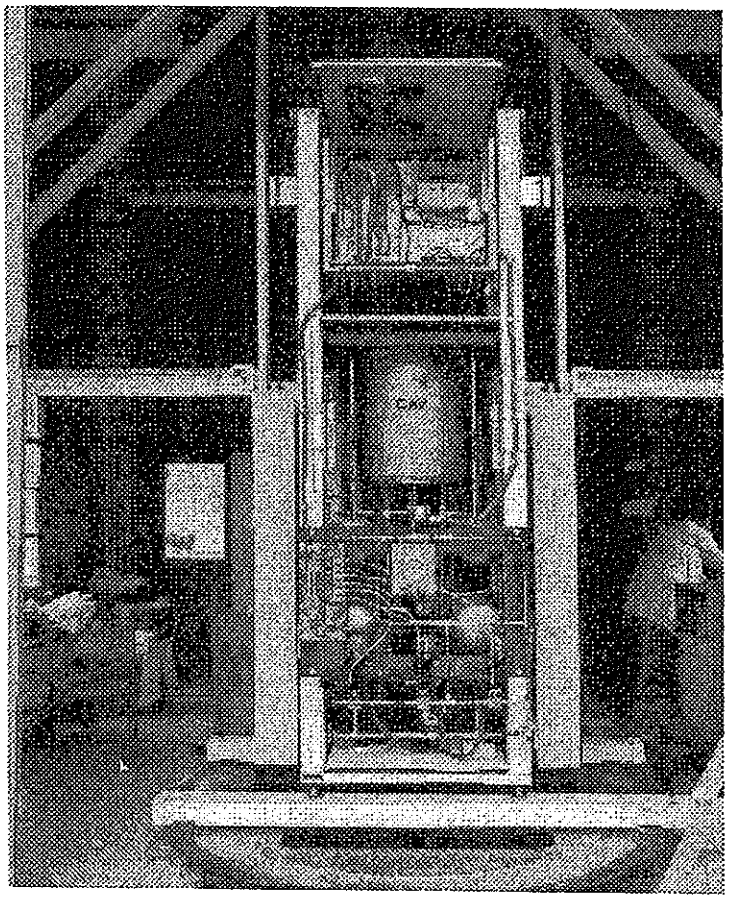
JNC TN8200 2000-006 (1/2)

SHEBA Assembly



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Milestones/Performance Objectives for FY00

- Zeus
  - Complete initial series of graphite/HEU experiments including step-wise reduction of the moderating material down to the all oralloy case
  - Will likely be delayed to FY01
- Planet
  - Complete experiments with six of the remaining twelve matrix materials
  - The future of Kiva 1?
- SHEBA
  - Complete SHEBA upgrades – 2nd quarter
  - Validate performance of new actuator – 3rd quarter
  - Identify source of funding to package and ship the CERES samples – 4th quarter

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JNC TN8200 2000-006 (1/2)

Criticality Safety Training

- Collaborative Effort with ESH-6
- LACEF Provides Hand-On Experience with SNM
- 3-Day and 5-Day Basic Courses
  - Hand stack of class foils (1/M approach to critical)
  - Free run on either Flattop or SHEBA
- 5-Day Advanced Course
  - SHEBA free run
  - BeRP Ball Demonstration
  - Planet critical with modified distributions

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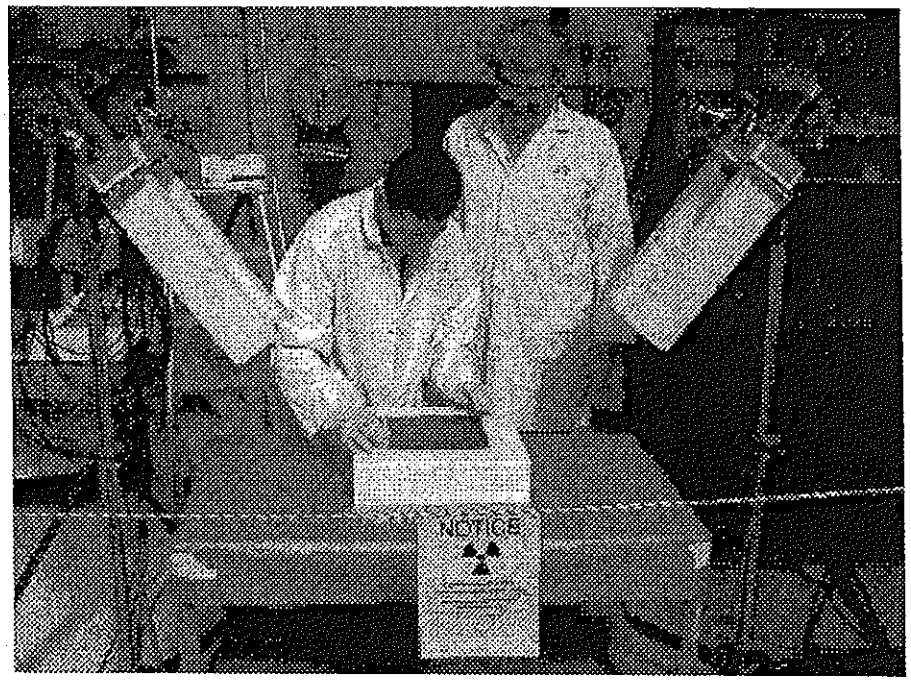
Basic 3 and 5-Day Courses



- Hand stack class foils
- Observe the effects of multiplying systems
- Go critical on Planet

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Slide 15

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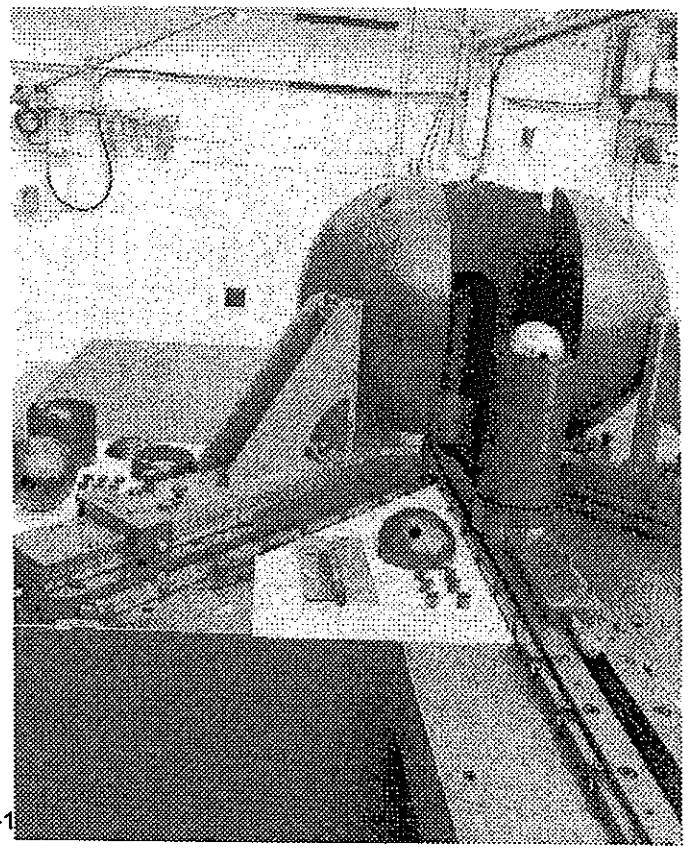
JNC TN8200 2000-006 (1/2)

Basic 3 and 5-Day Courses
(continued)



- Flattop Free Run
- SHEBA Free Run

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Slide 16

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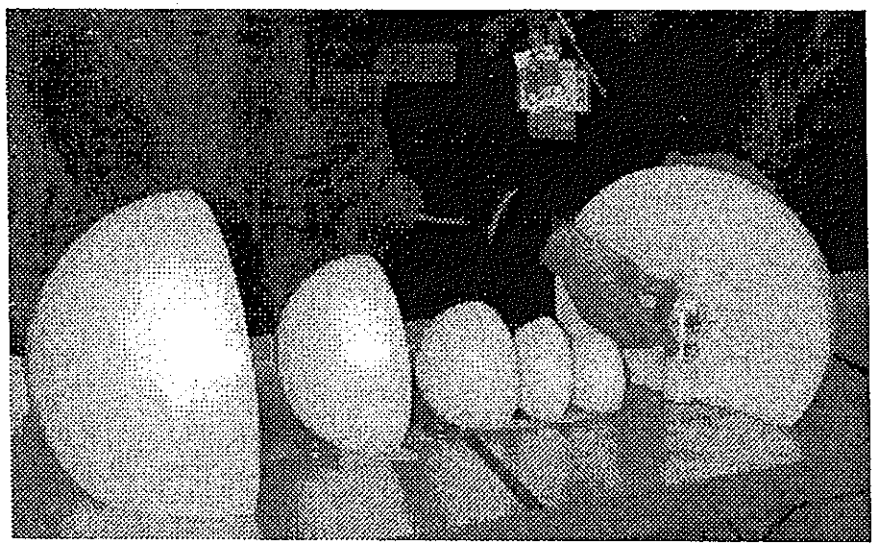
5-Day Advanced Class

(BeRP Ball Demonstration)



BeRP Ball "Infinitely" Reflected by Polyethylene

BeRP Ball Enclose in Copper "Dog House"



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Slide 17

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JNC TN8200 2000-006 (1/2)

Benchmarking, Nuclear Data, and Code Development

- Provide data for benchmark program
  - Zeus intermediate energy spectrum
  - Planet waste matrix materials
- Nuclear Data
  - Replacement measurements on the CERES samples
    - Support the evaluation of spent fuel shipping container loading limits
  - Cross section measurements
- Code Development
  - Fundamental nuclear data for benchmarking codes
    - Unique experiments (i.e., neutron lifetime)

Publications, Presentations, and Conferences
(general communication with the outside world)

- International Conference on Nuclear Criticality Safety (ICNC'99), Versailles France
  - 5 Publications
- PHYSOR 2000
  - 1 Publication
- ANS Winter Meeting 1999
  - 1 Publication
- ANS Summer 2000
  - 2 Publications
- Various NCSP Program Meetings
  - This meeting
  - Benchmark program in Russia

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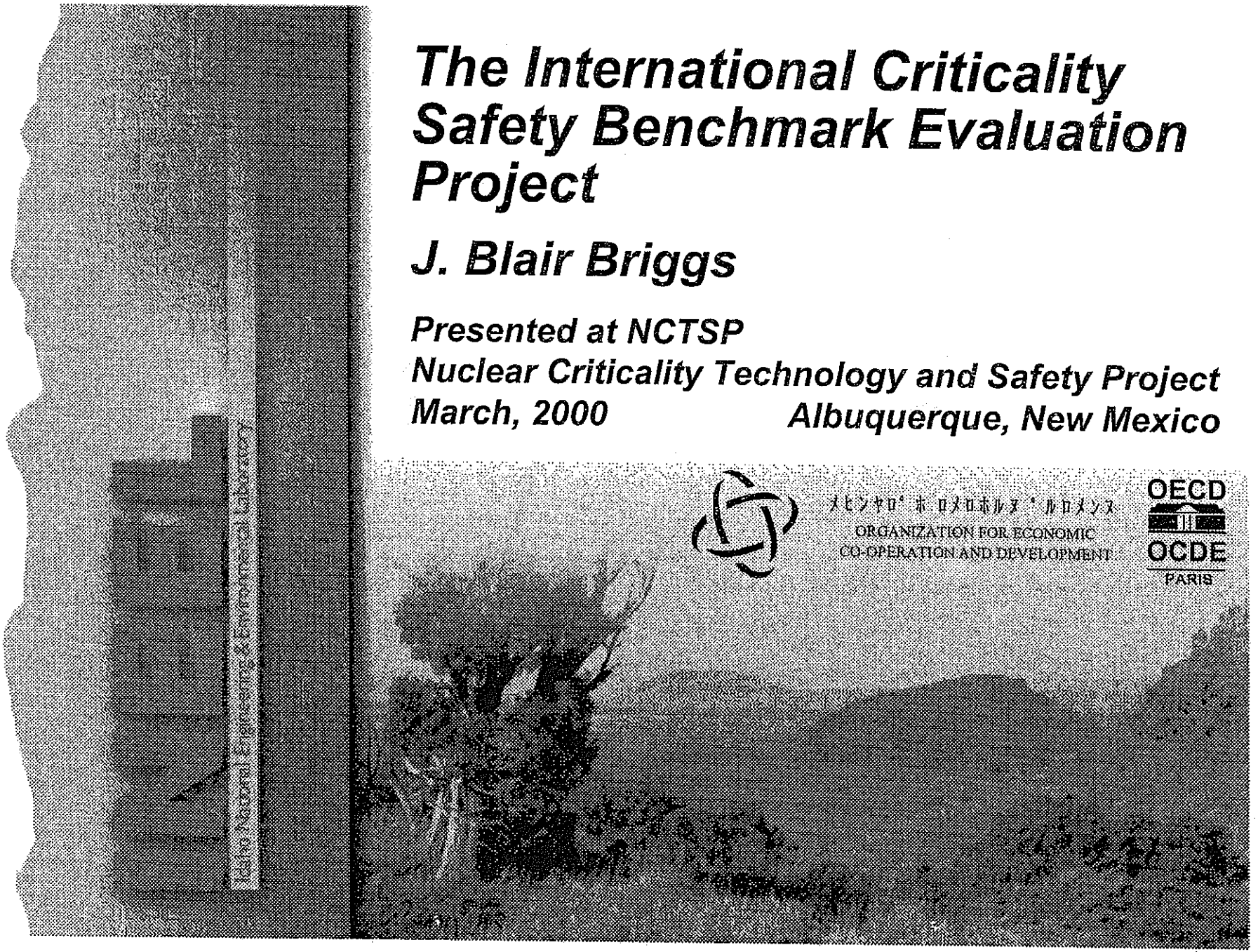
JNC TN8200 2000-006 (1/2)

The International Criticality Safety Benchmark Evaluation Project

J. Blair Briggs

Presented at NCTSP
Nuclear Criticality Technology and Safety Project
March, 2000 *Albuquerque, New Mexico*



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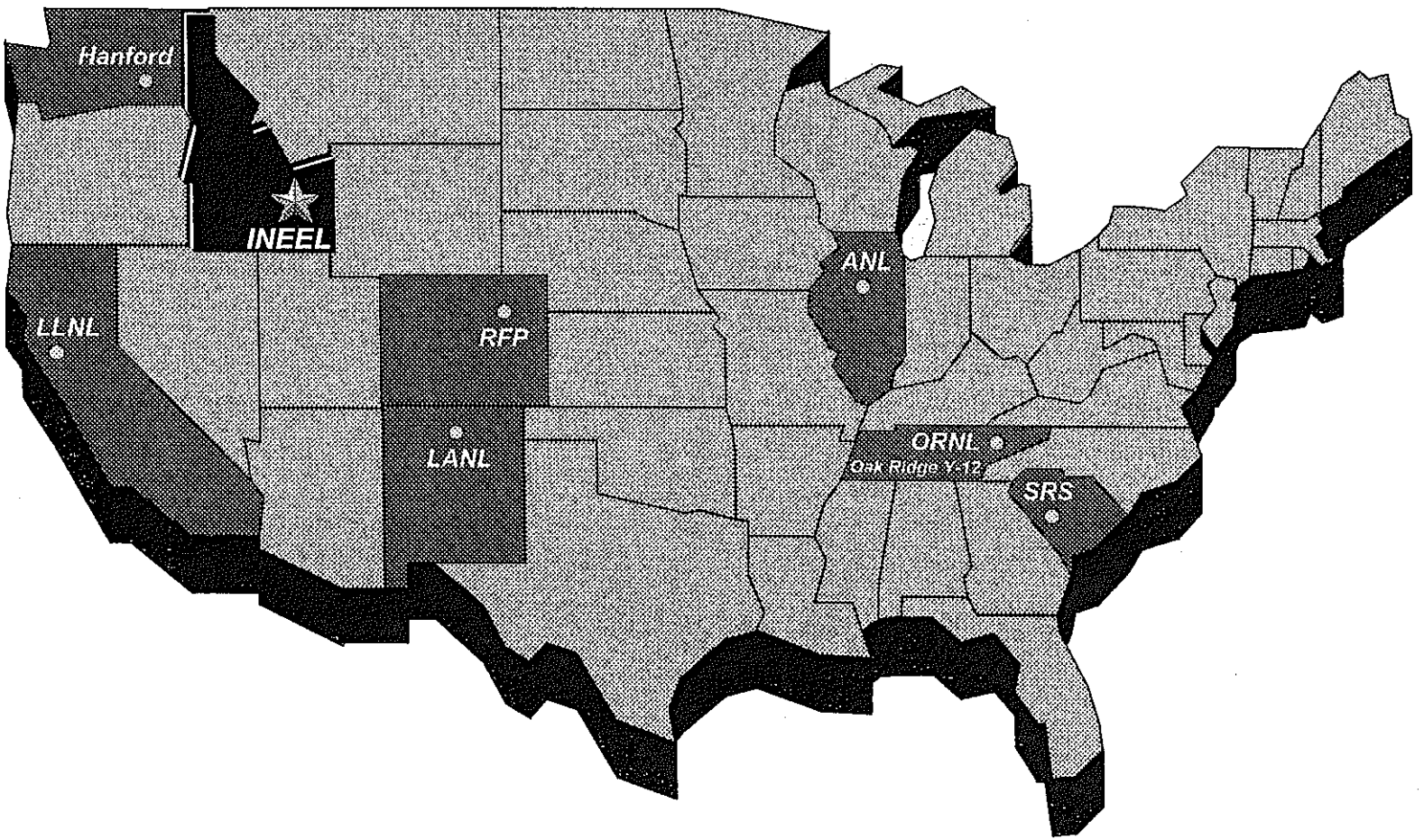
The Idaho National Engineering and Environmental Laboratory

U.S. Participants - ICSBEP



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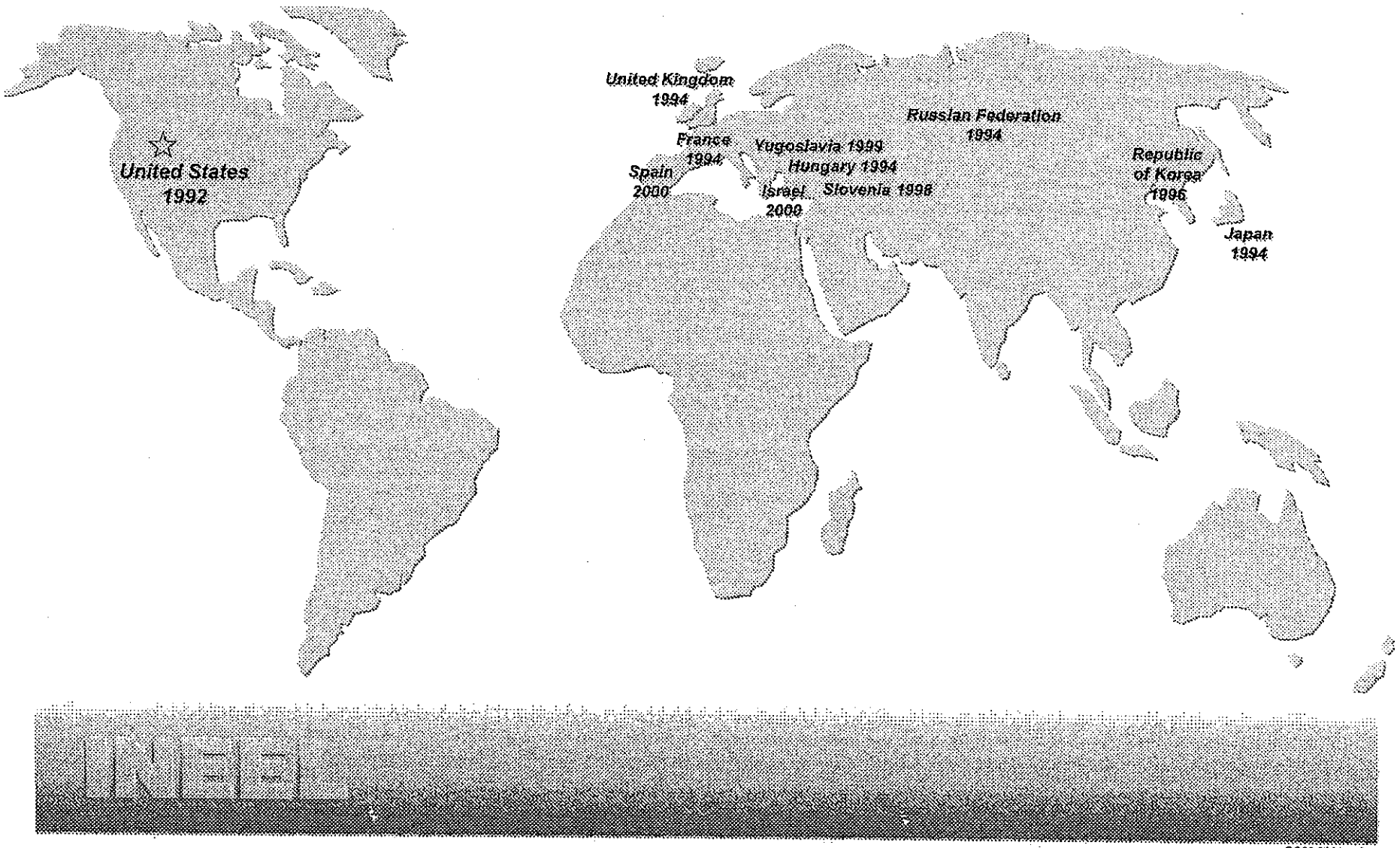
International Participants - ICSBEP



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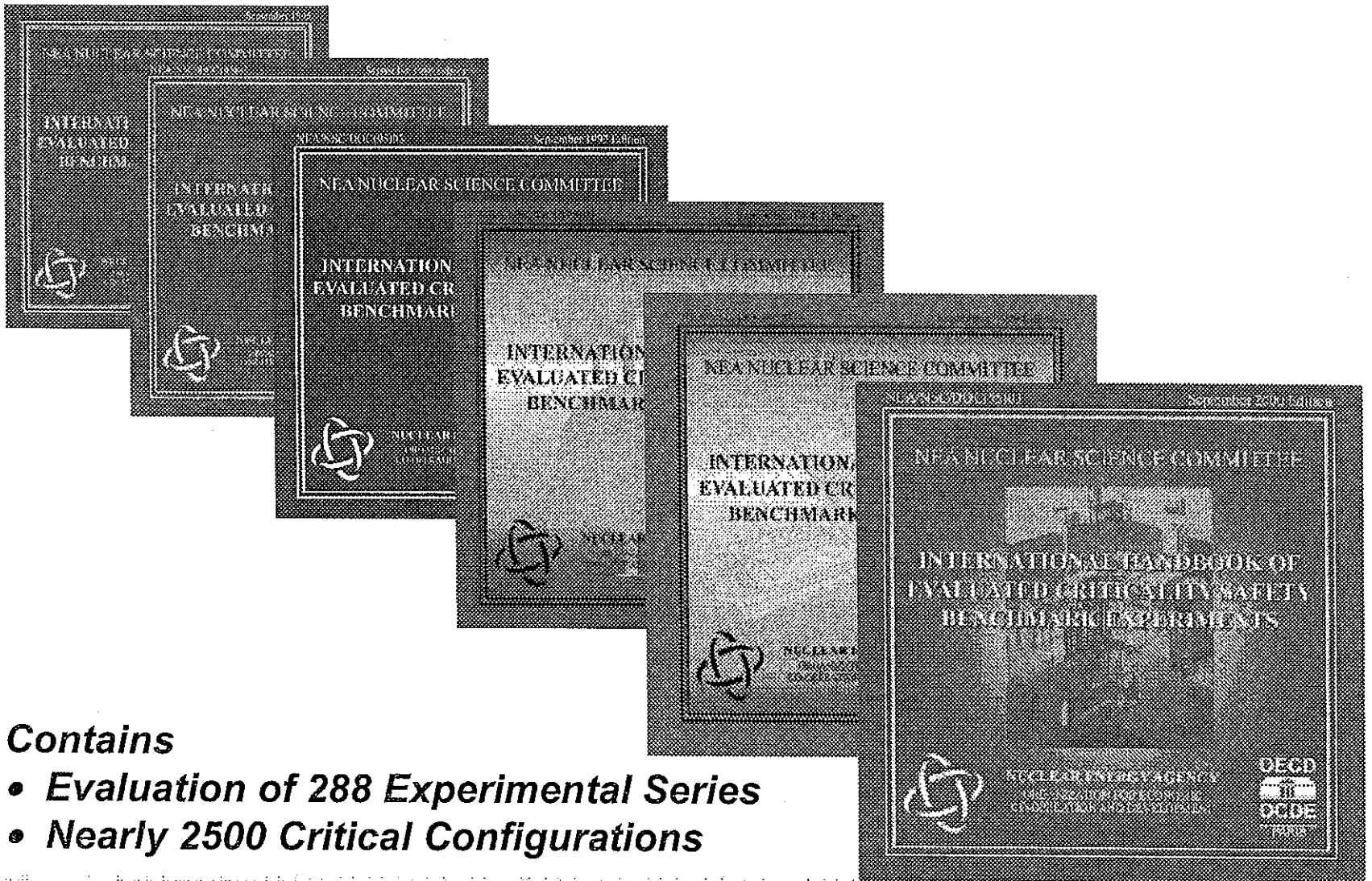
JNC TN8200 2000-006 (1/2)

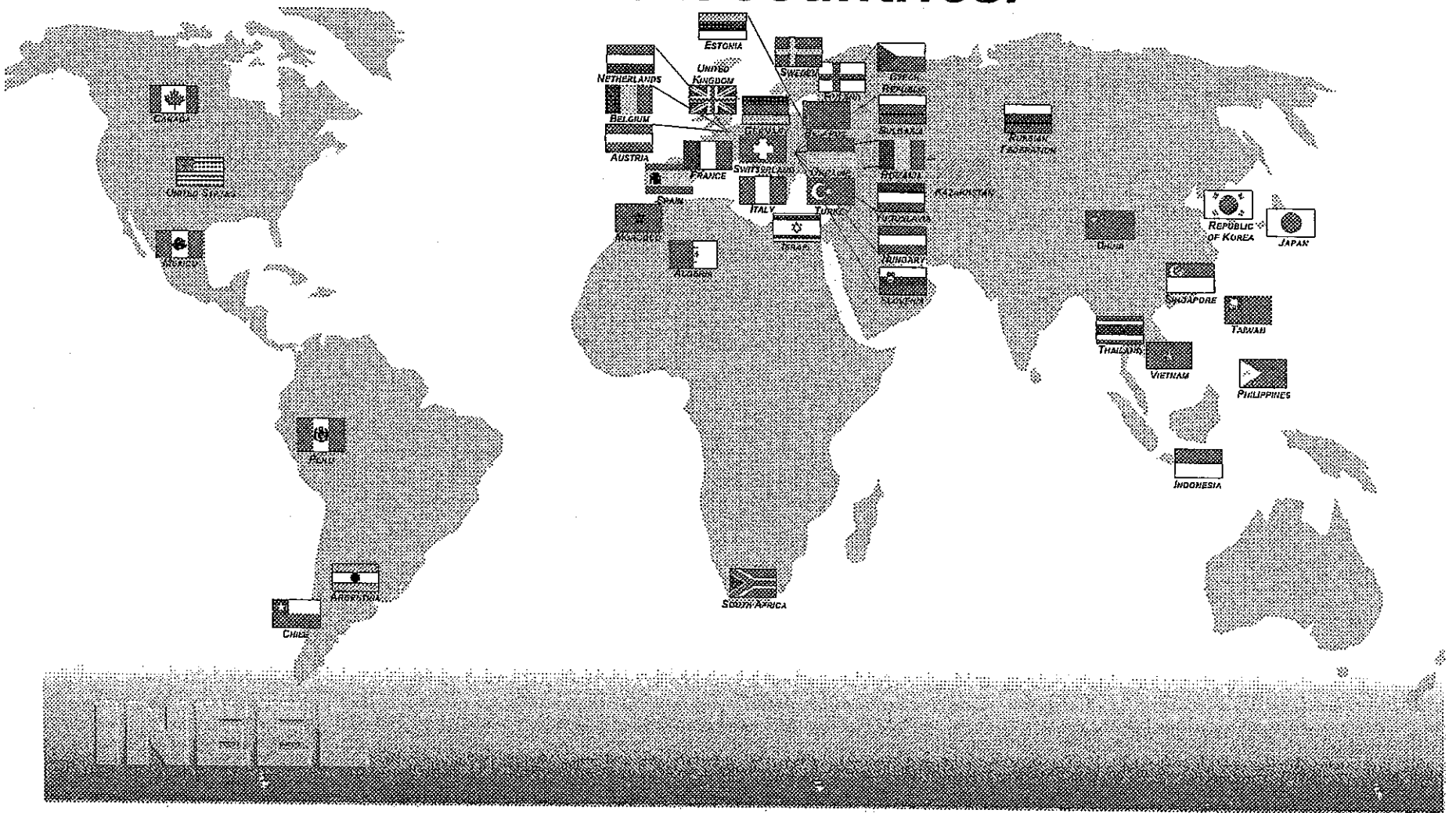


Contains

- **Evaluation of 288 Experimental Series**
- **Nearly 2500 Critical Configurations**

GC00 0114 4

The "International Handbook of Evaluated Criticality Safety Benchmark Experiments" is in use in 42 different countries.



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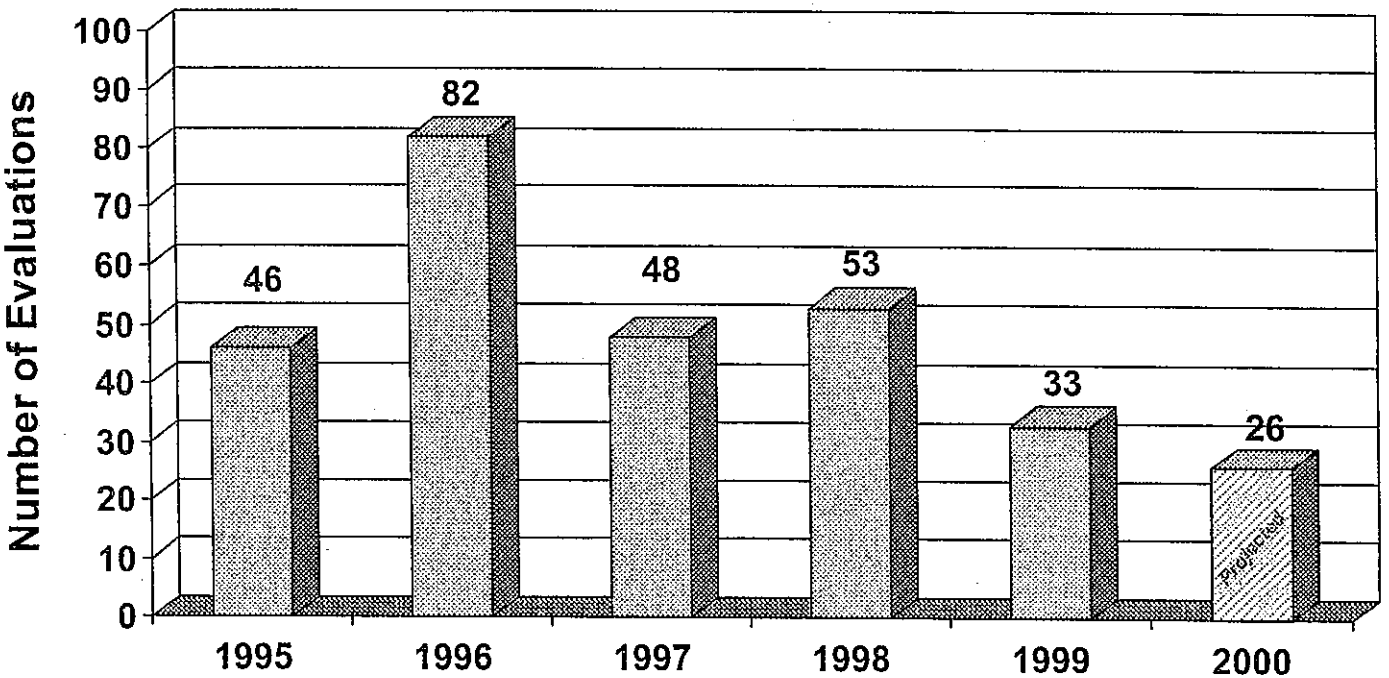
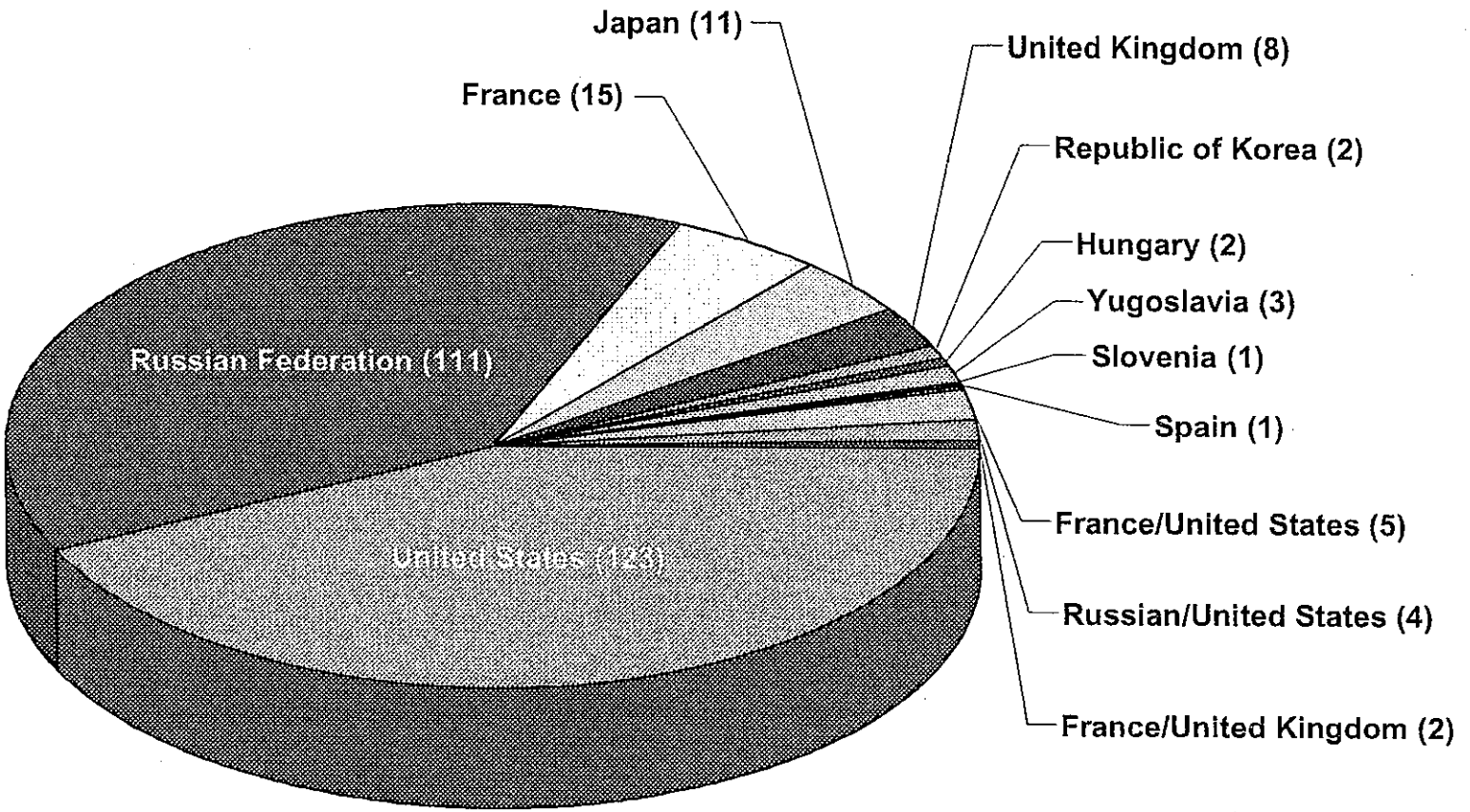
Growth of Handbook 1995 - 2000

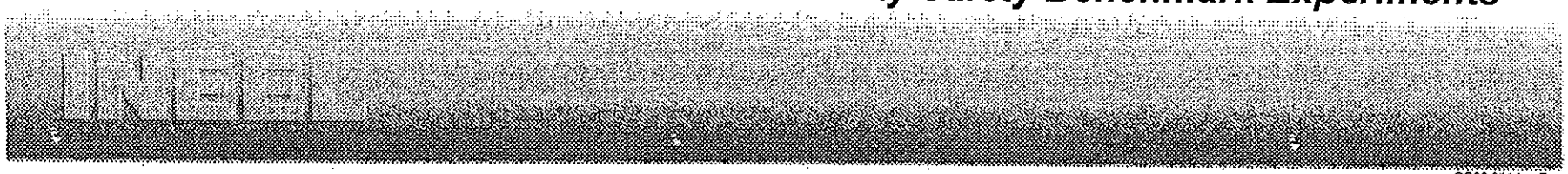


Total Number of Evaluations = 288

Contribution by Country



2000 Edition of the
"International Handbook of Evaluated Criticality Safety Benchmark Experiments"



GC00 0114 7

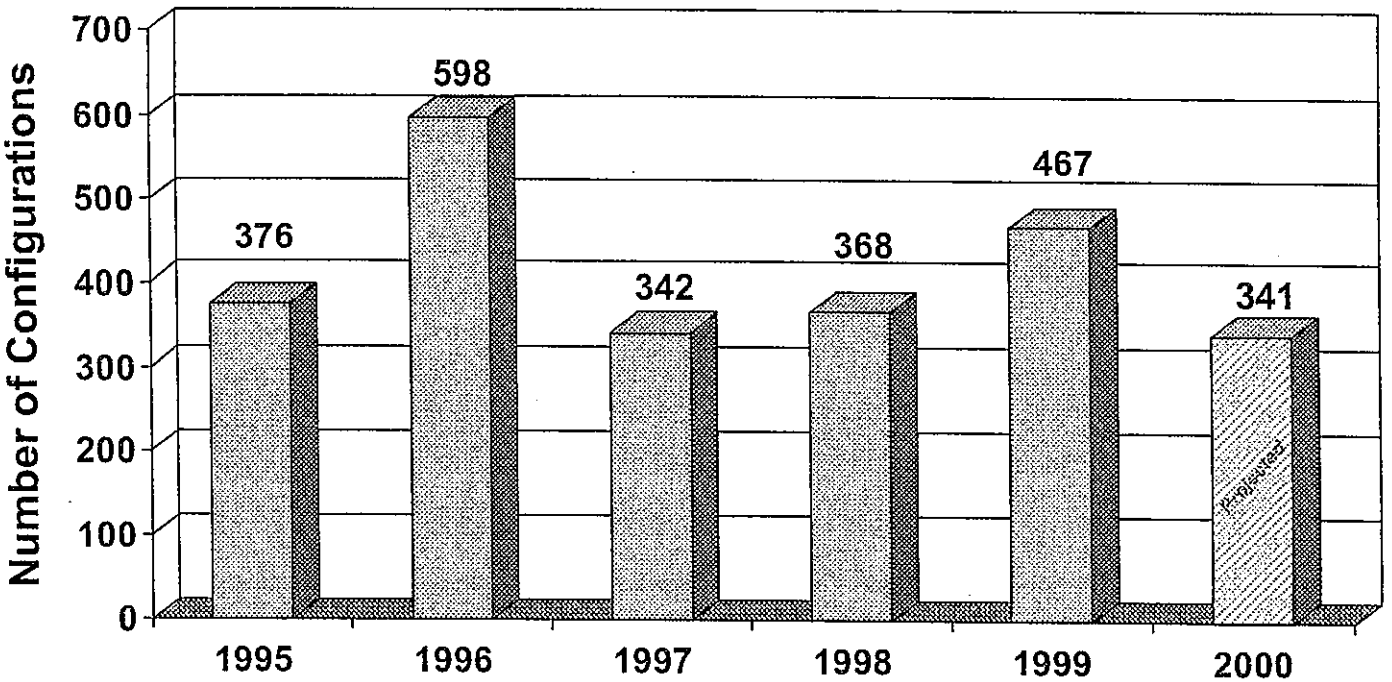
Evaluations In Progress for the 2000 Publication

EVALUATION #	TITLE	CONTRIBUTOR
PU-MET-FAST-034	Asymmetric Spherical Plutonium Reflected by Steel and Oil - Part I	LANL United States
PU-MET-MIXED-001	Plutonium SiO_2 or SiO_2/CH_2 Matrix (BFS-1)	IPPE Russian Federation
HEU-COMP-INTER-003	Enriched Uranium Hydride Critical Assemblies	LANL United States
HEU-COMP-THERM-017	Lattices of 80%-Enriched Uranium Elements in Heavy Water	VINCA Yugoslavia
HEU-MET-INTER-006	ZESUS: Platters of HEU Moderated by Graphite and Reflected by Copper	LANL United States
HEU-MET-FAST-039	Unreflected and Steel-Reflected Massive Enriched Uranium Metal Spherical and Hemispherical Assemblies	LANL United States
HEU-MET-FAST-055	ZRR-3 Assembly 23: A ^{235}U(93%)/Aluminum Cylinder Reflected by Depleted-Uranium	ANL United States
HEU-MET-MIXED-005	HEU SiO_2 or SiO_2/CH_2 Matrix (BFS-1)	IPPE Russian Federation
HEU-SOL-THERM-043	Large Unreflected Spheres of Uranium Oxyfluoride Solutions	WXSMS United States
HEU-SOL-THERM-044	Poison Tube Tank	ANL United States
HEU-SOL-THERM-045	Slabs and Cylinders of HEU Solutions	WXSMS United States
SUB-HEU-SOL-THERM-001	Unreflected High-Enriched Uranyl Nitrate Solution Subcritical Noise Measurements	ORNL United States

Evaluations In Progress for the 2000 Publication (continued)

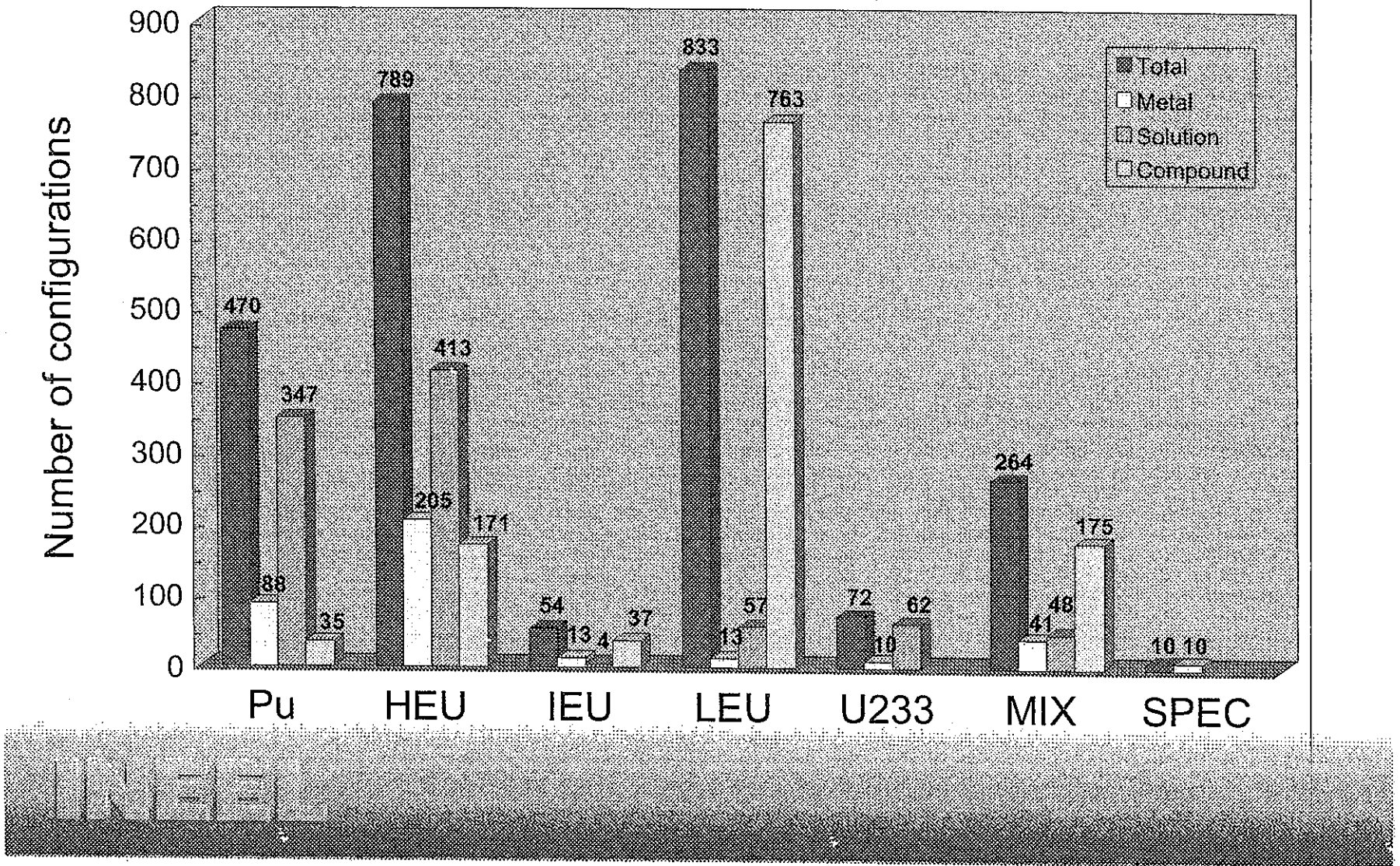
EVALUATION #	TITLE	CONTRIBUTOR
LEU-COMP-THERM-033	Critical Assemblies of 2% and 3% Enriched Uranium in Paraffin (was 030)	NUPEC Japan
LEU-COMP-THERM-047	DIMPLE Reactor Lattices 1	AEA Technology United Kingdom
LEU-COMP-THERM-048	LEU Fuel Rod Lattices in Water Poisoned by Gd	AEA Technology United Kingdom
LEU-COMP-THERM-050	149 SM Solution Tank in the Middle of a Water Moderated 4.738 Wt.% Enriched Uranium Dioxide Fuel Rods Arrays	CEA-IPSN France
LEU-COMP-THERM-051	Close Proximity Water Storage of PWR Fuels	Shielding Eng. & Analysis Spain
LEU-COMP-THERM-052	LEU Fuel Rods in Gd Nitrate Solution	CEA-IPSN France
LEU-SOL-THERM-016	STACY: SLAB Experiments (Water Reflected)	JAERI Japan
LEU-SOL-THERM-017	STACY: SLAB Experiments (Un-Reflected)	JAERI Japan
U233-SOL-THERM-003	Paraffin Reflected 4.5, 5.0, 5.4, 6.0, 6.6, 7.5, 8.0, 8.5, 9.0 Inch Diameter Cylinders of 233U Uranyl Fluoride Solutions	ORNL United States
U233-SOL-THERM-010	French U-233 Solution Experiments	CEA-IPSN France
U233-SOL-INTER-001	FALSTAFF Experiment: U-233 Fluoride Solutions in Spherical Geometry with Various Reflector Materials (H/U = 24)	LLNL United States
MIX-COMP-THERM-006	Mixed Oxide Fuel Pin Lattice – 2.0 wt.% PuO2, 8% Pu-240, Natural Uranium	WXSMS United States
MIX-SOL-THERM-006	Mixed Uranium Plutonium (29.87%) Nitrate Solutions Poisoned with Gadolinium	CEA-IPSN France

Growth of Handbook 1995 - 2000 (continued)



Total Number of Configurations = 2492

Distribution of Critical Configurations



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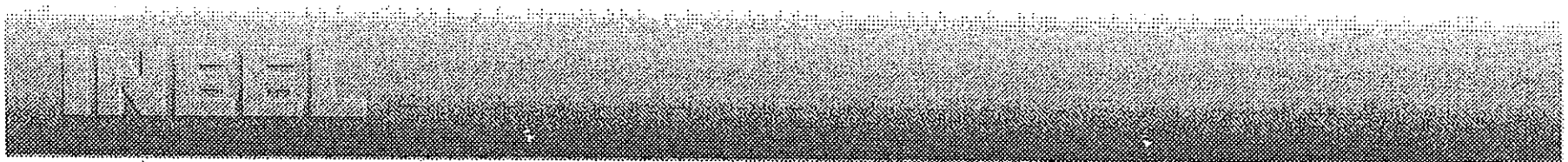
ICSBEP Energy Breakpoints

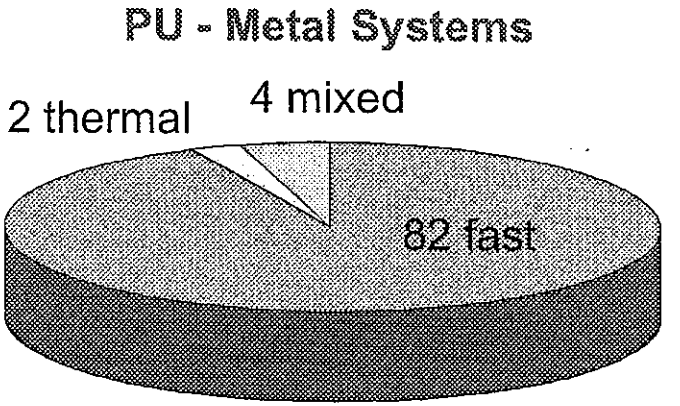
Fast: Energy > 100 KeV

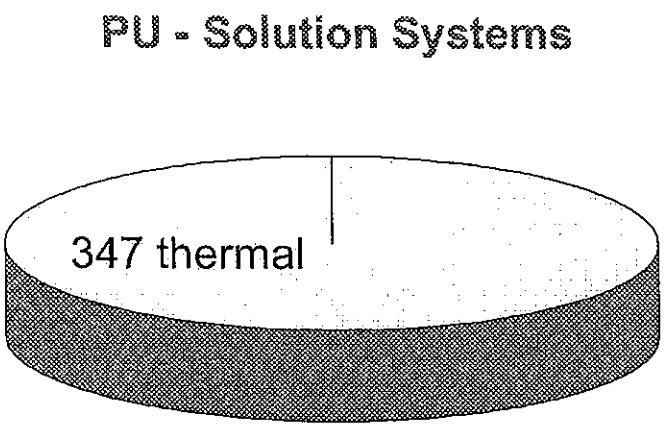
Intermediate: 0.625 eV ≤ Energy ≤ 100 KeV

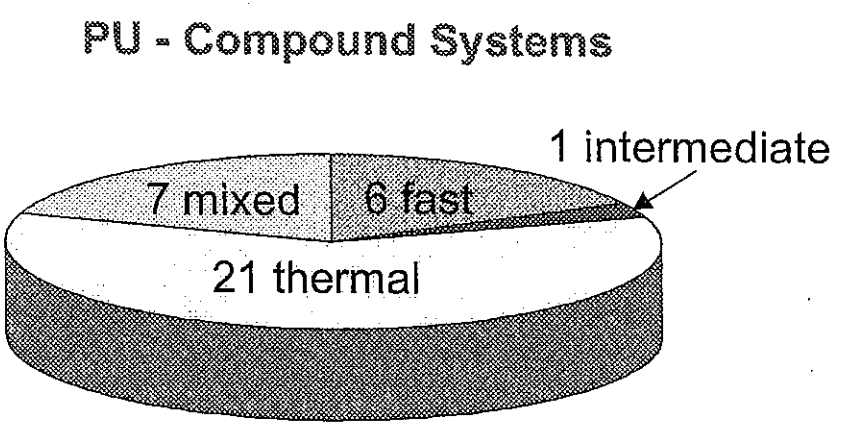
Thermal: Energy ≤ 0.625 eV

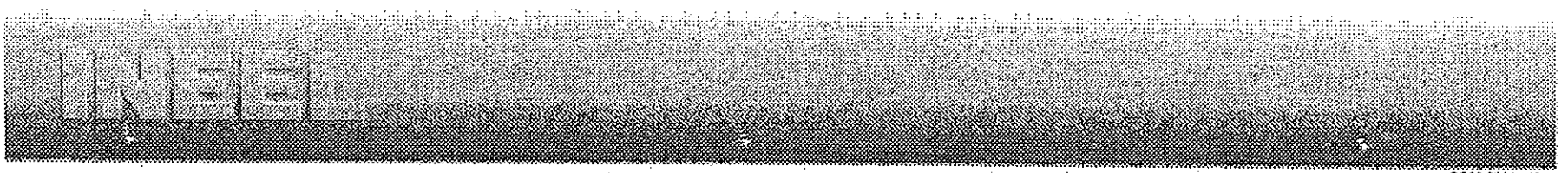


Plutonium Systems (470 Configurations)









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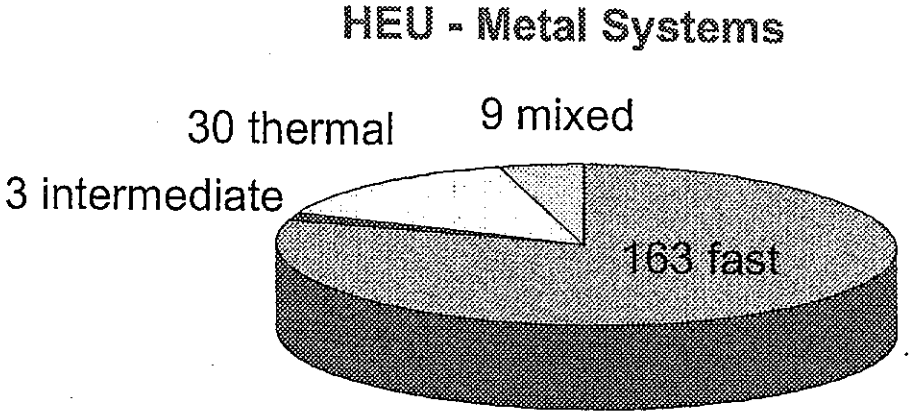
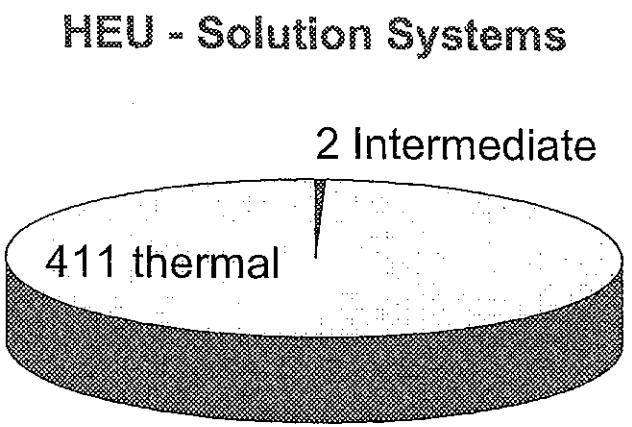
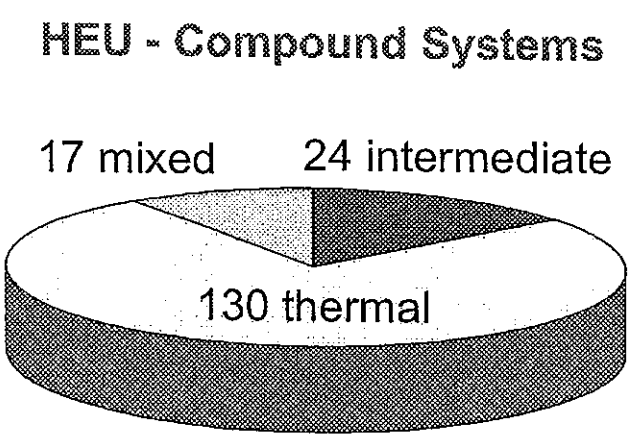
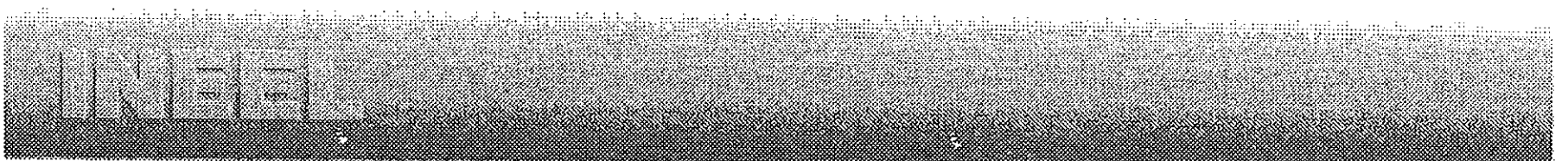
JNC TN8200 2000-006 (1/2)

Highly Enriched Uranium Systems (789 Configurations)









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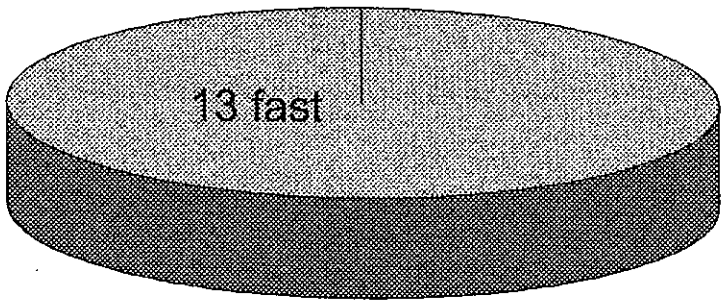
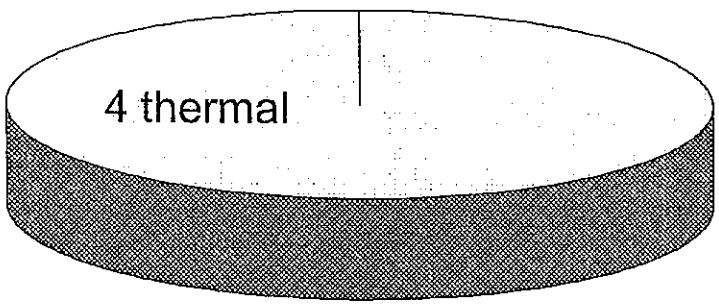
Intermediate and Mixed Enrichment Uranium Systems (54 Configurations)

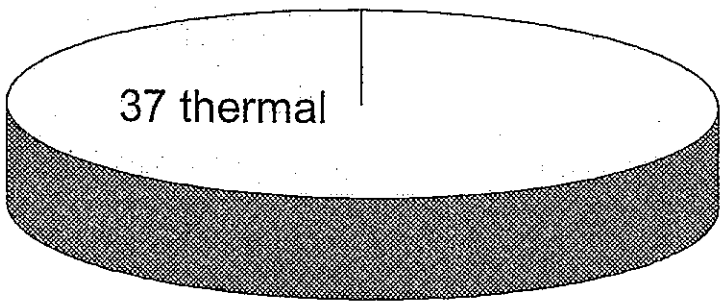
IEU - Metal Systems

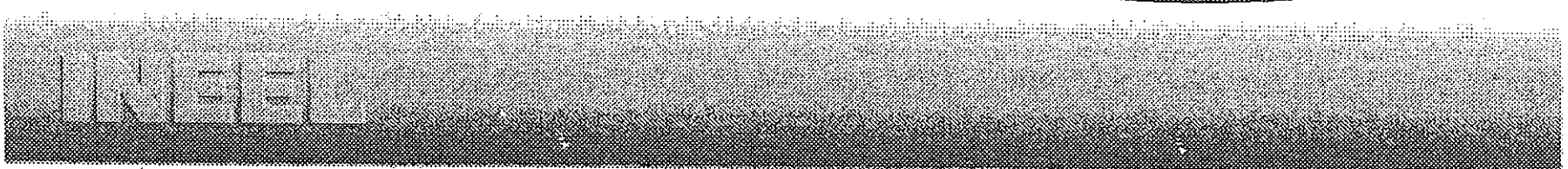


IEU - Solution Systems



IEU - Compound Systems





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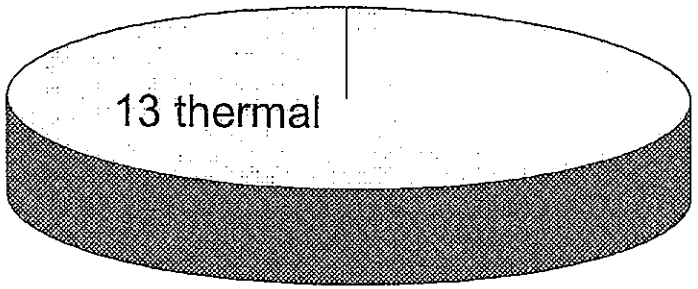
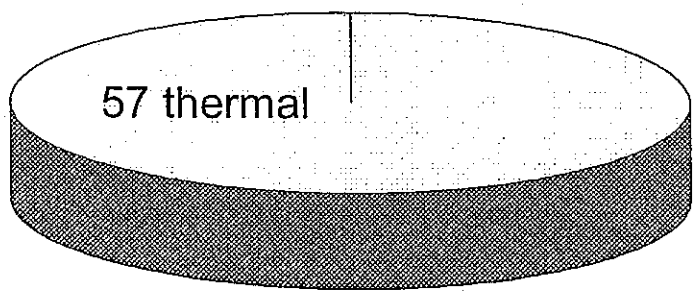
Low Enriched Uranium Systems (833 Configurations)

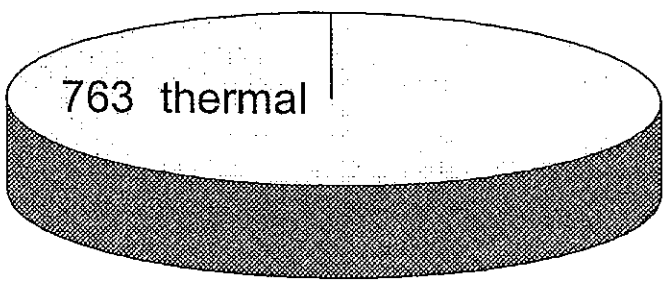
LEU - Metal Systems

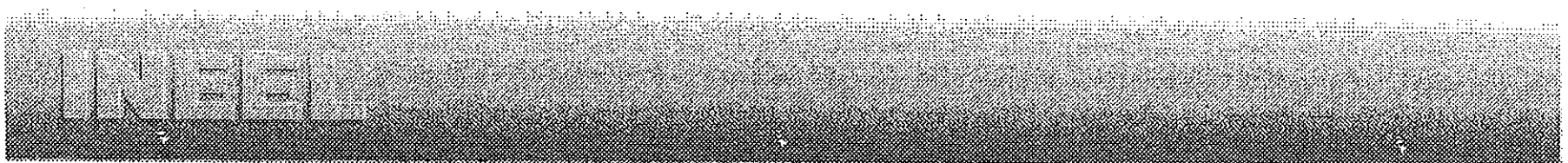


LEU - Solution Systems



LEU - Compound Systems





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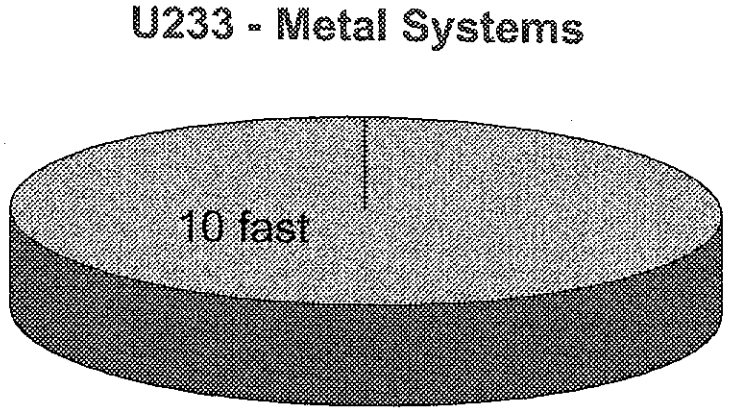
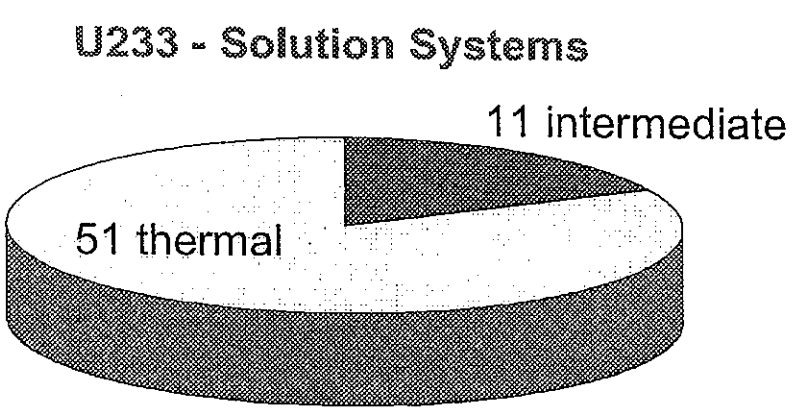
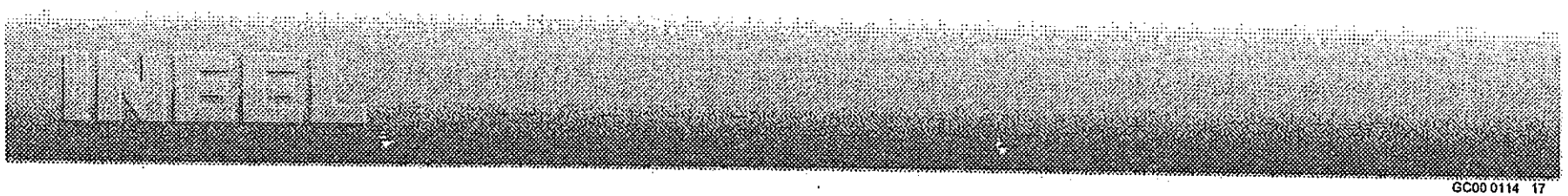
JNC TN8200 2000-006 (1/2)

Uranium-233 Systems
(72 Configurations)







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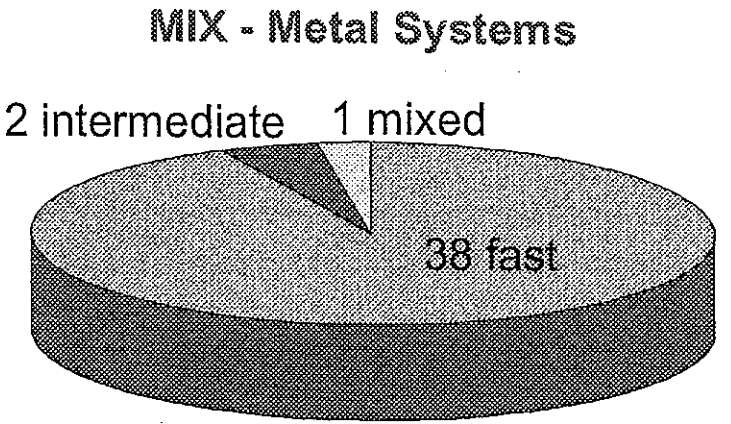
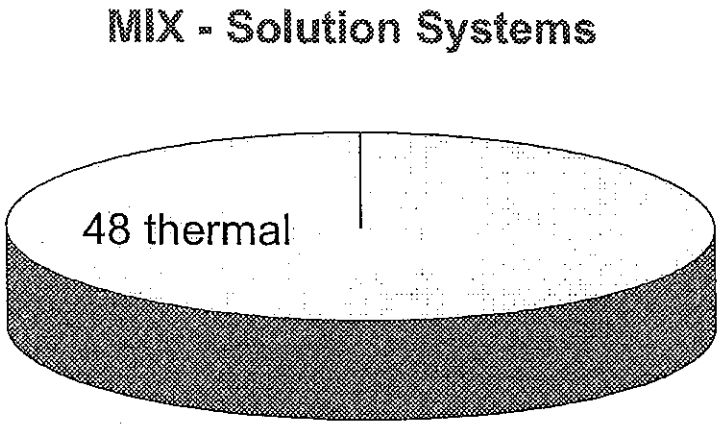
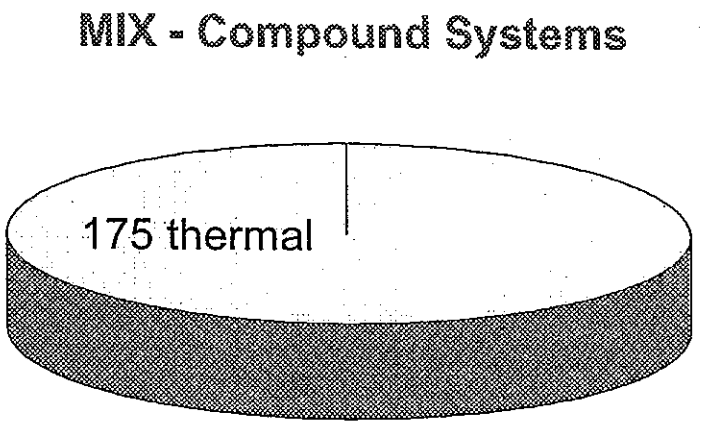
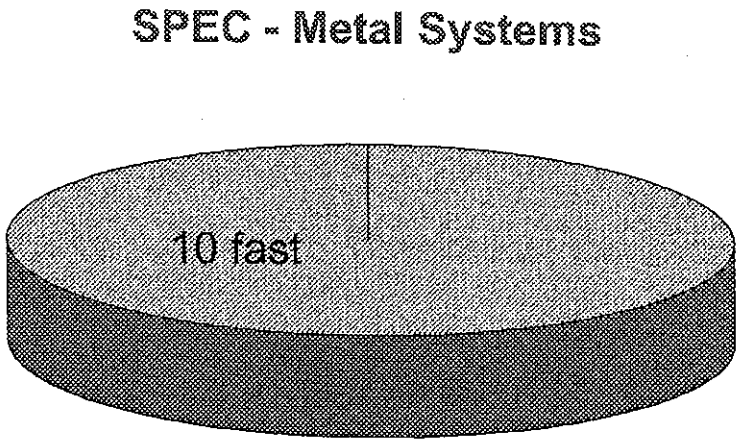
Mixed Plutonium-Uranium Systems (264 Configurations)





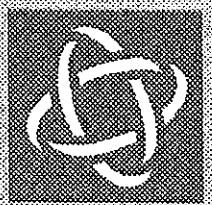


Special Isotope Systems
(10 Configurations)



ICSBEP Internet Site

http://icsbep.inel.gov/icsbep



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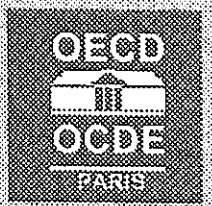
OECD
OCDE
PARIS



- About the International Criticality Safety Benchmark Evaluation Project
- International Handbook of Evaluated Criticality Safety Benchmark Experiments
- U.S. Department of Energy Nuclear Criticality Safety Program
- Request for Evaluation
- Evaluations in Progress

The International Criticality Safety Benchmark Evaluation Project is an official activity of the *Organization for Economic Cooperation and Development* - *Nuclear Energy Agency* (OECD-NEA). This web site is maintained at the *Idaho National Engineering and Environmental Laboratory* a facility operated for the *U.S. Department of Energy*.

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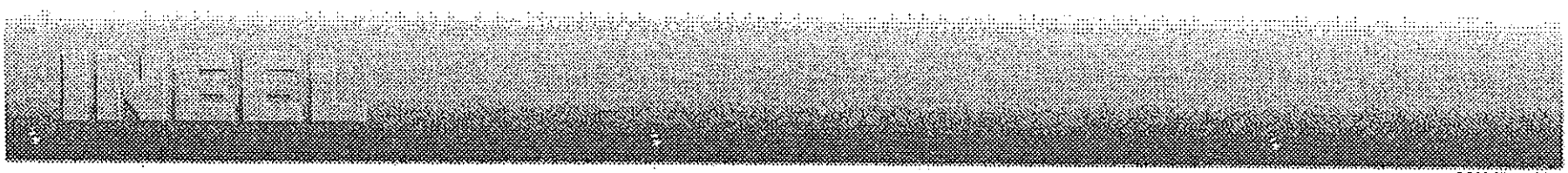
Future Work of the ICSBEP

- Evaluate and Compile Critical Benchmark Data
- Evaluate and Compile Criticality Alarm/Shielding Benchmark Data
- Evaluate and Compile Sub-Critical Benchmark Data



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ICSBEP Future Evaluations – 2001 and Beyond

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PU-MET-FAST-042	Plutonium Hemishells in Oil - Part II	LANL
PU-MET-FAST-043	Plutonium Hemishells in Oil - Part III	LANL
PU-MET-FAST-044	Pu Metal Sphere with Different Metal+Polyethylene Reflectors (Table IIIA2 of LA-30067-MS)	LANL
PU-SOL-THERM-019	Plutonium 35% and 5.2 % Nitrate Solutions in a Double Water Reflector Tank	CEA-IPSN
HEU-COMP-FAST-002	Graphite-and Beryllium-Reflected Highly Enriched UO2 Metal Fuel Rods	ORNL
HEU-COMP-THERM-009	Critical Experiments of HFIRCE-3 Fuel Element with Water and Lead Reflection	INEEL
HEU-COMP-THERM-018	Arrays of U(97.7)F6 Neutron-Coupled through Concrete	ORNL
HEU-MET-FAST-025	Unreflected Uranium (93.205) Metal Sphere	ORNL / ISRAEL
HEU-MET-FAST-040	U(93.2) Metal Cylinders, 2X2X2 Array, Unreflected and Paraffin, Plexiglas, and Graphite Reflected [Table 5, CAS25, CAS27, CAS28, CAS15]	ORNL
HEU-MET-FAST-042	U(93.2)-Mo Alloy Cylinder Annulus [Table 5, CAS04]	ORNL

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ICSBEP Future Evaluations - 2001 and Beyond (continued)

HEU-MET-FAST-043	Water Reflected U(93.2) Metal Hemishell [Table 5, CAS07]	LANL
HEU-MET-FAST-044	Graphite Reflected U(93.2) Metal Annulus [Table 5, CAS08]	ORNL
HEU-MET-FAST-045	Natural Uranium Reflected U(94) Metal Cuboid [Table 5, CAS09]	ORNL
HEU-MET-FAST-046	Unreflected U(93.2) Metal Annular Assemblies [Table 5, CAS 12, CAS22]	ORNL
HEU-MET-FAST-047	GROTESQUE: A U(93.2) Metal Assembly [Table 5, CAS23]	ORNL
HEU-MET-FAST-048	U(93.1) Metal Hemispherical Shell, Oil Reflected, One with Steel Center [Table 5, CAS10-CAS11]	RFP
HEU-MET-FAST-049	Oak Ridge Unreflected Uranium (93.2) Metal Spheres	ORNL
HEU-MET-FAST-050	Uranium (93.2) Metal Units in Complex Geometries (Including Grotesque)	ORNL
HEU-MET-FAST-051	Interacting Uranium (93.2) Metal Cylinders	ORNL
HEU-MET-FAST-052	Graphite and Polyethylene Reflected Uranium (93.2) Metal Cylinders and Annuli	ORNL
HEU-MET-FAST-053	Annular Uranium (93.2) Metal Rings Containing Various Moderating Materials (Graphite, Polyethylene, Beryllium, Potassium, etc.)	ORNL

ICSBEP Future Evaluations - 2001 and Beyond (continued)

HEU-MET-FAST-054	Iron Moderated and Reflected Uranium (93.2) Metal Rods (Including SORA)	ORNL
HEU-MET-???-0??	Graphite - Oy – D_2O System (C/U: 500 – 35000)	LLNL
HEU-MET-???-0??	Lead Reflected Oy; 5 Exp)	LLNL
HEU-MET-???-0??	NIMBUS Experiments (Be Reflected Oy; 5 Exp)	LLNL
HEU-MET-???-0??	SPADE Experiments -- BeO Moderated Oy with materials such as Iridium, Rhenium, Hafnium, Silver, Tantalum, Hastalloy, Indium, Cadmium, Tungsten, Niobium, Gold, or Aluminum in a central slot (~250 Configurations)	LLNL
HEU-MET-THERM-001	HEU Foils Reflected by SiO2 and Polyethylene	LANL
HEU-MET-THERM-004	Graphite Moderated Assemblies with High C/U Ratios	INEEL
HEU-MET-THERM-007	Critical Experiments of Stainless Steel Clad Spert Fuel in Water - III	INEEL
HEU-SOL-THERM-026	Aqueous Solutions of 235U Poisoned With Raschig Rings	INEEL
HEU-SOL-THERM-034	Highly Enriched Uranyl Nitrate in Annular Tanks with Concrete and Plaster Reflection: Combinations of 6 Tanks	INEEL
HEU-SOL-THERM-038	WINCO Slab Tanks Containing Highly Enriched Uranyal Nitrate Solutions	INEEL

ICSBEP Future Evaluations - 2001 and Beyond (continued)

HEU-SOL-THERM-039	Plexiglas Reflected 4 X 4 Array of U(93.2)O2(NO3)2 Solution Cylinders Standing in a Solution Slab [Table 5, CAS14]	RFP
HEU-SOL-THERM-040	U(93.1)O2(NO3)2 Solution in Steel Containers, with a Square Central Column and 8 Perpendicular Cylindrical Arms [Table 5, CAS19]	RFP
HEU-SOL-THERM-041	U(93.2)O2F2 Solution Slab Tank Arrays [Table 5, CAS30-CAS59]	ORNL
HEU-SOL-THERM-042	U(93.2) O2(NO3)2 in Large Diameter Cylinders [Table 6, CAS12 – CAS16, CAS21 – CAS23]	ORNL
LEU-COMP-THERM-005	Critical Triangular-Pitch Arrays of U(2.35)O2 Fuel Rods in Water Containing Gadolinium	INEEL
LEU-COMP-THERM-011	Critical Triangular-pitch Arrays of U(4.31)O2 Fuel Rods in Water Containing Gadolinium	INEEL
LEU-COMP-THERM-013	Critical Water-moderated Clusters of U(4.31)O2 Fuel Rods Separated by Stainless Steel, Borated Stainless Steel, Boral, Boroflex, Copper, and Cadmium Plates with Steel Reflecting Walls	INEEL
LEU-COMP-THERM-014	Critical Arrays of U(4.31)O2 Fuel Rods in Borated Water	INEEL
LEU-COMP-THERM-028	Critical Lattices of Low-enriched U02 and U02-Gd203	LANL
LEU-COMP-THERM-030	Critical Experiment for the NS Savannah Core	Babcock & Wilcox
LEU-COMP-THERM-043	Unreflected and Water Reflected U(4.89)3O8 Sterotex Blocks [Table 1, CAA19 – CAA29]	ORNL

ICSBEP Future Evaluations - 2001 and Beyond (continued)

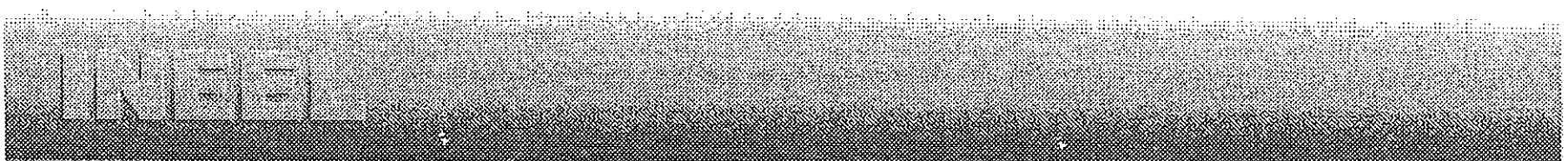
LEU-COMP-THERM-044	Unreflected and Reflected Rectangular Parallelepiped of U(1.4 - 3.0)F4 and Paraffin [Table 3, CAS04 – CAS06, CAS 11-32]	ORNL
LEU-COMP-THERM-045	U(4.46)3O8, H/U = 0.77 - 2.03 [Table 3, CAR01 – CAR20]	RFP
LEU-COMP-THERM-046	PCTR - Infinite Multiplication Constants of Slightly Enriched UO3 - H2O Mixtures	Hanford Report
LEU-MET-THERM-003	Water Moderated Arrays of U(4.89) Metal Rods Reflected by H2O, Plexiglas, and Pb [Table 1, CAA01 – CAA11]	ORNL
LEU-MET-THERM-004	Arrays of U(4.89) Metal Rods in UO2 F2 Solution [Table 1, CAA12 – CAA18]	ORNL
LEU-MET-THERM-005	Arrays of U(3.85) Metal Rods in Water [Table 2, CAB01 – CAB16]	ORNL
LEU-SOL-THERM-011	U(4.89)O2 F2 Solution in 15-, 20-, and 30-inch Diameter Cylinders [Table 1, CAA30, CAA32, CAA34, CAA35, CAA37, CAA39]	ORNL
LEU-SOL-THERM-012	U(4.89)O2 F2 Solution in a 20x20-inch Aluminum Box [Table 1, CAA31]	ORNL
LEU-SOL-THERM-013	U(4.98)O2 F2 Solution in Steel Cylinders with Water, Steel, and Cadmium Side Reflection [Table 3, CAS33-CAS34]	ORNL
LEU-SOL-THERM-014	An Unreflected Sphere of U(4.98)O2F2 with an H/X of 490 [Table 3, CAS35]	ORNL
LEU-SOL-THERM-015	An Unreflected Cylinder of U(4.98)O2F2 Solution at an H/X of 496 [Table 3, CAS36]	ORNL
U233-SOL-THERM-005	Water and Non-Refected 10.0, 10.4, and 12.0 Diameter Cylinders of 233U Uranyl Fluoride Solutions	ORNL

ICSBEP Future Evaluations - 2001 and Beyond (continued)

U233-SOL-THERM-006	Reflected and Unreflected Single Cylinders and Arrays of Cylinders of Uranyl Nitrate Solutions	ORNL
U233-SOL-THERM-007	Bare Spheres of Nitrate Solutions Including Thorium and Boron	ORNL
U233-SOL-THERM-009	U-233 O2(NO3)2 in Large Diameter Cylinders and Spheres [Table 6, CAS09, CAS17 – CAS20]	ORNL
U233-SOL-THERM-011	FALSTAFF Experiment: U-233 Floride Solutions in Spherical Geometry with Various Reflector Materials (H/U = 31)	LLNL
U233-SOL-THERM-012	FALSTAFF Experiment: U-233 Floride Solutions in Spherical Geometry with Various Reflector Materials (H/U = 52)	LLNL
U233-SOL-THERM-013	FALSTAFF Experiment: U-233 Floride Solutions in Spherical Geometry with Various Reflector Materials (H/U = 56)	LLNL
U233-SOL-THERM-014	FALSTAFF Experiment: U-233 Floride Solutions in Spherical Geometry with Various Reflector Materials (H/U = 57)	LLNL
U233-SOL-THERM-015	FALSTAFF Experiment: U-233 Floride Solutions in Spherical Geometry with Various Reflector Materials (H/U = 74)	LLNL
U233-SOL-THERM-016	FALSTAFF Experiment: U-233 Floride Solutions in Spherical Geometry with Various Reflector Materials (H/U = 102)	LLNL
U233-SOL-THERM-017	FALSTAFF Experiment: U-233 Floride Solutions in Spherical Geometry with Various Reflector Materials (H/U = 201)	LLNL
U233-SOL-INTER-001	FALSTAFF Experiment: U-233 Floride Solutions in Spherical Geometry with Various Reflector Materials (H/U = 24)	LLNL
MIX-COMP-INTER-001	Low-Moderated Mixtures of Plutonium and Uranium Oxices (with 8,15, and 30 wt% Plutonium)	unassigned

ICSBEP Future Evaluations - 2001 and Beyond (continued)

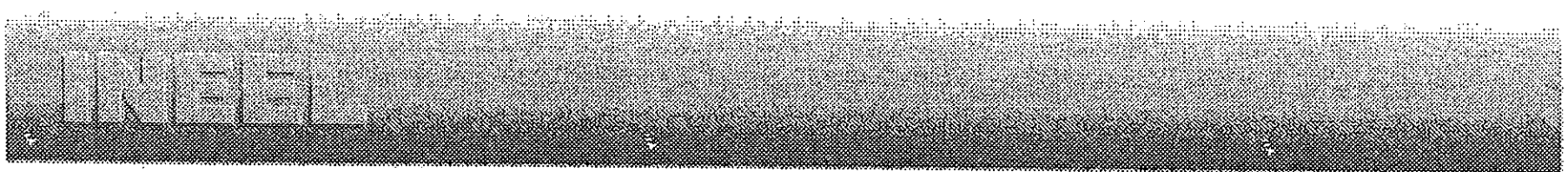
MIX-COMP-INTER-002	Homogeneous Mixtures of Polystyrene-Moderated Plutonium and Uranium Oxides	unassigned
MIX-COMP-INTER-003	Neutron Poison Plates in Assemblies Containing Homogeneous Mixtures of Polystyrene-Moderated Plutonium and Uranium Oxides	unassigned
MIX-MET-FAST-006	Sphere of Plutonium Surrounded by Highly Enriched Uranium and Reflected by Steel and Polyethylene	VNIITF Chelyabinsk-70
SPEC-MET-FAST-005	Replacement Measurements Performed with Am-241	LANL
SPEC-MET-FAST-006	Replacement Measurements Performed with Am-243	LANL



Conclusions

1. *The ICSBEP continues to:*
   - *Identify, evaluate, verify, compile, and document criticality safety benchmark data that are essential to the validation efforts of the international, criticality safety community*
   - *Identify areas where more data are needed and work within the international criticality safety community to fill needs*
   - *Identify discrepancies between calculations and experiments that could be due to deficiencies in data or inadequate approximations in data processing and / or neutron transport codes*

2. *Much data have been identified that have not yet been evaluated and published*



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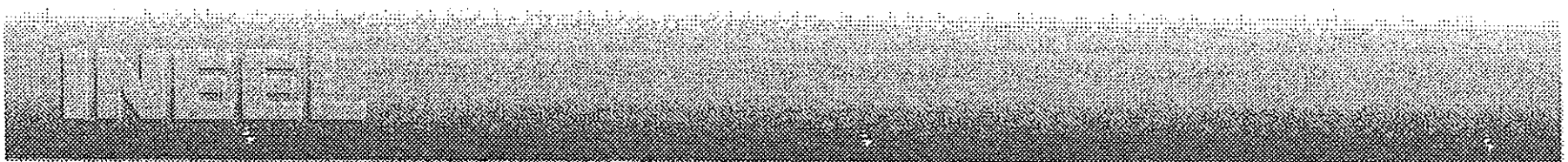
Conclusions (continued)

3. *Much data continues to be identified, including subcritical measurement and criticality alarm data*

4. *Input is needed from the criticality safety community to help prioritize the order in which data are evaluated; understand the value of the subcritical benchmarks and criticality alarm data to the user community; and, ultimately, help DOE justify continued support to the ICSBEP.*



ANALYTICAL METHODS TASK

Lester Petrie, Oak Ridge National Laboratory
Bob Little, Los Alamos National Laboratory
Ed Fujita, Argonne National Laboratory

DOE's Nuclear Criticality Safety Program Review
Presented by Mike Westfall
Monday, March 27, 2000

ANALYTICAL METHODS TASK PURPOSE AND OBJECTIVES

PURPOSE - Provide State-of-the-Art Analytical Methods Qualified for DOE Fissile System Applications

PRIMARY OBJECTIVE - Independent, Redundant Capability for Corroborative Analyses in Production and Benchmarking Applications

SECONDARY OBJECTIVE - Software Upgrades to Overcome Known Deficiencies and/or Treat More Complex Systems

ANALYTICAL METHODS TASK, FOUR SUBTASKS

- KENO/SCALE WORK AT ORNL
- MCNP & ASSOCIATED SOFTWARE WORK AT LANL
- VIM & ASSOCIATED SOFTWARE WORK AT ANL
- SOFTWARE PACKAGING & DISSEMINATION BY RSICC AT ORNL

SOFTWARE CAPABILITY MAINTENANCE

- IMPLEMENTATION ON NEW COMPUTER PLATFORMS, COMPATIBILITY WITH COMPILERS
- CONFIGURATION CONTROL & SOFTWARE QUALITY ASSURANCE
- SOFTWARE BUG INVESTIGATIONS & FIXES
- SOFTWARE VERIFICATION, CODES & DATA VALIDATION

TRAINING & USER ASSISTANCE

- FOUR DAY WORKSHOPS, CODE TUTORIALS AT ANS MEETINGS
- ASSISTANCE IN INPUT PREPARATION & RESULTS INTERPRETATION OVER ELECTONIC MEDIA
- IMPROVEMENTS IN USER INTERFACES - GRAPHICS, GUI'S, OUTPUT ENHANCEMENTS

NEEDED IMPROVEMENTS UNDERWAY AND/OR NEAR COMPLETION

- ORNL - SCALE/CENTRM SEQUENCE FOR RESOLVED RESONANCE PROCESSING
- LANL - PROBLEM-DEPENDENT UNRESOLVED RESONANCE PROCESSING WITH PROBABILITY TABLES IN MCNP
- ANL - INVESTIGATION OF STRATIFIED SAMPLING TECHNIQUES FOR FISSION SOURCE CONVERGENCE

NEEDED IMPROVEMENTS, FY2000 TO FY2002

- ORNL - ENHANCEMENT OF SCALE/CENTRM, KENO3D GRAPHICS FOR KENO-VI GEOMETRY, UTILIZATION OF MATERIAL REGION & ZONE VOLUMES, ENDF/B-VI BASED CRITICALITY SAFETY MULTIGROUP LIBRARY-INCUDE IN ICSBEP
- LANL - JUSTINE GRAPHICS AND INPUT PROCESSING, CAD, FISSION SOURCE & MACROBODY GEOMETRY SPECIFICATIONS, SPECTRAL INDICIES CONSISTENT WITH ICSBEP ,DELAYED NEUTRON PHYSICS, AUTOMATIC GEOMETRY TESTING AND ENHANCED USER WARNINGS
- ANL - COMPLETION OF STRATIFIED SAMPLING, GRAPHICS & GUI'S FOR VIM, VIM FUEL CYCLE ANALYSIS INCLUDING ENERGY & TEMPERATURE INTERPOLATION OF DATA, SPECTRAL INDICIES & STATISTICAL TESTS

ORNL

METHODS OUTYEARS' ACTIVITIES

- EXTENSIVE VALIDATIONS USING NEW EXPERIMENTS, CROSS SECTIONS & UNCERTAINTY DATA
- IMPROVED TRANSPORT MODELING BASED ON RESULTS OF AROBCAD SENSITIVITY/UNCERTAINTY/OPTIMIZATION STUDIES
- POTENTIAL IMPROVEMENTS - PERTURBATION CAPABILITIES IN KENO & MCNP, ENHANCEMENT OF DETERMINISTIC CODES, ENERGY POINTWISE VERSION OF KENO, VIM OPTIMIZATION AND GENERATION OF PROBLEM-DEPENDENT CROSS SECTION LIBRARIES

ornl

Radiation Safety Information Computational Center

www-rsicc.ornl.gov

Computer Codes – Number of Copies Distributed

	FY 1999	FY 2000	
MCNP	222	78	(major release expected)
SCALE	147	11	(major release expected)
VIM	4	0	

Workshops	FY 1999	FY 2000
	Number (Attendees)	Number (Attendees)
MCNP	8 (126)	3 (96)
SCALE	2 (38)	1

Electronic Notebook – User helpline from web

MCNP	47 entries
SCALE	218 entries

ornl

NCSP Progress at ANL

E. K. Fujita

March 27, 2000

Albuquerque, NM

Argonne National Laboratory



VIM Libraries

Expanded the VIM cross section libraries

ENDF/B-V: 118 nuclides/materials

ENDF/B-VI: Added 30 nuclides
Now includes 185 nuclides/materials

JEF2.2: Added 143 nuclides
Now includes 171 nuclides/materials

Argonne National Laboratory



ICSBEP Benchmarking

PU-MET-FAST-001, -002, -007, -011, -022, -024, -027, -031

PU-COMP-FAST-001, -002

PU-COMP-THERM-001, -002

PU-COMP-MIXED-001, -002

PU-SOL-THERM-001

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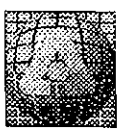

Monte Carlo Source Convergence

Performed comparison of superhistory and stratified sampling methods -- to be presented at PHYSOR 2000.

Began statistical testing of basic fission site algorithms on simple test problems (Ely Gelbard).

Drafted charter, presented by Enrico Sartori to NEANSC. NSC approved Task Force on Monte Carlo Source Convergence Issues in Criticality Safety.

TF will be organized at September CS Working Party meeting.

Argonne National Laboratory



VIM Accessibility & Usability

Developed a color viewing system for VIM input geometries that works for all geometry options.

VIM web site operational:

- **Front page with DOE NCSP info**
- **Links to RSICC, DOE NCSP page**
- **Includes improved User's Guide**

Argonne National Laboratory



Future Work

- Additional GUI work, including integration with Justine.
- Further benchmarking.
- Additional fission source algorithm testing.
- Identification of source convergence benchmark problems and development of specifications for NEANSC Convergence TF. Additional data forthcoming from Japan and Europe.

Argonne National Laboratory



Resonance Theory

- Focused on improved treatment of probability table methods in the unresolved resonance energy region.
- Two reports on Unified Resonance Theory:
  - R. N. Hwang, "Critical Examinations of Commonly Used Numerical Methods for Broadening of Cross Sections," ANL-NT-72.
  - C. Jammes and R. N. Hwang, "Generalized Pole Representation and Interpolation of Cross Sections at Any Temperature," ANL-NT-101.

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JNC TN8200 2000-006 (1/2)

Sensitivity / Uncertainty Analysis

- Work is in progress to provide covariance data for use with ENDF/B-V cross sections for Cu, Cd, Ca, K, ^{234}U, ^{238}Pu, ^{243}Am, ^{143}Nd, ^{149}Sm, ^{103}Rh, ^{151}Sm, ^{133}Cs, ^{99}Tc, ^{152}Sm, ^{154}Gd, ^{153}Eu, ^{145}Nd, ^{147}Sm, ^{150}Sm, ^{95}Mo, ^{109}Ag, ^{101}Ru, ^{154}Eu, and ^{155}Eu.
- Covariance information for these files will be generated using methodology described in the Argonne National Laboratory report ANL/NDM-148.

Argonne National Laboratory



MCNP4C

- Released to RSICC 2/29/00
- Major New Features:
  - Unresolved resonance probability tables
  - Perturbation enhancements
  - Superimposed mesh weight window generator
  - Alpha eigenvalues
  - Macrobodies

MCNP4C (cont.)

- Major New Features (cont.)
  - ENDF/B-VI improvements
  - PC enhancements
  - Electron physics enhancements
  - Parallelization enhancements
  - Delayed neutrons

Additional LANL Accomplishments

- MCNP Infrastructure / Maintenance / User Support
  - two intermediate versions (4XS, 4XU) sent to RSICC specifically for NCS community
  - corrections of user-reported errors
    - only four $20 awards in 4 years for MCNP4B bugs
    - eight $4 awards for bugs found in 4B that existed earlier
  - ~40 errors identified and corrected by MCNP staff following testing procedures during development of 4C
  - development of formal code development environment (RAZOR)
  - training
    - 1999 - 5 courses presented
    - 2000 - 7 courses scheduled

Additional LANL Accomplishments (cont.)

- Verification and Validation Reports:
  - Sood, Forster, and Parsons, "Analytical Benchmark Test Set for Criticality Code Verification," LA-13511 (1999).
  - Frankle, "A Suite of Criticality Benchmarks for Validating Nuclear Data," LA-13594 (1999).
  - Frankle, "Criticality Benchmark Results Using Various MCNP Data Libraries," LA-13627 (1999).
  - Frankle and Briesmeister, "Spectral Measurements in Critical Assemblies: MCNP Specifications and Calculated Results," LA-13675 (1999).
- Justine - distribution delayed until 6/1/00

NCS Plans for MCNP Development

- FY00
  - macrobody assessment and enhancements
  - point and click plotting of geometries, tallies, and cross sections
  - KCODE automatic source generation (begin)
- FY01
  - command line keyword for geometry checking
  - file name-length parameterization

NCS Plans for MCNP Development (cont.)

- FY01 (cont.)
  - material macros
  - enhanced criticality safety primer
- MCNP Data Libraries (FY00)
  - ENDF66 - continuous energy library for ~175 isotopes based on ENDF/B-VI up through and including release 6
  - New S(α,β) library based upon ENDF/B-VI
- Note: Plans are subject to change based on NCS priorities

Nuclear Data Activities at the Oak Ridge National Laboratory

Luiz Leal
Nuclear Data Group
Radiation Information Analysis Section
Computational Physics Engineering Division
Oak Ridge National Laboratory
www.cad.ornl.gov/~jzw/NUCDATA/NDgroup.html

Nuclear Criticality Safety Project
Albuquerque, New Mexico
March 27-31, 2000

ACTIVITIES IN SUPPORT OF THE NUCLEAR CRITICALITY SAFETY PROGRAM

Nuclear Data Group at ORNL

Permanent Staff:

N. M. Larson (SAMMY development and cross section evaluation)

K. Guber (cross section measurements and evaluation)

R. Q. Wright (benchmark analysis and data evaluation)

R. O. Sayer (cross section analysis and evaluation)

H. Derrien (cross section evaluation and covariance matrix generation)

T. Valentine (benchmark and sub-criticality experiments and evaluation)

C. Y. Fu (nuclear models - high energy range - TNG computer code)

Part Time Staff:

J. Harvey (cross section measurements)

N. Hill (cross section measurements)

Temporary Staff (postdoctoral):

F. Guimaraes (code development)

Nuclear Data Group (NDG) Objectives

To perform data measurements, analysis and evaluation for criticality safety applications

Data needs originate from deficiencies in the data identified by:

Benchmark testing calculations,

Criticality safety design calculations, and

Discrepancies on the existing evaluated data in various nuclear data libraries.

Actions taken by the Nuclear Data Group:

Together with the criticality safety designers the NDG understands and identifies the data deficiencies

Sets up strategies to correct the problem (data measurements, analysis and evaluations), and

Makes data available to the criticality safety community (data are submitted to the CSEWG for inclusion in the ENDF library).

NUCLEAR DATA ACTIVITIES FOR 1999

MEASUREMENTS AT ORELA:

- **Capture cross section measurements for ^{27}Al up to 600 keV**

  Motivation:

  To address problems raised by Palmer in the calculation of multiplication factors.

- **Transmission measurement for natural Chlorine up to 400 keV**

  Motivation:

  To address problems on wastes in which PVC material is present.

- **Capture cross section measurements for natural Silicon up to 600 keV**

  Motivation:

  Improve criticality calculations for concrete packaging.

EVALUATIONS WITH SAMMY

- **^{27}Al resolved resonance region (completed)**

  Evaluation done up 850 keV

  Generation of covariance and sensitivity data

- **^{16}O resolved resonance region (nearly completed)**

  Evaluation done up 6.3 MeV

  Generation of covariance and sensitivity data

- **^{233}U resolved resonance region (completed)**

  Evaluation done up 600 eV

  Generation of covariance and sensitivity data

- **^{235}U unresolved resonance region (in progress)**

  Evaluation done from 2.25 keV up 200 keV

- **Covariance generation for silicon isotopes up to 1.5 MeV (data for the AROBCAD project)**

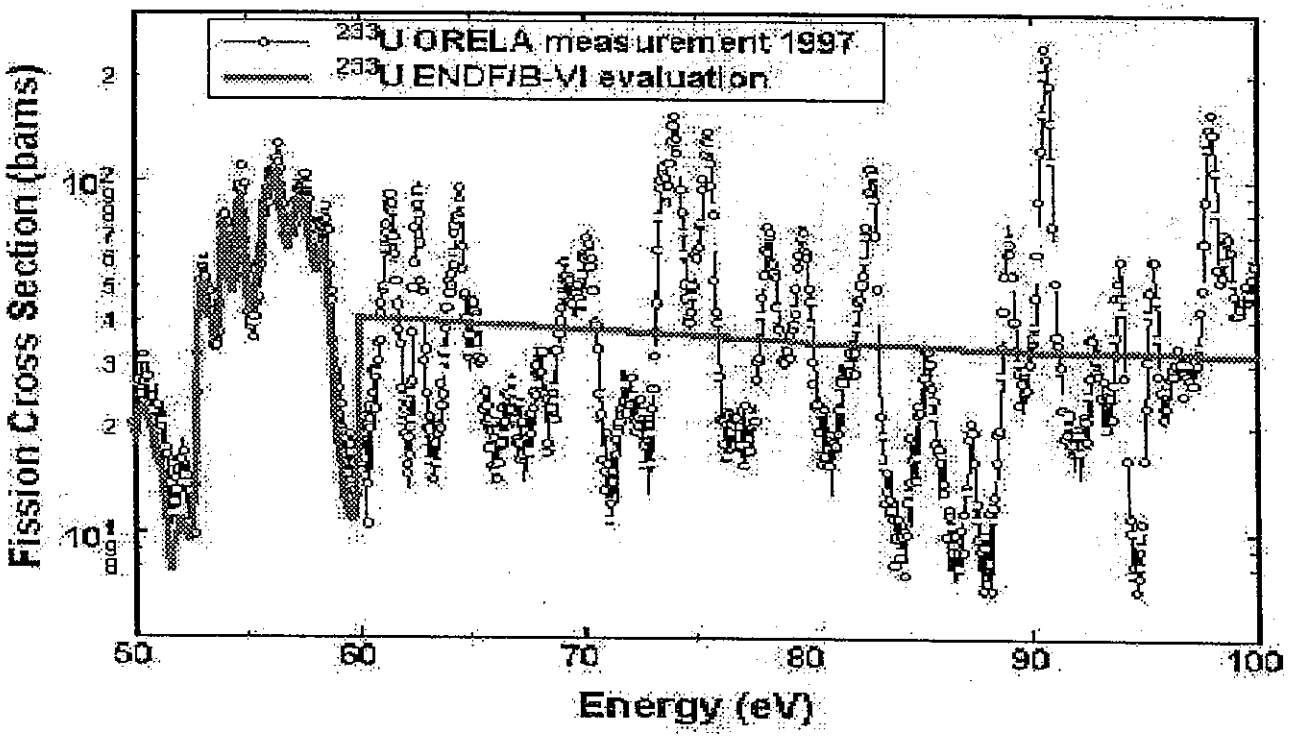
Palmer problem: $Al/^{235}U = 2470$

Code and Cross Section	k.
SCALE 238-Group: ENDF/B-V	0.9802
MCNP Continuous: ENDF/B-V	0.9983 ± 0.0016
MONK Point Energy UKNDL	1.0627 ± 0.0008
SCALE 199-group NDG new evaluation	1.1043

Comparison of Calculated K_{eff} using ENDF/B-VI and NDG/ORNL Cross Section Evaluations

$^{27}Al/^{235}U$	radius(cm)	ENDF/B-VI	NDG Evaluation	AEF*
10	42.397	1.0128	1.0115	353.24
30	61.605	1.0212	1.0143	207.02
50	79.093	1.0310	1.0191	139.00
100	165.2	1.0641	1.0446	27.96
300	260.2	1.0276	1.0431	3.81
500	308.5	1.0014	1.0417	1.39
1000	392.25	0.9484	1.0280	0.35

*AEF = Energy Corresponding to Average Lethargy of Fission.



Comparison of the ^{233}U ENDF/B-VI evaluation and NDG/ORNL Fission Cross Section Measurements

NUCLEAR DATA ACTIVITIES FOR 2000

MEASUREMENTS AT ORELA:

- Two sets of transmission measurements for ^{233}U up to 400 keV
- Capture cross section measurements for Natural Chlorine up to 600 keV
- Two sets of transmission measurements for Natural Potassium up to 400 keV

EVALUATIONS WITH SAMMY

- Unresolved resonance evaluation for ^{233}U
- Unresolved resonance evaluation for ^{27}Al
- Resolved resonance analysis for Chlorine and Potassium
- Covariance data generation

Benchmark Calculations for ORNL ^{233}U Spheres Using 199-Group Cross Sections

CASE	H/X	ENDF/B-VI	NDG Evaluation
ORNL-5	1533.0	0.9968	0.9990
ORNL-6	1470.0	0.9972	0.9995
ORNL-7	1417.0	0.9970	0.9993
ORNL-8	1369.0	0.9969	0.9992
ORNL-9	1324.0	0.9963	0.9986
ORNL-11	1986.0	0.9954	0.9976
Average		0.9966	0.9989

Benchmark Calculations for ^{233}U Spheres Using 199-Group Cross Sections

CASE	ENDF/B-VI	NDG Evaluation
U233-MET-FAST-001	0.9929	1.0003
U233-MET-FAST-002a	0.9952	0.9987
U233-MET-FAST-002b	0.9975	0.9994
U233-MET-FAST-003a	0.9958	0.9988
U233-MET-FAST-003b	0.9971	0.9979
U233-MET-FAST-004a	1.0027	1.0059
U233-MET-FAST-004b	1.0061	1.0052
U233-MET-FAST-005a	0.9949	0.9978
U233-MET-FAST-005b	0.9974	0.9987
FLATTOP-23	1.0004	0.9990
Average	0.9980	1.0002

Benchmark Calculations for ^{233}U Uranyl-Nitrate Spheres Using 199-Group Library

CASE	H/X	ENDF/B-VI	NDG Evaluation
JTS01	190.70	0.9962	0.9970
JTS02	248.70	1.0003	1.0015
JTS03	344.50	0.9953	0.9967
JTS04	575.80	0.9987	1.0006
JTS011	189.40	0.9955	0.9963
JTS012	268.10	0.9951	0.9963
JTS013	542.72	0.9991	1.0009
Average		0.9972	0.9985

XSDRN/KENO-V.a Calculations for ^{235}U (NDG unresolved evaluation included)

CASE	AEF	ENDF/B-VI (R5)	NDG Evaluation
GODIVA	830.0	0.9966	0.9937
BIGTEN	467.0	1.0130	1.0069
ZPR-3/11	437.0	1.0141	1.0078
ZPR-3/12	284.0	1.0109	1.0031
UH3-UR	9.74	1.0089	1.0046
UH3-NI	2.32	1.0176	1.0117
HISS-UR	0.136	1.0115	1.0077
ZEUS-1D (XSDRN)	4.95	0.9916	0.9812
ZEUS25A (KENO-V.a)	4.56	1.0227 ±0.0017	1.0158 ±0.0020

Note: ZEUS-1D and ZEUS25A are numerical benchmarks; the real has k_{eff} of about 1.010 using ENDF/B-VI (R5)

DOE Nuclear Criticality Safety Program Review

- Training Development and Qualification
  - NCSET Modules
  - Contractor training and qualification standard
  - Federal technical qualification standard

Training Development and Qualification Activities

- NCSET Modules
  - Introductory Nuclear Criticality Physics
  - Neutron Interactions
  - Fission Chain Reactions
  - Neutron Scattering

Training Development and Qualification Activities

- NCSET Modules
  - Criticality Limits
  - Diffusion Theory
  - Introductory Monte Carlo Methods

Training Development and Qualification Activities

- Future NCSET Modules
  - Criticality Accident Calculations
  - Hand Calculation Methods
  - ?

Training Development and Qualification Activities

- Contractor Qualification
  - DOE-STD-1135-99, Guidance for Nuclear Criticality Safety Engineer Training and Qualification
  - ? Implementation and Application Manual

JNC TN8200 2000-006 (1/2)

Training Development and Qualification Activities

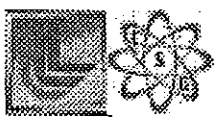
- Federal (DOE) Qualification
  - Criticality Safety Functional Area Qualification Standard

Information Preservation and Dissemination

NCSP Website

Presented to:
NCSP Review

March 27, 2000



Song T. Huang
Group Leader
Criticality Safety Group
Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory, P.O. Box 808, Livermore, CA 94551



U.S. Department of Energy
Nuclear Criticality Safety Program

You're Visitor # 007548

Welcome to the U.S. DOE Nuclear Criticality Safety Program Web site. This site is the focal point for DOE criticality safety activities, resources and references, plus links to other sites actively involved in the collection and dissemination of criticality safety information.

This WWW resource was developed as part of the DOE response to the DNFSB Recommendation 97-2, which reflected the need to make criticality safety information available to a wide audience. To the extent possible, the hyperlinks on these pages direct the user to original source of the reference material in order to ensure accuracy and access to the latest versions.

This website is the result of the efforts of many members of the criticality safety community and is maintained by Lawrence Livermore National Laboratory. It is intended that the site provide information that the user community needs, so your feedback is important. Please contact the Webmaster with comments and suggestions.

Among the features included here are:

- general help for new criticality safety practitioners
- a discussion of computational methods
- collections of bibliographic references and validation experiments
- an interactive question and answer forum for the criticality safety community

- NEW NCSP is currently soliciting your input to enhance Nuclear Criticality Safety Program to serve you more effectively. Please take a moment of your time and fill out the NCSP user survey by click here

- NEW The NCSP program review slides from Albuquerque, NM March 27, 2000 are now available. Please click here to download the individual presentation slides.

Related high-level links:	
U.S. Department of Energy	DOE HQ Criticality Safety Web Site
U.S. Nuclear Regulatory Commission	LANL Criticality Safety Information
Defense Nuclear Facilities Safety Board	ORNL Criticality Safety Information
American Nuclear Society	ANSI/ANS-8 Criticality Safety Standards

Registration

NEXT



UC RL-HI-132027
LLNL Disclaimer



Send us your comments, questions, and suggestions.

U.S. Department of Energy
Nuclear Criticality Safety Program

Site Map

DOE Nuclear Criticality Safety Engineer Training modules six and seve

Master Index of Data and References

Descriptions and links to a variety of databases including published reference material, benchmark experiments and experimental data.

Basic Nuclear Criticality Safety Information

An introduction to the field of criticality safety, a basic reference set for new practitioners, sample criticality safety evaluations, frequently asked questions and more.

Nuclear Criticality Safety Engineer Training NEW!

Links to series of training modules being developed by DOE Nuclear Criticality Safety Program to assist site training organizations in developing a comprehensive criticality safety training program.

Nuclear Criticality Safety related DOE Orders, Regulations, and Standards

Links to various WWW sites containing DOE Orders, DOE Standards, NRC Regulatory Guides, and ANSI Standards.

Other Internet Resources

A hot list of links to an assortment of Nuclear Criticality Safety related WWW sites around the world.

New opportunities in the Nuclear Criticality Safety field NEW!

Links to various web sites contain employment position posting throughout the DOE complex.

How to contribute info to this Website

Information containing on who to contact and how to contribute to this web site.

DOE Criticality Safety Organizations and Groups

Links to an assortment of formal and informal groups actively involved in criticality safety within the DOE, including the Nuclear Criticality Safety Program Management Team, the Criticality Safety Coordinating Team and the Endusers Group.

U.S. DOE NCSP Five Year Plan NEW!

The DOE Nuclear Criticality Safety Program Five Year Plan is a comprehensive plan that integrates seven technical elements into a program that provides for the maintenance of a stable, cross-organizational criticality safety infrastructure while improving the technical basis of criticality safety practices. The Executive Summary provides an introduction to the Five Year Plan.

Training and Conference News

Contain detail information on schedule, location, and workshop agenda for training/conferences.

DNFSB Actions and Operating Experience NEW!

Links to Defense Nuclear Facilities Safety Board regarding recommendations and actions, DOE Operating Experience Weekly Summaries.

Criticality Safety Codes and Data

Descriptions of the codes and code systems used in criticality safety analyses and links to the sites supporting those codes.

Messages Board

This message board was provided to encourage communication among various criticality safety professionals in the DOE Complex. It is the responsibility of the personnel participating in the message board to provide accurate and meaningful dialogue to enhance communication process.

PREV

Website Features

- Site map to assist information dissemination
- Links to major laboratories and organizations involved in criticality safety
- Collection of bibliographic references
- General help for new criticality safety practitioners
  - Including basic technical references and training modules
- Discussion of computational methods
- Email directory listing of nuclear criticality safety professionals
- Interactive question and answer forum for the criticality safety community

Website Statistics

- More than 6200 visitors in 1999
- Approximately 200 registered users
  - Utilized as an information tool
  - Utilized as a portal to other DOE and NCS related web sites
- 7 training modules
  - Introductory Nuclear Criticality Physics
  - Neutron Interactions
  - The Fission Chain Reaction
  - Neutron Scattering and Moderation
  - Criticality Safety Limits
  - Introduction to Diffusion Theory
  - Introduction to the Monte Carlo Method
- More than one thousand downloads of the Nuclear Criticality Safety Engineer Training modules
- Bibliographic reference databases are the most used section of the website
  - Over 7000 accesses and searches

AROBCAD Project Review
Community Feedback

US DOE Nuclear Criticality Safety Program (NCSP)
Task response to DNFSB 97-2
Sub-recommendation 3

March 27, 2000
Albuquerque, NM

C. M. Hopper

ornl

AROBCAD Overview

Applicable Ranges: Bounding Curves and Data

- Program Goals
- Features
- Evolution of Competence
- Technology Considerations
- Allocated Team / Resources for Success
- Conduct and Administration of AROBCAD Project
- Products
- Status
- Expected Results

AROBCAD Program Goals

- BENCHMARKING AREAS OF APPLICABILITY & BOUNDING MARGINS OF SUBCRITICALITY FOR SAFETY
- ENHANCEMENT TO OTHER PROJECTS
- SUPPORT FOR PROJECT COMPLETION
- HIGH - LEVEL TIMING GOALS

AROBCAD Program Goals

- BENCHMARKING

Defining Applicable Ranges of Validations

Grounded in Sound Theories and Technologies

for

Defining Bounding-Curves / Data

In Evaluations Determining Adequate Margins
of Nuclear Subcriticality

for

USE BY CONTRACTORS AND DOE OVERSIGHT

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JNC TN8200 2000-006 (1/2)

AROBCAD Program Goals

- ENHANCEMENT TO OTHER DOE PROJECTS

  – NCSP
  - » Identifies needed critical experiments / adjuncts
  - » Compares computed / measured benchmark uncertainties
  - » Links final product software to analytical methods
  - » Assists nuclear data needs identification
  - » Provides training and qualification in use of AROBCAD software products

  – EMSP
  - » SAMS
  - » NEWT

AROBCAD Program Goals

- SUPPORT FOR AROBCAD PROJECT COMPLETION

AROBCAD Products Maintain

» ***Cognizant Acceptance/Promotion by***

US DOE NCSP Criticality Safety Support Group (CSSG)

US DOE NCSP Project Management Team (PMT)

US DOE NCS Community (THE DOERS)

AROBCAD Products Engender

» ***Fiscal Support from***

US DOE

AROBCAD Program Goals

- HIGH - LEVEL TIMING GOALS

  DOE MISSIONS ATTAINMENT

  - » Software and Evaluation Guidance
  - » Environmental / Non - reactor Nuclear Facility Remediation
  - » Waste Disposal
  - » Fissile material dispositioning programs
    - NSNF Program (transportation, emplacement, etc.)
    - Hanford K-Basin sludge transfer to Tanks (now mute)
    - Plutonium - uranium mixed oxide fuel design / fabrication (processing, fabrication, transportation, etc.)

AROBCAD Features

- SENSITIVITY / UNCERTAINTY
  METHODS ATTRIBUTES
- OPTIMIZATION COMPUTATION METHOD

AROBCAD Features

- SENSITY / UNCERTAINTY METHODS ATTRIBUTES
  - » Reveal Fine Structure of Problems
  - » Identify Potential Fix Points
  - » Define Acceptable Margins of Subcriticality for Safety
  - » Define Applicability of Validation Benchmarks for Safety Evaluations

AROBCAD Features

- **OPTIMIZATION COMPUTATION METHOD**

  BOUNDING - CURVES Development Advantage

  (Preparatory for NCS Evaluations)

  - » Supports automated examination of importance parameters
  - » Supports maximization (nuclear reactivity)
  - » Supports minimization of critical mass, etc.

FOR MORE INFO...

- **US DOE Technical Program Plan for Development of Guidance for Defining Applicable Ranges of Bounding Curves and Data Relative to Nuclear Criticality Safety (NCS)**, Rev 4, September 28, 1998
- **US DOE Nuclear Criticality Safety Program Five Year Plan**, August 1999 (http://ncsc.llnl.gov:8080/plan/FINAL_5-YEAR.PDF)

Evolution of Competence

- HISTORIC METHODS COMPARED TO AROBCAD
- WEAKNESSES OF HISTORIC METHODS
- STRENGTHS OF AROBCAD METHODS

Evolution of Competence

HISTORIC METHODS FOR BIAS-TRENDING / DATA-POOLING COMPARED TO AROBCAD

- **HISTORIC: SUBJECTIVE**
  - » Moderator-to-fissile atom ratios (i.e., H/X, C/X, B/X, etc.)
  - » Average neutron energy group causing fission
  - » Energy of average lethargy causing fission
  - » Crude (3 - 5 energy group) spectral indexes
- **FLAWED VALIDATION of NCS COMPUTATIONAL AREAS OF APPLICABILITY FOR EVALUATIONS**

Evolution of Competence

HISTORIC METHODS FOR BIAS-TRENDING / DATA-POOLING COMPARED TO AROBCAD

- **AROBCAD: OBJECTIVE**
  - » NUCLEAR PHYSICS PARAMETERS
- **ACCURATE VALIDATION of NCS COMPUTATIONAL AREAS OF APPLICABILITY FOR EVALUATIONS**

Evolution of Competence

HISTORIC METHODS FOR BOUNDING CURVES / DATA COMPARED TO AROBCAD

- **HISTORIC: EXPERT JUDGEMENT**
  - » Extracted from SAFETY handbooks for estimating adequate margins of subcriticality (apples / oranges)
  - » Safety principles / measures not specific to application fissile materials of concern
    (MAINLY water moderated, water reflected, as well as unreflected)
- **AROBCAD: OBJECTIVE, NUCLEAR PHYSICS PARAMETER EVALUATION / EXPERT JUDGEMENT**

Evolution of Competence

- WEAKNESSES OF HISTORIC METHODS
  - » **Inadequate objective guidance** for areas of applicability
  - » **Frequently misapplied** to accommodate technical or production goals

Evolution of Competence

- STRENGTHS OF AROBCAD
  - » Standardized use of well established sensitivity and uncertainty (S/U) theories for determining areas of applicability from nuclear physics parameters
  - » Comparison / trending between benchmark & safety evaluation
    - » D_X – nu-bar, capture, scatter
    - » c_k, – Correlation coefficients of common variations between benchmarks & evaluation
    - » E_X – fission, capture, scatter

Evolution of Competence

- STRENGTHS OF AROBCAD
  - » Flexible data adjustments estimate Benchmark validation bias
  - » Evaluation bias predicted using the generalized linear least squares method (GLLSM)
  - » Modifies and will apply sound optimization theories to the well developed SCALE suite of "production" nuclear criticality safety codes into the developing SWAN - SCALE sequence
    - XSDRN – SEN1 (US NRC initiated)
    - NEWT – SEN2 (US DOE EMSPsupported)
    - KENO-Va – SAMS (US DOE EMSP supported)

Evolution of Competence

- AROBCAD GROWTH OPPORTUNITIES (weaknesses?)
  - » Unfamiliarity
  - » Complexity
  - » Ease of "black-boxing" "the answer"
  - » Trap of getting "the answers", void of "common sense"

FOR MORE INFO...

B. L. Broadhead, C. M. Hopper, R. L. Childs, and G. V. Parks, ***Sensitivity and Uncertainty Analyses Applied to Criticality Validation***, *Methods Development* and *Illustrative Applications and Initial Guidance*, NUREG/CR-5593, Vol. 1 & 2, ORNL/TM-13692/V1&2,(http://www.nrc.gov/NRC/NUREGS/CR6655/cr6655v1.pdf, and http://www.nrc.gov/NRC/NUREGS/CR6655/cr6655v2.pdf).

Technology Considerations

- S/U TECHNOLOGY NEW TO NCS
  - » Successful during fast breeder reactor (FBR) design days
  - » Mathematically / physically sound for range of applicability determination
  - » Structured application of ANSI/ANS-8.1-1998 Standard
    - Code validation
    - Areas of applicability
    - Bias
    - Bias uncertainties

AROBCAD Project Success
Allocated Team / Resources

- TEAM PERSONNEL EXPERIENCE
- FISCAL SUPPORT
- PRODUCTS

AROBCAD Project Success
Allocated Team / Resources

- TEAM PERSONNEL EXPERIENCE

  ORNL STAFF

  RELEVANT, NCS ISSUES

  » Sensitivity & Uncertainty Software Development
  » Authorship & Applications Expertise

ornl

AROBCAD Project Success
Allocated Team / Resources

- TEAM PERSONNEL EXPERIENCE

ORNL STAFF

BROAD VERSATILITY & EXPERTISE

Employs Both Historic & Current Approaches Regarding

- » Shielding Optimization Code
- » Development
- » Maintenance
- » Distribution
- » Education & Training
- » User - Assistance Through the SCALE System

ORNL

AROBCAD Project Success
Allocated Team / Resources

- TEAM PERSONNEL EXPERIENCE

  ORNL, ANL & LANL

  EXPERTISE

  - » Cross Section Measurement
  - » Evaluation
  - » Processing: Data & Data-Uncertainty Determination

AROBCAD Project Success
Allocated Team / Resources

- TEAM PERSONNEL EXPERIENCE

  UC BERKLEY STAFF

  EXPERTISE

  » SWAN Optimization Code

AROBCAD Project Success
Allocated Team / Resources

- FISCAL SUPPORT
  - » US DOE NCSP
    Direct Project Support
  - » US NRC Research
    Indirect, Initial Developmental Support

AROBCAD Project Success
Allocated Team / Resources

PRODUCTS

US DOE NCSP

» 2006 - AROBCAD Products Completed

» 2006 - Major AROBCAD Support Terminated

» 2008 - Preliminary Training & Software Transition Completed

AROBCAD BACKGROUND

- BEGINNING - ORNL Conceived / Managed
- CLIENT - US DOE NCSP
- INPUT SOURCES
  - » Expert Team Members
  - » Cognizance / Approval by
    - › US DOE NCSP CSSG
    - › PMT
- FEEDBACK - Potential User Communities
  - » American Nuclear Society
  - » US DOE Nuclear Criticality Safety Program Workshops
- DNFSB Members & Staff Actively Monitoring Progress

ornl

AROBCAD Products

- Ranges of Applicability report draft including
  - » Description of the developing CANDD(E) code
  - » Description of the refined GLLSM code
  - » Interfacing of SEN1 and SAMS codes
  - » Prototypic testing on DOE EM issues
    - Hanford K-Basin to Waste Tank
    - SNF disposal
    - Review of critical experiment results
  - » Prototypic Testing
- Summary draft report on NCS practices for defining bias and margins of subcriticality for safety
- SWAN-SCALE Manual draft including
  - » Expanded Optimization Theory
  - » Implementation Approach
  - » Prototypic Testing

AROBCAD Schedule

FY 2000

- FINAL REPORT
- NIST Discrepancies Report Draft

AROBCAD Schedule

FY 1999

- RANGES OF APPLICABILTY REPORT DRAFT (delayed)
  - » IPPE & LACEF HEU / SiO_2 Experiments to NSNFP
  - » Available / Potential Gadolinium Data from LACEF
  - » Hanford K-Basin-to-Tank Benchmarks

AROBCAD Schedule

- FY 1999

  VARIOUS REPORT DRAFTS (in final draft)

  - » Expanded Optimization Theory
  - » Implementation Approach
  - » Prototypic Testing

AROBCAD Schedule

- FY 1999

DRAFT SUMMARY (delayed)

» Practices for Identifying Acceptable Margins of Subcriticality

AROBCAD Schedule

FY 2000

- FINAL REPORT
- NIST Discrepancies Report Draft

FOR MORE INFO...

US DOE Nuclear Criticality Safety Program Five Year Plan, August 1999

Current AROBCAD Status

- PROJECT INITIATED, First 2nd Qtr FY 99
- PROJECT PROGRESS
  - » Optimization Code
  - » NIST Water Sphere Data Study
  - » Prototypic Sensitivity / Uncertainty (S/U) Analyses
    - Specific DOE applications
  - » Technical Guidance Drafting
    - Interpolating / Extrapolating Bounding Curves & Data
    - Establishing Bounding Margins of Subcriticality for Safety

FOR MORE INFO...

C. M. Hopper, *US DOE NCSP AROBCAD Project Status*, Oak Ridge National Laboratory, 1999 ANS Annual Meeting, Boston, Massachusetts, June 9, 1999.

SAIC

Expected Results of AROBCAD

- Scientifically Defensible Tools for DOE / Contractors to Quantify:
  - » Validated areas of applicability
  - » Computational bias, and bias uncertainty
  - » Adequate margins of subcriticality for nuclear criticality safety

Expected Results of AROBCAD

- Recognition of Departmental Commitment to NCS Program
- Useful, Supportive of all Program Offices

Expected Results of AROBCAD

- Defining Cost Effective Operations / Nuclear Criticality Safety Applications

海外出張報告書

臨界安全技術プロジェクトワークショップ(NCTSP)

資料集

(会議報告)

2000年7月

核燃料サイクル開発機構
東海事業所

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2000

海外出張報告書
臨界安全技術プロジェクトワークショップ(NCTSP)

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RECOMMENDATION 97-2 TO THE SECRETARY OF ENERGY

Pursuant to 42 U.S.C. § 2286a(a)(5),
Atomic Energy Act of 1954, As Amended

Dated: May 19, 1997

In the first two or three decades following the Manhattan Project, nearly every laboratory of the Atomic Energy Commission (AEC) had an active program addressing some phase of the physics of neutron chain-reacting systems. Each such study included a balance of experiment and theoretical analysis, as is common in engineering research. Some of the programs supported the design of nuclear weapons, some were directed at the design of nuclear reactors, and some were conducted simply as basic engineering research.

As a result of these programs, expertise in neutron chain–reacting systems was widespread; there was an abundance of individuals skilled in achieving and controlling neutron chain reactions. These individuals usually became expert as well in methods for avoiding a chain reaction when this is not desired. The state of a self-sustaining chain reaction is commonly called "criticality." Guidance by these knowledgeable individuals helped establish an admirable record of criticality safety in the many programs the AEC conducted with fissionable material. While occasional accidental criticality did occur at the peak of AEC activity, it seldom caused injury to workers, and never led to radiation affecting individuals off site. Furthermore, the last such instance of inadvertent criticality in the United States occurred about 20 years ago.

Some criticality research continued to replenish the supply of these experts through the era of the Energy Research and Development Administration (ERDA) and into the period of the Department of Energy (DOE), though at a steadily reduced rate. Today there is almost no theoretical research in criticality being conducted, although university courses continue to instruct students in the theoretical expertise that has already been developed. However, most of the early experts in criticality safety control were drawn from experimental research programs. For a number of years, the DOE complex placed its reliance for criticality safety on the diminishing number of such criticality control experts developed in earlier years. Recently, however, DOE has been forced to supplement that group with engineers trained on the job in the conduct of criticality calculations. The latter group contains few individuals who have conducted critical mass experiments. Thus collectively they have little practical experience pertinent to avoiding chain reactions in nonreactor environments.

In 1993, the Defense Nuclear Facilities Safety Board (Board) sensed that the source of experimental competence in prevention of inadvertent criticality was in danger of being lost entirely as a result of DOE's impending closure of the last critical mass facility in the country. That closure would have ended the hands-on education of new generations of scientists and engineers in the properties and behavior of critical systems. However, expertise in criticality safety will continue to be needed as long as fissionable material is used and stored. The Board viewed the end of experimental criticality studies as a threat to criticality safety in future DOE

activities, and issued Recommendation 93-2, which advised against such action. As stated in that Recommendation,

> The Board believes it is important to maintain a good base of information for criticality control, covering the physical situations that will be encountered in handling and storing fissionable material in the future, and to ensure retaining a community of individuals competent in practicing the control.

The Secretary accepted Recommendation 93-2 on May 12, 1993, noting the importance of (1) improving and maintaining a criticality control information base, especially to support future operations in handling, processing, and storage or disposal of fissionable material; (2) retaining a cadre of individuals competent in practicing criticality control and safety; (3) continuing an experimental program; (4) continuing an education program for criticality safety professionals; (5) coordinating the criticality program among various users; (6) performing a criticality assessment with respect to defense nuclear facilities to determine the scope of current and future requirements for criticality experiments, predictability, and training; and (7) investigating the mission requirements, program funding, and landlord issues.

Since Recommendation 93-2 was issued, DOE has made substantial progress in coordination and implementation of the criticality experiments program. Funding for the program has stabilized, albeit at a low level, and work has been initiated on a prioritized list of experiments. However, a basic set of problems continues to exist throughout the DOE complex with regard to criticality control. Among the problems are the following:

1. In the past, it was found that only a few experienced criticality engineers were needed to guide criticality safety at even the most complex facilities. However, at the majority of DOE facilities where accidental criticality is currently a potential issue, the number of engineers assigned to criticality control is surprisingly large. The typical criticality safety staff consists mainly of individuals who have no prior first-hand experience in criticality, and who have been trained on the job in analytical aspects of criticality control after being hired. They lack background in neutron physics on a fundamental level, and are not familiar with work on assemblies near the critical state, activities that would foster intuitive approaches to criticality control. Therefore, when faced with the need to determine what must be done to avoid a chain reaction, they most frequently fall back on complex multidimensional Monte Carlo calculations. Their use of simplified methods and their reliance on published data are minimal. The Board points out that complex analysis may be needed for some cases, such as those with difficult geometry, but such analysis is time-consuming and may dramatically slow preparation for the activities being evaluated.

2. Operational practices at some DOE facilities place criticality control in a central position in operations, with the criticality engineer establishing certain aspects of

operation for safety reasons. Effectively, the criticality engineer, with all the shortcomings described in 1 above, becomes the critical path for line management. This causes delays in the ability of the line management to develop overall safety requirements.

3. In the past, most of the criticality safety data in guidance documents has been directed to activities involving production of nuclear weapons. The guidance has incorporated data from several experimental programs established to ensure avoidance of unintentional criticality in weapons programs. The experimental data has often been generalized by analysis of the experimental results and by theory benchmarked against experiments. The missions of DOE have changed substantially, however, and guidance for other types of activities is now needed. It is particularly important that guidance be developed to help in analyzing the safety of cleanup operations and the handling, storage, and shipping of miscellaneous containers that include fissionable material mixed with other material.

The above problems have had a significant effect on the productivity of several DOE operations. They have adversely affected safety by extending the period of time required for meeting safety commitments, such as those responding to Board Recommendation 94-1. In so doing, they have absorbed resources potentially needed for other safety-related activities at DOE's defense nuclear facilities. In this light, the Board believes action should be taken to eliminate these problems and to ensure that criticality safety can continue to be achieved efficiently in DOE's future operations.

Therefore the Board recommends that DOE:

1. Restructure the program of experimental research in criticality established under the Implementation Plan for Recommendation 93-2 to emphasize determination of bounding values for criticality of systems most important in the current programs at DOE facilities.

2. Organize the records of calculations and experiments conducted to ensure the criticality safety of DOE's past operations so as to provide guidance for criticality safety in similar situations in the future and avoid repetition of past problems.

3. Establish a program to interpolate and extrapolate such existing calculations and data as a function of physical circumstances that may be encountered in the future, so that useful guidance and bounding curves will result.

4. Collect and issue the experimental and theoretical data from the above in a publication as guidance for future activities.

5. Clarify in guidance that simple, bounding methods of analysis can be used in place of specific theoretical analysis in setting criticality limits for processes, and that limits derived in this

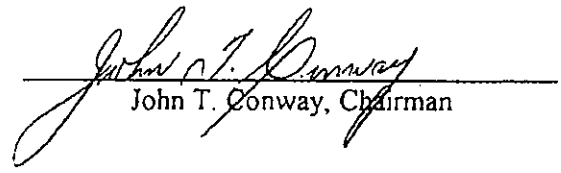
manner are even preferable where they serve the purpose. The decreasing order of preference should be experimental data, theory benchmarked against experimental data, and nonbenchmarked criticality analysis with an adequate safety margin.

6. Develop and institute a short but intensive course of instruction in criticality and criticality safety at DOE's criticality experiments facility to serve as the foundation for a program of formal qualification of criticality engineers. This course should instill in students a familiarity with the factors contributing to criticality, the physical behavior of systems at and near criticality, and a theoretical understanding of neutron multiplication processes in critical and subcritical systems. A goal would be for reliance for criticality safety at any DOE facilities to rest in a group of individuals endowed with such experience.

7. Where not already done, assign criticality safety as a staff function assisting line management, with safety responsibility residing in line management.

8. Identify a core group of criticality experts experienced in the theoretical and experimental aspects of neutron chain reactions to advise on the above steps and assist in resolving future technical issues.

9. Organize funding of the criticality research and instruction program to improve its stability and to recognize the cross-cutting importance of this activity.



John T. Conway, Chairman

Department of Energy
Implementation Plan

for

Defense Nuclear Facilities Safety Board
Recommendation 97-2

Criticality Safety

December 1, 1997

Executive Summary

On July 14, 1997, the Department of Energy (the Department) accepted Defense Nuclear Facilities Safety Board (the Board) Recommendation 97-2. The recommendation addresses the effectiveness of criticality safety programs at defense nuclear facilities. In developing this Implementation Plan, the Department builds on the actions taken for Board Recommendation 93-2, *The Need for Critical Experiment Capability*. The Implementation Plan for Board Recommendation 93-2 established programs to ensure the viability of the Department's critical experiments program. It resulted in the five-element Nuclear Criticality Predictability Program (NCPP) as described in the NCPP five-year plan of November 1996. The ongoing activities of the NCPP will be managed under the program established for Board Recommendation 97-2. Effective implementation of the 97-2 crosscutting criticality safety activities is important to the successful completion of other Departmental programs, such as those programs which address Board Recommendations 97-1, 94-1, 94-4, and 95-2. The Implementation Plan for Board Recommendation 97-2 will support the efficient integration and functioning of criticality safety programs across all Departmental operations involving fissile material.

The Department recognizes the need to integrate safety into its work. Initiatives are being implemented, as appropriate, to apply graded or tailored approaches to the work and any associated hazards. Where operations involve significant quantities of fissile material, accidental criticality is a hazard that must be analyzed and for which controls must be identified and implemented. The Department recognizes that the process of identifying and analyzing credible accident scenarios and implementing appropriate controls to prevent or mitigate an accidental criticality must involve an efficient process that does not use excessive resources and that allows the work to be accomplished in a timely manner. Therefore, this Implementation Plan identifies and will address the following central safety issue: the need for improved criticality safety practices and coherent programs to alleviate the potential adverse impacts on safety and productivity of Department of Energy operations.

The Department will take the following actions to address this issue:

1. Improve the technical knowledge of criticality safety personnel. This will be accomplished by updating and improving the training offered at DOE's critical experiments facility, improving site training and qualifications programs by identifying and incorporating best practices, and by identifying exceptional criticality safety curricula offered at institutions outside the Department;

2. Improve the availability and use of criticality safety information (i.e., experimental data, calculational studies, and evaluations) and guidance. Effective use of criticality safety Internet web pages will ensure widespread availability of information, and guidance will stress the appropriateness and application of simplified methods of criticality safety analysis; and

3. Verify that sites having fissile material operations have appropriately considered criticality safety in the work planning process through the implementation of the Integrated Safety Management System (ISMS), and that their criticality safety programs are organized as a staff function advising line management.

Table 1 summarizes the commitments in this plan, which are described further in Section 6.

Table 1. Summary of Implementation Plan Commitments and Deliverables/Milestones

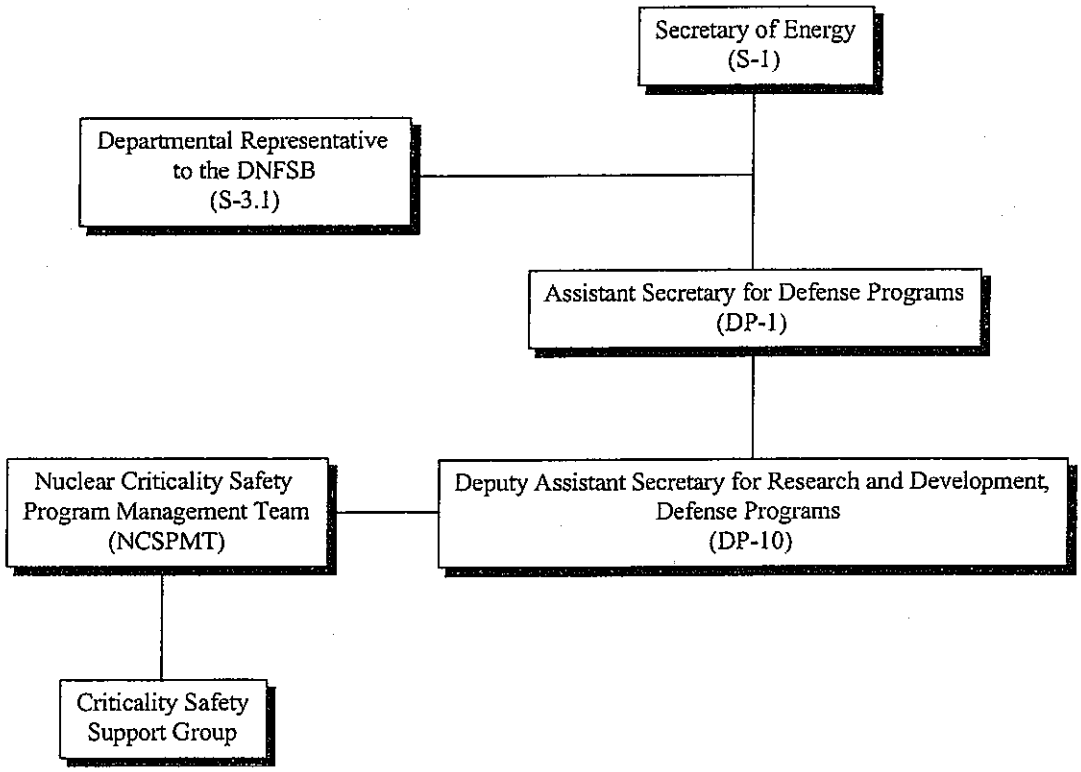
Commitment	Deliverable/Milestone	Due Date	Responsibility
6.1 Reexamine the experimental program in criticality research	1. Assessment report of criticality research program	March 1998	NCSPMT
6.2.1 Perform CSIRC pilot program	1. Identify an experiment to archive	November 1997	NCSPMT
	2. Archive logbook(s) and calculation(s) for that experiment	December 1997	NCSPMT
	3. Videotape the original experimenter	January 1998	NCSPMT
	4. Digitize data and calculations	February 1998	NCSPMT
	5. Publish data and calculations	April 1998	NCSPMT
6.2.2 Continue to implement the CSIRC program	1. Collocate logbooks (copies or originals) from all U.S. critical mass laboratories	December 1998	NCSPMT
	2. Screen existing logbooks with original author/experimenter	December 1998	NCSPMT
	3. CSIRC program plan	December 1998	NCSPMT
6.3 Continue and expand work on ORNL sensitivity methods development	1. Technical program plan	July 1998	NCSPMT
	2. Document initiation of priority tasks from the program plan in the quarterly report to the Board	January 1999	NCSPMT
6.4 Make available evaluations, calculational studies, and data by establishing searchable databases accessible through a DOE Internet web site	1. DOE criticality safety web site	March 1998	NCSPMT
	2. Y-12 evaluations on DOE web site	June 1998	NCSPMT
	3. Calculations compiled by the Parameter Study Work Group on DOE web site	September 1998	NCSPMT
	4. Nuclear Criticality Information System Database on DOE web site	March 1999	NCSPMT
6.5.1 Revise and reissue DOE-STD-3007-93	1. Revise DOE-STD-3007-93	September 1998	NCSPMT
6.5.2 Issue a guide for the review of criticality safety evaluations	1. Departmental guide for reviewing criticality safety evaluations	May 1999	NCSPMT
6.6.1 Expand training course at LACEF	1. Expanded LACEF training course	July 1998	NCSPMT

Commitment	Deliverable/Milestone	Due Date	Responsibility
6.6.2 Investigate existing additional curricula in criticality safety	1. Assessment of additional training needs and review of available supplementary curricula	June 1998	NCSPMT
	2. Initiate a program which addresses identified needs	December 1998	NCSPMT
6.6.3 Survey existing contractor site-specific qualification programs	1. Report on the review of site qualification programs	June 1998	NCSPMT
	2. Guidance for site-specific criticality safety training and qualification programs	September 1998	NCSPMT
	3. Guidance to procurement officials specifying qualification criteria for contractor criticality safety practitioners	September 1998	NCSPMT
	4. DOE Field will provide line management dates upon which contractors will have implemented guidance in Deliverable #2, above	March 1999	Field Office Managers
6.6.4 Federal staff directly performing criticality safety oversight will be qualified	1. Qualification program for Departmental criticality safety personnel	December 1998	NCSPMT
	2. DOE criticality safety personnel qualified	December 1999	NCSPMT
6.7 Each site will conduct surveys to assess line ownership of criticality safety	1. Individual sites issue report of findings	June 1998	Field Office Managers
6.8 The Department will form a group of criticality safety experts	1. Charter for Criticality Safety Support Group approved by the NCSPMT	January 1998	NCSPMT
6.9 Create NCSPMT charter and program plan	1. NCSPMT charter	January 1998	NCSPMT
	2. NCSPMT program plan	June 1998	NCSPMT

Figure 1 illustrates the organization of the Department's criticality safety function. The Assistant Secretary for Defense Programs (DP-1) will be responsible for leading the Department's criticality safety activities. The Departmental Representative to the Defense Nuclear Facilities Safety Board (S-3.1) will assist DP-1 in resolving funding issues, if necessary. The Responsible Manager will be the Deputy Assistant Secretary for Research and Development, Office of Defense Programs (DP-10), who will oversee the execution of this plan. A Nuclear Criticality Safety Program Management Team (NCSPMT) will be responsible for the execution of this Plan as well as ongoing activities from the Department's response to Board Recommendation 93-2. The NCSPMT will receive technical support from a Criticality Safety Support Group. Both the NCSPMT and the Criticality Safety

Support Group will be established under charters developed as part of this Implementation Plan.

Figure 1. Department of Energy Nuclear Criticality Safety Program Organization



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1. Background

On May 19, 1997, the Board issued Recommendation 97-2, addressing the need for improved criticality safety practices and programs to alleviate potential adverse impacts on safety and productivity of Department of Energy operations. This Plan describes the actions which will enhance criticality safety in the Department's operations and will effectively respond to the Board's specific recommendations listed below:

Subrecommendation 1: Restructure the program of experimental research in criticality established under the Implementation Plan for Recommendation 93-2 to emphasize determination of bounding values for criticality of systems most important in the current programs at DOE facilities.

Subrecommendation 2: Organize the records of calculations and experiments conducted to ensure the criticality safety of DOE's past operations so as to provide guidance for criticality safety in similar situations in the future and avoid repetition of past problems.

Subrecommendation 3: Establish a program to interpolate and extrapolate such existing calculations and data as a function of physical circumstances that may be encountered in the future, so that useful guidance and bounding curves will result.

Subrecommendation 4: Collect and issue the experimental and theoretical data from the above in a publication as guidance for future activities.

Subrecommendation 5: Clarify in guidance that simple, bounding methods of analysis can be used in place of specific theoretical analysis in setting criticality limits for processes, and that limits derived in this manner are even preferable where they serve the purpose. The decreasing order of preference should be experimental data, theory benchmarked against experimental data, and nonbenchmarked criticality analysis with an adequate safety margin.

Subrecommendation 6: Develop and institute a short but intensive course of instruction in criticality and criticality safety at DOE's criticality experiments facility to serve as the foundation for a program of formal qualification of criticality engineers. This course should instill in students a familiarity with the factors contributing to criticality, the physical behavior of systems at and near criticality, and a theoretical understanding of neutron multiplication processes in critical and subcritical systems. A goal would be for reliance for criticality safety at any DOE facilities to rest in a group of individuals endowed with such experience.

Subrecommendation 7: Where not already done, assign criticality safety as a staff function assisting line management, with safety responsibility residing in line management.

Subrecommendation 8: Identify a core group of criticality experts experienced in the theoretical and experimental aspects of neutron chain reaction to advise on the above steps and assist in resolving future technical issues.

Subrecommendation 9: Organize funding of the criticality research and instruction program to improve its stability and to recognize the cross-cutting importance of this activity.

2. Underlying Causes

The Department recognizes the need for improved criticality safety practices and coherent programs to alleviate potential adverse impacts on safety and productivity of Department of Energy operations. The Department believes that the following items have contributed to the current situation which has resulted in Board Recommendation 97-2:

A. Criticality safety has not been systematically integrated into work planning and implementation. In some instances, this has resulted in inadequate process descriptions, procedures, and scope of applicable process upsets during the development of criticality safety evaluations and limits.

B. The criticality safety data, calculational studies, and evaluations that have been identified and made readily accessible to the practitioner are not sufficiently inclusive of all data, calculational studies, and evaluations that exist. Much of the available information still resides in logbooks and internal reports at individual sites. For most of these, there is no catalog, retrieval, or distribution system which can make them available to the criticality safety practitioner.

C. Adequate criticality safety data supporting some current missions do not exist. If this deficiency is not addressed, criticality safety personnel will have to impose additional conservative margins of subcriticality on the affected operations. In a few instances where this has happened in the past, this practice has resulted in inefficiencies in operations and has delayed completion of the supporting criticality safety evaluations.

D. Some criticality safety personnel have not had sufficient practice in the application of methods for determining margins of subcriticality alternative to those relying on detailed computer modeling to permit generalization and extrapolation from existing calculations or data. This results in over-reliance on complex computational methods which may in some cases be less efficient than using alternative analytical methods, where such methods can be shown to be applicable.

E. Criticality safety practitioners often lack the practical experience with fissile material operations necessary to identify or assist operating personnel in identifying the proper set of credible process upset conditions applicable to operations. Reliance instead is improperly placed on the review process for identification. The lack of experience with operations also detracts from the ability of the criticality safety practitioner to justify why a particular set of process upsets make up a necessary and sufficient set of scenarios. It is in the better interest of both safety and efficiency for such proper-set identification to occur earlier in the criticality safety evaluation process.

3. Baseline Assumptions

In the development of this Implementation Plan, the following assumptions are made:

A. Recommendation 97-2 builds upon the successful actions taken in response to Recommendation 93-2, The Need for Critical Experiment Capability, which established the Nuclear Criticality Predictability Program.
B. Funding for out-year tasks in this Plan will be provided.
C. Recommendation 97-2 is viewed as supplementing the scope of Recommendation 93-2 activities to

focus on remaining practical criticality safety issues.

4. Related Activities

The following ongoing or completed activities are relevant to the issues in this Plan:

A. The International Criticality Safety Benchmark Evaluation Project is promulgating benchmarked criticality data to the field (benchmarking program element of NCPP) including previously undocumented United States experiments as well as data from outside the United States.
B. Los Alamos National Laboratory has archived the Rocky Flats, Hanford, and Brookhaven critical mass laboratory logbooks.
C. Criticality safety related web pages are under development.
D. Y-12 has developed a relational database for criticality safety evaluations and document indexes that may be used as an example for information sharing (inactive data bases include LLNL, NCIS, Hanford, etc.).
E. Russian process criticality accident histories are being researched and documented and will be promulgated.
F. A Departmental Review Guide for criticality safety evaluations has been drafted and issued to the Oak Ridge Operations Office.
G. The Department developed the NCPP five-year plan of November 1996 in response to Board Recommendation 93-2, which consists of the following five elements:
    - Experiments;
    - Training;
    - Benchmarking;
    - Methods; and
    - Nuclear Data.
H. A Department Good Practices Guide for criticality safety is in draft form and is ready for review.
I. Nuclear data and criticality calculational methods continue to be published and issued to the Department's nuclear criticality safety practitioners by the Radiation Safety Information Computational Center (RSICC) as supported, in part, by the Department's objectives for 93-2.

5. Organization and Management

The Department recognizes the need to conduct a coherent nuclear criticality safety program which performs essential crosscutting activities such as improving the technical training and qualification of the criticality safety community and providing criticality safety information and guidance for the practitioner. These activities will enhance the safety of all operations involving fissile material while improving the efficiency of criticality safety programs. Since criticality safety issues affect a number of Departmental Program Offices, involvement of all affected Program Offices is essential to conduct a coherent and efficient criticality safety program.

The Assistant Secretary for Defense Programs (DP-1) will be responsible for leading the Department's criticality safety activities. The Departmental Representative to the Defense Nuclear Facilities Safety Board (S-3.1) will assist DP-1 in resolving funding issues, if necessary. The Responsible Manager is the Deputy Assistant Secretary for Research and Development, Office of Defense Programs (DP-10), who will oversee the execution of this plan. A Nuclear Criticality Safety Program Management Team (NCSPMT) will be responsible for the

execution of this Plan as well as ongoing activities from the Department's response to Board Recommendation 93-2. This team will consist of representatives from the following offices: Defense Programs (DP); Environmental Management (EM); Environment, Safety and Health (EH); Energy Research (ER); Fissile Materials Disposition (MD); and Nuclear Energy, Science and Technology (NE). The NCSPMT, co-chaired by DP and EM, will advise and assist the Responsible Manager on technical and programmatic issues involving the implementation of crosscutting activities of the Department's criticality safety program. The NCSPMT will receive technical support from an Criticality Safety Support Group. This Criticality Safety Support Group will be a standing group of recognized criticality safety experts from Department of Energy and contractor communities, and will help resolve present and future technical criticality safety issues. Both the NCSPMT and the Criticality Safety Support Group will be established by charter designating initial members.

5.1 Change Control

Long-range plans require sufficient flexibility to address changes in commitments, actions, or completion dates that may be necessary because of additional information, improvements, or changes in the Department's baseline assumptions. The Department's practice is to (1) bring to the Board's attention any substantive changes, and their bases, to this Implementation Plan as soon as identified and prior to the passing of the milestone date, and (2) have the Secretary approve all revisions to the scope and schedule of plan commitments. Fundamental changes to the Plan's strategy, scope, or schedule will be provided to the Board through formal revision of the Implementation Plan. Other changes to the scope or schedule of the planned commitments will be formally submitted in appropriate correspondence approved by the Secretary, along with the basis for the changes and appropriate corrective actions.

5.2 Reporting

To ensure that the various Department implementing elements and the Board remain informed of the status of the plan implementation, the Department's policy is to provide periodic progress reports until the Implementation Plan commitments are completed. For this plan, the Department will provide quarterly reports to the Board. The first report will be due April 1998, with subsequent reports due every three months thereafter until closure of the recommendation.

6. Central Safety Issue

The central safety issue is the need for improved criticality safety practices and coherent programs to alleviate potential adverse impacts on safety and productivity of Department of Energy operations. The Department will address this central safety issue by assuring the viability of a coherent Departmental criticality safety program. With these improvements, important safety programs such as the stabilization of nuclear materials, deactivation of contaminated facilities, and providing for secure and safe storage of fissile materials can be accomplished in a safe, efficient, and timely manner. These improvements will address the nine Subrecommendations and will resolve the associated issues.

6.1 Issue 1

Issue Description:

The current critical experiments program does not emphasize the production of bounding experimental results

for support of current missions of the Department.

Board Subrecommendation 1:
Restructure the program of experimental research in criticality established under the Implementation Plan for Recommendation 93-2 to emphasize determination of bounding values for criticality of systems most important in the current programs at DOE facilities.

Resolution Approach:

In responding to Board Recommendation 93-2, the Department established a prioritization system for experiments that weighted them in categories, one of which was multi-purpose experiments, of which bounding experiments were assumed to be natural members. The experimental program established under the NCPP and its implementation will be reexamined to emphasize determination of bounding values for criticality of systems most important in the current programs at DOE facilities.

One example of an identified program which will produce useful bounding data involves integral critical benchmark experiments using W82 units. This program was identified in 1995, and the Department has initiated actions to facilitate performing the experiments. This program will provide unique data directly applicable to the storage of fissile units.

Another example is the planned Waste Matrices experiment which will be performed utilizing the ZEUS apparatus at LACEF. This critical experimental series will produce integral bounding data which will permit the Department to better characterize the nuclear properties of waste matrices.

It should be noted that, in some cases, nuclear cross section and integral critical experiment data necessary to produce bounding curves are not currently available, and both must be acquired. For example, nuclear cross section and integral experiment data for U-233 in the intermediate energy range, which are necessary to address specific EM criticality safety issues, must be acquired if reliable bounding curves are to be derived and utilized.

Commitment 6.1:

The Department will reexamine its experimental program in criticality research to emphasize the appropriate prioritization of experiments for obtaining data to produce bounding experimental results for support of its current missions.

Deliverable/Milestone	Due Date
Assessment report of the criticality research program	March 1998

6.2 Issue 2

Issue Description:

Some existing data and calculational studies which are relevant to current and future Departmental missions have not been organized and made available to criticality safety practitioners who would benefit from them.

Board Subrecommendation 2:
Organize the records of calculations and experiments conducted to ensure the criticality safety of DOE's

past operations so as to provide guidance for criticality safety in similar situations in the future and avoid repetition of past problems.

Resolution Approach:

The Department has already begun to consider this subrecommendation under the Criticality Safety Information Resource Center (CSIRC) program. The Department plans to preserve and index criticality experimental logbooks and related notebooks through digitization, videotape commentary, and archival preservation. The archive will be maintained at the Los Alamos National Laboratory. The CSIRC program will incorporate selected criticality calculational studies included previously in various data bases. The scope of available logbooks and experiments has already been identified to facilitate selection of data for further documentation. The Criticality Safety Support Group (defined below) will assist in the development of a comprehensive list of existing data and calculational studies and will concur in the final selection of material for more extensive documentation.

The most important goal of the CSIRC program will be preservation of logbooks and notebooks against loss, the lesson learned being the apparent loss of the Savannah River Laboratory experiment logbooks. Preference will be given to preservation of experiment logbooks and notebooks. Calculational notebooks, studies, and reports will also be preserved, but secondarily in accordance with the preference given experimental over calculational data in section 4.2.5 of ANS-8.1.

The first step in implementing CSIRC will be a demonstration of the complete process: a digitized version of a sample logbook (chosen to benefit from a videotape commentary), with videotape commentary by the experimenter to add important information not found in the logbook. The final CSIRC product will result by applying this demonstrated process to produce, in standardized, digitized format, indexed experiment logbooks and notebooks (that have first been screened for their usefulness), augmented by video commentaries where appropriate.

Commitment 6.2.1:

The Department will perform a CSIRC pilot program to provide a complete near-term deliverable consisting of archived logbook(s), videotaped interview, and digitized data and related calculations resulting in a publication available to the criticality safety community at large.

Deliverables/Milestones	Due Dates
1. Identify an experiment to archive	November 1997
2. Archive logbook(s) and calculation(s) for that experiment	December 1997
3. Videotape the original experimenter	January 1998
4. Digitize data and calculations	February 1998
5. Publish data and calculations so that the results are generally available	April 1998

Commitment 6.2.2:

The Department will continue to implement the CSIRC program by applying the demonstration process described in Commitment 6.2.1 to other experiment logbooks and notebooks. First, however, logbooks and notebooks whose authors are still available will be screened for usefulness. In parallel, all logbooks, or copies thereof, will be collocated at LANL. A CSIRC program plan will then be developed to screen remaining

collocated logbooks and produce indexed experiment logbooks and notebooks in standardized, digitized format. The program plan will include an evaluation of the cost vs. benefit of the program elements based on the experience gained in the pilot program.

Deliverables/Milestones	Due Dates
1. Collocate logbooks (originals or copies in the case of ORNL) from all U.S. critical mass laboratories, past or present, at LANL	December 1998
2. Screen existing logbooks with original author/experimenter	December 1998
3. CSIRC program plan	December 1998

6.3 Issue 3

Issue Description:

The Department has not provided enough technical guidance for computational methods used to interpolate and extrapolate limited experimental data which may be utilized to establish bounding values for safety applications.

Board Subrecommendation 3:
Establish a program to interpolate and extrapolate such existing calculations and data as a function of physical circumstances that may be encountered in the future, so that useful guidance and bounding curves will result.

Resolution Approach:

The Oak Ridge National Laboratory has been investigating, under an NRC program, the broad issues of areas of applicability, parameter sensitivity and uncertainties, and extrapolation and interpolation of data. This work is currently funded only by NRC as described below. The purpose is to develop sensitivity and uncertainty analyses for critical experiment data and methods to interpolate and extend the area of applicability of existing data.

The Department will develop a technical program plan, with milestones and identified funding, which expands the current work to include activities of interest to both the NRC and the Department. When implemented, the program will extend the range of applicability of neutronics codes and data that are now validated by limited benchmarks and identify needed differential and integral experiments to resolve issues where insufficient validations exist for safety analysis. The program will provide guidance on the use of computational methods for the development of useful bounding curves.

The program plan will include tasks to utilize improved nuclear data with criticality modeling codes, along with advanced sensitivity methods, to establish their applicability and performance in the analysis of fissile systems under current and/or projected areas of DOE responsibility. The coordinated tasks will be performed by ORNL, LANL, ANL, and other National Laboratories, as appropriate. In addition to the continuing work established with committed funding for the NCPP in response to Board Recommendation 93-2, these tasks will be chosen and will be coordinated to complement and supplement current work under NRC JCN W6479, "Development and Applicability of Criticality Safety Software for Licensing Review," dated May 27, 1997, and DOE FWP EMSP102, "Development of Nuclear Analysis Capabilities for DOE Waste Management Activities," dated April 11, 1997.

The preliminary scope of the work includes guidance for extending the area of applicability for existing data, sensitivity studies of various parameters important to previous experiments, and the investigation of long-standing criticality physics questions as well as fissile systems specific to emerging DOE applications. Some already identified areas for investigation are: (1) fission source convergence in Monte Carlo methods; (2) the physics of neutrons slowing down, intermediate energy kinematics; (3) neutron transport in loosely-coupled systems; (4) reactivity worth of moderating reflectors; and (5) reactivity worth of the actinides.

Commitment 6.3:

The Department will develop a technical program plan, with milestones and identified funding, which expands the current work to include activities of interest to both the NRC and the Department (e.g., extending areas of applicability, sensitivity and uncertainty studies, unresolved discrepancies, etc.). When implemented, this program will extend the range of applicability of neutronics codes to address identified and emerging Departmental missions and experimental needs and will provide guidance on the use of computational methods for the development of useful bounding curves.

Deliverables/Milestones	Due Dates
1. A program plan containing technical objectives and milestones	July 1998
2. Document initiation of priority tasks from the program plan in the quarterly report to the Board	January 1999

6.4 Issue 4

Issue Description:

The Department has not efficiently distributed the experimental and theoretical data obtained from past experiments and studies.

Board Subrecommendation 4:
Collect and issue the experimental and theoretical data from the above in a publication as guidance for future activities.

Resolution Approach:

Over the last twenty years, the Department has partially recognized and acted on aspects of this subrecommendation. The deliverables/milestones listed below represent past or ongoing Departmental actions which will be continued.

One major effort which has been underway for over five years is the International Criticality Safety Benchmark Evaluation Project (ICSBEP). This Department-funded program has led to stronger confidence in published benchmark descriptions and has eliminated much duplication of benchmarking and validation efforts at different DOE sites. The benchmark manuals produced by the ICSBEP are currently available on a web page. The ICSBEP, which was initiated in October 1992, was included as a program element of the NCPP in response to Board Recommendation 93-2.

Previously, LLNL published a bibliography (Nuclear Criticality Information System Database) of criticality experiments which, while valuable in itself, did not address the issue of unreported experiments. This

information is in an easily retrievable form and will be disseminated to the community via a web page. Web pages devoted to criticality safety currently exist at LLNL, INEEL, SRS, and LANL.

As part of a different activity, a Parameter Study Work Group, which was previously funded by DOE, produced a compilation of criticality evaluations over a period of approximately ten years. This information is nearly in publishable form and exists in a relational database which can be formatted for general use.

The Nuclear Criticality Safety Department at Y-12 has produced a searchable database catalog of all unclassified evaluations performed there. This information will be made available on the DOE web site.

The Department will make available the evaluations, calculational studies, and data cited above by establishing a DOE criticality safety Internet web site with searchable databases of criticality safety information and hyperlinks to other sites with related information.

Commitment 6.4:

The Department will make available evaluations, calculational studies and data by establishing a DOE criticality safety Internet web site with searchable databases of criticality safety information and hyperlinks to other sites with related information.

Deliverables/Milestones	Due Dates
1. DOE criticality safety web site for data, calculational studies, and evaluations	March 1998
2. Y-12 evaluations on DOE web site	June 1998
3. Calculations compiled by the Parameter Study Work Group on DOE web site	September 1998
4. Nuclear Criticality Information System Database on the DOE web site	March 1999

6.5 Issue 5

Issue Description:

Some criticality safety personnel have not had sufficient practice in the application of methods for determining margins of subcriticality alternative to those relying on detailed computer modeling to permit generalization and extrapolation from existing calculations or data. This results in over-reliance on Monte Carlo methods, which may in some cases be less efficient than using alternative analytical methods, where such methods can be shown to be applicable. This deficiency has been exacerbated by the lack of clear guidance and examples in the use of simple, bounding methods of analysis in place of detailed computational analysis, where possible, in setting criticality limits for processes.

Board Subrecommendation 5:
Clarify in guidance that simple, bounding methods of analysis can be used in place of specific theoretical analysis in setting criticality limits for processes, and that limits derived in this manner are even preferable where they serve the purpose. The decreasing order of preference should be experimental data, theory benchmarked against experimental data, and nonbenchmarked criticality analysis with an adequate safety margin.

Resolution Approach:

The Department will clarify in guidance that simple, bounding methods of analysis can sometimes be used in place of detailed computational analysis in setting criticality limits for processes. Furthermore, the guidance will indicate that simple, bounding methods are even preferable where they serve the purpose of documenting that the process in question will remain subcritical under all normal and credible abnormal conditions.

The decreasing order of preference for establishing subcritical limits (as specified in ANSI/ANS-8.1) should be experimental data, computational methods benchmarked against experimental data, and computational methods which extend the area of applicability of experimental data with an adequate additional margin of subcriticality. Except for instances relying upon broadly peer reviewed evaluations of "critical," "subcritical," and "safe" values determined from applicable data measurements such as in Nuclear Criticality Control of Special Actinide Elements (ANSI/ANS-8.15-1981; R1987), the use of completely nonbenchmarked, non-validated computational methods is inconsistent with ANSI/ANS-8.1 and is unacceptable to the Department. Without some form of validation or logical theoretical basis, there is no way to determine an adequate margin of subcriticality or margin of safety.

Commitment 6.5.1:

The Department will revise and reissue DOE-STD-3007-93 to include specific annotated examples of criticality safety evaluations which rely upon comparative analysis to existing data and calculations to emphasize the acceptability of this approach. The annotations will explain the logic used in preparing the evaluation with emphasis on the following general types of topics as they apply: 1) hand calculations, 2) development and use of models, 3) reactivity uncertainty, 4) validation, 5) establishing safety margins, 6) establishing margins of subcriticality, and 7) use of bounding data.

Deliverable/Milestone	Due Date
Revise DOE-STD-3007-93	September 1998

Commitment 6.5.2:

Issue a Departmental guide for the review of criticality safety evaluations. This guide will emphasize the acceptability of using bounding values and simplified analytical methods where applicable. The guide will stress the importance of practical, efficient criticality safety analysis, practices, and controls to the reviewer.

Deliverable/Milestone	Due Date
A Departmental Guide for reviewing criticality safety evaluations	May 1999

6.6 Issue 6

Issue Description:

The typical criticality safety staff consists largely of individuals who have no first-hand experience in critical experiment facilities and consists of some individuals who have been trained on the job in analytical aspects of criticality control but without a theoretical understanding. While experience in critical experiment facilities is not necessary to perform proper criticality safety evaluations, such experience is desirable and should be obtained when practical. Some on-the-job training is necessary and desirable from the standpoint of familiarity with site

operations. However, such training does not uniformly ensure that criticality safety personnel have had sufficient practice in the application of methods for determining margins of subcriticality alternative to those relying on detailed computer modeling to permit generalization and extrapolation from existing calculations or data. This results in over-reliance on Monte Carlo methods, which may in some cases be less efficient than using alternative analytical methods, where such methods can be shown to be applicable. This deficiency has been exacerbated by the lack of clear guidance and examples in the use of simple, bounding methods of analysis in place of detailed computational analysis, where possible, in setting criticality limits for processes.

The Department recognizes that being grounded in neutron physics is a necessary, although not a sufficient, prerequisite for the application of academic knowledge to criticality safety. Since most criticality safety engineers have nuclear engineering or physics degrees, lack of adequate knowledge of neutron physics is not a general concern. Criticality safety practitioners often lack the practical experience with fissile material operations to identify the proper set of credible process upset conditions applicable to operations, relying instead on the review process for such proper-set identification. In such situations, senior criticality safety and/or operations personnel review the draft evaluation to ensure that no credible upset scenarios have been missed. The lack of experience with operations also detracts from the ability of the criticality safety practitioner to justify why a particular set of process upsets makes up a necessary and sufficient set of scenarios. It is in the better interest of both safety and efficiency for such proper-set identification to occur earlier in the criticality safety evaluation process.

To develop and maintain competency, there is further need to assure that criticality safety practitioners thoroughly understand site-specific operations and possess related analysis skills, such as the ability to reliably determine process upset conditions.

> *Board Subrecommendation 6:*
> *Develop and institute a short but intensive course of instruction in criticality and criticality safety at DOE's criticality experiments facility to serve as the foundation for a program of formal qualification of criticality engineers. This course should instill in students a familiarity with the factors contributing to criticality, the physical behavior of systems at and near criticality, and a theoretical understanding of neutron multiplication processes in critical and subcritical systems. A goal would be for reliance for criticality safety at any DOE facilities to rest in a group of individuals endowed with such experience.*

Resolution Approach:

The Department will continue to use the Los Alamos Critical Experiments Facility (LACEF) to the maximum extent practical to address training needs. The Department will also survey existing educational curricula to determine if they can be used to supplement the training at LACEF. In addition, the Department will review existing site-specific training and qualification programs and issue guidance that identifies essential elements of an adequate qualification program.

Commitment 6.6.1:

The Department will upgrade and expand the current five-day training course at LACEF to ten days by offering additional experiments, and increasing the emphasis on solving practical, operational criticality safety problems, including the practical application of simplified analytical methods and bounding values. Participants will be sensitized to proper methods of identifying and analyzing process upsets and producing documented criticality safety evaluations. Attendees at this course will be limited to criticality safety practitioners, in part due to the rigorous emphasis on practical analytical methods which require thorough familiarity with neutron physics. The

threefold emphasis of this new course will be: 1) expanded experience with critical systems, 2) application of simplified analytical methods, and 3) emphasis on identifying the proper set of process upset conditions for realistic applications.

Deliverable/Milestone	Due Date
Expanded LACEF Training Course	July 1998

Commitment 6.6.2:

The Department will assess criticality safety training needs with a broader perspective on applications such as contingency and safety analysis which consider methods of identifying process upsets, developing effective controls, and implementing controls through procedures and postings. This assessment will also include a complete criticality safety practitioner job task analysis. Existing curricula in criticality safety (e.g., Los Alamos courses, University courses, Site Specific Criticality Safety Curricula, etc.) will be surveyed to determine if identified needs can be met though utilization of existing training or if development of new training is required. Based on its findings, the Department will initiate a program which addresses the identified needs for additional criticality safety training.

Deliverables/Milestones	Due Dates
1. Assessment of additional training needs and review of available supplementary curricula	June 1998
2. Initiate a program which addresses identified needs	December 1998

Commitment 6.6.3:

The NCSPMT will survey existing contractor site-specific qualification programs and develop a report that documents the variety of requirements currently in place. The purpose of this survey is to identify common elements and those elements judged essential to an adequate training program to facilitate development of Departmental guidance. In the longer term, the Department will issue guidance concerning development of site-specific criticality safety training and qualification programs. Sites will then be responsible for considering this guidance in developing criticality safety training and qualification programs.

Deliverables/Milestones	Due Dates
1. Report on the Review on Site Qualification Programs	June 1998
2. Guidance for development of site-specific nuclear criticality safety training and qualification programs	September 1998
3. Guidance to procurement officials specifying qualification criteria for contractor criticality safety practitioners	September 1998
4. DOE field will provide to line management dates upon which contractors will have implemented guidance in Deliverable/Milestone #2, above	March 1999

Commitment 6.6.4:

The Department will ensure that federal technical staff directly performing criticality safety oversight be qualified commensurate with that identified for contractor personnel.

Deliverables/Milestones	Due Dates
1. Qualification program for Departmental criticality safety personnel	December 1998
2. DOE criticality safety personnel qualified	December 1999

6.7 Issue 7

Issue Description:

Not all Departmental contractor criticality safety programs are functioning in such a way to assure that criticality safety is a staff function assisting line management, with safety responsibility residing in line management. Operations and line management have not, in all cases, provided thorough process descriptions, procedures, scope of applicable process upsets and operator-oriented language for use in criticality safety postings during the development of criticality safety evaluations and limits. This has resulted in re-work of some criticality safety evaluations, performing more calculations than is sometimes necessary, and impractical criticality safety postings. This inefficient integration of criticality safety into line management has exacerbated the central safety issue.

Board Subrecommendation 7:
Where not already done, assign criticality safety as a staff function assisting line management, with safety responsibility residing in line management.

Resolution Approach:

ANSI/ANS-8.1 and 8.19 require that line management assume responsibility for its criticality safety program. These Standards, invoked by Department of Energy Order 420.1, Section 4.3, when properly implemented, affirm both line ownership of safety responsibility and the independence of criticality safety as a staff (not line) function. Each site will assess the degree of proper implementation of line ownership of criticality safety consistent with the Integrated Safety Management System expectation of continuous feedback and improvement.

The Department has adopted, through the efforts for Board Recommendation 95-2, contract reforms and requirements to achieve Integrated Safety Management Systems, which include requirements for integrated work planning, integrated hazard assessment, integrated hazard control development, integrated confirmation of work readiness and work performance with appropriate feedback. Moreover, the Department of Energy Acquisition Regulations clause requires line management responsibility for safety, the establishment of clear roles and responsibilities, and that contractors ensure personnel possess experience, knowledge, skill, and abilities to discharge duties. Departmental actions relative to 97-2 will be consistent with the recently enacted Department of Energy Acquisition Regulations described above.

Commitment 6.7:

Field managers at sites with significant quantities of fissile material will conduct a survey of their respective sites to determine if line management is functioning properly with respect to ownership of criticality safety, using criteria consistent with the Integrated Safety Management principles.

Deliverable/Milestone	Due Date
Individual sites issue reports of survey findings	June 1998

6.8 Issue 8

Issue Description:

The Department lacks a standing expert technical support function to offer guidance to management for managing and overseeing a coherent criticality safety program.

Board Subrecommendation 8:
Identify a core group of criticality experts experienced in the theoretical and experimental aspects of neutron chain reaction to advise on the above steps and assist in resolving future technical issues.

Resolution Approach:

The Department will form a group of criticality safety experts that is composed of persons from its staff and contractors having collective knowledge in a broad spectrum of criticality safety areas to advise the NCSPMT on programmatic issues and to help resolve present and future technical criticality safety issues. The Criticality Safety Support Group will consist of a core set of members plus ad-hoc members when needed to provide inputs on specific issues. The Group will provide important operational perspectives on Departmental missions such as fissile materials stabilization and storage, facilities decommissioning, and waste disposal which can be factored into experiments, training, organizational structures, methods, and nuclear data requirements for performing criticality safety analyses in support of these activities. Also, as directed by the NCSPMT, the Criticality Safety Support Group will review applicable Departmental Orders and Standards periodically to assure criticality safety is appropriately addressed in these documents.

Commitment 6.8:

The Department will form a group of experts that is composed of persons from its staff and the site contractors having collective knowledge in a broad spectrum of criticality safety areas to advise the Departmental management team on programmatic issues and to help resolve present and future technical criticality safety issues. The Criticality Safety Support Group members will be identified in an appendix to the Group's charter.

Deliverable/Milestone	Due Date
Charter for the Criticality Safety Support Group approved by NCSPMT	January 1998

6.9 Issue 9

Issue Description:

The Department has not developed an organizational structure supported by appropriate funding to assure the viability of a coherent Departmental criticality safety program.

Board Subrecommendation 9:
Organize funding of the criticality research and instruction program to improve its stability and to recognize the cross-cutting importance of this activity.

Resolution Approach:

As discussed in Section 5, Organization and Management, the Department will establish the organizational structure to conduct a Department criticality safety program. The Department will create the Nuclear Criticality Safety Program Management Team (NCSPMT) that will manage allocated funds to implement this plan and to continue ongoing activities in response to Recommendation 93-2. It will also ensure that crosscutting activities of the program are effectively implemented and will advise and assist the Responsible Manager on programmatic and technical issues concerning the program. The NCSPMT will be composed of representatives from the following offices that benefit from an effective criticality safety program: Defense Programs (DP); Environmental Management (EM); Environment, Safety and Health (EH); Energy Research (ER); Fissile Materials Disposition (MD); and Nuclear Energy, Science and Technology (NE). The NCSPMT, co-chaired by DP and EM, will develop and execute a program plan to guide the Department's crosscutting criticality safety activities.

The funds required to implement the Department's criticality safety program include existing funded requirements developed in response to Recommendation 93-2, and additional unfunded requirements established in response to Recommendation 97-2.

For FY 1998 and FY 1999, DP, EM, and EH will be responsible for fully funding their elements of the Nuclear Criticality Predictability Program (NCPP), established in response to Recommendation 93-2. ER will be responsible for maintaining the Oak Ridge Electron Linear Accelerator. The Chief Financial Officer (CFO), in consultation with the Departmental Representative to the Defense Nuclear Facilities Safety Board and the NCSPMT, will be responsible for obtaining the funding required for commitments under this implementation plan.

For formulation of the FY 2000 budget and beyond, DP proposes to establish a line item for criticality safety programs. The CFO will adjust the DP FY 2000 and outyear funding targets to include the full funding level for nuclear criticality safety. Funding targets will be moved from the appropriate program offices to the DP line item.

Commitment 6.9:

The Department will establish the organizational structure and provide stable funding necessary to conduct a viable criticality safety program. The NCSPMT will be chartered to manage the program and develop a program plan for assuring the continued viability of a coherent Departmental criticality safety program. The Chief Financial Officer will obtain the funding for commitments in this plan as required.

Deliverable/Milestone	Due Date
1. NCSPMT charter	January 1998
2. NCSPMT program plan	June 1998

ATTACHMENT A: Glossary

Bounding values, as it relates to criticality, are those enveloping dependent values (masses, volumes, concentrations, densities, temperatures, flow rates, vessel dimensions, etc.) that describe specific systems given assumed limits of independent parametric variation.

Data, as it relates to criticality, refers to values obtained directly from experimental measurements of critical or near critical systems. For nuclear cross section data within the context of the Recommendation 93-2 Nuclear Criticality Predictability Program, "data" additionally refers to values obtained from: 1) the experimental measurements of nuclear cross section data, 2) the generation of the corresponding Evaluated Nuclear Data Files (ENDF/B), and 3) the analytical processing methods needed for the calculational codes to utilize those files.

Evaluations, as it relates to criticality, refers to the complete set of documentation demonstrating the subcriticality of an analyzed process or system for all normal and credible abnormal conditions. Evaluations may contain data and calculations.

ATTACHMENT B: List of Acronyms

ANL	Argonne National Laboratory
ANS	American Nuclear Society
ANSI	American National Standards Institute
CFO	Chief Financial Officer
CSIRC	Criticality Safety Information Resource Center
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DP	Office of Defense Programs
EH	Office of Environment, Safety and Health
EM	Office of Environmental Management
ENDF/B	Evaluated Nuclear Data File
ER	Office of Energy Research
FWP	Field Work Proposal
ICSBEP	International Criticality Safety Benchmark Evaluation Project
ISMS	Integrated Safety Management System
INEEL	Idaho National Engineering and Environmental Laboratory
JCN	Job Control Number
LACEF	Los Alamos Critical Experiments Facility
LANL	Los Alamos National Laboratory
LLNL	Lawrence Livermore National Laboratory
MD	Office of Fissile Material Disposition
NE	Office of Nuclear Energy, Science, and Technology
NCIS	Nuclear Criticality Information System
NCPP	Nuclear Criticality Predictability Program
NCSPMT	Nuclear Criticality Safety Program Management Team
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
RSICC	Radiation Safety Information Computational Center
SRS	Savannah River Site
Y-12	Uranium Fabrication and Processing Facility in Oak Ridge, Tennessee

United States Department of Energy

Nuclear Criticality Safety Program

Five Year Plan

August 1999

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LIST OF ACRONYMS

ANL	Argonne National Laboratory
ANS	American Nuclear Society
ANSI/ANS	American National Standards Institute/American Nuclear Society
APT	Accelerator Production of Tritium
AROBCAD	Applicable Ranges of Bounding Curves and Data
BIO	Basis for Interim Operation
BNL	Brookhaven National Laboratory
CAAS	Criticality Accident Alarm System
CERES	Franco-British Critical Experimental Series
CSBEP	Criticality Safety Benchmark Evaluation Project
CSCT	Criticality Safety Coordinating Team
CSEWG	Cross Section Evaluation Working Group
CSIRC	Criticality Safety Information Resource Center
CSSG	Criticality Safety Support Group
DNFSB	Defense Nuclear Facilities Safety Board
DOE	United States Department of Energy
DP	Office of Defense Programs
EH	Office of Environment, Safety and Health
EM	Office of Environmental Management
ENDF	Evaluated Nuclear Data File
FM	Facility Management
FTE	Full-Time Equivalent
ICNC	International Conference on Criticality
ICSBEP	International Criticality Safety Benchmark Evaluation Project
INEEL	Idaho National Engineering and Environmental Laboratory
IPD	Information Preservation and Dissemination
IPPE	Institute of Physics and Power Engineering
LACEF	Los Alamos Critical Experiments Facility
LANL	Los Alamos National Laboratory

US DOE Nuclear Criticality Safety Program Five Year Plan

EXECUTIVE SUMMARY

The objective of nuclear criticality safety is to ensure that fissile material is handled in such a way that it remains subcritical under both normal and credible abnormal conditions to protect workers, the public, and the environment. A robust line criticality safety program requires knowledgeable people and technical resources. It is essential that the infrastructure which provides these two key elements be maintained so the Department of Energy (DOE) can continue to do work safely with fissile materials.

The Department of Energy recognized the need for maintaining criticality safety infrastructure in its implementation plan in response to Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 97-2, *Continuation of Criticality Safety*. This Recommendation, and the earlier Recommendation 93-2, *The Need for Critical Experiment Capability*, stem from DNFSB concerns that due to reductions in the DOE budget, the national support structure for nuclear criticality safety of site operations was declining to the point that the ability to do work safely and effectively with fissile materials was in jeopardy. The DOE addressed the DNFSB concerns by initiating the Nuclear Criticality Safety Program (NCSP). The NCSP is a comprehensive program which will maintain essential nuclear criticality safety infrastructure.

The Assistant Secretary for Defense Programs (DP-1) is responsible for leading the Department's criticality safety activities. The Departmental Representative to the DNFSB (S-3.1) assists DP-1 in resolving funding issues, if necessary. The Responsible Manager is the Deputy Assistant Secretary for Research, Development and Simulation, Office of Defense Programs (DP-10), who oversees the execution of the NCSP. The Nuclear Criticality Safety Program Management Team (NCSPMT) is responsible for the execution of this Plan. This team consists of representatives from the following offices: Defense Programs (DP); Environmental Management (EM); Environment, Safety and Health (EH); Science (SC); Fissile Materials Disposition (MD); and Nuclear Energy, Science and Technology (NE). The NCSPMT, co-chaired by members from DP and EM, advises and assists the Responsible Manager on technical and programmatic issues involving the implementation of crosscutting NCSP activities. The NCSPMT receives technical support from the Criticality Safety Support Group (CSSG). The CSSG is a standing group of recognized criticality safety experts from Department of Energy and contractor communities, and helps resolve technical criticality safety issues.

This Five Year Plan for the DOE NCSP is focused on maintaining fundamental infrastructure that enables retention of DOE capabilities and expertise in nuclear criticality safety necessary to support line criticality safety programs. In the past, weaknesses have developed in the DOE criticality safety program due to funding reductions and the fact that the program was spread among many program and field offices. Such weaknesses can have significant impacts on operations, including operations necessary to resolve safety commitments. As an example, difficulties in implementing criticality safety practices have negatively impacted some activities associated with the DOE response to DNFSB Recommendation 94-1, *Improved Schedule for Remediation*. The focus of the NCSP is to address these weaknesses by providing a stable, cross-organizational infrastructure to implement criticality safety improvements. These include

LLNL	Lawrence Livermore National Laboratory
MD	Office of Fissile Materials Disposition
MOX	Mixed Oxide Fuel
NCS	Nuclear Criticality Safety
NCSD	Nuclear Criticality Safety Division
NCSET	Nuclear Criticality Safety Engineer Training
NCSP	Nuclear Criticality Safety Program
NCSPMT	Nuclear Criticality Safety Program Management Team
NCTSP	Nuclear Criticality Technology and Safety Project
NE	Office of Nuclear Energy, Science and Technology
NIST	National Institute of Standards and Technology
NRC	United States Nuclear Regulatory Commission
NSNFP	National Spent Nuclear Fuel Program
OECD-NEA	Organization for Economic Cooperation and Development - Nuclear Energy Agency
ORELA	Oak Ridge Electron Linear Accelerator
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Office
PNNL	Pacific Northwest National Laboratory
RFETS	Rocky Flats Environmental Technology site
RSICC	Radiation Safety Information Computational Center
S/U	Sensitivity and Uncertainty
SAR	Safety Analysis Report
SC	Office of Science
SNM	Special Nuclear Material
SRS	Savannah River Site
SRTC	Savannah River Technology Center
TDQ	Training, Development and Qualification
TWRS	Tank Waste Remediation System
ZEUS	Critical Assembly Machine at Los Alamos
ZPR	Zero Power Reactor

improving the technical knowledge of criticality safety personnel and improving the availability and use of criticality safety information, tools and guidance throughout the DOE complex. Effective implementation of NCSP activities is important to the successful completion of Departmental programs to address safety concerns raised in DNFSB Recommendations 97-1, 94-1, and 95-2.

The NCSP will also be able to respond to changing requirements in the field of criticality safety. The primary means for achieving this goal is to maintain the criticality safety infrastructure within the DOE so that programs in individual areas such as training, critical experiments, benchmarking, data and methods development can be conducted in coordination with each of the other areas of the NCSP. With these improvements, important safety programs such as the stabilization of nuclear materials, deactivation of contaminated facilities, and providing for secure and safe storage of fissile materials can be accomplished in an efficient, and timely manner. One priority DOE mission already benefitting from the work of the NCSP is the the Spent Nuclear Fuel Program at Idaho.

The NCSP includes the following seven technical task areas:

> Critical Experiments: provide experimental data for the validation of the calculation methods used to support criticality safety analyses.
>
> Benchmarking: identify, evaluate and make available benchmarked data to support criticality safety analyses.
>
> Nuclear Data: provide nuclear cross section data required for codes to address the effect of different materials which are being mixed with fissile material in waste conditioning/disposal operations.
>
> Analytical Methods: support and enhance numerical processing codes used in criticality safety analyses.
>
> Applicable Ranges of Bounding Curves and Data: develop method(s) to interpolate and extrapolate from existing data.
>
> Information Preservation and Dissemination: collect, preserve and make readily available criticality safety information.
>
> Training and Qualification: maintain and improve training of criticality safety practitioners and establish federal and contractor qualification standards."

Each of these areas is interdependent on the others and together form a complete criticality safety program. If any of these program tasks is eliminated, the ability of the Department's criticality safety engineers to perform their work will be compromised. The technical task areas will be coordinated under an administrative task, Program Management and Integration.

A summary budget for the NCSP is shown below. Details for each task are given in the respective sections of the Plan.

Program Task or Subtask	Laboratory or Office	FY 2000 & Beyond Budget ($k)
NCSP Management	DP-10/EM-66	170
Critical Experiments	LANL LACEF	3,950
Benchmarking	INEEL, LANL, LLNL, ORNL, Y-12, ANL, SRS	1,500
Nuclear Data	ORNL, LANL, & ANL	2,217
Analytical Methods	ORNL, LANL, & ANL	1,303
Applicable Ranges of Bounding Curves And Data (AROBCAD)	ORNL	700
Information Preservation and Dissemination	LANL, LLNL	110
Training, Development & Qualification	LANL, ANL	250[1]
	TOTAL:	10,200
(1) Supplemented by ~ $84k from tuition collection		

United States Department of Energy
Nuclear Criticality Safety Program

Five Year Plan

1.0 Introduction

1.1 Background

The objective of criticality safety is to ensure that fissile material is handled in such a way that it remains subcritical under both normal and credible abnormal conditions. Maintenance of an effective criticality safety program requires a comprehensive plan that integrates the knowledge, experience and capabilities of Department of Energy (DOE) resources and personnel from a number of areas including safety, nuclear science, facility operations and process control. To execute this plan, it is essential that the requisite criticality safety program infrastructure be maintained so that program activities such as training, critical experiments, nuclear data measurements, methods development and other technical tasks can be performed.

The Department of Energy recognized the need for maintaining criticality safety infrastructure in its implementation plan in response to Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 97-2, *Continuation of Criticality Safety*[1]. This Recommendation, and the earlier Recommendation 93-2, *The Need for Critical Experiment Capability*[2], stem from DNFSB concerns that due to reductions in the DOE budget, the national support structure for nuclear criticality safety of site operations was declining to the point that the ability to do work safely and effectively with fissile materials was in jeopardy. The DOE addressed the DNFSB concerns by initiating the Nuclear Criticality Safety Program[3] (NCSP). The NCSP is a comprehensive program which will maintain essential nuclear criticality safety infrastructure.

1.2 Plan Benefits

The NCSP is essential for continued safe, efficient operation with fissile materials. Over the years, the strong base of expertise in the area of criticality safety has steadily diminished along with the Department's capability to perform critical experiments. The primary goal of the NCSP is to maintain a satisfactory capability in the field of criticality safety by reversing this trend through training new practitioners, maintaining facilities to conduct critical experiments and nuclear cross section measurements, developing new and improved analytical methods, and increasing the database of validation benchmarks.

The data, methods, benchmarks and critical experiments programs that were developed in support of the weapons production and reactor development missions in prior years are not necessarily directly applicable to the new DOE missions of deactivation and decommissioning, stabilization of residues, and processing wastes. The diverse operations at sites across the DOE complex now involve hundreds of tons of highly enriched uranium and weapons-grade plutonium, nearly 100,000 spent light water reactor fuel assemblies, other defense and DOE reactor fuel, and

hundreds of thousands of transportation and storage packages containing fissile material. The technical tasks of the Plan are meant to maintain the infrastructure and support all programs with fissile material operations and to focus the use of this infrastructure on these changing needs.

In the past, weaknesses have developed in the DOE criticality safety program due to funding reductions and the fact that the program was spread among many independent offices[4]. Such weaknesses can have significant impacts on operations, including operations necessary to resolve safety commitments. As an example, difficulties in implementing criticality safety practices have negatively impacted some activities associated with the DOE response to DNFSB Recommendation 94-1, *Improved Schedule for Remediation*[5]. The focus of the NCSP is to address these weaknesses by providing a stable, cross-organizational infrastructure to implement criticality safety improvements. These include improving the technical knowledge of criticality safety personnel and improving the availability and use of criticality safety information and guidance throughout the DOE complex. Effective implementation of NCSP activities is important to the successful completion of Departmental programs to address safety concerns raised in DNFSB Recommendations 97-1, 94-1, and 95-2.

The NCSP will also be able to respond to changing requirements in the field of criticality safety. The primary means for achieving this goal is to maintain the criticality safety infrastructure within the DOE so that programs in individual areas such as training, critical experiments, benchmarking, data and methods development can be conducted in coordination with each of the other areas of the NCSP. With these improvements, important safety programs such as the stabilization of nuclear materials, deactivation of contaminated facilities, and providing for secure and safe storage of fissile materials can be accomplished in an efficient, and timely manner. One example of a priority DOE mission already benefitting from the work of the NCSP is the Spent Nuclear Fuel Program at Idaho.

1.3 Requirements

In addition to the fundamental requirement to maintain criticality safety, there are statutory requirements as defined by Title 10 of United States Code of Federal Regulations and the DOE Orders.[6,7] Those statutory requirements are drawn directly from national standards[8] that require the competent and responsible application of the necessary knowledge to Departmental work and activities in a safe manner while assuring acceptable risks and efficiency of operations. In particular, Departmental operations and oversight of operations must maintain an administrative and technical infrastructure to competently administer a nuclear criticality safety program. These standards are the basis for the pursuit, development, and optimization of applied knowledge, methods, and applications of techniques to address safety and the evolving needs of the Department.

The Department's mission focus has changed dramatically in the past decade from materials production and processing for use in nuclear weapons and nuclear fuels to materials processing to stabilize fissile materials for storage or disposal. Operations that support the disposition of the Department's fissile materials present new criticality concerns because they involve partially

moderated systems where intermediate-energy neutrons are major potential contributors to the state of criticality of the system. In the past, the intermediate-energy portion of the neutron spectrum was of little concern to nuclear reactor and nuclear weapon designers. However, to a criticality safety engineer, faced with analyzing processes related to stabilizing fissile material for storage or disposal, the entire neutron energy spectrum, including the intermediate energy region, must be considered. In addition, these systems contain packaging and storage materials, some of which have received scant previous attention with regard to the measurement and qualification of nuclear cross section data.

In the past, with regard to nuclear criticality concerns, conservatism was employed when uncertainties in calculational methodologies arose. In most cases, this conservatism translated into additional storage or process line space which increased operational costs. Currently, during this time of extreme budget pressure, it makes sense to address the uncertainties in calculational methodologies that lead to the application of unnecessary and costly conservatism. A modest investment in improving nuclear criticality predictive capability could yield large operational cost savings while enhancing criticality safety. Considering the change in Departmental missions coupled with the persistent budget pressure, maintaining a viable nuclear criticality predictive capability is as important today as ever.

Each task within the NCSP contributes to the ability of the DOE to meet these requirements by establishing a coordinated infrastructure necessary to establish and implement a cross-cutting criticality safety program. Individual tasks are also developed to meet current needs of the DOE that are related to its ongoing missions. The relationship of the NCSP tasks to these needs and requirements are detailed in the following sections of this Plan.

1.4 Plan Summary

This Five Year Plan for the DOE NCSP presents the integrated program needed to maintain the infrastructure that will allow the DOE to retain its capabilities and expertise in this area for the next five years. Within the limits of the resources available to the program, and in support of its primary focus, the NCSP will address specific evolving issues in criticality safety. NCSP personnel will solicit information from field sites and DOE programs so that such evolving issues (e.g., remediation of new combinations of materials, impact of cross section uncertainties on operational limits) can be addressed and included in NCSP planning.

The NCSP includes seven technical task areas: Critical Experiments, Benchmarking, Nuclear Data, Analytical Methods, Applicable Ranges of Bounding Curves and Data, Information Preservation and Dissemination, and Training and Qualification. Each of these areas is interdependent on the others and together form a complete criticality safety program. If any of these program tasks is eliminated, the ability of the Department's criticality safety engineers to perform their work will be compromised. The technical task areas will be coordinated under an administrative task, Program Management and Integration.

Each task area will be discussed in the following sections of this Plan, but the contributions of

each task to the program areas follows.

Critical Experiments: provide experimental data for the validation of the calculation methods used to support criticality safety analyses. Currently, experiments being planned and conducted at Los Alamos National Laboratory (LANL) will provide data for validation of criticality safety evaluations for the Spent Nuclear Fuel Program at Idaho.

Benchmarking: identify, evaluate and make available benchmarked data to support criticality safety analyses. In order for analytical results to be properly validated, they must be compared to benchmark experiments. Benchmarking is a major international effort led by the United States to compile and disseminate benchmark data to fill important gaps in our data base. Data compiled by this program is being used at every DOE site where criticality safety evaluations are being produced.

Nuclear Data: provide nuclear cross section data required for codes to address the effect of different materials which are being mixed with fissile material in waste conditioning/disposal operations; this involves the following major activities: measure nuclear cross section data at the Oak Ridge Electron Linear Accelerator (ORELA), evaluate it, assemble it into libraries, and update the required numerical processing methods so that the libraries can be used for criticality calculations. Nuclear cross section data is being acquired and processed at Oak Ridge to support calculations for criticality safety evaluations for priority DOE missions.

Analytical Methods: support and enhance numerical processing codes used in criticality safety analyses. Complex neutronics codes (KENO, MCNP, VIM) are being supported and enhanced by the NCSP; these codes are being used by criticality safety practitioners throughout the DOE complex to perform criticality safety evaluations.

Applicable Ranges of Bounding Curves and Data: develop method(s) to interpolate and extrapolate from existing experimental benchmark data. A plan to develop the bounding data and curves methodology has been approved and work began in January 1999. First outputs are expected in the Fall of 1999. This will help criticality safety practitioners validate calculations in areas where experimental benchmark data are unavailable or very limited.

Information Preservation and Dissemination: collect, preserve and make readily available criticality safety information. Data and information that may otherwise have been lost is being preserved and placed on the web; data and other information important to criticality safety is now available on a web site with links to other useful sites.

Training and Qualification: maintain and improve training of criticality safety practitioners and establish federal and contractor qualification standards. Hands-on training at Los Alamos always has been and is still in demand; a new training course at Los Alamos will be piloted this fiscal year; other training materials have been developed and will be made

available on the web this fiscal year; qualification standards for federal and contractor employees have been developed and are going through final review and approval for use.

2.0 Program Management and Integration

2.1 Organization

The Department recognizes that a coherent nuclear criticality safety program which performs essential crosscutting activities that are spread throughout the complex and various program offices requires an effective management team with strong technical support. Involvement of all affected Program Offices and communication with the technical community are essential to conduct a coherent and efficient criticality safety program. Only with sound technical support will the program managers be able to prioritize the tasks of the NCSP within the limited budget of the Program.

Figure 1 depicts the NCSP management structure. The Assistant Secretary for Defense Programs (DP-1) is responsible for leading the Department's criticality safety activities. The Departmental Representative to the DNFSB (S-3.1) assists DP-1 in resolving funding issues, if necessary. The Responsible Manager is the Deputy Assistant Secretary for Research, Development and Simulation, Office of Defense Programs (DP-10), who oversees the execution of the NCSP. The Nuclear Criticality Safety Program Management Team (NCSPMT) is responsible for the execution of this Plan. This team consists of representatives from the following offices: Defense Programs (DP); Environmental Management (EM); Environment, Safety and Health (EH); Science (SC); Fissile Materials Disposition (MD); and Nuclear Energy, Science and Technology (NE). The NCSPMT, co-chaired by members from DP and EM, advises and assists the Responsible Manager on technical and programmatic issues involving the implementation of crosscutting activities of the Department's criticality safety program. The NCSPMT receives technical support from the Criticality Safety Support Group (CSSG). The CSSG is a standing group of recognized criticality safety experts from Department of Energy and contractor communities, and helps resolve technical criticality safety issues. Both the NCSPMT and the CSSG were established by charters designating initial members[9].

In order to enhance communications with DOE criticality safety practitioners, an additional group has been formed that regularly discusses problems and conveys results to and from the NCSPMT. The Criticality Safety Coordinating Team (CSCT) is composed of DOE representatives from each of the field offices whose sites conduct activities with fissile materials. The CSCT is the primary source of information for DOE field office concerns, and promulgates guidance and information from the NCSPMT to the field. The CSCT charter is approved by the NCSPMT.

Several paths for communication with the NCSPMT and the CSSG exist: criticality safety practitioners at DOE contractor sites have formed an end-users group to discuss criticality safety matters; the Nuclear Criticality Safety Division of the American Nuclear Society organizes several technical sessions at each national meeting and holds special sessions to discuss the NCSP; the

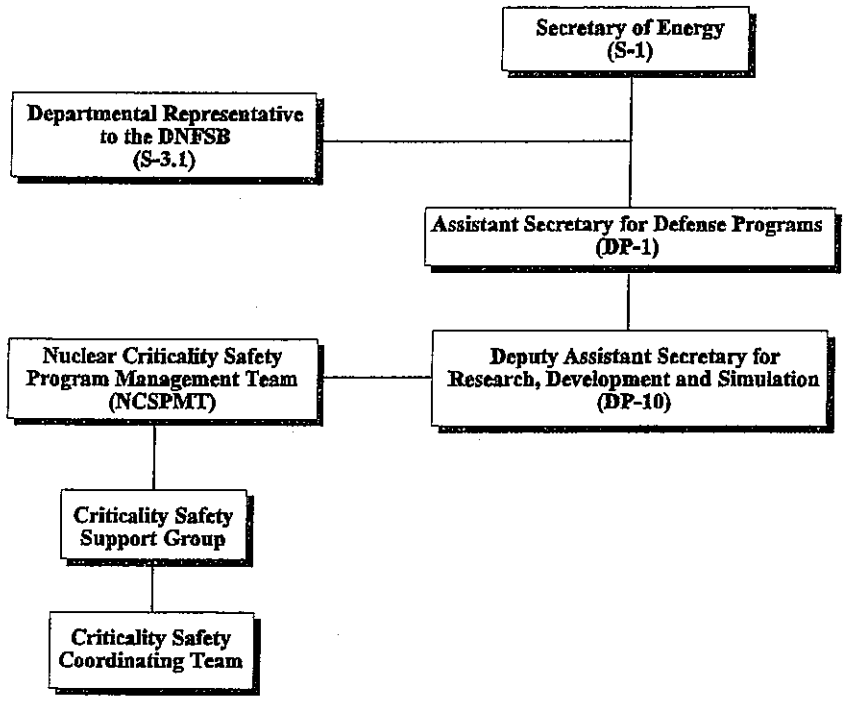

Figure 2-1. Department of Energy Nuclear Criticality Safety Program Organization

Nuclear Criticality Technology and Safety Project (NCTSP) holds an annual meeting with a format that promotes discussion of current criticality safety programs and issues.

In addition to the routine exchange of information among the above-mentioned groups, it is expected that more formal methods will be used to assess the needs of individual sites and to provide program direction based on those assessments. To that end, periodic discussions will be held with DOE field managers to inform them of the NCSP status and solicit feedback to help prioritize tasks within the NCSP. To initiate this series of discussions, a workshop on the NCSP for DOE field managers was conducted August 3-4, 1999..

To provide the same level of interaction with DOE contractor organizations, site visits will be scheduled to discuss the NCSP with line management, nuclear criticality safety (NCS) site representatives and site practitioners. Members of the NCSPMT and CSSG will conduct these visits to encourage a free exchange of information that can be used to help adapt the NCSP to changing needs of the sites.

2.1 Budget Summary

A summary budget for the NCSP is shown in Table 2-1. Details for each task are given in the following sections. This budget projection assumes a flat budget for the next five fiscal years.

The NCSPMT will retain a small amount of program funds to support CSSG activities and respond to unforseen program needs. The projected NCSPMT budget is $170k per year.

Table 2-1. NCSP Funding by Program Task and Subtask

Program Task or Subtask	Laboratory (Point of Contact)	FY 2000 & Beyond Budget ($k)
NCSP Management	DP-10/EM-66	170
Critical Experiments	LANL LACEF (Rick Anderson)	3,950
Benchmarking	INEEL, LANL, LLNL, ORNL, Y-12, ANL, SRS (Blair Briggs)	1,500
Nuclear Data	ORNL, LANL, & ANL (Bob Roussin)	2,217
Analytical Methods	ORNL, LANL, & ANL (Mike Westfall)	1,303
Applicable Ranges of Bounding Curves And Data (AROBCAD)	ORNL (Calvin Hopper)	700
Information Preservation and Dissemination	LANL (Tom McLaughlin) LLNL (Song Huang)	110
Training, Development & Qualification	LANL (Tom McLaughlin) ANL (Jim Morman)	250 (1)
TOTAL		10,200

(1) Supplemented by ~ $84k from tuition collection

3.0 Critical Experiments

3.1 Introduction

Historically, most of the expert criticality safety personnel obtained their experience by participating in experimental programs. These personnel are rapidly disappearing, leaving a need to adequately train and qualify new criticality safety engineers in the field of critical experiments.

The Critical Experiments task of the NCSP maintains a fundamental capability for the DOE to be able to perform critical measurements, and within the limits of is resources, to address specific site needs on a prioritized basis. This task includes sub-tasks to:

1) maintain the capability to perform critical experiments that are required to support DOE programs;

2) in coordination with site safety personnel, and considering the results of other tasks with the NCSP, evaluate the critical experiment needs and critical experiments priorities within the DOE;

3) conduct critical experiments to confirm the evaluated nuclear cross section data used to perform calculations in support of nuclear criticality safety evaluations;

4) transfer this knowledge to the criticality safety engineering community through publications and other activities;

5) provide steady-state and pulsed-radiation capability to operationally test and qualify equipment (criticality alarms, dosimetry, etc).

This task also provides support for the hands-on nuclear criticality safety training programs at the Los Alamos Critical Experiments Facility (LACEF) (see Section 9).

In addition, and beyond the scope of the NCSP, infrastructure maintained by the critical experiments task also supports specific program requirements in the stockpile stewardship program, emergency response and counter terrorism program, and the non-proliferation and arms control program.

3.2 Departmental Requirements

In addition to the general requirements of Section 1.2, the Critical Experiments task of the NCSP is also intended to address the needs of the DOE community to meet specific requirements of the American National Standards Institute/American Nuclear Society (ANSI/ANS) Series 8 Standards. These standards form the core of the requirements contained in DOE Orders 5480.24 and 420.1 related to nuclear criticality safety.

The principal requirement met by the Critical Experiments task is that of ANSI/ANS- 8.1. Section 4.3 of this standard states that the bias in a calculational method be "established by correlating the results of critical experiments." This requires that critical experiment results, applicable to the operation, be available. The conduct of a credible critical experiments program, including the publication of scientific results, is essential to maintain expertise and the capability to properly address the nuclear criticality safety issues associated with the conduct of current DOE programs. The Critical Experiments task is needed to improve the basis of criticality safety methodology, answer criticality questions involving new and previously unevaluated materials and configurations, assist in the development and education of criticality safety engineers and other process personnel, and provide a general purpose and highly capable test bed for equipment and methodology qualification and testing.

By maintaining an operating critical experiments program, DOE is in a position to respond quickly to site specific questions as criticality safety branches into non-traditional areas such as long-term geological waste storage and remediation of legacy materials. Within the limits of its resources, the Critical Experiments task will work to include specific requests for information into its ongoing program.

DOE requirements also include training and qualification of personnel in both the scientific and operational aspects of criticality safety. Criticality safety engineers combine both areas of knowledge to evaluate process operations. Process operations personnel mainly utilize the operational knowledge, but also need to be aware of the technical basis of criticality safety and to be introduced to the importance and types of operational controls for this hazard.

The Critical Experiments task also maintains the capability to perform calibrations of criticality alarms and radiation dosimetry equipment and to benchmark the supporting methodology.

The specific experiments needed to meet the Departmental Requirements for critical experiments data are summarized in LA-UR-99-2083. This updated document summarizes the results of the1998 review of LA-12683, *Forecast of Criticality Experiments and Experimental Programs Needed to Support Nuclear Operations In The United States of America: 1994 - 1999*, originally published in July, 1994. This update was generated in a national consensus process, and the update includes a listing of the proposed experimental programs and an overview of the information pertaining to prioritizing critical experiments. The conclusion of the yearly reevaluation of the experimental program is that the program is strongly determined by the criticality safety needs of the DOE complex. Many of the proposed measurements can be incorporated into current experimental activities without a large reallocation of resources.

Table A-1 of Appendix A contains a short summary of the collected experiments and includes an estimate of ranking and resource requirements. A more complete description of the experiments is contained in Appendix A of LA-UR-99-2083. The ranking estimates of low, medium, or high reflect the current priorities. The resource requirements are estimates of the experimental program funding necessary to complete the experiment or experimental program.

Table A-2 is a consensus ranking of the newly collected critical experiments combined with the current high-priority list. The members of the CSSG met and discussed the current experimental program and merged these new experiments into the existing priority list.

The experiments being performed at LANL provide valuable benchmark data for use by the criticality safety community, and the results are transmitted to the International Criticality Safety Benchmark Evaluation Project (ICSBEP) for independent review and dissemination (see Section 4).

3.3 Program Objectives

The Critical Experiments task is a crucial element in meeting the requirements defined in the previous section. The overall objective of the Critical Experiments task is to serve as the basis for the validation of calculational methodologies. This is especially important since new Departmental activities involve non-fissile materials and special nuclear material in new situations not encountered previously, and often involve nuclear cross section data for which no experimental tests are available. For example, essentially no critical experiments data are available to validate calculations and safety evaluations involving Pu and common waste matrices, Pu or ^{235}U in silicon or silicon/water mixtures, Pu or ^{235}U with iron, ^{233}U with anything other than water, and essentially all types of mixed oxide configurations.

Information provided by the Critical Experiments task is needed to confirm the applicability of the nuclear cross section data for new materials (e.g., silicon and iron), new configurations, and in new neutron energy regimes (i.e., intermediate neutron energy systems). Thus, the Critical Experiments task provides data to validate safety evaluations in areas such as: environmental and nuclear facility remediation; and packaging, storage, transportation, and disposition of waste and weapons material.

The hands-on training that is provided as part of the Critical Experiments task of the NCSP has an impact far beyond that obtained in classroom training and is considered to be a high priority activity. In its Recommendation 97-2, the DNFSB noted the importance of such training and urged the development of an additional, advanced hands-on training course. Both the traditional courses and the new advanced course will be offered under the NCSP. Because training is a foundation upon which many other NCSP activities rely, it benefits all organizations that perform or supervise nuclear materials handling operations. The training courses are given at both the introductory and advanced levels. The former are aimed at process line operators and supervisors, regulators, etc. and the latter are aimed at practicing nuclear criticality safety professionals. All DOE and contractor organizations that require qualification of this type benefit from this program.

The high-priority list given in Table A-2 of Appendix A contains 10 experiments. These experiments support both DOE programmatic requirements and the maintenance of capability, which is a basic part of the DOE criticality safety infrastructure. At current resource levels, only the Priority 1, 2, and 7 activities receive significant attention, although planning and discussion

relating to the performance of the other high-priority activities does take place. Performance of these experiments beyond more than a rudimentary level (including aspects that may be conveniently performed under activities 1, 2, or 7) typically depends on obtaining some extra resources specifically for those activities. Appendix A contains an extended description of these ten programs, which are summarized below.

Priority 1: Intermediate-energy reactivity worth and dosimetry experiments using non-fissile matrix materials (ZEUS)

Priority 2: Intermediate- and thermal-energy in specified waste matrices

Priority 3: Measurements of worth of CERES fission-product samples for support of burn-up credit

Priority 4: Single-unit and array experiments for pit storage and transportation, including experiments to simulate dissolution

Priority 5: Experiments to determine effects of special moderators (e.g., beryllium, graphite, D_2O, high-density polyethylene) and absorbers (e.g., chlorine) on fissile materials in homogeneous and heterogeneous systems

Priority 6: Lattice experiments with mixed-oxide (MOX) fuel pins, including replacement measurements for various materials

Priority 7: Criticality (accident) alarm system (CAAS) testing with SHEBA-II and Godiva.

Priority 8: Verification of positive temperature coefficients for dilute systems with nearly pure ^{239}Pu

Priority 9: Extension of National Institute of Standards and Technology (NIST) neutron slowing-down experiments in water to larger spheres of water

Priority 10: Source jerk/pulsed neutron measurements for subcritical systems

3.4 Accomplishments

The LACEF provides critical experiments data for use in validation of calculational methodology in support of DOE programs in the areas of weapons, nuclear emergency response, environmental management and materials disposition. Current LACEF programs are intended to provide data for systems for which data either does not exist (e.g., ^{239}Pu, ^{233}U and expected matrix materials) or is sparse (e.g., ^{235}U) in the composition or energy regions of those systems.

Recent specific accomplishments at the LACEF include the following.

1. Intermediate energy cross section tests for ^{235}U, ^{239}Pu, and ^{233}U

The first ZEUS experiments have been completed using a carbon-^{235}U heterogeneous assembly on the COMET assembly. This program provides data from critical assemblies where the fissions take place at intermediate neutron energies. Subsequent measurements will provide similar data for ^{239}Pu and ^{233}U, and for common matrix materials encountered in the storage, transportation, and disposition of waste and excess weapons materials. Examples of activities requiring this data include materials disposition, such as casting of ^{239}Pu into glass and the storage, transportation, and disposition (e.g., into geologic storage) of those materials; handling and disposition of large scale waste boxes containing ^{235}U-iron (steel) mixtures; handling and disposition of ^{233}U currently stored under thermal (well understood) conditions; and validation of spent fuel burn-up credit.

2. Thermal spectrum tests of common matrix materials

Similar to the intermediate energy experiments described above, the cross section tests for common waste or other matrix materials are in progress. These tests are being performed on the PLANET assembly, using a heterogeneous mixture of ^{235}U, polyethylene, and the matrix material. The first matrix material being tested is silicon (actually, silicon dioxide in the form of glass) with the amount of matrix material and Plexiglas varied to provide different hydrogen to material ratios. When the silicon tests are complete, the experiments will proceed to other matrix materials of immediate interest such as iron and aluminum. Data from these tests, as with item (1) above, are needed by those programs which handle any of the three fissile species in conjunction with the matrix materials tested. This set of experiments, together with those conducted under (1) above, form a complete set of validational data for the three fissile species and the common matrix materials which are expected to be encountered in cleanup and disposition of the DOE complex. This includes spent fuels, excess weapons materials, and current ^{235}U and ^{239}Pu waste streams (e.g., the Hanford waste tanks).

3. Replacement measurements for ^{233}U using the SHEBA assembly

Reactivity worths for ^{233}U were measured for three representative fission-causing spectra. The results compared well with Monte Carlo calculations for the experiments. These results are needed for validation of nuclear materials handling processes involving ^{233}U (including storage, transportation, and disposition) in other than thermal energy spectra.

4. Conduct of nuclear criticality safety training

In collaboration with the LANL criticality safety group, LACEF provides the facilities used in the basic nuclear criticality safety training class for DOE complex personnel. In mid-August 1998, the facility went into a stand-down mode, and the classes did not resume until July 1999. These classes are essential in the training of personnel involved in nuclear operations where criticality is a concern and are included in the qualification program for federal employees involved in nuclear materials handling operations. An advanced version of the traditional course (for subject matter experts) will be piloted in August 1999 and fielded in FY 2000.

5. Process operations support at LANL
LACEF provides critical experiments and other tests of proposed process operations at LANL. Examples are the replacement measurements conducted using the SHEBA assembly and the gadolinium scan tests (in process) conducted in support of the use of gadolinium-loaded plastic in the construction of storage tanks for ^{239}Pu solutions. Construction of the Nuclear Materials Storage Facility at LANL may involve storage under conditions tested under activities (1) and (2) above, e.g., the use of a significant quantity of iron in the storage cans. Planning is underway for the measurement of potential positive temperature coefficients which have been theoretically predicted for dilute plutonium solutions. Critical or near-critical experiments will be conducted using the PLANET assembly machine and sub-critical measurements will be conducted using a tank.

6. Criticality alarm testing
Qualification of the Portsmouth criticality alarms was performed in March 1999, using the Godiva and SHEBA assemblies. These tests are required for Portsmouth by its United States Nuclear Regulatory Commission (NRC) License. Tests of this type are expected to be required in the foreseeable future, as equipment and methodology change. As in the case of Portsmouth, such changes are often driven by manufacturer changes beyond the control of the facility. Similar calibration support is provided to NRC organizations and DOE contractor organizations from across the complex.

7. Dosimetry calibrations
Tests similar to those in activity (6) are performed to qualify neutron dosimetry tools within the DOE complex. Radiation fields of the proper type (neutron spectra and neutron/gamma ratio) were provided to qualify neutron dosimetry equipment for DOE contractor organizations from across the DOE complex. Facilities that do neutron dosimetry are required to qualify the equipment and methodology used for these purposes.

8. Critical mass and delayed neutron properties for ^{237}Np
Replacement measurements using the FLATTOP assembly and activation measurements using the Godiva assembly were made to measure the critical mass and the delayed neutron yields for ^{237}Np. These basic criticality physics parameters are needed to support materials handling processes involving ^{237}Np for anything other than thermal systems.

9. Qualification of Accelerator Production of Tritium (APT) targets
Targets for both the accelerator version and the reactor version were qualified by measuring the relevant parameters using the SHEBA assembly. The SHEBA assembly is a liquid-fueled assembly, and has neutron characteristics similar to those anticipated using the two forms of production devices.

10. Initiation of prompt bursts
This is a collaborative experiment which supports the LANL weapons program.

11. Weapons safety tests

This is an experiment designed to validate calculational methodology used in the evaluation of weapons safety under accident conditions.

3.5 Budget and Schedule

Table 3-1 shows the budget, tasks and associated deliverables for the Criticality Experiments task of the NCSP for fiscal years 2000 through 2002. The total estimated funding estimates for fiscal years 2003 and 2004 are given in Table 3-2.

Table 3-1. Schedule and Budget for Critical Experiments Task of the NCSP

	Deliverables and Budget		
	FY 2000 ($k)	FY2001 ($k)	FY2002 ($k)
Task	3950	3950	3950
1) maintain the capability to perform critical experiments	• maintain authorization basis (finish BIO, begin SAR revision) • begin FM staff hiring • initiate disposition of unneeded SNM (U-235, other) • complete acquisition of Pu-239 needed under task 3 • initiate acquisition of U-233 needed under task 3• initiate acquisition of other materials • perform priority maintenance (facility)	• maintain authorization basis (continue SAR revision) • complete FM staff hiring • requalify assembly personnel (operators) • continue SNM disposition (U-235 solution) • complete U-233 acquisition • complete acquisition of other materials • perform priority maintenance (assemblies)	• maintain authorization basis • continue disposition of SNM (other) • perform priority maintenance (assemblies)
2) evaluate the critical experiment needs and critical experiments priorities	• issue call for input • evaluate/prioritize input • revise experiments list as applicable • issue report	• issue call for input • evaluate/prioritize input • revise experiments list as applicable • issue report	• issue call for input • evaluate/prioritize input • revise experiments list as applicable • issue report

3) conduct critical experiments	• initiate conduct of highest priority experiment (Comet/Zeus) • U-235 intermediate energy) • initiate conduct of next priority experiment - waste matrices, thermal energy (Planet) for high priority waste matrices (Si, Fe, Al) • initiate planning for next priority experiment - alternative materials, positive temperature coefficient (Planet, Flattop, solution tanks, ...)	• complete conduct of highest priority intermediate energy U-235 experiments (Comet/Zeus) • initiate conduct of Pu-239 intermediate energy, waste matrices • complete conduct of next priority experiment - waste matrices, thermal energy (Planet) for high priority waste matrices (SI, Al, Fe) • initiate conduct of second priority waste matrices experiments (Cl, Ca, Mg, packing materials) • initiate conduct of third priority experiments - alternative materials, Pu positive temperature coefficient (Planet, Flattop, solution tanks, ...)	• complete conduct of highest priority Pu-239 experiment (Comet/Zeus) • initiate U-233 intermediate energy, waste matrices • continue conduct of second priority experiment - waste matrices, thermal energy (Planet) • initiate conduct of next priority experiment - alternative materials, Pu positive temperature coefficient (Planet, Flattop, solution tanks, ...) • complete one of the third priority experiments (alternative materials, ...)
4) transfer this knowledge to the criticality safety engineering community	• issue progress reports at least annually • publish nationally, e.g., ANS, NCTSP, ICNC, etc.	• issue progress reports at least annually • publish nationally, e.g., ANS, NCTSP, ICNC, etc.	• issue progress reports at least annually • publish nationally, e.g., ANS, NCTSP, ICNC, etc.
5) provide a test bed and pulsed-radiation capability to operationally test and qualify equipment	• maintain SHEBA, Godiva for operations • characterize Godiva (as needed) • characterize SHEBA (free runs, prompt critical operations) • initiate accident methodology studies • submit approval package - SHEBA prompt critical operations with uranyl fluoride fuel	• maintain SHEBA, Godiva for operations • characterize SHEBA and Godiva • SHEBA prompt critical operations (uranyl fluoride fuel)	• maintain SHEBA, Godiva for operations • characterize SHEBA and Godiva • SHEBA prompt critical operations (uranyl nitrate fuel)

Table 3-2. Estimated Out-Year Funding for the Critical Experiments Task of the NCSP

Year	Budget ($k)
2003	3950

Table 3-2. Estimated Out-Year Funding for the Critical Experiments Task of the NCSP	
Year	Budget ($k)
2004	3950

3.6 Extended Program Opportunities

3.6.1 Critical Experiments

The critical experiments task is focused on maintaining the capability to conduct experiments by actually doing one or two critical experiments per year from the priority experiment list. One extended program opportunity would simply be to increase to a more robust critical experiments program by increasing the level of effort on current experiments and by including several additional experiments from the top priority list. This would help the experiments program meet customer needs in a more timely fashion, and meet a wider range of needs. Funding opportunities that would allow the LACEF to conduct the CERES experiments, the verification of the predicted positive temperature coefficients for dilute plutonium systems, and several varieties of subcritical measurements. In addition, the experiments conducted under the NCSP have been concentrated in the area of process criticality safety applications. The end of underground nuclear weapons testing has brought about an era where certification of the stockpile will rely much more heavily on the predictions of calculational models. The validation of these calculational methodologies will be a much more important activity now. Critical experiments can play a vital role in this validation process.

LACEF personnel have been meeting with a number of stockpile stewardship personnel, and a program review has been held with these personnel. The purpose of these activities is to determine new directions for the LACEF program to specifically support stockpile stewardship program needs. Several short white papers are being developed collaboratively among LACEF and stockpile stewardship personnel. It is anticipated that such activities would be extended to include criticality safety and stockpile stewardship personnel from Lawrence Livermore National Laboratory (LLNL) and Sandia National Laboratories (SNL).

3.6.2 Subcritical Experiments

Since the NCTSP meeting, discussions have been held about the use of subcritical experiments to enhance our understanding of methods of predicting criticality. Such methods could be used to complement the work in the various tasks of the NCSP. In discussions with the Oak Ridge National Laboratory (ORNL), such work could be initiated. An example would be a subtask such as:

> Subcritical Noise Measurements with Uranium foils at LACEF (begin in FY 1999 and end in FY 2000, depending on LACEF schedule)

Current plans at LACEF include critical measurements with various moderator and reflector plates using uranium foils. These measurements will provide benchmark data for testing nuclear data being developed under the NCSP. Performance of subcritical noise analysis measurements using the same facility and configurations would be a wonderful complement to the critical experiments. Inclusion of subcritical noise measurements would provide benchmark data at various degrees of subcriticality. These measurements can be performed in collaboration with ORNL and LACEF staff and can be analyzed by ORNL. This would provide the most complete set of data to examine effects of nuclear cross sections uncertainties on calculations at various degrees of subcriticality.

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4.0 Benchmarking

4.1 Introduction

The critical experiments program described in Section 3.0 is supplemented by a broad base of available criticality benchmark data. These measured data represent an important resource for validating and enhancing calculational methods. Until recently, no effort had been made to take full advantage of this resource. In 1992, the DOE initiated the Criticality Safety Benchmark Evaluation Project (CSBEP) at the Idaho National Engineering and Environmental Laboratory (INEEL). The purpose of this project is to identify and evaluate a comprehensive set of critical benchmark data, verify the data to the extent possible, compile it into standardized format, perform calculations of each experiment, formally document the work and make it available for use throughout the complex.

In early 1994, the DOE expanded the CSBEP into the International Criticality Safety Benchmark Evaluation Program (ICSBEP) which was accepted as an official activity of the Organization for Economic Cooperation and Development - Nuclear Energy Agency (OECD-NEA). Also managed through the INEEL, the ICSBEP members include the United States, the United Kingdom, Russia, Japan, France, Hungary, South Korea, Slovenia, and Yugoslavia. This project, led by the United States, established an international forum for the exchange of nuclear criticality benchmark data. The first series of evaluations performed by the ICSBEP was published in May of 1995, as an OECD-NEA handbook entitled, "International Handbook of Evaluated Criticality Safety Benchmark Experiments". The handbook more than doubled in size in September of 1996 when the first revision of the handbook was published and experienced substantial growth for the second and third revisions in September 1997 and 1998, respectively.

The primary area of focus of the ICSBEP is to: consolidate and preserve the information base that already exists in the United States; identify areas where more data are needed; draw upon the resources of the international criticality safety community to help fill identified needs; and identify discrepancies between calculations and experiments. This program represents a tremendous capability. It provides the United States with the ability to access the global database of experimental benchmarks to validate calculational methods that simulate the neutronic behavior of fissile systems.

The ICSBEP continues to be managed at the INEEL; however, the project involves nationally known criticality safety experts from a number of DOE Laboratories including: LANL, LLNL, Savannah River Technology Center (SRTC), ORNL, the Y-12 Plant, Hanford, Argonne National Laboratory (ANL), and the Rocky Flats Environmental Technology Site (RFETS). This broad cross-section of participants ensures that the needs of each DOE site are being met. In general, participants focus on data that are of importance to their site. Participants are also asked to evaluate data that were generated at their respective sites since they are in the best position to access the data, facilities and experimenters who were directly involved with the generation of the data. The ICSBEP is a labor-intensive task that demands the attention of many more criticality safety experts than exist at any one site. It is essential that the benchmarking effort proceed at a

fast pace to ensure that all important relevant data are retrieved and evaluated while original experimenters, most of whom are now retired, are still available to answer questions.

4.2 Departmental Requirements

The necessity to validate calculational methodologies by comparison with experimental data has been recognized and practiced by criticality safety experts for decades. Establishment of a bias in any methodology by correlating benchmark experiment results with results obtained by the methodology being validated is a requirement of ANSI/ANS-8.1-1998, whose adherence is required by DOE Order O 420.1. There are also regulatory drivers for transportation and storage of fissile materials that require similar validation of methodologies that are used to establish safety margins.

Since the beginning of the nuclear industry, DOE and comparable government agencies within other countries have performed thousands of criticality safety related experiments. Many of these experiments can be used as benchmarks for validation of calculational techniques. However, many were performed without a high degree of quality assurance and were not well documented. This broad base of criticality safety benchmark data constitutes an important part of the DOE NCSP infrastructure, but evaluation and comprehensive documentation of these data are required to make the data useful to the general community of criticality safety practitioners.

The ICSBEP is an integral part of the DOE Nuclear Criticality Safety Program infrastructure. It systematically consolidates and preserves the benchmark information base that already exists in the United States and expands it by drawing upon the resources of the international criticality safety community. The ICSBEP maintains an essential interface with the Critical Experiments, Analytical Methods, Nuclear Data, Information Preservation and Dissemination, and Applicable Ranges of Bounding Curves and Data tasks. The "International Handbook of Evaluated Criticality Safety Benchmark Experiments" is also an excellent training tool for new criticality safety engineers.

In addition to the broad base of existing experimental data that is addressed and managed by the ICSBEP, there are specific experimental needs that are identified for the Critical Experiments task of the NCSP. For example, the National Spent Nuclear Fuel Program (NSNFP) at the INEEL has a need to validate criticality safety calculations for systems containing large amounts of SiO_2. This effort is focused on moving highly enriched uranium fuels from interim storage at the INEEL to the geological repository at Yucca Mountain. (These data are also of value to all activities associated with fissile contaminated waste streams involving soil or glass.) Failure to move this fuel out of Idaho within the specified time limits would violate agreements between DOE and the State of Idaho and could result in fines and the interruption of naval fuel shipments into Idaho. Because few appropriate benchmarks exist, experiments funded by the NSNFP are being performed at the Institute of Physics and Power Engineering (IPPE) in Obninsk, Russia that will provide at least part of the necessary data. Complementary experiments are being conducted at LACEF. Documentation of these experiments will be submitted to the ICSBEP for review, evaluation, and publication.

4.3 Program Objectives

4.3.1 ICSBEP Support to the DOE NCSP Infrastructure

Large amounts of critical experiments data exist within the United States that have not been evaluated and documented. ORNL and the Y-12 Plant have identified approximately 30 series of experiments representing over 200 critical configurations that are frequently used for validations at their facilities, but have not yet been scheduled for evaluation by the ICSBEP. Engineers at Rocky Flats, Savannah River and the INEEL have also identified several other series of experiments that are used at their facilities that have not yet been evaluated. They also use several from the ORNL list of needed evaluations. LLNL has identified several experimental series that are required at their facilities, including several classified experimental series that could be declassified and evaluated. The ICSBEP systematically evaluates and documents these data according to the selection and prioritization criteria outlined in Section 4.3.2. In addition, the NCSPMT has directed that all critical experiments being conducted or planned at the LACEF should be designed to consensus benchmark specifications and evaluated for inclusion in the ICSBEP handbook.

The DOE must also continue its review of foreign data commensurate with its commitment as part of the ICSBEP process. Continuation of this work at an appropriate level is important because many of these evaluations are very useful in supporting the DOE's mission needs. Some of the data obtained from outside the United States, which is summarized in Appendix B, illustrates how the ICSBEP draws upon the international criticality safety data base to help fill DOE needs.

All non-United States data were obtained at little or no cost to DOE. All have significant value and some can no longer be generated in the United States without major expense. Some of the data given above have helped fill United States data needs that are classified as "high priority" (e.g., dilute plutonium solution data). These data would cost DOE several million dollars to produce in the United States.

There are two additional types of criticality safety data that are equally important, but have only received limited consideration by the ICSBEP. These two areas are (1) criticality alarm and shielding experiments and (2) subcritical experiments. As efforts to evaluate and document critical experiment data begin to decline, the ICSBEP will focus more attention to these areas. It is projected that a decline in critical experiment benchmarking activities can begin during FY 2002 and will reach a "status quo" level near FY 2003. However, by keeping funding for the benchmarking program task at a constant level, work can begin on the other two focus areas.

4.3.2 Experiment Evaluation Selection Criteria and Prioritization

Most of the major DOE Laboratories that deal with fissile material, outside of reactors, have representation on the ICSBEP. Essentially all ICSBEP Working Group members are experienced criticality practitioners, criticality safety experimentalists, or code/data experts. Most are

currently on or provide direct support to the criticality safety staff at their respective sites and are very familiar with the validation needs at these sites. Data are selected for evaluation, by these individuals, in consultation with the Chairman of the ICSBEP Working Group according to the following criteria.

1. Unless prior agreement exists to do otherwise, those experimental data that were generated at a particular facility are the responsibility of the evaluator at that facility. In most cases these experiments were performed in support of operations at that facility and are naturally needed by the local criticality safety staff. Those data that are needed most at the generating facility are evaluated first. In most, if not all cases, these data are of use to multiple facilities.

2. Evaluators who are responsible for a particular facility that requires certain experimental data that cannot be immediately evaluated by an evaluator at the point of origin evaluates the required data themselves.

3. Facilities are periodically surveyed to identify specific needs.

4. Beginning in FY 1999, specific benchmark evaluation requests can be submitted through the ICSBEP Internet site (http://icsbep.inel.gov/icsbep). This site can also be accessed through the DOE Nuclear Criticality Safety Program Internet site. Requests that cannot immediately be addressed by the ICSBEP will be discussed with the Criticality Safety Support Group to gain a consensus of the relative importance of the work in progress.

Most evaluated benchmarks are used at multiple DOE sites. For example all plutonium data are of particular importance at LANL, RFETS, LLNL, Hanford, Pacific Northwest National Laboratory (PNNL), and SRTC; however, these data are also used at the INEEL to demonstrate the safety of plutonium bearing waste streams under their responsibility, including licensing of the TRUPACT-II. Low concentrated plutonium solution data were recently listed among the top United States data needs. Once again, these data are not only important to support plutonium operations, but are also essential tc validate criticality safety calculations for plutonium bearing waste streams. These data were not available in the United States and would have cost several million dollars over several years to produce. However, these data were obtained from France for only an insignificant cost to review and publish the data.

Low enriched uranium data are valuable to operations at ORNL and at the Oak Ridge Y-12 Plant. Low enriched uranium data from ORNL and PNNL are also used at the INEEL where numerous commercial light water reactor assemblies are or have been used in various DOE programs. Safety analysis calculations supporting INEEL operations involving the TMI-II core debris are validated using many of these same low enriched data.

4.3.3 ICSBEP Support to Specific Programmatic Needs

The ICSBEP will continue to identify data within the international criticality safety community that will help fulfill specific United States needs and will seek ways to encourage contribution or procurement of the needed data. For example, the ICSBEP is supporting the NSNFP at the INEEL in its effort to obtain criticality safety data that can be used to validate calculations of fissile bearing waste streams containing large amounts of SiO_2. The ICSBEP will evaluate and provide independent review of these data as soon as they become available. Working Group review of these data is planned for the spring of 2000 with publication of the data scheduled for September of 2000. If inadequacies are identified in the silicon data, this information will be forwarded to those responsible for the Nuclear Data task.

4.4 Accomplishments

The efforts of the ICSBEP have eliminated much of the redundant and inconsistent efforts of research and model description that took place throughout the DOE complex. For example in 1995, the Savannah River Site (SRS) reported over a $1 Million dollar savings in validation costs at their site alone because of access to the "International Handbook of Evaluated Criticality Safety Benchmark Experiments". SRS Facilities that were directly impacted by the readily available data in the handbook include H-Canyon, F-Canyon, HB-Line, FB-Line, 235-F, and the Receiving Basin for Off-Site Fuels Facility. Similar validation efforts are made at all DOE non-reactor nuclear facilities and are applicable to all activities involving fissile material.

Over 150 scientists from around the world have combined their efforts to document the work of the ICSBEP as the "International Handbook of Evaluated Criticality Safety Benchmark Experiments". The 1999 version of the handbook will span seven volumes and contain approximately 268 evaluations with benchmark specifications for nearly 2250 critical configurations. As a result of these efforts, a large portion of the tedious and redundant research and processing of critical experiment data has been eliminated. The necessary step in criticality safety analyses of validating computer codes with benchmark critical data is greatly streamlined, and valuable criticality safety experimental data is preserved. The work of the ICSBEP has highlighted gaps in data, has retrieved lost data, and has helped to identify limiting assumptions in cross section processing codes. The Handbook is currently being used in 35 different countries, with nearly 400 copies already distributed. Appendix B contains a detailed listing of the distribution of the Handbook.

During 1998 ICSBEP participants at the INEEL and the IPPE began the large task of recalculating every configuration in the "International Handbook of Evaluated Criticality Safety Benchmark Experiments" and collecting the spectral characteristics of each experiment. These data represent a significant enhancement to the Handbook and will enable criticality safety practitioners to more clearly understand the range of applicability for each configuration in the Handbook.

Recent contributions from ANL and the IPPE have identified large (>10% in some cases) discrepancies for certain kinds of systems containing large amounts of iron, chromium, nickel, stainless steel, or zirconium. ICSBEP personnel and individuals responsible for analytical methods at ORNL were able to identify both limiting assumptions in cross section processing codes and inadequacies in nuclear cross section data.

As another example, the first contribution to the ICSBEP from Slovenia included data for arrays of 20% enriched uranium TRIGA reactor fuel elements. These data are applicable to transportation and storage of TRIGA reactor fuels at the INEEL. This was a significant contribution because very little data exist for this type of fuel.

4.5 Budget and Schedule

Table 4-1 summarizes the schedule of activities for years FY 2000 through FY 2002 and the associated minimum budget requirements.

Similar tasks will continue during the years 2003 and 2004. However, as data from existing critical experiments are exhausted, benchmarking efforts in this area, at least in the United States, will decline to a level that will enable the evaluation, review, and publication of only new experiments. (Note: If the program at LACEF expands significantly during the out years, the decline in the benchmarking effort could be delayed.) At the same time, the focus of the ICSBEP will turn to the identification, evaluation, and documentation of (1) criticality alarm and shielding experiments and (2) subcritical experiments. The total estimated funding requirements for the years FY 2003 and FY 2004 are given in Table 4-2.

Table 4-1. Schedule and Budget for the Benchmarking Task of the NCSP

Tasks by Laboratory	FY 2000 ($k)	FY 2001 ($k)	FY 2002 ($k)
INEEL: Provide technical project management support for the International Criticality Safety Benchmark Evaluation Project which is managed by DOE Defense Programs. Provide or coordinate independent review efforts, graphic arts support, technical editing, and publication of the International Handbook of Evaluated Criticality Safety Benchmark Experiments. Participate in the ICSBEP as follows: evaluate and, to the extent possible, verify criticality safety benchmark experiment data, compile the data into a standard format that will provide an accurate basis document for future validation efforts, and perform calculations using the data with standard criticality safety neutronics codes. INEEL will focus primarily on high, intermediate, and low enriched uranium systems and on plutonium solution systems. Where possible, the INEEL will also provide for the documentation of undocumented experimental data.	600	570	420 +50*
LANL: Participate in the ICSBEP with primary focus on high enriched uranium, plutonium, ^{233}U, and mixed plutonium - uranium metal systems.	280	280	180 +100*
SRS: Participate in the ICSBEP with primary focus on high enriched uranium and plutonium metal and solution systems.	195	200	195
ORNL & Y-12: Participate in the ICSBEP with primary focus on high, intermediate, and low enriched uranium metal, compound and solution systems, and on ^{233}U solution systems.	195	200	185 +150*
ANL: Participate in the ICSBEP with primary focus on Zero Power Reactor (ZPR) benchmark data that are relevant to non-reactor criticality safety issues.	180	200	170
RUSSIAN FEDERATION: Participate in the ICSBEP with primary focus on non-reactor criticality safety data that are available within the Russian Federation. Provide spectral data for all evaluations.	50	50	50
TOTAL:	1,500	1,500	1,500

*Specifically allocated for criticality alarm and shielding benchmark data and subcritical benchmark data.

Table 4-2. Estimated Out-Year Funding for the Benchmarking Task of the NCSP	
Year	Budget ($k)
2003	1500
2004	1500

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5.0 Nuclear Data

5.1 Introduction

Accurate differential nuclear cross section data and their covariances are at the foundation of nuclear criticality predictability. In order for nuclear cross section data to be utilized, it has to be measured, evaluated, put into standard format, tested, released as part of the Evaluated Nuclear Data File (ENDF) library, and then processed into specific formats for subsequent use by the analytical methods. It is important to point out that both the evaluation and the processing activities mentioned here entail significant nuclear-methods development and application efforts that must incorporate fundamental but complex nuclear reaction formalisms, nuclear models, and associated approximations before the measured nuclear cross section data can be used by criticality analytical methods. This is important to note in order to gain a proper perspective for the effort requirements necessarily associated with the Nuclear Data task. As these methods develop (see Section 6), additional data such as covariance matrices are needed. As DOE missions change, new cross section data is often needed for material and energy regions that were not important for past work. Encompassing all of these nuclear data requirements, the Nuclear Data task of the NCSP is divided into three subtasks.

Subtask 1: ORNL – measurement, evaluation, testing, evaluation and processing method development, covariance development, and Cross Section Evaluation Working Group (CSEWG) and international interactions.

Subtask 2: LANL – evaluation, testing, processing method development, covariance development and CSEWG and international interactions.

Subtask 3: ANL – testing, processing method development, covariance development and CSEWG and international interactions.

In the past, analytical methods for criticality prediction used simple geometric and nuclear models of the system. The situation has changed dramatically with the advent of very fast computers and the refinement of the analytical methods. In most of the cases the uncertainty in the results of calculations can be traced to the data rather than to the physical model. Therefore, the uncertainties in the calculations can be reduced if accurate data are used in analyses.

The CSEWG has developed the United States ENDF nuclear data library, with emphasis on the fast, thermal, and fusion reactor communities. Nuclear data needs of the criticality safety community were not given much attention in past versions of ENDF. Now, participants in the Analytical Methods, Benchmark, Nuclear Data, and Applicable Ranges of Bounding Curves and Data (AROBCAD) tasks of the NCSP are actively involved in CSEWG to assure that ENDF will evolve into a reference nuclear data library well suited for criticality safety applications. In addition, one member of the CSSG is a member of CSEWG, and will continue to provide liaison to ensure that the DOE criticality safety nuclear data needs are addressed.

The nuclear data programs at ORNL, LANL, and ANL provided the vast majority of evaluations for ENDF/B-VI, which is the most recent and complete cross section compilation (1990). All three laboratories are participating in the Nuclear Data task. ORNL plays a major role in nuclear data measurement and evaluation. The measurements are performed at the ORELA. ORELA is ideally suited for providing data for criticality safety applications since data can be measured with high resolution over the energy regions important for criticality safety applications. At ORNL, there also exists expertise in data measurements and data evaluation in the resolved and unresolved resonance region. The author of the tool for data evaluation, the SAMMY code, is at ORNL. With SAMMY data, evaluations are made with full uncertainty files (covariance and sensitivity parameters) which are essential for meaningful assessments of the uncertainty in calculated parameters for criticality safety applications. These uncertainties directly impact the calculated margin of sub-criticality. As will be explained in subsequent sections, these types of data are also needed for the AROBCAD task. Resolved resonance covariance data for ^{27}Al, ^{233}U, and ^{235}U will be provided for use by AROBCAD in FY 2000.

Integral benchmark experiments performed at experimental facilities such as the LACEF at LANL serve to test the adequacy of the evaluated data prior to their use in criticality safety calculations.

ANL has played an important role in the area of nuclear data, with significant contributions in the development and application of a wide range of nuclear reaction formalisms in connection with the processing methods in nuclear data. A particularly major contribution is the pole representation of resonance parameters in momentum space, which has been implemented at ORNL in connection with AMPX with support from the ANL and funding from the NRC. Further work in processing methods at ANL continues with incorporation of the of the Single Level Breit Wigner and Multi Level Breit Wigner formalisms in the pole representation and a deterministic treatment for unresolved resonances for VIM. Other areas of contribution at ANL include validation of cross sections and other aspects of nuclear data. ANL will also evaluate a series of covariance files for the ENDF/B-V library currently used by the AROBCAD development group. As budgets permit, ANL, LANL and ORNL will focus on the validation of data evaluations and uncertainty data as confirmed through sensitivity and uncertainty evaluations in concert with the international benchmarking effort. The NCS user community will be alerted to any nuclear data having potential adverse impacts on systems identified through Subtask 3 of the AROBCAD task or other relevant sources of information.

Since 1994, criticality safety practitioners have been surveyed periodically to help identify nuclides which they think have deficiencies and which are relevant to Department operations. Some 60 isotopes or elements with nuclear data deficiencies have been identified in this way. Because of the condition of these evaluated data, many will require new measurements at the ORELA, followed by an evaluation or new evaluation of the ENDF/B-VI file. The goal is to assure that the intermediate energy region is represented well by a resonance parameter fit with SAMMY, including covariance data. Where appropriate, evaluations will be upgraded in the higher energy region at LANL to assure a complete evaluation to 20 MeV (required by ENDF/B).

5.2 Departmental Requirements

As noted in Section 1, the DOE requires compliance appropriate with DOE Orders, Standards and nuclear safety rules. Programmatic drivers include commitments to the DNFSB and environmental, safety and health requirements of DOE. The NCSP is an integrated system set in place to meet these requirements. The NCSP requires a minimum infrastructure to be in place and properly maintained so that it can respond efficiently and effectively to develop specific products to meet customer needs.

The vast majority of the effort in the Nuclear Data task is devoted to the NCSP infrastructure. At ORNL, this includes: having the ORELA facility available for use as part of the NCSP; maintaining a staff of experienced experimentalists, electronics and crafts technicians, and evaluators; maintaining evaluation codes for cross-section processing and benchmark analysis; providing for project management; and participation in CSEWG, the NCTSP, the ANS Nuclear Criticality Safety Division (NCSD) and criticality Standards work. Additional expenditures are required to fabricate samples and pay the cost for operating ORELA during the actual measurements. At LANL the infrastructure deals with maintaining evaluation codes, cross-section processing, and participation in CSEWG, NCTSP, and the ANS NCSD. At ANL, the infrastructure deals with cross-section processing and participation in CSEWG, NCTSP, and the ANS NCSD.

Nuclear criticality safety in DOE fissile material operations, storage, transportation, and waste management relies on accurate nuclear cross section data and analytic methods. Examples of processes involving materials that criticality safety specialists have so far identified to the Nuclear Data task include:

- lithium, sodium, potassium carbonates used in heat treating raw fissile material metals
- freon used in heat transfer systems such as freezer-sublimer equipment in UF_6 enrichment cascades, and also used in thermal shock processes for breaking bonds between materials
- organic/aqueous chemical recovery processes
- process residues/deposits of fissile materials in silicates, chlorides, nitrates, phosphates, carbonates, etc.
- elements of equipment construction materials such as stainless steels, specialized materials (e. g., inconels, hastelloys, monels, etc.)
- hydrated/unhydrated NaCl influences on waste storage configurations
- fresh/spent fuel shipping container analyses.

5.3 Program Objectives

The objective of the Nuclear Data task is to provide accurate nuclear cross section data and their uncertainties in forms useable for criticality safety analyses. The emphasis is on improving nuclear data in the energy regions important for criticality safety applications, and providing it where none exists. The intermediate energy region is the initial focus of this task because that region was not emphasized in earlier versions of ENDF that concentrated on thermal, fast, and fusion reactors. Where new measurements are required they will be performed at ORELA. Evaluations will be done to fit the measured data in the resolved and unresolved resonance region and to produce resonance parameters and their uncertainties. Evaluated data will be placed in ENDF format, tests will be performed to check the data, processed libraries will be produced and calculations of criticality benchmarks will be performed. Satisfactory evaluations will be submitted to CSEWG for inclusion in the ENDF.

Performers of this task will maintain close interaction with the Analytical Methods, Benchmarking, AROBCAD, and Critical Experiments tasks of the NCSP so that an integrated system can be achieved.

5.4 Accomplishments

A number of accomplishments can be cited. A measurement program has been established at ORELA and measurements have been performed on a number of nuclides. The effective use of the SAMMY evaluation code to provide resonance parameter fits and their uncertainties has been demonstrated and its extension to the unresolved region is under way. Collaboration between LANL and ORNL on joint evaluations has been demonstrated. Unresolved resonance processing with the LANL NJOY code and the inclusion of unresolved resonance treatment in the MCNP Monte Carlo code at LANL has been demonstrated.

Based on DOE needs solicited from criticality safety specialists and guidance derived from presentations to DOE management over the last four years, current ongoing projects include: measurements on ^{27}Al capture, ^{233}U transmission and capture, and Cl transmission and capture; evaluation of ^{27}Al, ^{16}O and ^{235}U unresolved resonance regions; review of the status of fission product evaluations; and development of SAMMY evaluation techniques for unresolved and resolved resonance regions and associated covariance matrices. The Al data will contribute to the DOE-EM operations involving aluminum-clad fuel elements and aluminum matrix materials; the ^{233}U data will enable more efficient remediation of sites containing ^{233}U-bearing waste.

5.5 Budget And Schedule

The FY 2000, FY 2001, and FY 2002 budgets are shown in Table 5-1. Inherent is the assumption that DOE's Office of Science (SC) continues to provide *in kind* support for ORELA operations valued at approximately $675k/year (in FY 1997 dollars).

Table 5-1. Schedule and Budget for Nuclear Data Task of the NCSP			
	Deliverables and Budget		
Task by Laboratory	FY 2000 ($k)	FY2001 ($k)	FY2002 ($k)
ORNL	1,776	1,826	1,826
1) Perform differential measurements of neutron cross sections in the energy range of importance to the NCSP using the ORELA at ORNL. Activities include sample and detector preparation.*	1) Potassium (02/2000) and fluorine (05/2000) are scheduled for FY 2000, but identified priority measurements may be substituted, resources permit.	1) Measurements on high priority isotopes related to DOE projects (09/2001)	1) Measurements on high priority isotopes related to DOE projects (09/2002)
2) Perform evaluations of neutron cross-sections for materials of importance to the NCSP using existing and newly measured differential cross-section data. Includes code development on the SAMMY Bayes' R-matrix Fitting Code.	1) Activities include evaluations of the ^{233}U unresolved resonance regions (12/1999), and the Cl resolved resonance region (03/2000); development of resolved resonance covariance data for Al, ^{233}U, ^{235}U, and Cl (03/2000).	1) Activities include evaluations for K and F resolved resonance region (03/2001); development of resolved resonance covariance data for K and F. (09/2001)	1) Activities include evaluations based on FY 2001 measurements. (continuing)
3) Collaborate in upgrading CSEWG benchmarks to reflect the needs of the NCSP, perform benchmark calculations of criticality benchmarks with the VITAMIN-B6 multi-group cross-section library, generate sensitivity profiles for criticality benchmarks to help guide new measurements and evaluations, and participate in the integration of the activities of CSEWG and the international criticality safety community.	1) Test the AMPX capability for the unresolved resonance region. (09/2000)	1) Develop unresolved resonance region covariance formats. (03/2001) 2) Test the AMPX capability for covariance processing. (09/2001)	1) Other activities required by programmatic needs. (continuing)
LANL	267	267	267
1) Collaborate with ORNL to provide complete evaluations concentrating on the fast energy region.	1) Complete fast energy evaluations for ^{235}U (12/1999) and ^{233}U (02/2000).	1) Complete fast energy evaluations for K (09/2001) and F (09/2001).	1) Complete high energy evaluations as needed. (continuing)
2) Processing code development.	Begin development of NJOY capability to process resolved resonance region covariance data.	Finish development of NJOY capability to process resolved resonance region covariance data. (09/2001)	Other activities required by programmatic needs. (continuing)

ANL	174	124	124
1) Collaborate in upgrading CSEWG benchmarks to reflect the needs of the NCSP.	(continuing)	(continuing)	(continuing)
2) Participate in the integration of the activities of CSEWG and the international criticality safety community.	(continuing)	(continuing)	(continuing)
3) Processing code development for ANL, support to ORNL and other special activities.	1) With ORNL and LANL, help assess covariance data and provide appropriate data to AROBCAD task. (09/2000)	1) Develop unified resonance formalism.	1) Develop improved unresolved resonance probability table method.
TOTAL:	2,217	2,217	2,217
*(NOTE: This activity depends on the DOE/ES commitment to the NCSPMT to maintain ORELA in operating condition and to provide technical assistance of up to 1 PY.)			

The total estimated funding for fiscal years 2003 and 2004 are given in Table 5-2.

Table 5-2. Estimated Out-Year Funding

Year	Budget ($k)
2003	2,217
2004	2,217

5.6 Points of Contact

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6.0 Analytical Methods

6.1 Introduction

The Analytical Methods task of the NCSP is central to an efficient criticality safety program. The methods are applied in the evaluation of fissile systems to establish safe margins of subcriticality. Furthermore, the analytical methods are used to establish controlled parameters through the demonstration of the sensitivity of the fissile system multiplication factor to the reactivity effect of the parameter variation. Design specifications on controlled parameters are incorporated into safety analysis reports, and control limits from criticality safety assessments are incorporated into facility operating procedures. The KENO/SCALE and MCNP software packages are widely used for these purposes. Thus the current and ongoing development and application of analytical methods is an integral part of the DOE NCS infrastructure.

The work under the Analytical Methods task of the NCSP breaks down into four subtasks:

Subtask 1 – Capability maintenance, training and user assistance and needed improvements are performed on the KENO/SCALE software by ORNL. Additionally, a limited amount of administrative and technical support is provided to the NCSP by ORNL staff.

Subtask 2 – Capability maintenance, training and user assistance and needed improvements are performed on the MCNP code and related software by LANL, with associated management support.

Subtask 3 – Capability maintenance, training and user assistance and needed improvements are performed on the VIM code and related software by ANL, with associated management support.

Subtask 4 – The Radiation Safety Information Computational Center (RSICC) at ORNL performs the important function of collecting, packaging, and disseminating the software (codes and cross-section libraries) to the criticality safety community.

Criticality safety is a DOE infrastructure activity that ensures safe fissile material operations throughout the DOE complex. The alternative to the conduct of a good criticality safety program is to restrict fissile material quantities to overly-conservative mass or concentration limits which lead to gross inefficiencies in operations involving significant quantities of fissile material. Since prevention of criticality accidents by maintaining safe margins of subcriticality is a mandatory requirement for fissile material operations in the United States, maintenance of a quality program that includes the proper analytical methods and data is a necessity.

The purpose of this task is to provide the DOE complex with state-of-the-art analytical methods qualified for the evaluation of DOE fissile system applications. Maintenance of an efficient criticality safety infrastructure dictates that sophisticated methods be qualified for the analysis of large quantities of fissile material configured in complex geometries. Analysis of complex geometries generally requires the application of the Monte Carlo method. Overall qualification of the analyses requires technology from the Critical Experiments, Nuclear Data, Benchmarking and

AROBCAD tasks of the NCSP. Additionally, the methods and data should be operational on modern computer platforms and available for distribution to the user community. Also, criticality safety specialists must be trained and assisted in the correct use of the methods and data. Thus, infrastructure maintenance activities include the technologies required to qualify the methods, production software compatibility with current computer platforms, software packaging and distribution to the user community, and training and user assistance. In this regard, the NCSP infrastructure maintenance requires the functions performed in the Analytical Methods task, supplemented by the technology from the four additional NCSP tasks listed above.

The strength of the United States capability in performing criticality safety analyses resides in the diversity of three relatively mature Monte Carlo codes: the KENO/SCALE codes at ORNL, the MCNP code at LANL and the VIM code at ANL. The KENO codes, which employ the fast but approximate energy multigroup approximation, have been in production use for criticality safety analyses for over three decades. The more general neutral particle transport codes, MCNP and VIM, employ the more rigorous continuous-energy representation in a direct physics analog of the neutron-nucleus interactions and particle kinematics. For both production analysis and benchmarking applications, the fully independent solution algorithms, including the processing of cross sections, utilized by these three code systems provide a redundant, corroborative capability free of common mode failure.

The need or justification for this independent, redundant, corroborative capability is best illustrated by a recent benchmark activity involving the application of the three Monte Carlo codes: KENO, MCNP and VIM. Specifically, ANL submitted the U-Fe benchmark solution to the ICSBEP (see Section 4.0), which showed discrepancies in k-effective of greater than 10% in some cases. From the analyses, the ICSBEP personnel and individuals responsible for analytical methods at ORNL were able to identify the problem (i.e., cross-section processing) and quickly perform the necessary corrective actions. Moreover, this redundant capability is required when experimental data are lacking and it is necessary to extend the analytical bias beyond the range of experimental conditions over which the bias has been established. As recommended in Section 4.3.2 of ANSI/ANS- 8.1[8]: *"where the extension is large, the method should be supplemented by other calculational methods to provide a better estimate of the bias, and especially of its uncertainty in the extended area (or areas), and to demonstrate consistency of computed results."*

6.2 Departmental Requirements

In addition to the regulatory requirements described in Section 1.3, Departmental programmatic requirements arise from the large quantity and wide variety of fissile material operations being conducted or in the planning stage. The overall scope of these requirements is illustrated by the fissile inventory, which includes:

- hundreds of tons of highly enriched uranium (HEU) and weapons grade plutonium;
- over 100,000 commercial reactor fuel assemblies;
- thousands of naval, production, research, demonstration and test reactor assemblies;

- hundreds of thousands of drums containing fissile waste;
- hundreds of millions of gallons of fissile waste in tank storage.

The handling, processing, storage and ultimate disposition of this material quite often involve situations lacking satisfactory validation and qualification of analytical methods and data. Deficiencies in experimental benchmarks and nuclear data are being addressed by other tasks of the NCSP (see Sections 4 and 5). The majority of the work under the Analytical Methods task is the maintenance of the capability or infrastructure needed to develop and refine calculational methods. However, certain parts of the needed improvements will also improve the qualification of these methods for new applications, thereby reducing risks and operating costs. Demonstrated analytical precision is highest for design conditions involving reactor fuel and weapons components. However, the vast majority of new DOE applications involve material conditioning and long-term storage in geologic media. Improvement and qualification of the analytical methods and data will substantially enhance DOE efforts in meeting both its procedural and programmatic requirements for these new missions.

6.3 Program Objectives

The primary objective of the Analytical Methods task is to provide independent, redundant capability for corroborative analyses in production and benchmarking applications, and to maintain the capability within the DOE to do such work. Therefore, during the first three years of this program, priority has been given to infrastructure considerations, such as capability maintenance, plus training and user assistance. Capability maintenance has been budgeted at 0.9 full-time equivalents (FTEs) under Subtasks 1, 2 and 3. With recognition of the limited number of VIM users, the training and user assistance activity has been budgeted at 0.8 FTEs for Subtasks 1 and 2, and 0.1 FTEs for Subtask 3. Beginning in FY 1999, RSICC is being funded to perform Subtask 4. Substantial progress has been made in all subtasks, and given the prospect for continuing stable funding, DOE is meeting the primary objective of this task.

The secondary objective of this task is to upgrade the software to make improvements needed to overcome known deficiencies in handling certain types of applications. Generally, these applications fall in the intermediate energy range under partial neutron moderation and/or they involve loosely coupled fissile units with known problems in fission-source convergence. Experiments to qualify the methods for these applications include the ZEUS intermediate-energy critical experiments and the planned experiments that address large arrays of small units (see Section 3). For the KENO/SCALE software, the top-priority enhancements have been in the area of resolved-resonance shielding, utilizing modern ENDF/B-VI data and more rigorous transport models regarding geometry-material combinations. For the MCNP software, the top-priority enhancement has been the development and implementation of a problem-dependent unresolved-resonance shielding capability, utilizing the probability table method. At ANL, the top-priority enhancement has been an effort to address the fission-source convergence problem through stratified sampling. These work areas have been supported through multiple sponsors and by accommodating staff time out of the primary objective. Some progress has been made in all three areas. However, absent additional funding, progress in code enhancements will continue to be slow. (see Section 6.6).

6.4 Accomplishments

6.4.1 Subtask 1 – KENO/SCALE Work at ORNL

Capability maintenance included software upgrades for operation on modern computing platforms and under modern compilers. Also, software bugs were investigated and fixed.

Training and user assistance included two SCALE/KENO four-day workshops and one KENO-VI tutorial per year. Also, approximately 400 efforts per year were expended in providing advice regarding input specifications, geometry modeling and interpretation of results.

Administrative and technical support included progress reports, a Field Work Proposal and updates to the Five-Year Plan. Recently, substantial ORNL effort was expended in presenting the benefits of the NCSP to DOE/ORO/EM Management. As part of the DOE/EH-sponsored work funded under this task, ORNL staff assist in organizing the Annual NCTSP Workshop, including chairing sessions and conducting surveys. Also, ORNL Staff participated in the development of professional consensus standards (national and international) and represented the United States in OECD-NEA criticality safety activities.

6.4.2 Subtask 2 – LANL Work on the MCNP Code and Associated Software

Capability maintenance included assurance of MCNP compatibility with new computer hardware, operating systems, graphics libraries, and parallelization libraries (PVM, MPI), user support, investigation of bug claims, bug fixes, software quality assurance, and documentation. A criticality verification test suite of analytic transport solutions was compiled and documented.

Training and user assistance included four MCNP four-day courses and approximately 400 efforts per year in providing advice regarding input specifications, geometry modeling and interpretation of results.

Management support included LANL staff participating in the NCSP planning meetings and program reviews.

6.4.3 Subtask 3 – ANL Work on the VIM Code and Associated Software

As part of capability maintenance, beginning in FY 1997 the VIM Code was made available to the criticality safety community and a User's Manual was developed. The VIM Code is available from RSICC.

Training and user assistance included a presentation on VIM capabilities at the September 1997 Criticality Safety Topical Meeting. VIM is being applied as one of the benchmarking codes in the ICSBEP. VIM user assistance involves providing advice regarding input specifications, geometry modeling and interpretation of results.

Progress has been made in the application of stratified sampling techniques for treating the fission source convergence problem. A comparison with the superhistory powering technique has been performed, and specifications for two benchmark convergence problems are being developed.

Management support included ANL staff participating in NCSP planning meetings and program reviews and representation of the United States in OECD-NEA criticality safety activities.

6.4.4 Subtask 4 – Collection, Packaging and Dissemination of Software by RSICC

During the first two years of the NCSP, the RSICC packaged SCALE 4.4 containing KENO-V.a and KENO-VI, the prototypic software MCNP4XS (restricted to a limited distribution), and a production version of VIM. RSICC co-sponsored a series of code workshops and distributed numerous copies of criticality safety codes as a direct result of the workshops. Table 6-1 lists the recent workshops, number of attendees and number of code packages distributed following the workshops.

Table 6-1. Recent RSICC Co-Sponsored Workshops

Name of Workshop	Date of Workshop	Number of Attendees	Number of Codes Distributed
LANL MCNP	March 10-13, 1998	13	
DORT TRANSPORT	April 24-25, 1998	27	26
SCALE KENO-VI	April 27-30, 1998	17	
JAPAN MCNP	May 11-15, 1998	18	
LANL MCNP	June 2-5, 1998	22	22
LANL MCNP	August 10-14, 1998	22	
ORNL MCNP	September 21-25, 1998	22	
ORNL SCALE	October 27-30, 1998	21	
ORNL SCALE	November 5-8, 1998	17	
DOE MCNP	March 15-19, 1999	15	
MCNP	March 23-26, 1999	5	
MCNP VISED	March 15-18, 1999	15	
	Total	230	48

6.5 Budget And Schedule

The following table is a summary of FY 2000 through FY 2002 activities and minimum budget requirements for the Analytical Methods task of the NCSP.

Table 6-2. Schedule and Budget for the Analytical Methods Task of the NCSP			
Tasks by Laboratory	Deliverables and Budget*		
	FY 2000 ($k)	FY 2001 ($k)	FY 2002 ($k)
Oak Ridge National Laboratory Subtask 1 KENO/SCALE software - capability maintenance, training and user assistance, administrative and technical support Needed improvements – documentation and release of SCALE/CENTRM sequence; compatibility of KENO3D graphics with KENO-VI geometry; determination and utilization of material region and zone volumes in KENO.	426 (continuing)	426 (continuing)	426 (continuing)
Subtask 4 RSICC collection, packaging and dissemination of criticality safety software (codes and cross-section libraries)	200 (continuing)	200 (continuing)	200 (continuing)
Los Alamos National Laboratory Subtask-2 MCNP and associated software – capability maintenance, training and user assistance, management support Needed improvements – JUSTINE graphics and input processing including repeated structures, CAD.	384 (continuing)	384 (continuing)	384 (continuing)
Argonne National Laboratory Subtask-3 VIM and associated software – capability maintenance, training and user assistance, management support Needed improvements – completion of stratified sampling, graphics and GUIs for VIM	293 (continuing)	293 (continuing)	293 (continuing)
Task Total:	1303	1303	1303
* Budget amounts listed in constant FY 1997 dollars.			

The total estimated funding requirements for the years FY 2003 and FY 2004 are given in Table 6-3.

Table 6-3. Estimated Out-Year Funding* for the Analytical Methods Task of the NCSP	
Year	Budget ($k)
2003	1303
2004	1303
*Budget amounts listed in constant FY 1997 dollars.	

6.6 Extended Work Opportunities

The qualification of analytical methods and data for new DOE applications will require a higher level of activity in this task. As new nuclear data and critical experimental benchmarks become available, additional activities will include the generation of new cross-section libraries, more extensive validation against experiments and studies to develop an improved understanding of the basic physics which are encoded within the methods.

The timetable for integrating the new nuclear data, experimental benchmarks and sensitivity and uncertainty capabilities from the AROBCAD task into an overall qualification of analytical methods and data for DOE applications has a target of FY 2008 for full capability. In addition to the extensive validation exercises utilizing the new cross section libraries and benchmark critical experiments, the results of the sensitivity and uncertainty work under the AROBCAD task will indicate where better transport modeling of the neutron kinematics is needed. To support these improvements, a graduated increase in the Analytical Methods task effort from approximately two FTEs to four FTEs per site will be required.

In addition to the needed improvements shown in Table 6-2, high-priority work at the three sites includes: 1) ORNL - development of an ENDF/B-VI based criticality safety multigroup library including utilization in the ICSBEP Task, spectral indicies consistent with ICSBEP; 2) LANL - fission source and macro-body specifications, delayed neutron physics, spectral indicies consistent with ICSBEP, automatic geometry testing and enhanced user warnings; and 3) ANL - VIM fuel cycle analysis including energy and temperature interpolation of data, enhanced statistical testing and spectral indicies consistent with ICSBEP.

Potential out year improvements in analytical methods at ORNL include perturbation capabilities with KENO-VI, an energy point-wise version of KENO, and extension of the flexible-geometry NEWT discrete-ordinates transport software from two- to three-dimensional geometries. Similar work has been proposed for the deterministic software at LANL, one task being the utilization of first-collision source ray-tracing with DANT for treating arrays of fissile units. Another long-standing proposal by LANL is the development of a suite of statistically determined parameters to characterize benchmark criticals relative to fissile applications. Proposed work at ANL includes the generation of problem-dependent cross section libraries with VIM and the optimization of the VIM algorithms for operation on massively parallel computer architectures.
Activity in subsequent years will include software capability maintenance, training and user assistance.

6.7 Points of Contact

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7.0 Applicable Ranges of Bounding Curves and Data

7.1 Introduction

The objectives of the AROBCAD project are to couple the DOE NCSP Critical Experiments, Benchmarking, Nuclear Data, Training and Information Dissemination tasks with standardized, "user friendly" analytical methods to permit the user and regulatory overseer to more objectively and technically justify margins of nuclear subcriticality for safety as well as the adequacy of benchmark critical experiments.

The AROBCAD task of the DOE NCSP provides ". . . a program to interpolate and extrapolate such existing calculations and data as a function of physical circumstances that may be encountered in the future, so that useful guidance and bounding curves will result"[10] as committed in the DOE Implementation Plan for the DNFSB Recommendation 97-2.[3] More particularly and primarily, the AROBCAD task provides a program to comply with the regulatory implementation[6, 7] of national consensus standards, specifically ANSI/ANS-8.1.[8]

The AROBCAD task provides for the development and implementation of mathematically sound sensitivity and uncertainty (S/U) analysis methods (i.e., first-order linear perturbation theory) and automated optimization methods to nuclear criticality calculations of benchmarks and safety-analysis applications. Both the S/U and optimization methods are to be developed, interfaced and refined within the SCALE[11] suite of codes.

The AROBCAD task has five technical subtasks that are identified to develop and demonstrate the terminal products, to include training, for the end user community, plus one administrative subtask. The subtasks are:

- Subtask 1 – implement use of optimization techniques for establishing bounding values;
- Subtask 2 – investigate anomaly and discrepancy effects relative to bounding values;
- Subtask 3 – investigate and apply quantitative methods for identifying experimental needs;
- Subtask 4 – develop guidance for interpolating and extrapolating bounding values;
- Subtask 5 – develop guidance for establishing bounding margins of subcriticality; and
- Subtask 6 – planning, administration, and reporting.

Subtasks 1 through 5 evolve through the development and demonstration stages of the AROBCAD program to the final documentation and distribution of the software and technology to the United States DOE user community.

The S/U methods application will allow evaluation of the validity and ranges of applicability when determining interpolated and extrapolated bounding curves or data for nuclear criticality safety. The S/U methods provide a theoretically rigorous methodology for evaluating the applicability and influence of materials and geometries impacting computational bias, bias trends, bias uncertainties, subcritical limits, and consistency with measurements for safety analysis applications. Conversely, the same S/U methods can provide a rigorous methodology to justify or deny the need for critical experiments as they could relate to nuclear criticality safety applications.

The optimization methods are to be used in the determination of bounding curves and data for the purpose of determining maxima or minima of nuclear material parameters. Specifically, the initial optimization methods to be pursued are material density and concentration oriented (in contrast with linear-dimension optimization). The method will provide four separate computational options for outputs and plots of:

- equal volume replacement effectiveness functions of all the constituent in a given zone relative to the first constituent in that zone;
- equal cost (weight) replacement effectiveness functions of all the constituents in a given zone relative to the first constituent in that zone;
- maximization of k_{eff} for a given fissile material mass; and
- minimization of fissile material mass for a given k_{eff}.

The optimization methods have been applied to nuclear and radiation-shielding analytical methods, but prior and recent applications[12] have not provided for appropriate flux-weighted group cross section processing during the optimization processing nor have the methods been "user friendly" for common usage.

The developing and terminal products of the AROBCAD project provide some of the necessary capability (i.e., analytical infrastructure for theoretically and technically defining and defending the applicability of bounding curves and data) to assure and defend that adequate margins of subcriticality are applied for nuclear criticality safety in DOE non-reactor facilities and fissile material operations.

The products of the AROBCAD task interrelate to various DOE NCSP tasks as follows.

- Critical Experiments – The S/U and optimization software developments of AROBCAD will be useful for identifying needed critical experiments for nuclear criticality safety applications.
- Benchmarking – The S/U software developments of AROBCAD will be useful for comparative analysis with quoted experimental or measurement uncertainties. Such comparisons will assist in the verification of the AROBCAD methods as well as the evaluations of the benchmarks.
- Analytical Methods – As the S/U and optimization software matures and is documented it will be transferred to the Analytical Methods task for maintenance and issuance to the user community.
- Nuclear Data – As applied in the AROBCAD task, the S/U and optimization software products will interrelate with the Nuclear Data task as appropriate as discrepancies between computed results and experimental measurements are observed and reported to the Nuclear Data task for consideration and disposition.
- Training and Qualification – Throughout the development and final documentation of the AROBCAD software products, technical papers and reports will be provided to the potential user community for familiarization and training with the technology. Upon the transfer of the documentation to the Analytical Methods task, user training courses will be developed and offered through the Training and Qualification task of the NCSP.

- Information Preservation and Dissemination – There will be limited interaction between the AROBCAD task and the Information Preservation and Dissemination (IPD) task of the NCSP. As the products of the AROBCAD project mature, it is expected that the documentation of the products will become available or referenced by the IPD task.

The AROBCAD project will be managed by ORNL. It will continue, with appropriately approved adjustments/revisions, as described in the seminal technical program plan[13] that was reviewed by the DOE CSSG and approved by the DOE NCSPMT.

7.2 Departmental Requirements

The development and application of the AROBCAD project is a crucial task for the global requirements of the NCSP as given in Section 1.3. That is, development of the AROBCAD methodologies is an integral component of the technical infrastructure of the DOE criticality safety program.

In addition, the sensitivity and uncertainty techniques of the AROBCAD task of the NCSP will help provide the methods to permit justifiable applications of well or poorly benchmarked computations for safety applications such as

- environmental or non reactor nuclear facility remediation,
- waste disposal, and
- fissile material dispositioning programs

that involve fissile materials and commingled disposition or waste matrixes that are uncommon to the historic pursuits of the DOE and its predecessor organizations (i.e, weapons production facilities and designs, reactor concepts and designs), including the potential inadequate justifications for past waste disposal activities. The optimization methods provide for the development of a sound methodology for determining bounding curves and data with more than historic macroscopic evaluations with coarse perturbation analyses.

Both products of the AROBCAD, the S/U and optimization methods, provide the opportunity for improved operational efficiency and improved safety bases for customer needs but also the potential basis for regulatory penalties resulting from historic inadequate safety analyses.

Examples of Departmental requirements that can be addressed by the AROBCAD project are the determination of computational biases and uncertainties for establishing the areas of applicability and the appropriate bounding margins of nuclear subcriticality, as required by national standards, for the safety of all operations involving fissile materials outside reactors (i.e., fissile material storage, processing, dispositioning, transportation, and handling).

7.3 Program Objectives

The objectives of the AROBCAD project are to couple the DOE NCSP Critical Experiments, Benchmarking, Nuclear Data, Training and IPD with standardized "user friendly" analytical

methods to permit the user and regulatory overseer to more objectively and technically justify margins of nuclear subcriticality for safety and the adequacy of benchmark critical experiments.

The AROBCAD project is to provide terminal products for independent user applications by FY 2005. Software product documentation, distribution, training and transfer to other tasks of the NCSP are to occur between FY 2006 and FY 2008. Prototypic demonstrations and applications of the AROBCAD methods will be provided throughout the developmental period of the project. The specific applications are directed at pertinent and current Departmental needs. Examples include assessments for the benchmarking applicability to the Hanford K-Basin waste transfer to storage tanks and the National Spent Fuel Disposition projects. Other Departmental objectives such as plutonium dispositioning and waste solidification and vitrification may be evaluated during the period of development. Of particular interest will be the use of benchmark criticality experiments and newly determined or developed nuclear data evaluations and associated covariance data. The S/U analytical method will be employed to examine and extrapolate critical experiment data along with other available benchmarks into areas which are applicable to program operations being analyzed. Examples include the range-of-applicability of $U(90)/SiO_2$ and Pu/SiO_2 criticality benchmark experiments that are to be performed during the development period of AROBCAD. The optimization methodologies will be applied to examine the minima and maxima of systems. The priority of efforts will be highly influenced by recommendations about the programmatic safety needs of the DOE as interpreted by the DOE CSSG and NCSPMT. The use of the S/U and optimization methods after FY 2006 will be the responsibility of the intended users (i.e., contractor and DOE oversight safety personnel). Beyond FY 2006, however, scheduled and impromptu tutorials and user assistance are expected to be provided through the IPD, Training, Development and Qualification, and Analytical Methods tasks of the NCSP.

7.4 Accomplishments

The AROBCAD project has had seminal development through a recent United States NRC project[14] which has demonstrated applicability to a trial set of benchmark experiments. Though an objective of the United States NRC project was to examine the influence of slightly increased enrichments of uranium (i.e., ^{235}U enrichments upwards of 10 weight percent from the Advanced Vapor Laser Isotope Separation process), greater sensitivities and concerns were discovered for poorly moderated systems (e.g., hydrogen to ^{235}U ratios less than 15).

The project has not progressed long enough to apply and demonstrate the value of the optimization methods for determining bounding curves and data.

7.5 Budget and Schedule

Task completion and schedule is provided in the September1998, Revision 4, Technical Program Plan for AROBCAD. The near-term schedule is given in Table 7-1.

As previously discussed, budgets and deliverables beyond FY 2002 are focused on the final documentation, dissemination, demonstration/training applications, and transitioning to the other formal US DOE NCSP tasks. The total estimated funding requirements for the years FY 2003 and FY 2004 are given in Table 7-2.

Table 7-1. Schedule and Budget for the AROBCAD Task of the NCSP

	Deliverables (all delivery dates are 9/30 of cited FY)		
Task	FY 2000 ($k)	FY2001 ($k)	FY2002 ($k)
1) Implement use of optimization techniques for establishing bounding values	150	150	100
	Technical report on the expanded optimization theory, implementation approach, and prototypic testing.	Development of SCALE optimization sequence: a) documentation of sequence within SCALE; b) sequence pre-production version to requesting users; c) determination of minimum critical parameters for selected applications	a) Release of sequence to RSICC within SCALE-5 b)Technical report with guidance and illustrative applications. Include recommendations to use expanded optimization process for design of experiment/operation.
2) Investigate means to resolve or incorporate anomaly and discrepancy effects into bounding values.	200	205	205
	Technical report on investigation of neutron slowing down & leakage discrepancies in NIST experiments.	a) Technical report on S/U analysis of epithermal systems. b) Initiate study of loosely coupled uranyl nitrate units	Technical reports on S/U analysis of uranyl nitrate arrays and US vs. French experiment anomalies.
3) Investigate utilization of S/U and statistical methods for identifying experimental needs (i.e., critical or near critical and cross section)	150	100	100
	Initiate studies using application(s) of interest to DOE (e.g., Hanford Waste Tanks, and plutonium salts)	Technical reports discussing viability of approach and recommendations from applications.	Guidance report with demonstration using ^{233}U systems (or appropriate substitute).
4) Develop guidance for interpolating and extrapolating bounding values	90	100	150
	Technical report on parametric phase space appropriate for establishing bounding curves and data useful to the NCS community	Technical report demonstrating preparation and use of bounding curves and data using GLLSM approach.	Guidance report with examples pertinent to DOE applications.
5) Develop guidance for establishing bounding margins of subcriticality	65	100	100
	Report summarizing current approaches to characterizing acceptable margins of subcriticality.	Technical guidance on recommended statistical approach(es). Initiate investigation to combine S/U and statistical methods for defining bounding margins of subcriticality.	Technical guidance for incorporating S/U analyses with statistical approach to define bounding margins of subcriticality.
6) Planning, administration, and reporting	45	45	45
	Budgeting, scheduling, planning, quarterly progress reports, etc.	Budgeting, scheduling, planning, quarterly progress reports, etc.	Budgeting, scheduling, planning, quarterly progress reports, etc.
Total	700	700	700

Table 7-2. Estimated Out-Year Funding for the AROBCAD Task of the NCSP	
Year	Budget ($k)
2003	700
2004	700

7.6 Extended Work Opportunities

As NCSP circumstances and fiscal support present windows of extended work opportunities before the completion of the AROBCAD program, the program will seek to coordinate the products and enhancements of the S/U and optimization codes developments and applications with the other NCSP tasks. An example might include unforeseen generic input/output computer code refinements for the design and analysis of benchmark experiments, evaluations of experiments, and specialized applications to improve the areas of applicability to safety evaluations and the determination of bounding curves and data.

Currently, the AROBCAD program includes the necessary subtasks to bring the program to its conclusion by FY 2008. These subtasks are planned to exchange and supply useful information among other NCSP tasks so that the S/U and optimization code developments and documented demonstration applications occur in an organized fashion to benefit the other NCSP tasks. The merits of unforeseen potential opportunities will be assessed as they occur for consideration as adjuncts to the planned AROBCAD program.

7.7 Points of Contact

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8.0 Information Preservation and Dissemination

8.1 Introduction

The Information Preservation and Dissemination (IPD) task of the NCSP is a program to preserve primary documentation supporting criticality safety and to make this information available for the benefit of the technical community. This primary information includes not only experimentalists' logbooks, notes, drawings, photographs, and material descriptions from those sites at which critical experiments were conducted in the past but also company reports and internal memoranda which might be of benefit to future criticality safety engineers.

There are two major subtasks within the IPD task of the NCSP:

1) the Criticality Safety Information Resource Center (CSIRC), which is tasked with collecting and preserving the multitude of documents directly related to critical experiments and criticality safety; and

2) the NCSP World Wide Web Internet site, which is the central focal point for access to criticality safety information collected under the NCSP subtask, and the gateway to a comprehensive set of hyperlinks to others sites containing criticality safety information resources.

8.1.1 CSIRC

There is a threefold benefit of this preservation and dissemination effort: the uncovering of original experimental results which had not previously been reported; the sharing of information to minimize duplication (of experimental results and analytical evaluations) worldwide; and the training of new criticality safety engineers. Recently an effort was started to videotape some of the pioneers in the field to capture their thoughts and philosophies as to proper approaches to the practice of criticality safety.

CSIRC was formally funded for the first time in FY 1998 by the DOE as part of the integrated response to DNFSB Recommendation 97-2. Previously the program had been evolving and developing informally beginning in the mid-1980s with the sending of the logbooks from the former Brookhaven National Laboratory (BNL) Critical Mass Laboratory to the LANL Archives Center for preservation. There was a strong concern that these logbooks were vulnerable to misplacement or destruction at BNL and the realization that they might contain valuable, previously unreported, critical experiment descriptions and measurement results. In some instances even previously reported journal articles do not contain experiment descriptions in the detail desired for today's benchmark purposes and it has been proven to be practical to return to original logbooks and extract additional, valuable information,

After this initial collection was moved to LANL, the experimental logbooks and related records from the Rocky Flats and Hanford critical mass laboratories were sent to Los Alamos for preservation. As word of this co-location of logbooks spread, those in need of benchmark critical data, which was not available in published sources, began to come to Los Alamos to search for

such data. Clearly, if "mining of the stockpile" is successful in uncovering required data, this activity is likely to be much less expensive and faster than performing new critical experiments.

8.1.2 NCSP Web Site

By establishing the NCSP web site, DOE intends to use the latest technology for rapid dissemination of criticality safety information. The web site is designed to be the focal point for DOE criticality safety activities without duplicating the efforts of other organizations. It will do this by a series of verified hyperlinks to sites containing the source of criticality safety information, such as the CSIRC web site at LANL. The NCSP web site is maintained at LLNL and its content is coordinated by the CSSG.

8.2 Departmental Requirements

8.2.1 CSIRC

As regulatory scrutiny and expectations become ever more stringent and the cost of large safety margins (in lieu of more relevant benchmark data) becomes less tolerable, the value of "mining the stockpile" of past experiments becomes more cost-effective. Similarly, the awareness and use of past (reports of) analyses is much more important not only as a time saver, but also as an instructional tool for the newer engineer. While in the past most criticality safety engineers had the opportunity to spend time performing critical experiments, today's criticality safety practitioners must learn largely from the documentation of their predecessors. The videotapes of the pioneers should prove valuable in this training effort also.

8.2.2 NCSP Web Site

It is important to the DOE that criticality safety information and news be distributed to the widest possible audience as rapidly as possible. The development of the NCSP web site is the response to that need. With the development of user-friendly tools to access and search the Internet, a central web site to coordinate information at numerous DOE sites offers a great advantage in the dissemination of nuclear criticality safety information to a wide audience. The NCSP web site is designed to not duplicate the information held at other sites, but only to present the reader with a structured set of links to those sites. This avoids duplication and maintenance of superceded versions of documents, and leads the reader, whenever possible, to the original source of the information. By maintaining communications with the CSSG, the NCSP web site manager is able to post NCS-related news items in a timely manner.

8.3 Program Objectives

8.3.1 CSIRC

Efforts are underway in FY99 to scan all logbooks stored at Los Alamos and those which are still maintained by LLNL and ORNL. These approximately 100,000 pages will be loaded onto the LANL Criticality Safety web site and will be available for electronic review by researchers worldwide.

Concurrently, it is planned to load electronic versions of general interest documents such as LA-12808, The Nuclear Criticality Safety Guide, and the in-progress update of the Review of Criticality Accidents, along with their approximately 200 references onto the CSIRC web site during the next two fiscal years. Relatedly, the first attempt at putting reference material particular to a site, in this case the Y-12 Plant, on the web site has occurred during FY 1999. While full documents from Y-12 are not yet available, the titles of a vast store of documents are already there. This previously published, but often difficult to find, information promises to be of value to current and future engineers as they often must otherwise duplicate efforts already undertaken.

Lastly, the videotaping of pioneers in the fields of criticality safety and critical experiments, often one and the same person, is proceeding. These videotapes will be made available first as "hard copy" and, as technology permits, on the web site. Their recollections and reflections should be valuable teaching tools and serve as original sources for the practices and operational philosophies that were subsequently codified in the ANS-8 National Consensus Standards.

The logbook scanning and availability on the Los Alamos web site is only the first step in mining this stockpile of historical information. A very labor-intensive effort, and one, which requires criticality staff time, will be the review and indexing of this scanned information. When the information is initially scanned it is not keyword searchable, and therefore, not user friendly. A follow-on effort, having the original experimenters review documentation for unreported data, has been very successful to date, but only minimally attempted. Significant effort by those who have personal and past professional contact with these experimenters will be required in many cases to entice them to review these logbooks. This is a labor intensive effort which, like the indexing mentioned above, can best be performed by those already practicing criticality safety, a resource in short supply.

The scanning and making available of past published documents, company reports, and internal criticality safety evaluations on the web site will prove exceedingly valuable if this wealth of documents is searchable by keyword. It is not yet clear how large or time-consuming an effort this might be, but it is definitely worthwhile to pursue.

Either linking to foreign web sites that have information holdings similar to CSIRC or importing such information onto the CSIRC web site is expected to be of major benefit to the worldwide community. The extent of this effort is largely unknown. Certainly there are criticality pioneers from other countries, particularly Britain, France, and Russia, whose recollections and reflections would be valuable to preserve on videotape.

One more small, but very significant, information set is the classified holdings, particularly from the nuclear weapons related facilities. The various tasks involved with making this information usefully available are essentially the same as those already accomplished or described above for the current, unclassified CSIRC program with one additional step - assuring proper declassification of the material is accomplished.

8.3.2 NCSP Web Site

The NCSP web site is intended to become the main DOE NCS reference site by maintaining a hierarchical structure of links to information useful to the NCS community. Included on the web site are:

- links to all major NCS web sites including DOE Orders, NRC, ANS and national laboratories;
- general help for new criticality safety professionals;
- collections of bibliographic references and validation experiments;
- listings of criticality safety working group and management team members; and
- a question-and-answer message board for the NCS community.

A major activity of the web site subtask is to add to the technical content of the site, including the latest important technical bulletins, lessons learned and tools to aid new practitioners in the field of criticality safety. Maintenance of the site is an ongoing activity needed to keep information current and respond to the needs of the web site users.

8.4 Accomplishments

8.4.1 CSIRC

As noted above, logbooks from BNL, Rocky Flats and Hanford critical experiments laboratories, as well as those from LANL, have been collected at the LANL Archives Center for preservation and use by the criticality safety community. Logbooks from LLNL and ORNL are being preserved at their respective sites until indexing and scanning can be accomplished.

Reviews of logbooks from Rocky Flats and ORNL by original experimenters have resulted in the discovering, further documenting, and publishing of benchmark quality information. The material gleaned from the Rocky Flats logbooks in particular was of such high quality that it has already been peer reviewed and accepted by the ICSBEP. While difficult to quantify, the value of this information in an era of ever increasing costs for nuclear research, a lack of facilities in which to perform such, and tightening budgets, is enormous.

8.4.2 NCSP Web Site

The NCSP web site was built upon the earlier Nuclear Criticality Safety Center web site at LLNL, and is now operational at http://ncsc.llnl.gov:8080/. The master index is in place for simple navigation through the site, and a search capability was established to assist in using the on-line reference materials. Links to key DOE, NRC and other sites with criticality safety information have been added. Refinements and additional material continue to be added to the site.

8.5 Budget and Schedule

The pace of some of this work has significant urgency, while other parts may not. As the pioneers and original experimenters dwindle in numbers and the memories of those remaining fade, irrecoverable loss occurs. Thus, the allocation of funds to support the review of logbooks by

original experimenters, where practical, and the videotaping of pioneers recanting the historical evolution of what have become accepted practices and in many cases regulatory norms will be given priority. The DOE and the NRC are each providing funding to achieve CSIRC objectives. The planned funding levels shown in Table 8-1 for both the DOE and NRC represent a level sufficient to continue to achieve meaningful progress. Should the planned funding level not materialize, this program plan and associated milestones will be revised accordingly.

Table 8-1. Schedule and Budget for the Information Preservation and Dissemination Task of the NCSP

	Deliverables		
Task	FY 2000 ($k)	FY2001 ($k)	FY2002 ($k)
CSIRC	50 + (50)[1]	50 + (50)[1]	50
1) Locate, secure, scan, review, index and make available on the CSIRC Web site logbooks, notes drawings, photographs and material descriptions from those sites at which critical experiments were conducted including relevant company reports and internal memoranda. A) Scan material to create electronic versions: B) Review and index scanned material to allow word search capability.	A) Scan logbooks located at LLNL (12/99) and LANL (9/00). Scan other documents at LANL, ORNL and LLNL (ongoing). B) Review and index logbooks located at LLNL and LANL (9/00). Review and index other documents at LANL, ORNL and LLNL (ongoing).	A) Scan other documents at LANL, ORNL and LLNL (ongoing). B) Review and index logbooks located at ORNL (9/01). Review and index other documents at LANL, ORNL and LLNL (ongoing).	A) Scan other documents at LANL, ORNL and LLNL (ongoing). B) Review and index other documents at LANL, ORNL and LLNL (ongoing).
2) Interview and videotape criticality safety pioneers and preserve this information for future use and benefit. Index videotapes to allow key word search capability. Make this information available on the CSIRC web site.	Interview and videotape criticality safety pioneers at LANL (ongoing)	Interview and videotape criticality safety pioneers at LANL (ongoing)	Begin to load videotapes on the CSIRC web site (ongoing).

3) Scan and place key reference documents on the CSIRC web site and make this information available on CD-ROMs. Place videotapes of pioneers on the CSIRC web site, technology permitting.(all LANL)	Scan and load LA-12808 and all 147 references in the document on the CSIRC web sire with search capability (3/00) Make LA-12808 and all 147 references in the document available on request on CD with search capability (6/00)	Load the updated Criticality Accident Report on the CSIRC web site (12/00) Scan and load all references to the updated Criticality Accident Report on the CSIRC web site (3/01) Make videotapes of the pioneers in nuclear criticality safety available on the CSIRC web site, technology permitting (9/01)	Continue indexing and loading information on the CSIRC web site (ongoing)
4) Coordinate the progress and information from the above tasks with the Benchmark program for the purpose of updating Benchmarked data. (LANL & INEEL)	Coordinate data with ICSBEP (ongoing)	Coordinate data with ICSBEP (ongoing)	Coordinate data with ICSBEP (ongoing)
NCSP Web Site	60	60	60
1) Maintain and update the NCSP web site as needed and provide status reports.	1. Update data on site: CSSG and NCSPMT announcements and meeting notes; NCS news items and information; remove obsolete items, etc. (ongoing)	1. Update data on site: CSSG and NCSPMT announcements and meeting notes; NCS news items and information; remove obsolete items, etc.	1. Update data on site: CSSG and NCSPMT announcements and meeting notes; NCS news items and information; remove obsolete items, etc.
2) System maintenance	1. Data backup , system maintenance, etc. (ongoing) 2. Message board maintenance and response to user problems (ongoing) 3. Task management reports: quarterly, monthly and conferences (ongoing)	1. Data backup , system maintenance, etc. (ongoing) 2. Message board maintenance and response to user problems (ongoing) 3. Task management reports: quarterly, monthly and conferences (ongoing)	1. Data backup , system maintenance, etc. (ongoing) 2. Message board maintenance and response to user problems (ongoing) 3. Task management reports: quarterly, monthly and conferences (ongoing)
DOE Total:	110	110	110
(1) Additional NRC funding in parentheses.			

Similar tasks will continue during the years 2003 and 2004. The total estimated funding requirements for the years FY 2003 and FY 2004 are given in Table 8-2.

Table 8-2. Estimated Out-Year Funding for the Information Preservation and Dissemination Task of the NCSP		
	Budget ($k)	
Project	FY 2003	FY 2004
CSIRC	50	50
NCSP Web Site	60	60
Total	110	110

8.6 Points of Contact

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9.0 Training and Qualification

9.1 Introduction

The Training, Development and Qualification (TDQ) activities of the NCSP were developed in response to the statement by the DNFSB in Subrecommendation 6 of Recommendation 97-2[1], that the proposed new hands-on course at Los Alamos National Laboratory should "serve as the foundation for a program of formal qualification of criticality engineers."

Well-trained criticality safety personnel form the key to maintaining the high standard of quality that must be applied to every aspect of the NCSP. The TDQ task is therefore an integral component of the criticality safety infrastructure of the DOE and affects every other task of the NCSP by providing the guidance and resources necessary to maintain the training and qualification of the specialists performing work in the other tasks of the Program. The TDQ task has three subtasks:

1) Continue to offer hands-on training courses at LANL, including the new five-day course, as needed by DOE;
2) Identify training needs, and the resources to meet those needs, developing new resources in areas where no suitable materials exist; and
3) Develop standard qualification programs for both federal and contractor criticality safety personnel.

The goal of the TDQ task can be summarized by the first of three action statements in the Executive Summary of the DOE Implementation Plan[3] for DNFSB Recommendation 97-2.

> Improve the technical knowledge of criticality safety personnel. This will be accomplished by updating and improving the training offered at DOE's critical experiments facility, improving site training and qualifications programs by identifying and incorporating best practices, and by identifying exceptional criticality safety curricula offered at institutions outside the Department.

While most criticality safety staff members have a background in nuclear engineering, nuclear physics or a related field, NCS staff must also understand the fissile material processes, human factors, and anticipated process upsets to develop proper criticality safety controls. This knowledge is not gained by university training. The Department has developed a new course and identified existing specialized courses that present hands-on, real-world applications of criticality safety principles.

The benefits to the DOE from having comprehensive criticality safety programs with well-trained staff members should be obvious. Among the benefits will be an immediate increase in the efficiency of operations involving fissile materials. When doing evaluations to support the handling, storage and transportation of fissile materials, a well-trained staff will know the proper analysis techniques to use for a given situation. By learning that a thorough understanding of operations is necessary, and how to properly interface with the operations staff, criticality safety evaluations of those operations can support efficiency as well as safety. Above all, the proper

training will instill the correct philosophy of criticality safety that will allow the practitioner to know what factors are important to criticality safety and how to develop the proper controls without being overly conservative to the point of restricting operations with no added safety benefits. Regulatory requirements can then be met in a way that minimize the impact on operations.

9.2 Departmental Requirements

In addition to the requirements of DOE Orders and Standards discussed in Section 1, it is essential that DOE operations be conducted by personnel who are competent and skilled in the application of their knowledge to both the analytical and operational aspects of nuclear criticality safety. One method to achieve this goal is through training and periodic retraining of criticality safety personnel, and formal verification of this training through the establishment of a rigorous qualification program.

As experienced criticality safety practitioners leave the field, there are fewer opportunities for entry-level staff to participate in long-term mentor programs to gain first-hand knowledge of practical criticality safety. However, the DOE must still provide an infrastructure wherein criticality safety staff members are able to gain and maintain a level of training commensurate with the responsibilities of their positions. The TDQ subtasks of the NCSP address this requirement by:

1) providing hands-on training courses where students actively participate in approach-to-critical experiments and see first-hand the effects of material interactions on the reactivity of various configurations;

2) identifying training resources, promoting the development of new training materials to supplement existing curricula and working with other organizations to quickly respond to training needs as new programs apply criticality safety to areas requiring new information; and

3) developing and implementing a uniform criticality safety qualification program for criticality safety staff throughout the DOE complex.

9.3 Program Objectives

The basic objective of the TDQ task of the NCSP is to provide criticality safety practitioners with the guidance, and to the extent possible, the tools to become properly trained in the wide variety of subjects that comprise the field of criticality safety.

One subtask of the TDQ task is to provide hands-on courses at LANL for both managers and practitioners. As noted in Section 9.1, a second five-day course was developed under the NCSP and will be fielded in FY-2000. The original five-day course and the three-day course will continue to be offered.

The TDQ task included an initial survey of training needs as perceived by criticality safety organizations and practitioners, then to match those needs, if possible, to existing training courses at DOE facilities, universities and colleges. In those areas where training does not exist, a program was to be initiated to develop materials to meet those needs. In a parallel effort, the identified training areas were used to develop the DOE criticality safety qualification standard, which will be used to implement qualification programs at DOE sites.

Reviews of training needs and site qualification programs shall be performed annually in order to respond to the changing needs of the criticality safety community. These reviews will gather information and feedback from the CSCT, which has members from each of the DOE field offices, and the Criticality Safety End-Users Group, which has representatives from the majority of the DOE contractor facilities. The review of site qualification programs is expected to be an ongoing process of interaction with the site criticality safety and training organizations in order to help establish and maintain uniform qualification programs across the DOE complex.

Each year identified training needs will be cross-referenced to available resources and the results of the work will be made available to the user community. It is expected that not all training needs will be covered by existing resources, so another part of the TDQ Program is to arrange for the development of training materials in those areas where either none exist or exist only in a location or format suitable for use by a small number of people. This development program has already begun, and will be routinely reviewed as the work is being done. One goal of the development program is to produce modular tools that can be used by site training organizations or by individuals for self-study programs as part of the site qualification program.

An annual review of the need for new training materials will be conducted and correlated to the training needs identified by the CSCT and the CSSG. The results will be used to develop a list of required new training materials. The same resources will be relied upon to determine the suitability of the DOE qualification program standard. Responses will be compiled and reviewed by the CSSG who will forward prioritized recommendations for TDQ task activities to the NCSPMT.

9.4 Accomplishments

Under the NCSP, a new five-day, hands-on training course has been developed. This course is complementary to the original five-day course and together they present the criticality safety practitioner with a good overview of proper handling of fissile material through a series of actual experiments, plus on-site reviews and discussions of several active fissile-material operations.

The CSSG has completed the initial survey of nuclear criticality safety training needs and available courses[15] based on a job task analysis of the general criticality safety staff member. This activity identified a lack of training resources in a number of areas, including neutronics, hand calculations and verification and validation. While some of these topics are available in a diffuse format in university courses, it was decided to pursue the development of training modules that could be distributed to the criticality safety community for use in on-site training classes.

The first set of modules in the Nuclear Criticality Safety Engineer Training (NCSET) program have been written and are being placed on the NCSP web site as they are completed. These modules include introductory neutronics (fission, neutron interactions, chain reactions, scattering and thermalization), criticality limits, transport and diffusion theory and Monte Carlo methods. Additional modules have been outlined to cover the topics of hand calculations and verification and validation, and will be developed within the year.

Development of these modules is seen as the first step in creating a training program that will supplement the courses available from DOE or university sources and become the basis for training by on-site organizations. This program will provide consistency across the DOE complex, allow training without the expense of travel and extended absence from work, and will interface with both the DOE and contractor qualification programs that are being developed in parallel with the training modules.

A criticality safety qualification standard[16] for federal criticality safety personnel was developed and reviewed by the CSSG. This standard is currently in the formal DOE review process. A draft of the guidance for contractor criticality safety qualification programs[17] has been written and is currently undergoing a broad-based user review before being issued as a formal DOE directive.

9.5 Budget and Schedule

Table 9-1 presents the budget and schedule for the TDQ task of the NCSP. It is assumed that six three-day courses and one each of the two five-day courses will be offered each year at the Los Alamos Critical Experiments Facility. Demand has been such that this schedule is expected to be adequate for the foreseeable future.

Table 9-1. Schedule and Budget for the Training Development and Qualification Task of the NCSP			
	Budget and Deliverables		
Task	FY 2000 ($k)	FY2001 ($k)	FY2002 ($k)
1) Continue to offer hands-on training courses at LANL, including the new five-day course, as needed by DOE.	200[1]	200[1]	200[1]
	1. Conduct six three-day hands-on courses (ongoing) 2. Conduct two five-day hands-on courses (one of each type) (ongoing) 3. Review the results and update the LACEF training program as necessary (9/00) 4. Provide progress reports to the CSSG and NCSPMT (quarterly)	1. Conduct six three-day hands-on courses (ongoing) 2. Conduct two five-day hands-on courses (one of each type) (ongoing) 3. Review the results and update the LACEF training program as necessary (9/01) 4. Provide progress reports to the CSSG and NCSPMT (quarterly)	1. Conduct six three-day hands-on courses (ongoing) 2. Conduct two five-day hands-on courses (one of each type) (ongoing) 3. Review the results and update the LACEF training program as necessary (9/02) 4. Provide progress reports to the CSSG and NCSPMT (quarterly)
2) Identify training needs and resources; develop new resources in areas where no suitable materials exist.	47[2]	47[2]	47[2]
	1. Perform an annual review and assessment of criticality safety training needs within the DOE complex (9/00) 2. Develop new training materials in response to the training needs assessment (9/00) 3. Coordinate development of new training materials and perform annual review and assessment of those materials (9/00)[3]	1. Perform an annual review and assessment of criticality safety training needs within the DOE complex (9/01) 2. Develop new training materials in response to the training needs assessment (9/01) 3. Coordinate development of new training materials and perform annual review and assessment of those materials (9/01)[3]	1. Perform an annual review and assessment of criticality safety training needs within the DOE complex (9/02) 2. Develop new training materials in response to the training needs assessment (9/02) 3. Coordinate development of new training materials and perform annual review and assessment of those materials (9/02)[3]
3) Develop and promulgate standard qualification programs for both federal and contractor criticality safety personnel.	3	3	3
	1. Perform annual reviews and assessments of site criticality safety qualification programs (9/00)	1. Perform annual reviews and assessments of site criticality safety qualification programs (9/01)	1. Perform annual reviews and assessments of site criticality safety qualification programs (9/02)
Total	250	250	250

(1) Supplemented by $84k from tuition collection.
(2) Budget split is: $5k to perform the annual review and assessment of training needs; $35k to develop new training materials; $7k to coordinate development of the materials and perform an annual assessment of them.
(3) Quarterly progress reports to be provided in the first three quarters of each fiscal year plus an annual report in the fourth quarter of each fiscal year

Similar tasks will continue during the years 2003 and 2004. The total estimated funding requirements for the years FY 2003 and FY 2004 are given in Table 9-2.

Table 9-2. Estimated Out-Year Funding for the Training Development and Qualification Task of the NCSP

	Budget ($k)	
Project	FY 2003	FY 2004
Hands-on Training	200	200
Training and qualification assessments, resource evaluation and development	50	50
Total	250	250

9.6 Points of Contact

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10.0 Example of Integrated NCSP Support for Departmental Programs

10.1 K Basin Sludge Removal Support

The NCSPMT was asked by EM to provide support to its Tank Waste Remediation System (TWRS) licensing for K Basin sludge processing at Hanford. Initial NCSP plans called for iron/plutonium benchmark experiments at Los Alamos, and evaluation and publication of the benchmark data in time to support TWRS licensing. However, in early May 1999, DOE decided that the K Basin sludge would be packaged and transported to the T-Plant for interim storage. The waste would then be combined with the M-91 waste streams for final treatment and disposal. This decision eliminated the need for iron/plutonium benchmark data. Even though the TWRS program no longer requires these data, iron/plutonium and iron/uranium benchmark experiments will remain on the priority experiments list because of the long-standing discrepancy between calculations and experimental data for these fissile systems and the number of DOE programs which could benefit from this work.

10.2 National Spent Nuclear Fuel Program Support

Fissile material in waste is frequently encountered in decontamination and decommissioning efforts, process sludge and settling tanks, in situ vitrification, and waste remediation efforts (including waste storage, retrieval, characterization, volume reduction, and stabilization). Presently, there are several sites in the United States in which fissile material has already migrated into a soil environment while others have the potential for such migration. The national geological repository at Yucca Mountain, Nevada is one example in which the gradual degradation of spent nuclear fuel and containment may eventually result in the migration of fissile material into the soil. The safety envelope for many fissile-bearing waste operations can be effectively defined by characterizing the waste matrices by major "non-neutron-absorbing" components. By neglecting impurities, the inclusion of which almost always results in a decrease in nuclear reactivity, conservative representations of waste matrices can be obtained. Silicon dioxide (SiO_2) is one of the more predominant and more reactive waste matrix materials that is encountered in typical dilute fissile contaminated waste systems, including Nevada tuft.

Even though criticality scenarios in most waste systems can be shown to be highly unlikely or incredible, it is always necessary to establish at what fissile material concentration criticality becomes a concern. Only when this information is known, is it possible to establish the likelihood of actually achieving such concentrations. It is therefore important that criticality safety analysts have confidence in the accuracy of their calculations. This confidence can only be gained through comparison of calculated results with experimental data. There are little or no experimental data available for most typically encountered waste matrix materials, including SiO_2.

Over the past three years the National Spent Nuclear Fuel Program, with the support of the INEEL Criticality Safety Organization and elements of the DOE NCSP has identified specific criticality safety issues associated with the proposed national geologic repository and have taken action to address these issues. Two of the issues identified by these organizations are:

(1) There are no critical experiments which have silicon dioxide as a principle constituent (similar to bounding soil conditions). Historical practice and experienced judgement indicate such experiments are highly desirable for validation of calculational methods and data used in support of the national geological repository at Yucca Mountain.

(1) The neutron absorber, gadolinium, is currently being considered for use inside some storage canisters to ensure the safety of those canisters. Additional data may be required to validate calculations associated with the use of gadolinium.

Actions taken to respond to these issues follow.

Critical Experiments And Benchmarking

Through DOE NCSP efforts, benchmarking facilities at the IPPE in the Russian Federation and at the LACEF were identified as facilities that could supply the SiO_2 data. Russia can provide silicon dioxide data with spectral characteristics that range from about 75% intermediate to about 75% thermal. The Planet assembly at LACEF can provide data at the extreme thermal end of the spectrum. Additional confirmatory data can be provided by the Comet (Zeus) facility at LACEF. The Comet facility can also serve as a back-up in the event that political conditions interfere with the planned experiments in the Russian Federation. Data for all of these experiments will be evaluated and documented by the ICSBEP and will be made available to the criticality safety community for application to all waste systems involving fissile contaminated soil or glass. The IPPE highly enriched uranium experiments and the LACEF Planet experiments should be completed by the end of fiscal year 1999. Additional plutonium data will be generated at IPPE early next fiscal year.

With regard to the potential need for gadolinium data, there are likely to be sufficient thermal homogeneous gadolinium data already available in the "International Handbook of Evaluated Criticality Safety Benchmark Experiments". However, if the use of thin sheets of gadolinium or a plasma spray coating containing gadolinium is selected as a means of ensuring adequate criticality safety margins, additional experimentation may be necessary. In this event, the Planet facility at LACEF could provide these experimental data using thin foils of highly enriched uranium and foils of gadolinium and sheets of polyethylene. In the unlikely event that data for heterogeneous SiO_2, gadolinium, polyethylene and uranium systems are required, both the IPPE and LACEF facilities could be used to obtain these data.

Nuclear Data

In FY 1999, the Nuclear Data task of the NCSP will generate covariance data for the resolved resonance region for silicon isotopes and provide them to the AROBCAD task. Evaluated data for oxygen will also be completed and similar covariance files will be made available in FY 1999. The status of silicon capture cross-sections will also be assessed and, if needed, measurements can be made at ORELA in FY 2000.

In order to demonstrate its principles, AROBCAD is currently using an ENDF/B-V based multigroup library, which has been broadly validated for a wide variety of fissile material applications. Therefore, covariance data relative to ENDF/B-V evaluations are needed. (As soon as practical, AROBCAD will incorporate multigroup cross-section data and covariance files based on new evaluations provided by the Nuclear Data task.) In October 1998, the Nuclear Data task committed to providing, in a timely fashion, reasonable covariance data for use by the AROBCAD task in its initial development stage. ANL is leading the effort to assess and provide reasonable covariance data, with support from ORNL and LANL. The AROBCAD project has identified 19 materials (Note: 17 of these are already on the list of materials identified by criticality analysts for the Nuclear Data task) needed to address the needs associated with the disposition of spent nuclear fuel.

As part of the process, the Nuclear Data task organized and led a workshop in April 1999 to assess the status of covariance data in evaluated nuclear data files. An international group of about 30 experts attended and a number of needs and recommendations were discussed to remedy the current situation of poor quality and missing covariance data. One immediate outcome was the identification of a library of multigroup covariance data based on ENDF/B-V prepared in Europe (VITAMIN-J/COVA, with 175 neutron groups) that might be helpful in the preparation of "reasonable" covariance data for AROBCAD.

With regard to the potential need for gadolinium data, similar efforts to reevaluate the basic nuclear properties of gadolinium can be made if deficiencies in available data become evident.

Analytical Methods

The analytical methods (MCNP, SCALE/KENO, and VIM) supported by the NCSP are the tools used by the NSNFP for performing design studies and safety evaluations related to criticality safety. Staff from NSNFP have been provided technical support and training as needed relative to the use of the codes and data. The codes and data used by the analysts are made available via RSICC. RSICC also provided ANL with the VITAMIN-J/COVA multigroup covariance data to assist in developing initial covariance files for AROBCAD.

Applicable Ranges Of Bounding Curves And Data

Using input from the Nuclear Data and Analytical Methods tasks, AROBCAD methodology will be used to interpret the data obtained from the NSNFP benchmark experiments. The sensitivity of the experiments to the presence of SiO_2 will be evaluated and the range of applicability of the data will be established. The effects of the large copper reflector used in the LACEF experiments on the Comet assembly (Zeus) will also be assessed. As the AROBCAD methodology is developed further, it will provide a valuable tool that can be used to ensure that future experiments are designed to achieve the desired tests of materials and geometric properties.

Table 10-1 shows the planned schedule for NCSP activities to support the NSNFP.

Table 10-1. Schedule for NCSP Support to the NSNFP	
Activity	Completion Date
NSNFP -- Completion of the IPPE HEU / SiO_2 Experiments *(J. Blair Briggs)*	30 September 1999
NSNFP -- Review of available gadolinium data – Determination whether additional data are required to support the NSNFP, either available, but unevaluated data, new experimental data - *(J. Blair Briggs -- support provided by ISU)*	30 September 1999
AROBCAD -- draft report on the applicability of the IPPE & LACEF HEU / SiO_2 Experiment *(Calvin M. Hopper)*	30 September 1999
DATA -- New Capture Measurements for silicon at ORELA *(Robert W. Roussin)*	1 October 1999
DATA -- Provide covariance data for Si & O *(Robert W. Roussin)*	1 November 1999
NEW EXPERIMENTS --Design of HEU / Gd / CH_2 Experiments for LACEF Planet assembly *(J. Blair Briggs & Richard E. Anderson -- support provided by ISU)*	30 November 1999
ICSBEP -- Internally Reviewed Draft Evaluation of the IPPE HEU / SiO_2 Experiments *(J. Blair Briggs)*	30 November 1999
ICSBEP -- Independent Peer Review of the Draft Evaluation of the HEU / SiO_2 Experiments *(J. Blair Briggs)*	10 December 1999
AROBCAD -- draft report on the range of applicability of available gadolinium data and the additional data that can be provided by the LACEF gadolinium experiments on Planet *(Calvin M. Hopper)*	TBD
AROBCAD -- final report on the applicability of the IPPE & LACEF HEU / SiO_2 Experiments *(Calvin M. Hopper)*	31 January 2000
NCSP & NEW EXPERIMENTS -- Decision to perform HEU / Gd / CH_2 Experiment at LACEF *(NCSPMT)*	TBD
ICSBEP -- Completed HEU / SiO_2 Experiments Evaluation submitted to ICSBEP *(J. Blair Briggs)*	6 January 2000
AROBCAD -- final report on the range of applicability of available gadolinium data and the additional data that can be provided by the LACEF gadolinium experiments on Planet *(Calvin M. Hopper)*	TBD
DATA -- If it is determined that additional Gd data are need to support the NSNFP covariance data will be generated for Gd and, if needed, additional measurements will made at ORELA *(Robert W. Roussin)*	TBD

ICSBEP -- Working Group Review & Approval of IPPE HEU / SiO_2 Experiment Evaluation *(J. Blair Briggs)*	30 June 2000
ICSBEP – Internet Publication of the IPPE HEU / SiO_2 Exp. Evaluation *(J. Blair Briggs)*	31 July 2000
NEW EXPERIMENTS -- If it is determined that additional Gd data are needed to support the NSNFP and that the LACEF HEU / Gd / CH_2 experiments will provide the necessary information the experiments will be planned, performed, and documented in the form of a draft ICSBEP evaluation. *(Richard E. Anderson)*	TBD [a]
ICSBEP – Formal Publication of the IPPE HEU / SiO_2 Exp. Evaluation *(J. Blair Briggs)*	30 September 2000
ICSBEP – Evaluation of the LACEF HEU / Gd / CH_2 Experiments if they are required *(J. Blair Briggs)*	TBD

a. According to the current (June 1999) NSNFP schedule, criticality safety evaluation (including validation activities) must be completed by 31 July 2000. New data provided after that date would be used only as confirmatory data. However, if it is determined that the additional data from LACEF experiments are essential, a much higher priority on these data would be assigned. While a July 31 deadline is probably unrealistic, new gadolinium data from the Planet assembly could be provide by 30 September 2000. Based on preliminary surveys of existing gadolinium data, it is not likely that these data will be considered essential.

11.0 References

1. Defense Nuclear Facilities Safety Board Recommendation 97-2, *Continuation of Criticality Safety*, May 1997.

2. Defense Nuclear Facilities Safety Board Recommendation 97-2, *Continuation of Criticality Safety*, May 1997.

3. Defense Nuclear Facilities Safety Board Recommendation 97-2, *Continuation of Criticality Safety*, May 1997.

4. "Criticality Safety Support Group (CSSG) White Paper," Memorandum from R. Dintaman to J. Tseng, January 20, 1999.

5. Defense Nuclear Facilities Safety Board Recommendation 94-1, *Improved Schedule for Remediation*, May 1994.

6. DOE Order 5480.24, *Nuclear Criticality Safety*.

7. DOE Order 420.1, *Facility Safety*.

8. ANSI/ANS-8.1-1998, *American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors*, American Nuclear Society, 1998.

9. Letter from Dr. Robin Staffin, Deputy Assistant Secretary for Research, Development and Testing (DP-10) to the Honorable John Conway, Chairman, Defense Nuclear Facilities Safety Board, February 2, 1998.

10. Subrecommendation 3 of the Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 97-2.

11. *SCALE: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluation*, April 1995. NUREG/CR-0200, Rev. 4 (ORNL/NUREG/CSD-2/R4), Vols. I, II, and III, Martin Marietta Energy Systems, Inc., Oak Ridge National Laboratory, Oak Ridge, Tennessee.

12. Y. Karni and E. Greenspan, "The Swan Code for Minimum Critical Mass and Maximum k_{eff} Determination," p. 181, *Topical Meeting on Criticality Safety Challenges in the Next Decade*, September 8-11, 1997, American Nuclear Society.

13. United States Department of Energy Technical Program Plan for Development of Guidance for Defining Applicable Ranges of Bounding Curves and Data Relative to Nuclear Criticality Safety (NCS), Revision 4, September 28, 1998.

14. NRC JCN W6479, "Development and Applicability of Criticality Safety Software for Licensing Review;" Revision 0 dated 9/13/95, Revision 1 dated 4/26/96 and Revision 2 dated 05/27/97.

15. *Quarterly Status of the Implementation Plan for Defense Nuclear Facilities Safety Board Recommendation 97-2*, letter from R. Staffin to Chairman John T. Conway, August 1998.

16. *United States Department of Energy Department-wide Functional Area Qualification Standard: Nuclear Criticality Safety Qualification Standard Competencies*

17. *Guidance for Criticality Safety Engineer Training and Qualification*

Appendix A

Table A-1 contains a short summary of the collected experiments and includes an estimate of ranking and resource requirements. A more complete description of the experiments is contained in Appendix A of LA-UR-99-2083. The ranking estimates of low, medium, or high reflect the current priorities. The resource requirements are estimates of the experimental program funding necessary to complete the experiment or experimental program.

Table A-1. Summary of Proposed Experiments

Ident.	Description	Requestor	Category	Priority	Resources
98-1	Component Flooding Safety Benchmark Experiments	Steve Payne, DOE/AL Dave Heinrichs, LLNL	Extension of 501	High	Low
98-2	Single Unit / Array Benchmark Experiments	Dave Heinrichs, LLNL Adolf Garcia, DOE/ID	Extension of 501	High	Medium
98-3	Component Flooding Transient Behavior Experiment	Rick Paternoster, LANL Dave Heinrichs, LLNL	Extension of 504	Medium	High
98-4	Fissile Waste Matrix Benchmark Experiments	Blair Briggs, INEL	Restatement of 502, 609	High	Low
98-5	Pu Nitrate Solution with Boron & Gadolinium Poisons	Davoud Eghbali, WSRC	New 300 series	High	High
98-6	Experiments Representative of Fissile Accumulations in Yucca Mountain Tuft	Wesley Davis, Yucca Mtn	609 Ongoing	High	Low
98-7	Worths of Fission Products and Actinides in a Thermal Spectrum	Dale Lancaster, TRW Bill Lake, DOE/RW	Restatement Of 702, 502	Medium	Medium
98-8	Worths of Absorber, Structure and Reflector Materials In a Thermal MOX Spectrum	Dale Lancaster, TRW Bill Lake, DOE/RW	Restatement Of 702	Medium	Medium
98-9	Inelastic Scattering of Np237 Above Fission Threshold	Chuck Goulding, LANL	Restatement Of 601	High	Low - Medium
98-10	Central Ratio Measurements of Pu239 in Different Spectra	Bob Little, LANL Phil Young, LANL	Restatement Of 608	Medium	Low
98-11	Special Moderator Parameters	Calvin Hopper, ORNL	New base-theory	Low	Medium
98-12	Slowing Down Experiments in Water	Lester Petrie, ORNL	New base-theory	High	Low-Medium
98-13	Positive Bias in Pu / MOX Systems	Calvin Hopper, ORNL		Medium	Medium
98-14	Intermediate Enrichment Experiments	Calvin Hopper, ORNL Santiago Parra, NRC	Extension of 609	High	Medium
98-15	Critical Mass Experiments at Very Low Temperatures	Rene Sanchez, LANL Rick Paternoster, LANL	Extension of 107	Medium	Low

98-16	Bubble Formation and Reactivity Effects in Fissile Solutions	Prof. Sharif Hagar Univ. of New Mexico	207 Ongoing	Medium	Low
98-17	Radionuclide Extraction from Fissile Solutions	Prof. Gary Cooper Univ. of New Mexico	Extension of 504	Low	Low
98-18	Delayed Neutron Parameters in Higher Actinides	David Loaiza, LANL Ken Butterfield, LANL	605, 605a Ongoing	Medium	Low
98-19	Spectra and Yield Measurements of Delayed Neutrons	David Loaiza, LANL Ken Butterfield, LANL	605, 605a Ongoing	Medium	Low
98-20	Prompt Burst Behavior in LEU (5 – 20%) Solutions	Charlene Cappiello, LANL Ken Butterfield, LANL	Extension of 504	Medium	Low
98-21	Reactivity Temperature Coefficient in Dilute Pu Solutions	Rene Sanchez, LANL Rick Anderson, LANL	Extension of 504	High	High
98-22	Criticality Accident Alarm System (CAAS) Testing Program	Bill Casson, LANL	Restatement of 503	Medium	Low
98-23	Criticality Accident Dosimeter Intercomparison Studies	Bill Casson, LANL	Restatement of 503	Medium	Low
98-24	Neutron Dosimeter Calibration Studies	Bill Casson, LANL	Restatement of 503	Medium	Low
98-25	Environmental Neutron Dosimetry Studies	Bill Casson, LANL	Restatement of 503	Medium	Low
98-26	Transport of Low-Energy Neutrons in Various Materials	Bill Casson, LANL	New base-theory	High	Low
98-27	Source Jerk / Pulse Neutron Subcritical Measurements	David Loaiza, LANL Chuck Goulding, LANL	Restatement of 505	High	Low
98-28	Intermediate Neutron Energy Measurements	Bill Casson, LANL	609 Ongoing	High	Low

Table A-2 is a consensus ranking of the newly collected critical experiments needs combined with the current high-priority list. The members of the CSSG met and discussed the current experimental program and merged these new experiments into the existing priority list.

The 100, 200, 300, . . . etc. series numbers used in LA-12683 are included in Appendix A of document LA-UR-99-2083 to help relate those programs to the newly proposed experiments.

Table A-2. Revised Recommendations for Priority of Critical Experiments		
Priority	Identifier	Description
1	609. 98-28	Intermediate-energy reactivity-worth and dosimetry experiments for non-fissile matrix materials (ZEUS)
2	98-4, 98-6	Intermediate- and thermal-energy experiments with fissile material (^{233}U, ^{235}U, Pu) in specified waste matrices (e.g., Yucca Mountain tuft)
3	98-7	Measurement of worth of CERES fission-product samples for support of burnup credit (in SHEBA-II)
4	98-1, 98-2, 501	Single-unit and array experiments for pit storage and transportation (W-82, etc.), including experiments to simulate flooding/dissolution accidents
5	98-11, 501, 502a, 602	Experiments to determine effects of special moderators (e.g., beryllium, graphite, D_2O, high-density polyethylene) and absorbers (e.g., chlorine) on fissile materials in homogeneous and heterogeneous systems
6	98-8, 98-13	Lattice experiments with MOX fuel pins, including replacement measurements for various materials
7	98-22, 503	Criticality Accident Alarm System testing with SHEBA-II and Godiva
8	98-21	Verification of positive moderator temperature coefficient for dilute systems with nearly-pure ^{239}Pu
9	98-12	Extension of NIST neutron slowing-down experiments in water to larger spheres of water
10	98-27, 505	Source jerk / pulsed neutron measurements for subcritical systems

Priority 1: Intermediate-energy reactivity worth and dosimetry experiments using non-fissile matrix materials (ZEUS)

The objectives of this program are to provide validation for the integral cross sections at intermediate neutron energies as represented in common Monte Carlo and deterministic computer codes. The highest priority cross sections in this program are those for the three common fissile isotopes, ^{235}U, ^{239}Pu, and ^{233}U, in that order. Second priority is for those non-fissile matrix materials expected to be encountered. These include silicon, iron, aluminum, chlorine, and other materials. The Priority 2 program below extends measurements for these untested matrix materials (primarily waste matrix materials) to thermal neutron energies encountered when water or hydrogenous materials are present or are added to the system (e.g., in accident scenarios). Facilities management programs and clean-up or disposition programs which plan for the transportation, storage, and disposal of excess weapons materials and wastes all require this data, because such data either does not exist or is sparsely represented in the current validation database. Examples where the fissile materials cross section validations are needed include: casting isotopes of enriched uranium or weapons-grade plutonium into silicon or ceramic plates or logs (SRS); addition of iron to solutions or sludges containing these isotopes (Hanford waste tanks); burial of weapons grade material (Yucca Mountain); reactor use of weapons materials, including Actinides (MOX reactors, accelerator or reactor-based burners); drum storage and

transportation (RFETS); removal from storage and disposal of ^{233}U (ORNL); disposal of machinery containing ^{235}U (ORNL); transportation and burial of spent reactor fuel, including civilian and military fuel (Yucca Mountain);

Priority 2: Intermediate- and thermal-energy in specified waste matrices

These objectives represent an extension of selected intermediate energy experiments for the untested matrix materials (primarily untested waste matrix materials) to thermal neutron energies. The beneficiaries of this data are primarily the facilities and programs dealing with waste and disposition activities. Such cross section test data is needed to support the ability to take credit for the presence of these isotopes in waste drums at the RFETS, for example.

Priority 3: Measurements of worth of CERES fission-product samples for support of burnup credit

These experiments are designed to test the cross-sections for the Actinides and fission-product isotopes contained in the CERES samples. Such cross-section test data is needed to support the ability to take credit for the presence of these isotopes in spent fuel. programs that store, transport, or dispose of such fuel (Yucca Mountain, reactor sites) will benefit from these measurements.

Priority 4: Single-unit and array experiments for pit storage and transportation, including experiments to simulate dissolution

These experiments are designed to validate safety analyses for accident scenarios for systems at issue (DoD, Pantex).

Priority 5: Experiments to determine effects of special moderators (e.g., beryllium, graphite, D_2O, high-density polyethylene) and absorbers (e.g., chlorine) on fissile materials in homogeneous and heterogeneous systems.

These experiments are an extension of the Priority 2 experiments to additional materials and special process situations such as low temperature. Materials such as beryllium at low temperatures are encountered in special process applications and in space.

Priority 6: Lattice experiments with MOX fuel pins, including replacement measurements for various materials

These experiments are designed to provide the validations for calculations of initial-design MOX reactors

Priority 7: Criticality accident alarm system testing with SHEBA-II and Godiva.

The devices are used to provide the radiation pulses to test CAAS systems under different accident conditions (e.g., fast pulse, slow cookers). All facilities, including NRC facilities, that have criticality alarms must validate the performance of these systems. Because the markets for

these systems are so small, manufacturers often make changes in their products which then requires requalification of the system. The inability to qualify these systems would require some sort of exemption to ANSI/ANS-8.3 and to DOE Order O 420.1. Similar testing requirements must be met for dosimetry, and various other types of equipment and methodology. This experiment also includes measurements to understand the history of solution accidents. Such activities as measurements of power histories, evaluations of shutdown mechanisms, etc. are performed.

Priority 8: Verification of positive temperature coefficients for dilute systems with nearly pure ^{239}Pu

Some theoretical models predict a positive temperature coefficient for dilute Pu systems. If such an effect were demonstrated, it would mean that solution processing systems containing Pu at concentrations less than about 30 g/L could have more severe accident yields than previously thought. All facilities that have solution systems with Pu concentrations less than about 30 g/l would be affected by the results of these measurements.

Priority 9: Extension of NIST neutron slowing-down experiments in water to larger spheres of water

This is not a critical experiment, and would be performed at NIST.

Priority 10: Source jerk/pulsed neutron measurements for subcritical systems

These experiments are designed to produce subcritical benchmarks for typical process evaluations, most of which involve subcritical systems. There is currently no such validation database and these experiments would improve the validation status of almost all criticality safety evaluations.

Appendix B

The list below shows the contributions of several countries to the ICSBEP. All of these contributions have significant value and provide data that can no longer be obtained in the United States without major expense.

France:

Dilute plutonium solution data (applicable to operations and / or waste streams at RFETS, LANL, SRS, LLNL, INEEL and Hanford) as well as higher concentrations in single units and arrays. The first evaluation from France included plutonium-in-solution data with concentrations ranging from 13.2 to 105.0 grams per liter of solution. There are five experiments reported in this evaluation with plutonium concentrations below 20 g/L. These data fill a gap in the United States data which was considered important enough to warrant one of the top ten priority experiments (Experiment number 98-21 on the Priority Experiments List); however, there is still a need for data between 7.5 and 13 grams of plutonium per liter.

Assemblies that are highly sensitive to thick lead reflectors (applicable to the transportation and storage of spent nuclear fuels) -- Data on lead reflectors are very limited. These data are much more sensitive to the presence of lead than other currently available data.

Arrays of "damp" low enriched uranium dioxide units (applicable to waste systems and fresh fuel manufacturing activities) –Data for "damp" powders are also very limited. The uncertainties on the French data are much lower than the uncertainties on the small amount of data from other similar type experiments.

Low enriched and mixed uranium – plutonium fuel rod lattices (applicable to plutonium disposition activities)

Russian Federation:

Several experiments in which a significant amount of the neutrons causing fission fall into the intermediate energy range including k_∞ measurements on systems comprised of the components of stainless steel and zirconium (applicable to waste systems, large storage arrays, and code / cross section development activities – some of these experiments have pointed to deficiencies in US codes and cross section data.)

Numerous plutonium and uranium metal experiments with a wide variety of reflector materials

	Numerous high, intermediate, and low enriched uranium solutions with and without various neutron absorbing materials. (applicable to waste systems and dissolution operations)
	Water-moderated arrays of high and low enriched fuel rods and assemblies with various values of pitch and assembly separation – experiments with stainless steel dividers (applicable to spent fuel storage and transportation) – Included are data for uranium enrichments between 5% and 10% ^{235}U (funded by the NRC and the United States Enrichment Corporation).
	Highly enriched uranium solution systems in various pipe intersections
	In addition to existing criticality safety benchmark data, scientists from the Russian Federation have provided detailed spectral characteristics for all configurations in the international handbook.
Slovenia:	Arrays of 20% enriched uranium TRIGA reactor fuel elements (applicable to transportation and storage of TRIGA reactor fuels at the INEEL) – Very little data exists for this type of fuel.
United Kingdom:	K_∞ measurements for experiments with fast and intermediate energy spectra using plutonium in a graphite, stainless steel, sodium and natural uranium matrix (applicable to waste systems)
	K_∞ measurements for experiments with intermediate energy spectra using plutonium in a graphite matrix and highly enriched uranium in a graphite matrix (applicable to waste systems)
	Mixed plutonium – uranium systems (applicable to plutonium disposition activities)
Japan:	10% enriched uranium solutions with no reflector, water reflector, concrete reflector, and polyethylene reflectors.
	Low enriched lattice experiments
Hungary:	Over 200 critical configurations using VVER fuels – (Applicable

to US efforts to assist with safety analysis of these types of fuels)

Korea: Evaluation of two series of US mixed oxide experiments

Yugoslavia Highly enriched, low enriched, and natural uranium heavy-water-moderated lattices

Over 150 scientists from around the world have combined their efforts to document the work of the ICSBEP as the "International Handbook of Evaluated Criticality Safety Benchmark Experiments". The handbook is currently being used in 35 different countries. The following table summarizes where handbook has been distributed.

Table B-1. Distribution of the "International Handbook of Evaluated Criticality Safety Benchmark Experiments"

Affiliation/Company	Number
Argonne National Laboratory	13
Babcock & Wilcox	2
Defense Threat Reduction Agency	1
Department of Energy	12
Foreign Countries	103
Hanford Site	10
Idaho National Engineering & Environmental Laboratory	12
Los Alamos National Laboratory	21
Lawrence Livermore National Laboratory	28
Military (Army, Air Force, Navy)	8
United States Nuclear Regulatory Commission	8
Oak Ridge National Laboratory	18
Oak Ridge Y-12 Plant	4
Oak Ridge K-25 Plant	2
Other / Consultants[1]	62
PANTEX	1
Pacific Northwest National Laboratory	1
Rocky Flats Environmental Technology Site	15
Sandia National Laboratory	4
Universities	31

Utilities	17
Westinghouse Safety Management Solution at Savannah River Site	19
Yucca Mountain Project	2
Consultants and consulting firms that almost exclusively support one particular DOE laboratory are including in the distributions to that laboratory	

QUARTERLY STATUS OF THE IMPLEMENTATION PLAN FOR DEFENSE NUCLEAR FACILITIES SAFETY BOARD RECOMMENDATION 97-2 SECOND QUARTER FISCAL YEAR 2000

The Department of Energy (DOE) began implementing Defense Nuclear Facilities Safety Board Recommendation 97-2 in January 1998 by formally establishing the Nuclear Criticality Safety Program (NCSP). Each of the seven NCSP Tasks (Critical Experiments, Benchmarking, Analytical Methods, Nuclear Data, Training and Qualification, Information Preservation and Dissemination, and Applicable Ranges of Bounding Curves and Data) is dependent upon the others for a successful program. Implementation of the NCSP is being accomplished according to the Five-Year NCSP Plan which was published in August 1999.

The Nuclear Criticality Safety Program Management Team (NCSPMT) and the Criticality Safety Support Group (CSSG) are performing their respective chartered functions in supporting the Responsible Manager's execution of the Implementation Plan (IP). During the quarter, the NCSPMT and CSSG coordinated activities aimed at completing IP milestones and continued to provide justification necessary for maintaining funding support. Of particular note was CSSG participation in criticality safety program reviews at the Hanford Plutonium Finishing Plant and Rocky Flats Building 371. This activity supported the Secretarial initiative aimed at strengthening Departmental criticality safety programs. Field reports for each of these reviews have been issued, and the compendium report to the Secretary will be issued soon. In addition, the CSSG has been asked by the Offices of Defense Programs (DP) and Environmental Management (EM) to provide technical review of criticality safety self assessments performed by DP and EM site contractors.

The NCSP held its annual program review on March 27, 2000, in Albuquerque, NM. The review focused on criticality safety community outreach. Feedback questionnaires were passed out and made available on the web site to collect feedback from the community. Feedback from the criticality safety community will be factored into future program planning to assure alignment of NCSP products with criticality safety practitioner priority needs.

This quarterly report provides a status of activities for each of the seven NCSP elements, as well as Recommendation 97-2 IP Milestones and Recovery Plans. Milestone 6.6.1.1., *Expand the LACEF Training Course,* was completed during this quarter. The Department has completed all actions identified under Commitment 6.6.1 and proposes closure of this commitment. All three of the remaining milestones are overdue. Recovery Plans, which were established to complete these milestones, are included in Attachment B to this report to chronicle progress. The Management Team is working very hard to complete all remaining milestones and to continue implementing the NCSP.

This report outlines steady progress in all seven NCSP task areas. All activities that were curtailed due to delayed funding, as reported in our last quarterly status report, have been resumed. There are two attachments to this report: Attachment A is a table depicting the status of all IP Deliverables and Milestones, and Attachment B contains Recovery Plans for the three remaining milestones.

Accomplishments and key issues in each of the program task areas which arose during the period are as follows.

Critical Experiments

A status of experimental activities conducted at the Los Alamos National Laboratory (LANL) during the period by critical assembly is as follows:

Flattop: Flattop was inoperable for almost this entire quarter due to a malfunction of one of the control rod drive systems. A path forward for re-start of Flattop which includes replacement of the 50-year old control rod drive system and the performance of a full readiness assessment has been developed and submitted to the Department of Energy, Los Alamos Area Office (DOE/LAAO). For these reasons, it is unlikely that Flattop will be operational for the remainder of this Fiscal Year.

Comet: Several additional proton recoil, Rossi-alpha, and foil irradiation measurements were made this quarter to further characterize the spectrum in the Zeus intermediate energy spectrum experiment. At this point, essentially all of the measurements that can possibly be made for this configuration have been made. No further measurements will be made with Zeus until approval is received from DOE/LAAO to proceed with the remaining experiments. (A request to continue with these experiments and all of the supporting safety documentation was submitted to DOE/LAAO in December of 1999.) The Comet machine is currently in the process of being de-fueled to assure fuel integrity while awaiting approval from DOE/LAAO to proceed.

SHEBA: SHEBA was declared operable on February 10, 2000. [SHEBA had been stood down as a result of a discrepant-as-found condition with the Remote Autoranging Picoameters (RAPs)]. Several SHEBA operations were performed in support of the three criticality safety classes held during the quarter and for operator training.

Godiva: Godiva assembly operations were terminated in the fourth calendar quarter of 1999 due to the discovery of a Potentially Inadequate Safety Analysis (PISA). The PISA originated when an error was discovered in a calculation performed by another group at Los Alamos. This calculation provided a part of the technical basis for DOE/LAAO's approval of a prior unreviewed safety question (USQ), hence the declaration of the PISA. The USQ for the PISA was originally submitted to DOE/LAAO for approval in the fourth calendar quarter of 1999 and then resubmitted on 6 January 2000. Approval of the USQ was received on April 11, 2000, but DOE/LAAO is requiring the implementation of several additional controls prior to authorizing operations. Authorization to restart Godiva operations is anticipated by the end of May 2000.

Planet: Planet operations were performed for the three criticality safety classes conducted during this quarter and Planet experiments to characterize the reactivity worth of waste matrix materials continued.

Benchmarking

Fiscal Year 2000 Funding for the International Criticality Safety Benchmark Evaluation Program (ICSBEP) was received and distributed to working group participants during February 2000, and work was restarted. Preparations for the next ICSBEP Working Group Meeting were initiated. This meeting will be held June 26, 27, and 28, 2000, in St. Petersburg, Russian Federation. Technical tours of the critical facilities at the Russian Research Center "Kurchatov Institute" in Moscow and at the Institute of Physics and Power Engineering in Obninsk are being arranged for June 29 and 30. Representatives from the United States, United Kingdom, Russia, France, Japan, Yugoslavia, Spain, Israel, China, and the OECD are expected to attend this meeting. Twenty-five evaluations are in progress and are expected to be completed in time for the Working Group Meeting in June. Thirteen of these evaluations are being contributed from outside the United States.

The ICSBEP Internet Site (http://icsbep.inel.gov/icsbep) was revised and updated. One previously approved, but unpublished evaluation and a significant amount of additional spectra data were made available on the site. Additional information on the project organization and status was added. A feedback questionnaire for the ICSBEP was prepared and submitted to DOE for inclusion on the DOE Criticality Safety Web Site.

Some ICSBEP personal participated in the FY-2000 NCSP Review and Nuclear Criticality Technology and Safety Project (NCTSP) Workshop in Albuquerque, New Mexico. Presentations on the ICSBEP were given in both of these meetings.

Analytical Methods

Staff at the Oak Ridge National Laboratory (ORNL) and LANL continued to maintain KENO and MCNP software and assist the nuclear criticality safety community in the use of this software. At ORNL this included completion of the software utilized by the new SCALE/CENTRM/KENO sequence to include the standard SCALE options for cross-section weighting (pin or cell) and fissile system analysis (1D Discrete Ordinates or 3D Monte Carlo). The document on SCALE/CENTRM validation for mixed oxides was published (ORNL/TM-1999/299). Additional design work to provide for resonance processing of more than one fissile mixture was performed. Preparations were made for a five-day KENO/SCALE Workshop to be conducted at ORNL in early April.

At LANL the MCNP4C code was completed and sent to Radiation Shielding Information and Computational Center (02/29/00) for packaging and distribution. It has ten major new features: 1) unresolved resonance probability tables, 2) perturbation enhancements, 3) superposed mesh weight window generator, 4) alpha eigenvalues, 5) macrobodies, 6) ENDF/B-VI improvements, 7) PC enhancements, 8) electron physics enhancements, 9) parallelization enhancements, and 10)

delayed neutron treatment. As a measure of recent code maintenance, approximately 40 errors were detected and corrected by the MCNP staff during the development of version 4C. Four verification and validation reports were published in 1999. Seven MCNP workshops are scheduled for Fiscal Year 2000.

At the Argonne National Laboratory (ANL), further studies on Monte Carlo source convergence were performed with a comparison of the superhistory and stratified sampling techniques. A detailed proposal on the specific work areas of the new OECD/NEA Task Force on Source Convergence in Criticality Safety Calculations will be presented at the Working Party on Nuclear Criticality Safety meeting in September 2000, and at the Nuclear Science Committee meeting. Additional covariance data files for use in the AROBCAD Task were developed and additional features were added to the new VIM web page.

Nuclear Data

Nuclear cross-section data measurement activities continued at the Oak Ridge Electron Linear Accelerator. Sample holders for the U-233 thick foil measurements have been designed and fabricated. These measurements will allow us to improve the U-233 cross section representation in the unresolved energy region. Fabrication and retrieval of the thick samples from Building 3019 has been a slow process, but is progressing. Reduction of the chlorine data has been completed and is ready to be analyzed. Reduction of the silicon data has been started.

Nuclear cross section data evaluation activities also progressed. Review of the documentation on the resolved resonance region evaluations for Al-27 and U-233 is underway. At LANL, some additional work on Cl-35 and Cl-37 evaluations was done and an improved R-matrix analysis of O-16 below 6.2 MeV was performed. Extensive changes were made at higher energies based on new experimental data.

The following publications were released: ORNL/TM-13723 "REVIEW OF ENDF/B-VI FISSION-PRODUCT CROSS SECTIONS"; and ORNL/TM-2000/19, "NUCLEAR DATA COVARIANCE WORKSHOP, April 22-23, 1999."

At ANL, work on resonance theory continues to focus on improved treatment of the probability table methods in the unresolved resonance energy range. The treatment for zero temperature has been done by analytical means and the coding for numerical treatment is in progress. ANL is also continuing to provide covariance information for ENDF/B-V cross sections used in the AROBCAD Task.

Training and Qualification

This program element includes three sub-elements: (1) hands-on criticality safety training at LANL; (2) training development; and, (3) criticality safety qualification program activities.

Hands-on criticality safety training continued at LANL. The new advanced 5-day class was conducted in February. A basic five-day class and a three-day class were both held in March. Five additional training courses are scheduled for the remainder of Fiscal Year 2000.

Training development activities were essentially discontinued this quarter due to the delay in funding distribution. One additional training module, Module 7, *Introduction to the Monte Carlo Method*, which was already in the pipeline, was reviewed and reformatted, then loaded onto the NCSP web site. Fiscal Year 2000 funding for this activity was included in the April Financial Plan, so work can be reinitiated in early May.

Regarding qualification activities, the Department is in the process of drafting a page change to DOE O 420.1 that requires contractors to implement a training and qualification program for Nuclear Criticality Safety Staff. Final wording for the page change is still in preparation and technical comments received on the initial draft are being resolved prior to issuance for external review which is anticipated by the end of May 2000 (see Recovery Plans for IP Milestones 6.6.3.3 and 6.6.3.4).

Departmental criticality safety personnel are working towards qualification by December 2000 (see IP Recovery Plan for Milestone 6.6.4.2). At least sixteen Federal employees from around the Complex plan to qualify. Milestone 6.6.4.2 will have been met when at least one Federal employee has qualified from each site which has a criticality safety program. The Department is tracking progress of these individuals. No one has completed the qualification process to date. Four plan to be finished by mid summer, and the remainder plan to be qualified by November or December 2000.

Information Preservation and Dissemination

This program element currently contains two sub-elements: (1) the Criticality Safety Information Resource Center (CSIRC); and (2) NCSP web page development.

Regarding the CSIRC Program, the following progress has been made. Compact Disks have been produced for the references to LA-10860 and distribution will be made to those requesting such through the web site. The 147 references to LA-12808 and the available references to the Criticality Accident Report (LA-13638) have been scanned into electronic format. Arrangements are being made with Dave Smith to videotape him in the near future. A videotaping conference is being planned for September 2000 at LANL to bring together criticality safety pioneers from ORNL and LANL to videotape their personal reminiscences of their years of work in criticality safety and recollections of particular experiments. The following reports are in the process of being published: editing of LA-13638, the Criticality Accident Report, has been completed and publication and distribution are planned for the next quarter; Robert E. Rothe, LANL consultant, is currently documenting the history of the critical experiment effort at Rocky Flats (over 30+ years). On February 17, 2000, Barbara D. Henderson made a CSIRC presentation to the Los Alamos Women in Science (LAWIS). It was well received, and a summary of the paper was published on the LAWIS web site.

The NCSP web site at Lawrence Livermore National Laboratory is being maintained and improved. This web site provides technical information and serves as a pointer to other web sites which are important to the NCSP. During the second quarter of Fiscal Year 2000, the NCSP web site highlights included:

(1) Announced the NCSP Review Meeting and published the Agenda;

(2) Presented a NCSP web site demonstration at the NCTSP;

(3) Enhanced the web site system to meet all cyber-security requirements;

(4) Added a banner to announce the NCTSP meeting, and included of a copy of the meeting agenda on the web page;

(5) Added Training Module 7, *Introduction to the Monte Carlo Method*;

(6) Announced availability of the report, "Sensitivity and Uncertainty Analyses Applied to Criticality Safety Validation" and provided of a hyperlink to the data source web site;

(7) Conducted an e-mail drive to encourage web site users to register at the web site to update the website users e-mail directory; and

(8) Added the NCSP Feedback Questionnaire to the web site.

Finally, some interesting web site statistics have been collected:

* The site hosted more than 6200 visitors in 1999.
* Currently, there are approximately 200 registered users.
* The site now contains 7 training modules.
  There have been more than 1000 downloads of these training modules.
* The Bibliographic references databases are the most visited section of the web site.
  Thus far, there have been over 7000 accesses and searches on these databases.

Applicable Ranges of Bounding Curves and Data

The five tasks of the AROBCAD program address Recommendation 97-2 commitments to develop technically justifiable methodologies and user tools for validating bounding data and calculations in areas where benchmark data is unavailable or excessively sparse and to aid in the selection or design of appropriate benchmarks, thereby providing greater confidence in the calculational validation. During the second quarter of Fiscal Year 2000, three of the five tasks were addressed and progress reports were provided to the NCSPMT and the NCTSP workshop audience. Additionally, a solicitation-for-feedback questionnaire was developed for the NCSPMT to assess criticality safety community support for AROBCAD task.

TPP Task 1 - *Implement use of optimization techniques for establishing bounding values.* The prototypic SWAN-SCALE one-dimensional material-optimization code has been completed and

incorporated into an ORNL SCALE driver system. The final draft of the user manual is with the University of California Berkeley (UCB) staff for final review, revision and discussion with ORNL staff before editorial review and approval for printing. Printing is projected by the end of the third quarter of Fiscal Year 2000. The issuance of the codes is still not projected to occur before the end of 2001.

TPP Task 2 - *Investigate means to resolve or incorporate anomaly and discrepancy effects into bounding values.* The draft technical report on the investigation of discrepancies in the National Institute of Standards and Technology experiments has been completed and is still expected to be published in the third quarter of Fiscal Year 2000.

TPP Task 3 - *Investigate utilization of sensitivity and uncertainty (S/U) and statistical methods for identifying experimental needs.* Work continued on the reduction of data and drafting of the report about sensitivity and uncertainty studies that were performed on a previously proposed sludge transfer from the Hanford K-Basin to Tanks and National Spent Nuclear Fuel (SNF) disposal parameters as compared to a suite of approximately 425 benchmarks. The draft report is expected to be completed in the third quarter of Fiscal Year 2000.

TPP Task 4 - *Develop guidance for interpolating and extrapolating bounding values.* Effort on this subtask currently continues at ORNL considering various methods for evaluating computational biases and uncertainties due to cross section and experimental benchmark measurements using various integral parameters derived from S/U information and Generalized Linear Least Squares Method. This subtask will progress as further relevant information is generated and evaluated using the results of AROBCAD Tasks 3 and 5.

TPP Task 5 - *Develop guidance for establishing bounding margins of subcriticality.* No work was conducted during the second quarter of Fiscal Year 2000 on the draft assessment report of the US nuclear criticality safety community, commercial and contractor, practices and methods for establishing bounding margins of subcriticality. It is expected that the report will be completed during the third quarter of Fiscal Year 2000.

ATTACHMENT A: IP COMMITMENT AND DELIVERABLE/MILESTONE STATUS

Commitment	Deliverable/Milestone	Due Date	Status
6.1 Assess critical experiments program	1. Assessment report of criticality research program	March 1998	Completed
6.2.1 Perform CSIRC pilot program	1. Identify an experiment to archive	November 1997	Completed
	2. Archive logbook(s) and calculation(s) for that experiment	December 1997	Completed
	3. Videotape original experimenters	January 1998	Completed
	4. Digitize data and calculations	February 1998	Completed
	5. Publish data and calculations	April 1998	Completed
6.2.2 Continue to implement the CSIRC program	1. Collocate logbooks (copies or originals) from all U.S. critical mass laboratories	December 1998	Completed
	2. Screen existing logbooks with original author/experimenter	December 1998	Completed
	3. CSIRC program plan	December 1998	Completed
6.3 Continue and expand work on ORNL sensitivity methods development	1. Technical program plan	July 1998	Completed
	2. Document initiation of priority tasks from the program plan in the quarterly report to the Board	January 1999	Completed
6.4 Make available evaluations, calculational studies, and data by establishing searchable databases accessible through a DOE Internet web site	1. DOE criticality safety web site	March 1998	Completed
	2. Y-12 evaluations on DOE web site	June 1998	Completed
	3. Calculations compiled by the Parameter Study Work Group on DOE web site	September 1998	Completed
	4. Nuclear Criticality Information System Database on DOE web site	March 1999	Completed
6.5.1 Revise and reissue DOE-STD-3007-93	1. Revise DOE-STD-3007-93	September 1998	Completed
6.5.2 Issue a guide for the review of criticality safety evaluations	1. Departmental guide for reviewing criticality safety evaluations	May 1999	Completed
6.6.1 Expand training course at LACEF	1. Expanded LACEF training course	July 1998	Completed: February 2000

Commitment	Deliverable/Milestone	Due Date	Status
6.6.2 Investigate existing additional curricula in criticality safety	1. Assessment of additional training needs and review of available supplementary curricula	June 1998	Completed
	2. Initiate a program which addresses identified needs	December 1998	Completed
6.6.3 Survey existing contractor site-specific qualification programs	1. Report on the review of site qualification programs	June 1998	Completed
	2. Guidance for site-specific criticality safety training and qualification programs	September 1998	Completed
	3. Guidance to procurement officials specifying qualification criteria for contractor criticality safety practitioners	September 1998	Overdue: Expected completion date is September 2000 - See Recovery Plan in Attachment B.
	4. DOE Field will provide line management dates upon which contractors will have implemented guidance in Deliverable #2, above	March 1999	Overdue: Expected completion date is March 2001 - See Recovery Plan in Attachment B.
6.6.4 Federal staff directly performing criticality safety oversight will be qualified	1. Qualification program for Departmental criticality safety personnel	December 1998	Completed
	2. DOE criticality safety personnel qualified	December 1999	Overdue: Expected completion date is December 2000 - See Recovery Plan in Attachment B
6.7 Each site will conduct surveys to assess line ownership of criticality safety	1. Individual sites issue report of findings	June 1998	Completed
6.8 The Department will form a group of criticality safety experts	1. Charter for Criticality Safety Support Group approved by the NCSPMT	January 1998	Completed
6.9 Create NCSPMT charter and program plan	1. NCSPMT charter	January 1998	Completed
	2. NCSPMT program plan	June 1998	Completed

ATTACHMENT B: RECOVERY PLANS FOR OVERDUE MILESTONES

Recovery Plan for IP Milestone 6.6.3.3: Guidance to procurement officials specifying qualification criteria for contractor criticality safety practitioners (was due 9/98).

Action	To Be Completed By	Responsibility
1. MA issues draft Page Change to Field Management Counsel (FMC) for initial review.	March 2000	Completed
2. FMC comments received and incorporated.	May 2000	DP-10
3 FMC approves release of Draft Page Change for review and comment.	May 2000	DP-10
4. MA issues draft Page Change for 60-day for review and comment.	May 2000	DP-10
5. Comments due; EH-31 starts comment resolution.	July 2000	Reviewers
6. EH-31 completes comment resolution; forwards final draft Page Change to MA.	September 2000	EH-31
7. MA releases approved Page Change.	October 2000	DP-10

Recovery Plan for IP Milestone 6.6.3.4: DOE Field will provide line management dates upon which contractors will have implemented guidance in Milestone 6.6.3.2 (was due 3/99).

Action	To Be Completed By	Responsibility
1. MA releases approved Page Change (Action #7 of Recovery Plan for Milestone 6.6.3.3).	October 2000	DP-10
2. Contractors inform DOE Field as to dates by which they will have implemented site specific training and qualification programs.	April 2001	Field
3. Field reports status to DP-10.	April 2001	Field

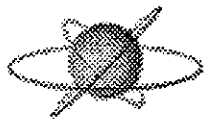
Recovery Plan for IP Milestone 6.6.4.2: DOE criticality safety personnel qualified (was due 12/99).

Action	To Be Completed By	Responsibility
1. DP will inform the FMC about the Federal Qualification Program.	June 1999	Completed
2. Publish Federal Qualification Standard.	November 1999	Completed
3. Lead Program Secretarial Officers (LPSOs) Task Field Managers.	March 2000	Completed
4. Fed Qual Plans Submitted to LPSOs.	May 2000	Field
5. DOE criticality safety personnel qualified.	December 2000	Field

別添資料2　　NCSP User Survey

http://ncsc.llnl.gov:8080/survey/NCSPsurvey.html

NCSP User Survey



U.S. Department of Energy
Nuclear Criticality Safety Program

NCSP USER SURVEY

THE DEPARTMENT OF ENERGY NUCLEAR CRITICALITY SAFETY PROGRAM

The Department of Energy (DOE) Nuclear Criticality Safety Program (NCSP) is focused on maintaining fundamental infrastructure that enables retention of DOE capabilities and expertise in nuclear criticality safety necessary to support line criticality safety programs. This includes improving the technical knowledge of criticality safety personnel and improving the availability and use of criticality safety information, tools, and guidance throughout the DOE complex.

- **SECTION 1 <———*Please click here***

  NCSP USER PROFILE. ***Please complete this section first before going to the individual NCSP Tasks (Sections 2 through 8)***

別添資料3　International Criticality Safety Benchmark Evaluation Project

http://icsbep.inel.gov/icsbep/

International Criticality Safety Benchmark Evaluation Project (ICSBEP)



International Criticality Safety Benchmark Evaluation Project



- About the International Criticality Safety Benchmark Evaluation Project
- International Handbook of Evaluated Criticality Safety Benchmark Experiments
- U.S. Department of Energy Nuclear Criticality Safety Program
- Request for Evaluation
- Evaluations in Progress

The International Criticality Safety Benchmark Evaluation Project is an official activity of the Organization for Economic Cooperation and Development - Nuclear Energy Agency (OECD-NEA). This web site is maintained at the Idaho National Engineering and Environmental Laboratory, a facility operated for the U.S. Department of Energy.

[Main Page | About | Evaluations in Progress | Handbook | Comments]

Notice to Users
This page was last modified on Tuesday, March 28, 2000

International Criticality Safety Benchmark Evaluation Project

The International Criticality Safety Benchmark Evaluation Project (ICSBEP) was initiated in October of 1992 by Dae Chung, Director of the Department of Energy Defense Programs Systems Engineering Division. The project is managed through the Idaho National Engineering and Environmental Laboratory (INEEL), but involves nationally known criticality safety experts from Los Alamos National Laboratory, Lawrence Livermore National Laboratory, Savannah River Technology Center, Oak Ridge National Laboratory and the Y-12 Plant, Hanford, Argonne National Laboratory, and the Rocky Flat Plant. An International Criticality Safety Data Exchange component was added to the project during 1994. Representatives from the United Kingdom, France, Japan, the Russian Federation, Hungary, Korea, Slovenia, Yugoslavia, Spain, and Israel are now participating on the project and others have expressed an interest in the project. The ICSBEP is now an official activity of the OECD-NEA.

The purpose of the ICSBEP is to:

1. Identify and evaluate a comprehensive set of critical benchmark data.
2. Verify the data, to the extent possible, by reviewing original and subsequently revised documentation, and by talking with the experimenters or individuals who are familiar with the experimenters or the experimental facility.
3. Compile the data into a standardized format.
4. Perform calculations of each experiment with standard criticality safety codes.
5. Formally document the work into a single source of verified benchmark critical data.

The work of the ICSBEP is documented as an International Handbook of Evaluated Criticality Safety Benchmark Experiments. Currently, the handbook spans seven volumes and contains 263 evaluations representing 2157 critical configurations. The handbook is intended for use by criticality safety analysts to perform necessary validations of their calculational techniques and is expected to be a valuable tool for decades to come. The Handbook is currently in use in 42 countries.

The ICSBEP Handbook is available both on CD-ROM and the Internet. You may request a CD-ROM by completing the CD-ROM Request Form. Access to the Handbook on the Internet requires a password. You may request a password by completing the Password Request Form.

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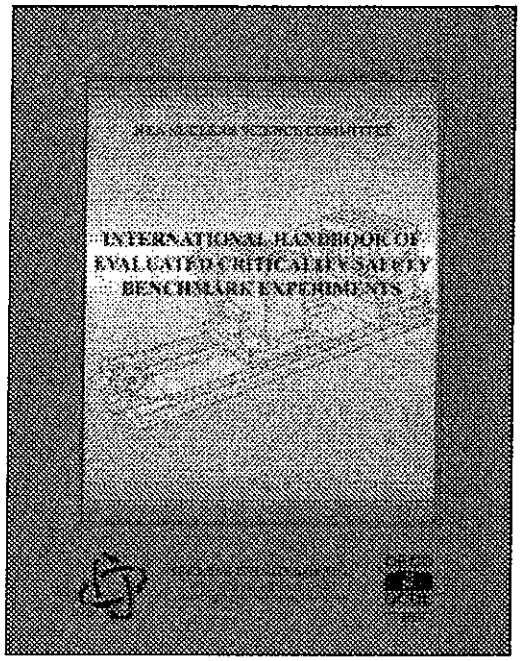
This page was last modified on Friday, March 24, 2000

International Criticality Safety Benchmark Evaluation Project (ICSBEP) - Handbook

International Criticality Safety Benchmark Evaluation Project



The International Handbook of Evaluated Criticality Safety Benchmark Experiments was prepared by a working group comprised of experienced criticality safety personnel from the United States, the United Kingdom, Japan, the Russian Federation, France, Hungary, Republic of Korea, Slovenia, Yugoslavia, and Israel. The handbook contains criticality safety benchmark specifications that have been derived from experiments that were performed at various nuclear critical facilities around the world. The benchmark specifications are intended for use by criticality safety engineers to validate calculational techniques used to establish minimum subcritical margins for operations with fissile material. The example calculations presented do not constitute a validation of the codes or cross section data.

The handbook contains 263 evaluations with benchmark specifications for 2157 critical or near critical configurations. Experiments that are found unacceptable for use as criticality safety benchmark experiments are discussed in the handbook evaluations; however, benchmark specifications are not derived for such experiments. A total of 360 experimental configurations are categorized as unacceptable for use as criticality safety benchmark experiments. Additional evaluations are in progress and will be added to the handbook periodically.

The online version of the ICSBEP handbook is in Adobe PDF format and **requires the use of the Adobe Acrobat Reader plug-in.** This means that the browser you use must be able to use the Adobe plug-in. The latest versions of both Netscape and Internet Explorer have this capability. If you are running Netscape, you can check to see if the plug-in is installed by going to the Netscape menu and selecting *Help* and then *About Plug-ins*. Scroll down the page if necessary until you find a section labelled *Adobe Acrobat*. If you don't find such a section then you do not have Adobe installed as a plug-in.

When the Adobe Acrobat Reader is running as a plug-in, it will appear inside of the browser's window and add it's own buttons at the top of the window. In other words, it will appear just as other Web documents do when viewed with a browser. See the troubleshooting guide for figures showing what you should see on your screen.

If you don't now already have the Adobe, it's free and you can download if from Adobe's Web Site. You may want to look at the preferred configuration page before beginning. This might help avoid problems. If, after getting your password, you are having trouble viewing the handbook, visit the troubleshooting guide for possible solutions.

The online version of the ICSBEP handbook was designed to function as close as possible to the CD version. (You may request a CD-ROM by completing the CD-ROM Request Form.) Navigation is accomplished using links within the PDF documents. Since the Adobe plug-in does not include a search button on its toolbar, a navigation bar providing search capability is included at the bottom of the browser window. This means that you must be using a browser that is capable of handling frames. If you use one of the preferred browsers, either Netscape or Internet Explorer, you should have no trouble viewing frames since both of these browsers support them. The latest version of Netscape and Internet Explorer can be found by following their respective links.

And finally, access to the ICSBEP Handbook is restricted and a password is required. If you already have a password, you may enter. Otherwise, you will need to request a password.

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別添資料4　Nuclear Criticality Safety Engineer Training

http://ncsc.llnl.gov:8080/ncset/ncset.html



U.S. Department of Energy
Nuclear Criticality Safety Program

Nuclear Criticality Safety Engineer Training

Nuclear Criticality Safety Engineer Training

As part of the DOE Nuclear Criticality Safety Program, a series of training modules is being developed to assist site training organizations in developing a comprehensive criticality safety training program. These modules are meant to be used in conjunction with other resources such as the Los Alamos hands-on courses and university courses. The material in these NCSET modules is suitable for introductory level training of criticality safety personnel who either do not have a nuclear engineering background or who need a basic level refresher course. The material covered in the first modules to be posted here is based on the results of a survey taken last year that indicated the areas in which people felt there was a need for additional training resources.

These training materials have been developed for the criticality safety user community. Feedback from the users is important so that new modules can be designed and current modules improved to maximize their benefit to the largest possible audience. Please send your comments, suggestions, etc. to J. Morman (jamorman@anl.gov).

Module 1: Introductory Nuclear Criticality Physics 

Module 2: Neutron Interactions 

Module 3: The Fission Chain Reaction 

Module 4: Neutron Scattering and Moderation 

Module 5: Criticality Safety Limits 

Module 6: Introduction to Diffusion Theory 

Module 7: Introduction to the Monte Carlo Method 

別添資料5　Criticality Safety Information Resource Center

http://crit-safety.lanl.gov/ncs/index.htm
または
http://www.csirc.net/

LANL-DOE Crit Safety Web

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別添資料7　US-DOE Nuclear Criticality Safety Program - Web Site

http://ncsc.llnl.gov:8080

Nuclear Criticality Safety Program



U.S. Department of Energy
Nuclear Criticality Safety Program

You're Visitor #

Welcome to the U.S. DOE Nuclear Criticality Safety Program Web site. This site is the focal point for DOE criticality safety activities, resources and references, plus links to other sites actively involved in the collection and dissemination of criticality safety information.

This WWW resource was developed as part of the DOE response to the DNFSB Recommendation 97-2, which reflected the need to make criticality safety information available to a wide audience. To the extent possible, the hyperlinks on these pages direct the user to original source of the reference material in order to ensure accuracy and access to the latest versions.

This website is the result of the efforts of many members of the criticality safety community and is maintained by Lawrence Livermore National Laboratory. It is intended that the site provide information that the user community needs, so your feedback is important. Please contact the Webmaster with comments and suggestions.

Among the features included here are:

- general help for new criticality safety practitioners
- a discussion of computational methods
- collections of bibliographic references and validation experiments
- an interactive question and answer forum for the criticality safety community

- NCSP is currently soliciting your input to enhance Nuclear Criticality Safety Program to serve you more effectively. Please take a moment of your time and fill out the NCSP user survey by click here

- The NCSP program review slides from Albuquerque, NM March 27, 2000 are now available. Please click here to download the individual presentation slides.

- The report to the Secretary of Energy, "Nuclear Criticality Safety at Key Department of Energy Facilities" is posted on the following website:

  http://tis.eh.doe.gov/criticality/reviews/ncs_report.html.

  The report was the subject of a DOE News Release and press briefing this afternoon, 5/11/2000. The news release may be found at:

  http://home.doe.gov/news/releases00/maypr/pr00133.htm

- The Office of Oversight Nuclear Criticality Safety Field Reports are now posted on DOE Headquarters' EH Criticality Safety web site. You may click here to go to EH Criticality Safety Web site or click on below hypertext links to get individual report from EH Criticality Safety Web site.

  - Hanford Plutonium Finishing Plant
  - Los Alamos National Laboratory Technical Area-55

Nuclear Criticality Safety Program

- Oak Ridge Y-12 Plant Buildings 9212 and 9818
- Rocky Flats Building 371
- Savannah River Site FB-Line and H-Area Outside Tanks

- NEW The quarterly report for "QUARTERLY STATUS OF THE IMPLEMENTATION PLAN FOR DEFENSE NUCLEAR FACILITIES SAFETY BOARD RECOMMENDATION 97-2 SECOND QUARTER FISCAL YEAR 2000" is now available. Please click here to download a copy.

Related high-level links:	
U.S. Department of Energy	DOE HQ Criticality Safety Web Site
U.S. Nuclear Regulatory Commission	LANL Criticality Safety Information
Defense Nuclear Facilities Safety Board	ORNL Criticality Safety Information
American Nuclear Society	ANSI/ANS-8 Criticality Safety Standards
Argonne National Laboratory	Idaho National Engineering and Environmental Laboratory
Pantex Nuclear Criticality Safety Program	

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NCSP Site Map

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Site Map

Master Index of Data and References

Descriptions and links to a variety of databases including published reference material, benchmark experiments and experimental data.

Basic Nuclear Criticality Safety Information

An introduction to the field of criticality safety, a basic reference set for new practitioners, sample criticality safety evaluations, frequently asked questions and more.

Nuclear Criticality Safety Engineer Training NEW

Links to series of training modules being developed by DOE Nuclear Criticality Safety Program to assist site training organizations in developing a comprehensive criticality safety training program.

Nuclear Criticality Safety related DOE Orders, Regulations, and Standards

Links to various WWW sites containing DOE Orders, DOE Standards, NRC Regulatory Guides, and ANSI Standards.

Other Internet Resources

A hot list of links to an assortment of Nuclear Criticality Safety related WWW sites around the world.

New opportunities in the Nuclear Criticality Safety field NEW

Links to various web sites contain employment position posting throughout the DOE complex.

DOE Criticality Safety Organizations and Groups

Links to an assortment of formal and informal groups actively involved in criticality safety within the DOE, including the Nuclear Criticality Safety Program Management Team, the Criticality Safety Coordinating Team and the Endusers Group.

U.S. DOE NCSP Five Year Plan NEW

The DOE Nuclear Criticality Safety Program Five Year Plan is a comprehensive plan that integrates seven technical elements into a program that provides for the maintenance of a stable, cross-organizational criticality safety infrastructure while improving the technical basis of criticality safety practices. The Executive Summary provides an introduction to the Five Year Plan.

Training and Conference News

Contain detail information on schedule, location, and workshop agenda for training/conferences.

DNFSB Actions and Operating Experience NEW

Links to Defense Nuclear Facilities Safety Board regarding recommendations and actions, DOE Operating Experience Weekly Summaries.

Criticality Safety Codes and Data

Descriptions of the codes and code systems used in criticality safety analyses and links to the sites supporting those codes.

Messages Board

This message board was provided to

NCSP Site Map

How to contribute info to this Website

Information containing on who to contact and how to contribute to this web site.

encourage communication among various criticality safety professionals in the DOE Complex. It is the responsibility of the personnel participating in the message board to provide accurate and meaningful dialogue to enhance communication process.



別添資料8　Nuclear Criticality Self-Improvement Initiative

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The Deputy Secretary of Energy
Washington, DC 20585

November 3, 1999

MEMORANDUM FOR: HEADS OF DEPARTMENTAL ELEMENTS

FROM: T. J. GLAUTHIER

SUBJECT: NUCLEAR CRITICALITY SELF-IMPROVEMENT INITIATIVE

The purpose of this memorandum is to direct a series of actions we will take over the next several months to strengthen the Department's ongoing nuclear-criticality safety programs and identify and make any necessary improvements in the management of fissile materials at our sites to ensure that we maintain appropriate nuclear criticality controls. These actions have been developed with the Under Secretary, Dr. Ernest Moniz, and other senior members of the Department and are essential to maintaining a workplace that is safe for our workers and protective of the public's health.

Over the lost several years, the Department has worked on several key initiatives associated with the criticality safety programs at our sites. These initiatives include stabilizing at-risk fissile materials for safe long-term storage; enhancing the analytical underpinnings of our criticality safety programs (e.g., by performing relevant critical experiments and other activities that enhance the numerical processing codes used in criticality safety analyses); developing mechanisms to attract, maintain, and retain qualified criticality safety professionals within the Federal and contractor workforces; and ensuring adequate criticality safety training facilities for criticality safety practitioners, Details of these initiatives and the actions underway are provided in the Department's Implementation Plans in response to Defense Nuclear Facilities Safety Board Recommendations 97-2, 94-1, and 97-1.

This past August, the Department also launched a nuclear criticality self-improvement initiative through a conference for senior Federal and contractor managers. This conference resulted in the identification of a series of specific, additional actions needed to strengthen out criticality safety programs.

In addition, in September we took another important step to improve the Department's management of fissile materials with the formation of the Nuclear Materials Council. The Council, chaired by the Under Secretary will guide the development of an integrated nuclear-materials management plan. The plan will be completed by March 2000 and will include an assessment of fissile material stabilization programs and identify opportunities for better integrating criticality expertise into our operations.

To support these initiatives, particularly in light of the recent criticality event in Japan, I am directing program and field offices and the Office of Environment, Safety and Health (EH) to

take the following steps to assess the adequacy of our nuclear criticality safety programs at our site and to identify and implement, where needed, enhancements to these programs.

Review of Key Facilities. A team of criticality safety experts from **Headquarters,** Federal staff from the field elements, and independent experts -- and led by the Office of Environment, Safety and Health -- will **work** collaboratively with field elements to conduct a high-level assessment of the operational criticality safety aspects of several key facilities in the Department, listed in order of priority: Oak Ridge Y- 12 plant; Los Alamos National Laboratory building PF-4 at TA-55; Savannah River Site FB-Line facility and H-Area exterior tank storage; the Hanford Plutonium Finishing Plant; and Rocky Flats Building 371.

The anticipated scope of the review is contained in Attachment 1. Within 90 days, the team will complete the review with relevant field elements and forward a report to Secretary Richardson that includes a summary of the results of this review -- including an identification of any immediate problems and related collective actions and an assessment of whether the operations and criticality safety risks at these facilities are well understood, analyzed, and controlled.

The results of these assessments also will be used by the Nuclear Materials Council in developing the Department's framework for long-term fissile materials stewardship.

2. Self-Assessments. On a broader basis and within 120 days, DOE field elements will complete self-assessment(s) for all facilities and operations involving fissile materials, using the criteria contained in Attachment 2. In addition, the Department's operating contractors also should be directed by appropriate field elements to conduct self-assessments using the criteria provided in Attachment 3.

The self-assessments will evaluate adequacy of procedures, procedural adherence; adequacy of criticality safety training, including training and qualification of criticality safety practitioners. The assessments also will include staffing analyses to ensure the short-term and 5-year adequacy of staffing for criticality safety professionals at the Federal and contractor levels at our sites.

Although an emphasis of the self-assessments is on the operational aspects of criticality safety, training and qualifications, the assessments should determine whether normal and accident conditions represented by the facilities/operations have been adequately considered and properly analyzed.

Deficiencies identified through these assessments -- and any deficiencies identified in the review of key facilities described above -- that cannot be corrected immediately, will require an accompanying corrective action plan (in accordance with the Department's Implementation Plan for the Defense Nuclear Facilities Safety Board Recommendation 98-1). Corrective actions plans, including plans to increase or change staffing, should specifically identify the actions planned, the affected facility(ies), schedule, and cost considerations, including potential sources or offsets for funding. Ensuring the safety of our sites clearly must take priority over other work.

These assessments must be performed by qualified criticality safety professionals. The Department's Criticality Safety Support Group should be consulted to identify qualified technical resources for these assessments. In addition, expertise represented on the Criticality Safety Support Group should be considered a technical resource for these assessments.

The results of the assessments, including any associated corrective actions, should be reported to the respective Program Secretarial Office, with a copy to the Office of Environment, Safety and Health. Within 30 days of receipt from the field, programs should review these materials, resolve comments with the field elements, and submit the reports to the Office of Environment, Safety and Health, indicating whether there are any outstanding issues that require resolution. The Office of Environment, Safety and Health will report regularly to me and the Under Secretary on the status of these reviews and corrective action plans.

3. EH Analysis of Results. Based on the submittals provided by the Program Secretarial Offices, the Office of Environment, Safety and Health will analyze the results and identify what field investigations will be performed by EH. These investigations will include a review of conduct of operations, a walk-down of work areas, and interviews with workers to assess worker knowledge of criticality risks and controls, Additionally, the EH analysis will evaluate the recommended Federal and contractor criticality safety resource needs across the complex.

Within 120 days of receiving these submittals, EH will provide a report to Secretary Richardson on the overall adequacy of the Department's criticality safety programs, including any additional general actions needed or significant open issues requiring senior management attention.

4. **Performance Metrics,** Within 120 days, DOE field elements should develop performance metrics that are specific to nuclear criticality safety at their sites that could be incorporated into the contract in subsequent contract modifications. Metrics should be tailored to meet the specifics of the site and contract. The metrics should be submitted to the Program Secretarial Offices for review, with subsequent transmittal to EH within 45 days of receipt.

5. **Options Study for Los Alamos Critical Experiments Facility.** A team will perform an options study Over the next 6 months on options for relocating the Critical Experiments Facility at Los Alamos TA -18, including whether to move to an existing facility at another site, or whether and where to construct a new facility, in order to maintain the Department's criticality safety experimental capability and the requisite training facilities for criticality safety practitioners. The team will include the Office of Defense Programs in a key role, and representation from the Offices of Nonproliferation and National Security, Security and Emergency Operations; Environmental Management; Science; Nuclear Energy; and Environment, Safety and Health. Members of the Department's Criticality Safety Support Group also will participate in the

effort, and will review and provide comments on the results of the options study.

This study will consider security, safety, and health aspects of each or the options as well as the cost and schedules for design, modification/ construction, operation of existing, replacement, or new facilities. The study should result in a recommendation to the Secretary, supported by a proposed transition plan that would ensure continuity of training and the retention of critical staff to manage and operate these facilities.

We look forward to the results of these efforts - and to working with you to strengthen our criticality safety programs. Thank you for your cooperation on this very important issue.

Attachments

SELF-ASSESSMENT FOR DOE CRITICALITY SAFETY PROGRAMS



OFFICE OF NUCLEAR AND FACILITY SAFETY, EH-3
OFFICE OF ENVIRONMENT, SAFETY AND HEALTH

U.S. DEPARTMENT OF ENERGY

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I. SCOPE

The Department of Energy (DOE) issued DOE P 450.5, *Line Environment, Safety and Health Oversight*, to set forth its expectations for line management environment, safety and health (ES&H) oversight. DOE line oversight and contractor self-assessments together ensure that field elements and contractors adequately implement the DOE Safety Management System. Both DOE and contractor line managers must acquire and maintain sufficient knowledge of program activities in order to make informed decisions on safety resources for these activities. The Department's line organizations have the following responsibilities:

A. Develop ES&H performance objectives, measures, and expectations tied to DOE's strategic goals and objectives, as well as to performance goals and objectives of the Safety Management System elements.
B. Develop contract performance measures and performance indicators that are linked to the DOE Safety Management System.
C. Develop a high level of performance assurance that results in improved ES&H performance.

II. PURPOSE

The purpose of this document is to provide an assessment tool to evaluate the elements of the DOE nuclear criticality safety (NCS) oversight program. The requirements are based on the criteria outlined in DOE P 450.5.

III. ASSESSMENT REQUIREMENTS

A. DOE LINE ENVIRONMENT, SAFETY AND HEALTH OVERSIGHT

Criteria for the review of DOE criticality safety programs were extracted from DOE P 450.5, *Line Environment, Safety and Health Oversight.*

Criterion: Elements of the DOE Criticality Safety Program must be documented.

a. Are the responsibilities of the DOE NCS Program Manager clearly defined and understood?
b. Are the elements of a DOE NCS surveillance plan documented?

Criterion: DOE must acquire and maintain sufficient knowledge of program activities in order to make informed decisions on criticality safety resources for these activities.

a. Are routine meetings held with contractor NCS management?
b. Are periodic meetings held with DOE contractor operations management?
c. Does the DOE NCS Program Manager review budget requests made by contractor NCS management?
d. Does the DOE NCS Program Manager review budget requests made by contractor operations management?

e. Does the DOE NCS Program Manager have input to the DOE site budget process?

Criterion: DOE maintains operational awareness of contractor work activities, typically through DOE line managers and staff such as Facility Representatives and criticality safety subject matter experts.

a. Do the DOE NCS Program Manager and Facility Representatives work closely on NCS-related issues in the field?
b. Does the DOE NCS Program Manager routinely spend time in the field performing walkdowns and interacting with Operations?
c. Does the DOE NCS Program Manager review contractor occurrence reports related to criticality safety programs?

Criterion: DOE reviews performance against formally established criticality safety performance measures, performance indicators, and contractor self-assessments.

a. Have contractor NCS program performance measures been established? See Appendix A for examples.
b. Is progress on the performance measures routinely reported to DOE?
c. Are contractor NCS self-assessments reviewed by the DOE NCS Program Manager?
d. Does the NCS Program Manager provide reports and feedback on contractor self-assessments to senior DOE site management?

Criterion: DOE performs criticality safety reviews and assessments in support of required readiness assessments, Operational Readiness Reviews, Safety Management System documentation and onsite verification reviews, and authorization basis documents including Criticality Safety Evaluations (CSEs).

a. Does the DOE NCS Program Manager participate in readiness assessments, Operational Readiness Reviews, and Integrated Safety Management reviews when necessary?
b. Does the DOE NCS Program Manager participate in the review and approval of facility NCS-related authorization basis documents (e.g., Safety Analysis Reports, Bases for Interim Operations, Unresolved Safety Questions, and Technical Safety Reports)?
c. Does the DOE NCS Program Manager review a sample of contractor CSEs on a routine basis?

Criterion: DOE performs periodic appraisals of the contractor criticality safety program, including for-cause criticality safety reviews, as necessary.

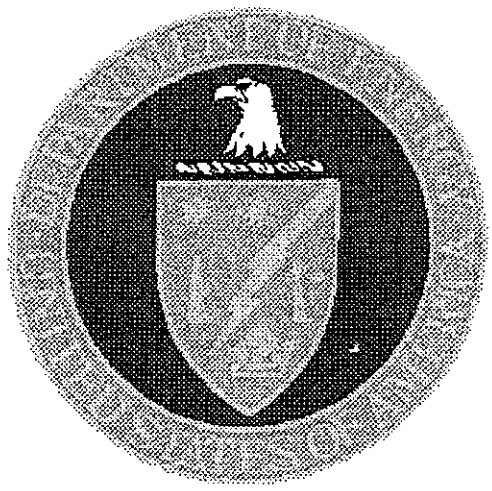
a. Have facility criticality safety surveillances been incorporated into the Field Office assessment plan?
b. Are appraisals and reviews documented?
c. Are corrective actions tracked to closure?
d. Does the DOE NCS Program Manager perform assessments of the contractor criticality safety program in accordance with a documented plan?

e. Are outside DOE NCS subject matter experts occasionally utilized to assist with reviews to provide independent feedback?

Criterion: DOE has a designated focal point for coordinating criticality safety oversight activities.

a. Has the DOE Field Office designated a single NCS focal point (i.e., NCS Program Manager)?
b. Has the DOE NCS Program Manager been qualified by completing the requirements in the Federal NCS Qualification Standard?
c. Does the DOE NCS Program Manager routinely meet with an Assistant Field Office Manager responsible for NCS?
d. Does the DOE NCS Program Manager represent the single authority on NCS issues to the contractor?
e. Does the DOE NCS Program Manager represent the Field Office on the Criticality Safety Coordinating Team (CSCT)?

REVIEW PLAN FOR DOE CONTRACTOR CRITICALITY SAFETY PROGRAMS



OFFICE OF NUCLEAR AND FACILITY SAFETY, EH-3
OFFICE OF ENVIRONMENT, SAFETY AND HEALTH
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REVIEW OF DOE CONTRACTOR CRITICALITY SAFETY PROGRAMS

PURPOSE

The purpose of this document is to provide an assessment tool for review of DOE Contractor criticality safety programs. Assessment of elements of this plan will evaluate whether the program meets the requirements of ANSI/ANS-8.19, *Administrative Practices for Nuclear Criticality Safety*, as well as related ANSI/ANS-8 series standards. These standards represent the best practices for criticality safety programs and are mandatory under DOE Orders 5480.24 and its successor 420.1.

SCOPE

This document encompasses all elements of the Contractor criticality safety program at DOE facilities. Criticality safety practices must conform to the expectations of the DOE Orders and the applicable national consensus ANSI/ANS Standards. The effectiveness of the criticality safety program is dependent upon management implementing its roles and responsibilities to integrate criticality safety into work practices as stated below:

An effective nuclear criticality safety program includes cooperation among management, supervision, and the criticality safety staff and relies upon conformance with operating procedures by all employees. (Introduction to ANSI/ANS-8.19)

In May of 1997 the Defense Nuclear Facility Safety Board (Board) issued Recommendation 97-2 dealing with criticality safety. Among the nine specific recommendations made were: 1) the need for DOE Sites to maintain a formally trained and qualified nuclear criticality safety staff including hands on experience at critical mass laboratories; 2) the use of simplified bounding methods of setting subcritical limits with priority given to existing experimental data; 3) line management ownership of criticality safety; and, 4) the formation of a core group of criticality safety experts available to assist the DOE with criticality safety related issues.

The applicable DOE Order for criticality safety is 5480.24 or DOE Order 420.1 as stated in the facility contract. Both mandate compliance with certain ANSI/ANS Standards for criticality safety. The assessment areas presented in this plan were drawn from the mandatory Standard, ANSI/ANS-8.19, *Administrative Practices for Nuclear Criticality Safety*, and are categorized as follows:

- Management Responsibilities - Management demonstrates ownership and participation in the criticality safety program; authorities and responsibilities are defined, understood and implemented; management provides a nuclear criticality safety staff that is competent in the physics of criticality and associated safety practices as well as familiar with fissile material

operations; management ensures that the nuclear criticality safety staff is independent of line management to the extent practicable; management assigns responsibility for criticality safety in a manner consistent with other safety disciplines; and, management establishes means of monitoring the criticality safety program and obtains feedback on the overall effectiveness of the program.

- Supervisory Responsibilities - Line supervision accepts responsibility for the criticality safety of their operations; supervisors understand the controls, contingencies, and criticality safety basis for operations under their control; classroom and job-specific training in criticality safety is provided to personnel; procedures govern all work and there are effective change control and configuration control mechanisms; supervisors verify compliance with criticality safety specifications before authorizing work; and supervisors require conformance with good safety practices, good housekeeping, and unambiguous identification of fissile materials.

- Nuclear Criticality Safety Staff Responsibilities - The nuclear criticality safety staff is comprised of specialists skilled in the techniques of nuclear criticality safety assessment and familiar with plant operations while, to the extent practicable, administratively independent of line management; the staff provides technical guidance for design of equipment, processes, and procedures; the staff reviews modifications to equipment, process, and procedures involving fissile material; the staff maintains familiarity with criticality codes, guides, standards, and best practices; the staff is interactive, both internally and externally having access to criticality safety professionals to provide assistance as needed; the staff understands the physics of criticality and makes use of experimental data, handbook data, and bounding methods where applicable; the staff participates in training personnel; the staff participates in audits of operations; and the staff examines reports of procedural violations and criticality infractions and recommends improvements in safety practices to management.

- Operating Procedures - Procedures are written and organized to facilitate operator use and understanding; procedures contain criticality controls; mechanisms are in place to facilitate revising and improving procedures on a periodic basis; new or revised procedures involving fissile material are reviewed by the nuclear criticality safety staff; procedures are supplemented by postings; postings are easily visible, understood by operators and contain clear, and contain all criticality controls implemented by the operator; deviations from procedures and processes and criticality infractions are investigated promptly, documented, reported to management, categorized according to approved procedures, and actions are identified to prevent recurrence; criticality infractions are resolved in a timely manner; and, operations are reviewed frequently (at least annually) to assure that processes and procedures have not been altered in a way so as to affect the applicable nuclear criticality safety evaluation.

- Process Evaluation for Nuclear Criticality Safety - All fissile material operations are analyzed to show that the processes will remain subcritical under all normal and credible abnormal conditions; the criticality safety evaluation is documented in a clear unambiguous manner; contingencies and controls are explicitly identified; calculational methods are properly validated; priority is placed on experimental data, handbook values, and bounding methods where applicable; engineered safety features are relied on to provide criticality safety to the

extent practicable; procedures for producing criticality safety evaluations, limits, and postings are used; and criticality safety evaluations are independently peer reviewed before operations are authorized.

- Materials Control - Movement of fissile materials is controlled; fissile material is labeled including mass, chemical form, and isotopic composition; storage areas are posted with applicable criticality safety limits; methods are established to monitor the presence and effectiveness of credited neutron absorbers; access to fissile material handling areas is controlled and fissile material handler qualification verified; and, control of spacing, mass, density and geometry of fissile material is maintained to assure subcriticality under all normal and credible abnormal conditions.

- Planned Response to Nuclear Criticality Accidents - Criticality accident detectors are capable of detecting the minimum accident of concern; the criticality accident alarm system (CAAS) is designed in such a way as to minimize false alarms; detector placement criteria for all permanent and temporary detectors is documented; a configuration management system is in place to assure the ongoing functionality of the CAAS; the CAAS can alarm all areas of the facility by either audible or visible means; emergency response procedures for criticality accidents are in place; personnel are trained in evacuation procedures; evacuation routes and assembly points are identified; procedures for accounting for personnel are in place; criticality accident drills are conducted at least annually and are as realistic as practicable; advance arrangements are in place for the treatment of exposed and contaminated individuals; radiation monitoring equipment is available to response personnel; radiation monitoring personnel are trained; and, emergency procedures address re-entry of facilities and the membership of re-entry teams.

ASSESSMENT REQUIREMENTS

The following elements should be contained in an facility assessment activity at least once during a three year period. The Assessor should establish appropriate lines of inquiry and may use the ones suggested below or may generate his/her own for a given assessment activity.

1.0 MANAGEMENT RESPONSIBILITIES

Criteria: Management shall accept overall responsibility for safety of operations. Continuing interest in safety should be evident. (ANSI/ANS-8.19, Section 4.1)

- Does the Contractor Facility Management demonstrate continuing interest in criticality safety as evidenced by conducting safety meetings, issuing safety bulletins, inspecting facilities on a regular basis, and ensuring continuous improvement in safety?
- Does the Contractor Facility Management demonstrate continuing interest in criticality safety as evidenced by regular meetings with the criticality safety engineers and the Nuclear Criticality Safety (NCS) manager?
- Does the Contractor Program Management regularly meet with the NCS manager?

CRITICALITY SAFETY PROGRAM REVIEW PLAN

Criteria: Management shall formulate nuclear criticality safety policy and make it known to all employees involved in operations with fissile material. (ANSI/ANS-8.19, Section 4.2)

- Does the Contractor have a written criticality safety policy?
- Are all fissile material handlers and their supervisors familiar with the criticality safety policy?
- How is compliance to the Contractor criticality safety policy required of all program personnel performing work?

Criteria: Management shall assign responsibility and delegate commensurate authority to implement established policy. Responsibility for nuclear criticality safety should be assigned in a manner compatible with that for other safety disciplines. (ANSI/ANS-8.19, Section 4.3)

- Are the roles and responsibilities of the Criticality Safety Engineers (CSEs) documented?
- Are the roles and responsibilities of the NCS Manager and Organization documented?
- Are the roles and responsibilities of the Criticality Safety Officers (CSOs) documented, if applicable?
- Is there a clear distinction between the roles of the CSO and the CSE?
- Is line management assigned responsibility for criticality safety?
- Has the Contractor assigned responsibility for oversight of the NCS program?

Criteria: Management shall provide personnel familiar with the physics of nuclear criticality and with associated safety practices to furnish technical guidance appropriate to the scope of operations. This function should, to the extent practicable, be administratively independent of operations. (ANSI/ANS-8.19, Section 4.4)

- Does the Contractor have sufficient funding to assure continuous support by NCS Staff?
- Does the Contractor management provide discretionary funding to the NCS manager to provide training and professional development for the NCS staff, to address laboratory wide issues, to maintain the NCS program documentation, and to ensure that criticality safety codes and platforms are verified and validated?
- Does the NCS Staff have unilateral, unscheduled access to the facility and operations personnel?
- Does the Contractor have a plan or policy to assure the NCS Staff is familiar with fissile operations? Does the Contractor issue requirements for the qualification and training of NCS Staff, including subcontractors?
- Is the Contractor NCS Staff administratively independent of operations?
- Do all members of the NCS Staff have technical degrees in physics or nuclear engineering?

Criteria: Management shall establish a means for monitoring the nuclear criticality safety program. (ANSI/ANS-8.19, Section 4.5)

- Who is responsible for monitoring the criticality safety program?
- Are all deficiencies related to criticality safety entered in a corrective action tracking system?
- Are mechanisms in place to validate closure of all criticality safety related deficiencies?
- Does line program management maintain awareness of criticality safety deficiencies through the use of a corrective action tracking system?
- Is there a program or procedure for trending deficiencies in the criticality safety program?
- Does the Contractor perform assessments of compliance to operating procedures?
- Does the Contractor assess implementation of conduct of operations?
- How are NCS funding levels proposed and approved?
- How does the Contractor management determine that funding for NCS is sufficient and is there a mechanism for adjusting the funding during the fiscal year?

CRITICALITY SAFETY PROGRAM REVIEW PLAN

Criteria: Management shall periodically participate in auditing the overall effectiveness of the nuclear criticality safety program. (ANSI/ANS-8.19, Section 4.6)

- Does the Contractor management participate in review teams or committees to assess facility criticality safety programs?
- Does the Contractor program management routinely audit operations for compliance to criticality safety requirements?
- Does the Contractor facility management routinely audit operations for compliance to criticality safety requirements?
- Does the Contractor perform NCS management self-assessments of their criticality safety staff and program?

Criteria: Management may use consultants and nuclear criticality safety committees in achieving the objectives of the nuclear criticality safety program. (ANSI/ANS-8.19, Section 4.7)

- Does management utilize a nuclear criticality safety committee to assist in monitoring and improving the criticality safety program?
- If nuclear criticality safety committees are used, do they report directly to the Senior Management? Are the findings from the nuclear criticality safety committee, or equivalent, entered into a tracking database and corrective actions implemented?
- Are outside consultants utilized to provide an independent viewpoint on the overall criticality safety program?

2.0 SUPERVISORY RESPONSIBILITIES

Criteria: Each supervisor shall accept responsibility for the safety of operations under his control. (ANSI/ANS-8.19, Section 5.1)

- Line program supervisors accept responsibility for criticality safety of their operations. Is ownership demonstrated by the following: 1) approving criticality safety postings; 2) reviewing and approving criticality controls in procedures; 3) participating in the development of criticality safety evaluations; 4) participating in the development of credible process upsets for the NCS staff to consider; and 5) approving criticality safety evaluations for operations?

Criteria: Each supervisor shall be knowledgeable in those aspects of nuclear criticality safety relevant to operations under his control. Training and assistance should be obtained from the nuclear criticality safety staff. (ANSI/ANS-8.19, Section 5.2)

- Does line program supervisors formally review credible process upsets and criticality accident scenarios analyzed by the NCS staff during development of the CSE?
- Do line program supervisors understand the underlying assumptions in CSEs which involve configuration of equipment, facility modifications, isotopic composition, etc.?
- Is the Nuclear Criticality Safety Staff requested to provide NCS training to line program supervisors?
- Does line program supervision know the safety basis for the criticality controls for their operations?
- Does the NCS staff provide advice and assistance to line program management regarding implementation of NCS controls?

Criteria: Each supervisor shall provide training and shall require that the personnel under his supervision have an understanding of procedures and safety considerations such that they may be expected to perform their functions without undue risk. Records of training activities and verification of personnel understanding shall be maintained. (ANSI/ANS-8.19, Section 5.3)

CRITICALITY SAFETY PROGRAM REVIEW PLAN

At a minimum, operators receive criticality safety training in accordance with ANSI/ANS-8.20, "Nuclear Criticality Safety Training."

- Do supervisors provide job specific training on procedures?
- Are walkthroughs and dry-runs on procedures provided?
- Do pre-job briefs cover criticality controls specific to the operations at hand?
- Do plan-of-the-day meetings address criticality safety related topics like work restrictions due to criticality safety infractions, availability of new procedures and postings, need for NCS Staff participation, results of recent criticality safety assessments/surveillances, etc?
- Do supervisors maintain training records for their personnel?
- Do supervisors ensure that their personnel are current in criticality safety classroom training?
- Are there required reading records or other evidence that personnel are knowledgeable of changes to procedures, and criticality safety postings?
- Can supervisors and operators answer questions about the basic criticality controls for their operations?
- Can supervisors generally describe the contingencies and controls for the contingencies for their operations including credited engineered features and key facility assumptions, if any?
- Do supervisors ensure that personnel have demonstrated an understanding of modified or revised procedures, and criticality safety postings prior to authorizing work?
- Are there records of job specific training on procedures and criticality safety postings?
- Do supervisors request assistance from the Nuclear Criticality Safety Staff to provide training for operations personnel?
- Do firefighters receive criticality safety training?
- Are firefighters aware of any moderator-controlled areas or processes?

Criteria: Supervisors shall develop or participate in the development of written procedures applicable to the operations under their control. Maintenance of these procedures to reflect changes in operation shall be a continuing supervisory responsibility. (ANSI/ANS-8.19, Section 5.4)

- Are all fissile material handling operations performed according to approved procedures?
- Are operations personnel or supervision involved in developing procedures?
- Is there a mechanism to assure that only current, approved procedures, CSEs, and postings are used for operations?
- How does the line program supervisor know when to authorize work after all NCS requirements have been met after modifications to the existing set of controls/procedures?
- Does a clear, unambiguous link between the CSE, procedure and posting exist such that it is traceable from floor level documentation?
- Is there a mechanism to ensure that OSR related controls and requirements in procedures or postings are not changed without proper analysis and approval?
- Are Unreviewed Safety Question Determinations (USQD) performed for all procedure modifications?

Criteria: Supervisors shall verify compliance with nuclear criticality safety specifications for new or modified equipment before its use. Verification may be based on inspection reports or other features of the quality control system. (ANSI/ANS-8.19, Section 5.5)

- Are there procedures or mechanisms in place and effective to ensure that modifications to equipment and/or processes results in a review of the applicable CSEs-procedure-posting set prior to implementing the modification?

- Are there documented surveillances or methods that ensure that new or modified operations conform to applicable CSEs-procedures-postings?
- Is there a process for ensuring that no new or modified operation is started until all applicable verification steps have been performed which includes presence of approved CSEs, postings, procedures and that no criticality infraction will result from startup?

Criteria: Each supervisor shall require conformance with good safety practices including unambiguous identification of fissile materials and good housekeeping. (ANSI/ANS-8.19, Section 5.6)

- Are stored, empty containers labeled as such?
- Are gloveboxes with criticality drains free of loose debris which could potentially clog the drain?
- Is fissile material stored in approved containers?
- Prior to beginning work at a workstation, is there a procedure to verify compliance with criticality safety requirements?
- Is there evidence of fissile material holdup or filings in gloveboxes?
- Are criticality drain liquid traps monitored for adequate liquid levels periodically?

3.0 NUCLEAR CRITICALITY SAFETY STAFF RESPONSIBILITIES

Criteria: The nuclear criticality safety staff shall provide technical guidance for the design of equipment and processes and for the development of operating procedures. (ANSI/ANS-8.19, Section 6.1)

- Does the NCS Staff provide design input for all new or modified equipment?
- Does the NCS Staff review all operating procedures involving fissile materials?
- Does the NCS Staff review and concur on final equipment and process designs?

Criteria: The staff shall maintain familiarity with current developments in nuclear criticality safety standards, guides, and codes. Knowledge of current nuclear criticality information should be maintained. (ANSI/ANS-8.19, Section 6.2)

- Do all members of the Nuclear Criticality Safety Staff understand and know how to properly utilize monte carlo codes (e.g. KENO and MCNP), criticality safety handbooks, critical experiment data, hand-calculations, etc.?
- Does the Nuclear Criticality Safety Staff maintain verified and validated computational techniques for performing criticality safety evaluations for the site?
- Does the Contractor NCS Staff participate in professional development activities such as ANS Standards Committees, Nuclear Criticality Technology Project Workshop, ANS Meetings, LANL/LACEF courses, UNM courses, etc.?
- Is there a training and qualification program for the Contractor NCS Staff? Are all the members of the Contractor NCS Staff qualified?
- Does the NCS Staff have working knowledge of criticality safety related standards, guides, and codes?

Criteria: The staff should consult with knowledgeable individuals to obtain technical assistance as needed. (ANSI/ANS-8.19, Section 6.3)

- Does a synergistic interaction exist among the NCS Staff assigned to specific facilities and the remainder of the Contractor NCS staff?
- Does the NCS Staff consult with offsite criticality safety experts periodically, particularly retirees from the facility?

Criteria: The staff shall maintain familiarity with all operations within the organization requiring nuclear criticality safety controls. (ANSI/ANS-8.19, Section 6.4)

- Does the NCS staff observe fissile material handling and processing operations?
- Are members of the NCS Staff knowledgeable of credible abnormal process upsets applicable to facility operations?
- Does the NCS Staff attend operations planning meetings for new or restarted processes?
- Does the NCS Staff have access to and familiarity with fissile material operating procedures?
- Does the NCS Staff attend pre-job briefs and plan-of-the-day meetings?
- Does the NCS Staff maintain familiarity with reports of deviations from expected process conditions even if these deviations do not result in a criticality infraction?

Criteria: The staff shall assist supervision, on request, in training personnel. (ANSI/ANS-8.19, Section 6.5)

- Does the NCS Staff participate in training personnel?
- Is the training documented?
- Does the training provided by the NCS Staff include job specific criticality safety related information?

Criteria: The staff shall conduct or participate in audits of criticality safety practices and compliance with procedures as directed by management. (ANSI/ANS-8.19, Section 6.6)

- Does the NCS Staff participate in periodic audits of operations and procedures?
- Are the results of audits shared among the NCS Staff?
- Are the results of audits reported to appropriate Facility Management?
- Are corrective actions developed for deficiencies?

Criteria: The staff shall examine reports of procedural violations and other deficiencies for possible improvement of safety practices and procedural requirements, and shall report their findings to management. (ANSI/ANS-8.19, Section 6.7)

- Are deficiencies identified by the occurrence of criticality safety infractions reviewed by the NCS Staff?
- Does the NCS Staff formally report findings and recommendations to Facility Management?
- Are lessons learned developed and recommendations to prevent recurrence made to Facility management?
- Are all criticality safety related deficiencies captured in a database and tracked until closure is verified?
- Is there a mechanism for trending criticality safety related deficiencies so that the collective significance of multiple minor incidents can be assessed and corrected?
- Are lessons learned from other facilities reviewed by the NCS Staff for potential application at the facilities?

4.0 OPERATING PROCEDURES

CRITICALITY SAFETY PROGRAM REVIEW PLAN

Criteria: The purpose of operating procedures is to facilitate the safe and efficient conduct of the operation. Procedures should be organized and presented for convenient use by operators. They should be free of extraneous material (ANSI/ANS-8.19, Section 7.1)

- Are criticality controls in procedures clear, concise, free of criticality safety jargon, and easily identifiable?
- Is the criticality safety related information presented in procedures free of unnecessary detail and directly applicable to the job task being performed?
- Do the operators find the criticality safety related instructions easy to understand and follow?

Criteria: Procedures shall include those controls and limits significant to the nuclear criticality safety of the operation. (ANSI/ANS-8.19, Section 7.2)

- Are criticality controls included in operating procedures?
- Are the criticality controls clearly identified as important to safety?
- Is there a clear, unambiguous, link between criticality controls in procedures and their parent CSE?
- Does the Contractor have a formalized process for determining which controls are incorporated in procedures?
- Do pre-fire plans incorporate criticality safety controls?
- Are criticality related instructions in pre-fire plans and firefighting procedures practical under actual conditions of responding to fires?

Criteria: Supplementing and revising procedures as improvements become desirable shall be facilitated. (ANSI/ANS-8.19, Section 7.3)

- Are procedures revised based on lessons learned to reduce occurrence of deviations and infractions?
- Do operators have a feedback process whereby improvements to procedures can be implemented?
- Are adequate resources available to facilitate procedure improvements as they are identified?
- Are procedure revisions timely?
- What change control mechanism is in place that assures only the current, approved procedures are utilized?

Criteria: Active procedures shall be reviewed periodically by supervision. (ANSI/ANS-8.19, Section 7.4)

- Are procedures periodically reviewed?
- Does the NCS Staff periodically participate in reviews of active operating procedures?
- What mechanisms are in place to ensure that all procedures are reviewed as planned?

Criteria: New or revised procedures impacting nuclear criticality safety shall be reviewed by the nuclear criticality safety staff. (ANSI/ANS-8.19, Section 7.5)

- Do new or revised procedures receive review by the NCS Staff?
- Is there a mechanism for resolving conflicting comments the NCS Staff and the other reviewers?

Criteria: Procedures should be supplemented by posted nuclear criticality safety limits or limits incorporated in operating check lists or flow sheets. (ANSI/ANS-8.19, Section 7.6)

- Are criticality safety postings easy to understand by operators?
- Do the postings contain only information controlled by the operator performing the task?

CRITICALITY SAFETY PROGRAM REVIEW PLAN

- Do the postings require any analysis on the part of the operator such as decoding "IF-THEN", "EITHER-OR" type options to select appropriate controls?
- What is the relationship between the controls in the posting and the controls in the procedures?
- Is there a formalized process for determining which controls appear on postings and which appear in procedures?
- What mechanism is in place to ensure that the controls in the posting are consistent with those intended by the parent CSE?
- Are postings easy to read from normal operator positions at the workstation?
- Do operators rely primarily on postings to obtain their criticality safety controls?
- Are all the controls necessary for criticality safety included in postings?
- Is it possible to comply with the requirements of the posting and still incur a criticality safety infraction because additional controls are contained in the procedures?

Criteria: Deviations from operating procedures and unforeseen alterations in process conditions that affect nuclear criticality safety shall be documented, reported to management, and investigated promptly. Action shall be taken to prevent a recurrence. (ANSI/ANS-8.19, Section 7.7)

- How are infractions graded?
- Are the contingencies and barriers for a given operation readily available to the NCS Staff investigating potential infractions?
- Do procedures exist to upgrade the assigned severity level of infractions due to adverse trends?
- Do procedures exist to upgrade the assigned severity level of infractions due to the magnitude of the decrease in the margin of subcriticality?
- Do operators immediately stop work, leave the immediate vicinity, notify supervision, post the area, and contact the NCS Staff promptly when a potential infraction is identified?
- Does the NCS Staff respond to the scene of a potential infraction?
- Are the responsibilities defined for responding to a potential infraction?
- Does the NCS Staff participate in management critiques of infractions, assigning levels of infraction, and developing corrective actions?
- Are infractions resolved promptly and normal operations restarted?
- When the NCS Staff recommends immediate corrective actions to recover from an infraction, are these recommendations made in writing, peer reviewed, and approved by line (Facility or Program) management?
- Are corrective actions stemming from criticality infractions entered into a tracking database and monitored until closure?
- Are minor criticality infractions tracked and trended?
- Are all criticality infractions, regardless of severity, documented?

Criteria: Operations shall be reviewed frequently (at least annually) to ascertain that procedures are being followed and that process conditions have not been altered so as to affect the nuclear criticality safety evaluation. (ANSI/ANS-8.19, Section 7.8)

- Are all operations reviewed at least annually?
- How do annual reviews determine that procedures are being followed?
- Do audits and reviews monitor the configuration of the facility and processes which could adversely affect criticality safety, such as movements of criticality detectors, installation of new equipment, inoperable emergency enunciators, etc.?
- Do personnel with NCS experience and knowledge of the operations perform the reviews?
- Do the reviews examine CSEs do verify that changes to the process have not compromised criticality safety?
- Are the results of the review reported to senior management as well as Facility and Program Management?
- Are deficiencies and proposed corrective actions documented and tracked to closure?

- Are procedures in place that verify that changes to process equipment over time have not degraded compliance with criticality safety controls?
- Do annual reviews of operations look at all the elements of the criticality safety program affecting operations?

5.0 PROCESS EVALUATION FOR NUCLEAR CRITICALITY SAFETY

Criteria: Before starting a new operation with fissile materials or before an existing operation is changed, it shall be determined that the entire process will be subcritical under both normal and credible abnormal conditions. (ANSI/ANS-8.19, Section 8.1)

Criticality safety evaluations shall conform to the requirements of ANSI/ANS-8.1, "Nuclear Criticality Safety in Operation with Fissionable Material Outside Reactors."

- Are natural phenomena hazards, especially seismic, considered in developing accident scenarios?
- Are firefighting scenarios considered (i.e. addition of moderator, displacement of fissile material in water streams, etc.)?
- Do the contingencies credited represent events that are at least unlikely and incorporate lessons learned from previous process upsets and infraction of NCS limits?
- Are the contingencies to be evaluated jointly developed by the NCS staff, responsible operations personnel, and responsible support engineering organization?
- Are all credible process upsets considered and either controlled or dispositioned appropriately?
- Are the criticality safety evaluations performed in a timely fashion?
- Do formalized procedures exist for generating criticality safety evaluations?
- Does staff familiar with the facility and operations under consideration perform the criticality safety evaluations?
- Does the NCS Staff take full advantage of simplifying methods, bounding calculations, critical experiment data, handbook data, etc. where appropriate to minimize dependence upon monte carlo techniques?
- Does the NCS Staff have access to archived criticality safety evaluations as reference?
- Do criteria and procedures exist to determine the magnitude of process change which can be implemented without revising the criticality safety evaluation?
- Does the NCS Staff work as a team with operations to develop credible accident scenarios and controls?

Criteria: The nuclear criticality safety evaluation shall determine and explicitly identify the controlled parameters and their associated limits upon which nuclear criticality safety depends. (ANSI/ANS-8.19, Section 8.2)

- Are controls developed in the criticality safety evaluation for each contingency?
- Are controlled parameters, contingencies, and credited barriers explicitly documented?
- Does the criticality safety evaluation identify those controls that are to be included in procedures and those that should be included in postings?

Criteria: The nuclear criticality safety evaluation shall be documented with sufficient detail, clarity, and lack of ambiguity to allow independent judgment of results. (ANSI/ANS-8.19, Section 8.3)

- Do the criticality safety evaluations conform to DOE-STD-3007-93, *Guidelines for Preparing Criticality Safety Evaluations at Department of Energy Non-Reactor Nuclear Facilities*?
- Do the CSEs contain a system/process description with enough detail for an independent reviewer to understand the system/process sufficiently to judge the results of the criticality safety analysis?

- Is there a change control and document control system in place for criticality safety evaluations?
- Are internal memoranda used to communicate limits and controls in place of formal evaluations?
- Are temporary limits and evaluations (i.e. those that expire after a specified period) used?
- Are all assumptions fully documented in the criticality safety evaluation?
- Can the criticality safety evaluation be read and understood by the line supervision?

Criteria: Before starting operation, there shall be an independent assessment that confirms the adequacy of the nuclear criticality safety evaluation. (ANSI/ANS-8.19, Section 8.4)

- Do all criticality safety evaluations receive and independent technical peer review before approval for use?
- Is there a process for confirming that all credited engineered features of a system or process are in place and meet the specifications anticipated by the evaluation prior to starting operations?

6.0 MATERIALS CONTROL

Criteria: The movement of fissile materials shall be controlled. (ANSI/ANS-8.19, Section 9.1)

- Are procedures in place to control the movement of fissile material between material balance areas?
- Are procedures in place to control movement of fissile material within a single material balance area?
- Are procedures in place to control transfers of fissile material out of the facility?
- Do the procedures have requirements to verify compliance with criticality safety limits at the shipping and receiving points of the transfer prior to performing the movement?
- Are material balance checksheets or equivalents used to maintain a running log of fissile mass contained in gloveboxes, storage arrays, etc.?

Criteria: Appropriate material labeling and area posting shall be maintained specifying material identification and all limits on parameters that are subject to procedural control. (ANSI/ANS-8.19, Section 9.2)

- Do fissile material labels contain all the information necessary to determine compliance to applicable NCS controls such as fissile mass, cladding, moderators, chemical form, shape, isotopic composition, etc.?
- Are all fissile material storage areas posted as such with criticality controls clearly identified?
- Can the mass and location of all fissile materials in a glovebox be determined by inspection of logs posted on the glovebox?

Criteria: If reliance is placed on neutron absorbing materials that are incorporated into process materials or equipment, control shall be exercised to maintain their continued presence with the intended distributions and concentrations. (ANSI/ANS-8.19, Section 9.3)

Any use of borosilicate raschig rings shall conform to the requirements of ANSI/ANS-8.5, "Use of Borosilcate-Glass Raschig Rings as a Neutron Absorber in Solutions of Fissile Material."

- Are any processes dependent upon the presence of fixed neutron absorbers?
- Are controls in place to monitor the continued effectiveness of credited neutron absorbers?
- Are any soluble neutron absorbers credited?
- If soluble neutron absorbers are credited, are procedures in place to ensure they remain in their intended distribution and concentration?

- Are practices dealing with fixed neutron absorbers generally consistent with ANSI/ANS-8.21, *Use of Fixed Neutron Absorbers in Nuclear Facilities Outside Reactors?"*

Criteria: Access to areas where fissile material is handled, processed, or stored shall be controlled. (ANSI/ANS-8.19, Section 9.4)

- Is access to fissile material handling areas controlled such that only trained, qualified, and authorized personnel can handle fissile material?
- Does facility management verify the qualification of fissile material handlers prior to authorizing work?

Criteria: Control of spacing, mass, density, and geometry of fissile material shall be maintained to assure subcriticality under all normal and credible abnormal conditions. (ANSI/ANS-8.19, Section 9.5)

Are fissile material storage areas in conformance with the requirements of ANSI/ANS-8.7, "Guide for Nuclear Criticality Safety in the Storage of Fissile Materials" where applicable?

- Are containers of residue and product fissile material stored in fixed arrays or have engineered spacers attached?
- When administrative spacing controls are used, has the criticality safety evaluation demonstrated that the system will remain subcritical in a seismic event?
- Are administrative spacing controls credited as unlikely events in criticality safety evaluations?
- Where engineered features are credited for criticality control, are inspections conducted to verify they are capable of performing the intended function?
- For solution storage areas are procedures in place to detect concentration and stratification changes in the solution?
- Are fissile solutions periodically monitored for changes in pH?
- Do double-block-and-bleed valve arrangements, or equivalent, where the addition of fissile material is prohibited, protect isolated, inactive fissile solution storage tanks?
- Has the criticality safety evaluation determined that all storage vaults, gloveboxes, and solution storage arrays will remain subcritical under the same design conditions the building /structure is designed to withstand (seismic events, flooding, high winds, etc.)?
- Does fissile material holdup in process vessels, gloveboxes, the HVAC, and other accumulation points present a credible criticality accident scenario?
- Is holdup of fissile material monitored and controlled?
- Will fissile material remain subcritical under credible firefighting scenarios?

7.0 PLANNED RESPONSE TO NUCLEAR CRITICALITY ACCIDENTS

Criteria: Guidance for the installation of nuclear criticality accident alarm systems may be obtained from the American National Standard Criticality Accident Alarm System, ANSI/ANS-8.3-1979[2]. Evacuation signals are addressed in the American National Standard Immediate Evacuation Signal for Use in Industrial Installations. ANSI/ANS-N2.3-1979[3]. (ANSI/ANS-8.19, Section 10.1)

- Is there a policy for how criticality accident alarm systems are evaluated and approved?
- Does documentation exist to demonstrate that the installed criticality detectors can detect the minimum accident of concern?
- Does documentation exist to show that existing criticality detector coverage provides the necessary redundancy and detection thresholds?

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- Is there one group responsible for analyzing criticality detector locations?
- Is there a procedure that governs the evaluation of criticality detector locations?

- Is there a documented analysis showing that the criticality alarm is audible at all occupied locations subject to an expected dose of 12 read in free air?
- Is there documentation that the audible alarm signal requirements of ANSI/ANS-8.3 are satisfied?
- Where audible alarms do not satisfy ANSI/ANS-8.3 signal requirements, are beacons present and visible?
- Is the criticality accident alarm system designed to minimize false alarms?
- Is there an organization responsible for the design, maintenance and testing of criticality accident alarm system hardware?
- Is testing and maintenance of criticality accident alarm systems performed to approved procedures?
- When portable, temporary alarms are used do they meet the requirements of ANSI/ANS-8.3?
- Before portable, temporary alarms are used is there an analysis to demonstrate that the detectors will alarm if the minimum accident of concern occurs?

Criteria: Emergency procedures shall be prepared and approved by management. Organizations, on and off-site, that are expected to provide assistance during emergencies shall be informed of conditions that might be encountered. They should be assisted in preparing suitable emergency response procedures. (ANSI/ANS-8.19, Section 10.2)

- Are emergency procedures available and approved?
- Do offsite organizations participate in emergency exercises for criticality scenarios?
- Do offsite organizations required to respond in the event of a criticality accident have emergency response procedures?
- Does the NCS Staff have a role in responding to criticality accidents?
- Are procedures in place to provide estimates of source terms and fission estimates in the event of a criticality accident?
- Are offsite responders aware of the plant conditions that might be encountered in the event of a criticality accident?

Criteria: Emergency procedures shall clearly designate evacuation routes. Evacuation should follow the quickest and most direct routes practicable. These routes shall be clearly identified and should avoid recognized areas of higher risk. (ANSI/ANS-8.19, Section 10.3)

- Do emergency procedures designate evacuation routes?
- Are evacuation routes identified and avoid areas of higher risk?

Criteria: Personnel assembly stations, outside the areas to be evacuated, shall be designated. Means to account for personnel shall be established. (ANSI/ANS-8.19, Section 10.4)

- Are personnel assembly stations clearly identified?
- Have the designated assembly areas been analyzed in advance to minimize radiation exposures from a criticality accident?
- Do procedures exist to account for all facility personnel, including visitors, in the event of an evacuation?

Criteria: Personnel in the area to be evacuated shall be trained in evacuation methods and informed of routes and assembly stations. Provision shall be made for the evacuation of transient personnel. Drills shall be performed at least annually to maintain familiarity with the emergency procedures. Drills shall be announced in advance. (ANSI/ANS-8.19, Section 10.5)

- Are personnel trained to evacuate by the quickest and most direct route?
- Do personnel know where they are to assemble?
- Are criticality drills performed at least annually?
- Are annual criticality drills an OSR requirement?
- Does the alarm tone for a drill mimic the alarm that will be heard in a real accident?
- Are personnel pre-staged for criticality alarm drills or are they at their normal work locations?
- Do multiple buildings participate in criticality alarm drills?
- Will more than one facility go into alarm if a criticality accident occurs?
- Are facility visitors indoctrinated in proper evacuation procedures?
- Is an emergency command center established for criticality accident drills?

Criteria: Arrangements shall be made in advance for the care and treatment of injured and exposed persons. The possibility of personnel contamination by radioactive materials shall be considered. (ANSI/ANS-8.19, Section 10.6)

- Are procedures in place to care for injured and exposed personnel?
- Are area hospitals equipped and trained to handle personnel with extreme radiation exposures?
- Are procedures in place to deal with contaminated personnel?

Criteria: Planning shall include a program for the immediate identification of exposed individuals and should include personnel dosimetry. Guidance for dosimetry may be found in American National Standard Dosimetry for Criticality Accidents, N13.3-1969 (R 1981) [4]. (ANSI/ANS-8.19, Section 10.7)

- Do radiation monitoring personnel participate in criticality drills?
- Do radiation monitoring personnel respond to the assembly areas to monitor for radioactive contamination?

Criteria: Instrumentation and procedures shall be provided for determining the radiation at the assembly area and in the evacuated area following a criticality accident. Information should be correlated at a central control point. (ANSI/ANS-8.19, Section 10.8)

- Are procedures in place to monitor radiation levels at the assembly areas?
- Are both gamma and neutron detectors available?
- Are radiation monitoring personnel trained in the interpretation of radiation data as it pertains to an ongoing criticality accident?
- Are procedures in place to move personnel from designated assembly areas in the event an unacceptably high radiation field is encountered?
- Are radiation readings reported to the emergency command center?

Criteria: Emergency procedures shall address re-entry procedures and the membership of response teams. (ANSI/ANS-8.19, Section 10.9)

- Do emergency response procedures address re-entry and clearly identify the incident commander responsible for approving re-entry?
- Can the criticality alarm system be reset remotely prior to re-entry?
- What is the membership of re-entry teams?
- Are members trained in the use of proper equipment such as portable radiation monitoring equipment, portable communications equipment and supplied breathing air?

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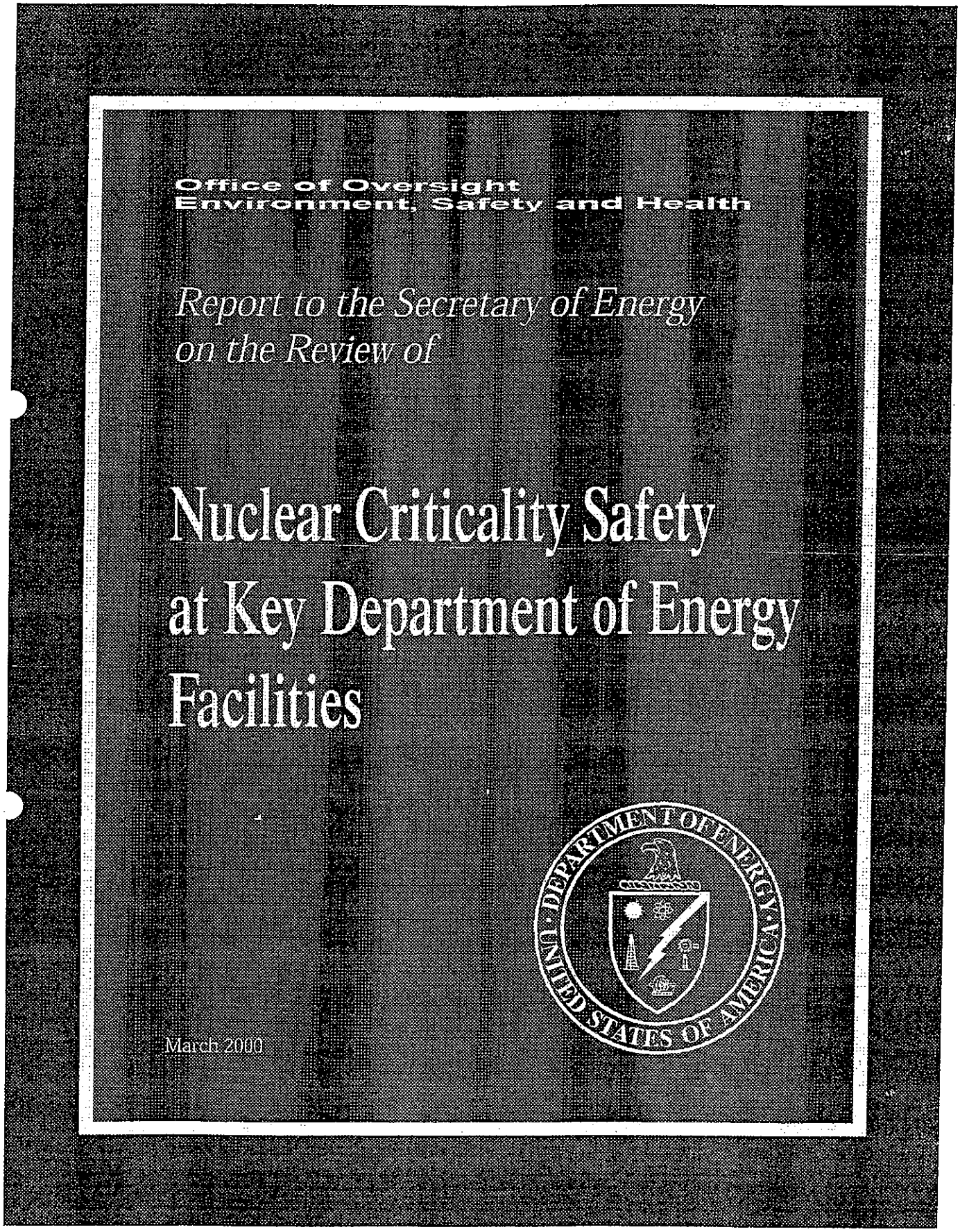
- Are members trained in the types of assignments they will likely be asked to perform and trained in the types of actions they should avoid (i.e., increasing the risk of high exposure of inadvertent actions that could result in re-criticality)?
- Does the incident commander have pre-determined criteria for authorizing re-entry?


Office of Oversight
Environment, Safety and Health
Report to the Secretary of Energy
on the Review of
Nuclear Criticality Safety
at Key Department of Energy
Facilities
DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA ·
March 2000

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Abbreviations Used in This Report

ANS	American Nuclear Society
ANSI	American National Standards Institute
DNFSB	Defense Nuclear Facilities Safety Board
DOE	U.S. Department of Energy
LANL	Los Alamos National Laboratory
TA	Technical Area

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Executive Summary

Scope

In November 1999, the Deputy Secretary of Energy directed a series of actions to strengthen Department of Energy (DOE) nuclear criticality safety programs. As one of those actions, a team of criticality safety experts from DOE Headquarters and the field conducted a high-level review of operational criticality safety controls at five DOE sites. The review, led by the Office of Oversight within the DOE Office of Environment, Safety and Health, focused on DOE facilities that process solutions of fissile materials because solutions represent the greatest risk of a criticality accident. The reviews of the individual sites focused primarily on four key elements of the nuclear criticality safety program and examined institutional requirements and processes. The Oversight team observed field implementation of selected operations but did not perform a comprehensive review of implementation of requirements.

Results

The overall conclusion of the Oversight review is that there are no imminent criticality safety hazards at the DOE facilities reviewed. DOE has adopted national consensus criticality standards that are specifically designed to reduce the risk of a criticality accident. The standards provide a mechanism for implementing the DOE integrated safety management policy in the nuclear criticality safety arena. The existence and application of these standards represent an important distinction between DOE sites and a facility in Tokai-mura, Japan, that experienced a widely publicized criticality accident on September 30, 1999. The lack of similar standards was one of the contributing factors in the Tokai-mura criticality accident.

While the Oversight team found weaknesses in the aspects of nuclear criticality safety programs that were the subject of this review, some aspects of DOE criticality safety programs are notably effective. For example, Los Alamos National Laboratory (LANL) demonstrates proper implementation of the national consensus criticality standards. In addition, the interaction between nuclear criticality safety staff and the operations personnel at LANL was particularly effective at the LANL facility reviewed (Technical Area 55 Building PF-4).

The most significant weaknesses were identified at the Y-12 Plant. Although no imminent hazards were identified, two safety issues—areas where provisions of DOE orders and national consensus criticality standards were not met—were noted at the Y-12 Plant. One safety issue involved inadequate control of movements of fissile nuclear materials. The second involved insufficient site reviews of operations to ensure compliance with nuclear criticality safety requirements. These two issues require a formal corrective action plan in accordance with DOE orders (i.e., DOE Order 414.1A, *Quality Assurance*). Other identified weaknesses were less significant but still warrant management attention and corrective actions.

There are several weaknesses that were evident at most or all of the five sites reviewed. The DOE field offices do not have the experienced nuclear criticality safety practitioners or the guidance needed to implement line management oversight of contractor programs as intended by DOE policy (DOE Policy 450.5, *Line Environment, Safety and Health Oversight*). Similarly, there are weaknesses in contractor line management oversight of nuclear criticality safety programs and its implementation. For example, some sites do not apply the necessary technical expertise on self-assessments and do not have sufficient processes (e.g., committees with a clear charter) to provide feedback to contractor management, as required by the standards and integrated safety management principles. In addition, contractor line management does not uniformly ensure that operators participate in the development and implementation of nuclear criticality safety controls, ensure that operators understand the basis for controls, and encourage interaction between criticality safety

professionals and operators. Some aspects of DOE Order 420.1, *Facility Safety*, conflict with the national consensus criticality standards in the area of developing criticality controls, creating confusion in the field about how to best develop effective controls. Finally, DOE has not issued requirements for training and qualifying criticality safety professionals. DOE committed to such requirements in its implementation plan for Defense Nuclear Facilities Safety Board Recommendation 97-2 but has not met the established milestone in this area.

Opportunities for Improvement

Additional attention is needed to ensure that DOE programs continue to improve through the application of the national consensus criticality standards and integrated safety management principles. This summary report identifies five opportunities to enhance DOE criticality safety programs throughout DOE:

- Ensure that criticality controls and their technical bases are understood.
- Ensure rigorous adherence to procedures and controls.
- Improve feedback and improvement processes.
- Revise DOE orders and guidance to remove inconsistencies with national consensus standards and promulgate needed requirements.
- Strengthen DOE field office nuclear criticality safety programs.

The opportunities for improvement above complement the site-specific opportunities for improvement that the Oversight team provided to the five DOE field offices that were reviewed as part of this effort.

Assessment reports for each of the five sites will be provided to DOE senior management and to the responsible operations office managers. These reports will provide more detailed results of the assessment at each site.

10 Introduction

As one part of a broader initiative to enhance Department of Energy (DOE) nuclear criticality safety programs, the Deputy Secretary of Energy directed the Office of Environment, Safety and Health (EH) Office of Oversight to review selected aspects of the nuclear criticality safety programs at five DOE sites. Consistent with the Deputy Secretary's direction, Oversight developed this summary report for the Secretary of Energy that includes: (1) an identification of any immediate problems and related corrective actions, and (2) an assessment of whether the operations and criticality safety risks are well understood, analyzed, and controlled.

Background

As documented in the Deputy Secretary of Energy's November 3, 1999, memorandum entitled "Nuclear Criticality Self-Improvement Initiative," DOE has ongoing initiatives to strengthen the DOE nuclear criticality safety program. Several DOE initiatives are described in the DOE Implementation Plans for Defense Nuclear Facilities Safety Board (DNFSB) Recommendations 94-1, 97-1, and 97-2. These implementation plans address various DOE actions, including efforts to stabilize fissile materials for safe long-term storage, enhance DOE's analytical techniques (including experiments to enhance the technical basis for computer codes used in nuclear criticality safety analyses), develop methods to attract and retain criticality safety professionals, and ensure adequate nuclear criticality safety training facilities for criticality safety practitioners.

In addition, an August 1999 DOE workshop for senior Federal and contractor managers, "Your Mission and Nuclear Criticality Safety," identified a series of specific actions needed to strengthen nuclear criticality safety. DOE has also taken actions to strengthen DOE oversight through implementation of a structured process (set out in DOE Order 414.1A, *Quality Assurance*) to ensure that independent oversight findings are effectively addressed and that corrective actions are verified to be effective.

In his November 3, 1999, memorandum, the Deputy Secretary directed a series of actions to support these ongoing initiatives. In addition to this Office of Oversight review of key facilities, these actions include self-assessments to be conducted by DOE field elements, Office of Oversight analysis of field element self-assessment results, development of performance metrics to be included in contract modifications, and an analysis of options for the relocation of the Los Alamos Critical Experiments Facility. The Deputy Secretary's memorandum specified that the results of this Oversight review of key facilities will be used by the DOE Nuclear Materials Council as one factor in developing the DOE framework for long-term fissile material stewardship.

Scope

As directed by the Deputy Secretary's memorandum, the Oversight reviews encompassed specific facilities at five DOE sites: the Oak Ridge Y-12 Plant, Los Alamos National Laboratory (LANL) Building PF-4 at Technical Area (TA) 55, Savannah River Site FB line facility and H-Area exterior tank storage, the Hanford Plutonium Finishing Plant, and Rocky Flats Building 371. Because the reviews were conducted on an expedited schedule, the Oversight team did not conduct a comprehensive, in-depth review of all elements of the site nuclear criticality safety programs. Rather, the Oversight team focused on four key nuclear criticality safety program elements as applied to selected fissile material operations. The review addressed the mandatory national consensus criticality safety standards developed by the American National Standards Institute (ANSI) and the American Nuclear Society (ANS) applicable to the four program elements . The Oversight team observed field implementation of selected operations but did not perform a comprehensive review of implementation of requirements.

The four key nuclear criticality safety elements reviewed were: criticality safety evaluations and controls, work control, change control, and line-management oversight. The criteria for each of these areas were provided by the Deputy Secretary and were derived from the national consensus standard ANSI/ ANS-8.19, which is required by DOE Order 420.1, *Facility Safety*, and from DOE Policy 450.5, *Line Environment, Safety and Health Oversight.*

The fissile material operations that were reviewed were those involving processing, handling, and storage of solutions of fissile materials. Criticality accidents typically involve safety management system breakdowns impacting fissile solution processing. Of the 22 known criticality accidents involving fissile material processing, 21 have involved solutions, including the recently publicized accident in Tokai-mura, Japan.

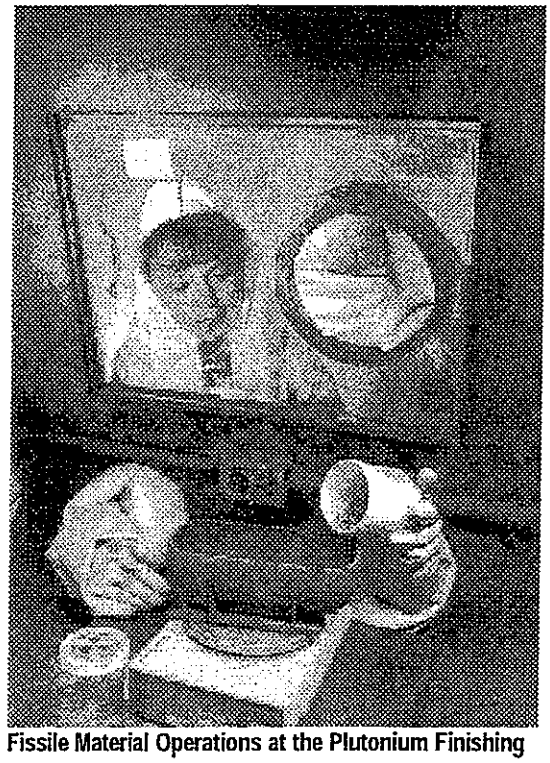
The common causes of criticality accidents to date have been failure to perform a criticality safety evaluation for a process; undetected process and system changes; failure to develop, review, and approve operating procedures; absence of effective worker training; and failure to conform to established procedures and limits. No criticality accident has occurred as a result of a faulty calculation of reactivity, and no known criticality accident has involved storage or transport of fissile material.

The Oversight team also reviewed the Tokai-mura criticality accident to identify lessons learned from that accident that are pertinent to this review. As stated in the DOE report on the information exchange with the government of Japan, issued by the Secretary of Energy on February 29, 2000, applicable lessons from the Tokai-mura accident include:

- "Ensuring fundamental understanding of criticality and consequences of criticality accidents by all levels of involved personnel.
- "Ensuring controls are understood and rigorously followed for operations involving fissile materials. This includes understanding why the controls are important by the people performing the work.
- "Ensuring sufficient oversight and monitoring of operations involving fissile materials by supervisory, management, and regulatory personnel."

The Oversight team determined that these lessons learned from Tokai-mura are similar to lessons learned in previous criticality accidents and are already addressed by the national consensus standards, which were developed after consideration of previous criticality accidents worldwide. Consequently, the Oversight team determined that DOE sites should focus on effectively implementing the national consensus standards, which are based on consideration of a wide range of accidents, rather than focusing exclusively on the lessons learned from the Tokai-mura accident.

The Oversight team began its site reviews in November 1999 and completed them in January 2000. The seven-person team included nuclear criticality safety experts from DOE Headquarters and field offices. Following each of the individual site reviews, the Oversight team developed a site-specific report identifying positive attributes, safety issues (which require a formal corrective action plan, pursuant to DOE Order 414.1A. *Quality Assurance*), other weaknesses, and opportunities for improvement. The results of the site-specific reviews have been provided to the individual sites.



Fissile Material Operations at the Plutonium Finishing Plant

Organization of the Report

This report is organized to provide the Secretary of Energy with information he can use to improve nuclear criticality safety, including the information specified by the Deputy Secretary related to immediate problems and risks:

- Section 2 summarizes the reviews of the nuclear criticality safety programs at the five sites, including positive aspects and weaknesses.
- Section 3 presents the Oversight team's overall conclusions and assessment of immediate problems, including whether the operations and criticality safety risks are well understood, analyzed, and controlled.
- Section 4 identifies opportunities for improvement that apply to contractors at all DOE sites. These are based on enhancing implementation of the national consensus ANSI/ANS criticality standards.
- Section 5 draws on the results of the reviews of the five sites to identify opportunities for DOE to improve nuclear criticality safety through enhancements in policy and DOE-wide programs.

Appendix A presents information about the conduct of the site-specific reviews and the composition of the Oversight team that conducted the reviews.

20 Summary of Site-Specific Review Results

No imminent criticality safety hazards involving fissile solutions were identified at any of the five sites. The facilities reviewed have the program infrastructure, based on the ANSI/ANS-8 standards, in place to analyze the potential for criticality and to establish adequate criticality safety controls. Proper implementation of the nuclear criticality safety program elements, including the four elements assessed as part of this review, should ensure that the likelihood of a criticality accident remains low.

Some aspects of DOE criticality safety programs are notable. At LANL, the interaction of nuclear criticality safety staff (i.e., ESH-6 personnel) with the operations personnel (i.e., Nuclear Materials Technology staff) at TA-55 Building PF-4 is exemplary. Technicians are well trained and participate in the development of nuclear criticality safety controls, contingencies, and safe operating procedures. The nuclear criticality safety personnel are well qualified and knowledgeable of Building PF-4 equipment and processes, and they spend significant time interacting with operations personnel to develop practical and effective nuclear criticality safety controls and provide nuclear criticality safety guidance and training to operators. Other positive aspects of the DOE programs reviewed are shown in Table 1.

Most sites have ongoing initiatives that are designed to further enhance nuclear criticality safety. For example, Westinghouse Savannah River Company is developing a new approach for linking procedural nuclear safety controls directly to authorization basis documents by annotating nuclear safety controls within the procedures.

Although the risk of a criticality accident is low and several positive attributes were identified, the Oversight team identified weaknesses at all five sites. The most significant weaknesses (which are identified as safety issues in the site-specific report, consistent with Office of Oversight protocols) were identified at the Y-12 Plant. The facilities reviewed at the Y-12 Plant (Buildings 9212 and 9818, which have most

Table 1. Positive Aspects of Nuclear Criticality Safety Programs

- At Los Alamos National Laboratory, Rocky Flats and the Hanford facilities, operations management has established positions (e.g., criticality safety officers or criticality safety representatives) within the operating organizations to ensure that criticality safety requirements are effectively implemented. Such positions have been effective in providing liaison with the nuclear criticality safety staff, communicating with operators, and applying controls.
- At the Hanford Plutonium Finishing Plant, operators and supervisors demonstrated a good understanding of nuclear criticality safety controls and contingencies. The informal training sessions (brown bag lunches) are a practical and inexpensive way to provide continuous professional development for nuclear criticality safety personnel and criticality safety representatives.
- At Rocky Flats, the nuclear criticality safety staff's presence in the fissile material areas and interaction with operations personnel have improved operator understanding and implementation of nuclear criticality safety controls.
- DOE Savannah River Operations Office and Y-12 Site Office personnel spend significant time in the facilities, conduct periodic program assessments, and evaluate contractor performance against established performance criteria.

of the solutions at the Y-12 Plant) did not meet the provisions of DOE orders in two important areas: (1) movements of fissile nuclear materials between work locations were not adequately controlled, and (2) nuclear criticality safety assessments and reviews of operations were not sufficient to ensure that procedures were being followed and that the process configuration was maintained within established limits. Other weaknesses at the Y-12 Plant include failure to properly plan and execute work, complicated and confusing nuclear criticality safety requirements, lack of operator involvement in the nuclear criticality safety program, and weak feedback and continuous improvement processes.

The weaknesses at other sites were less significant but still warrant management attention and corrective actions. Examples of weaknesses evident at more than one DOE site include:

- Some criticality safety controls were complex and were difficult for operators to understand.
- At some sites, criticality safety professionals did not spend enough time interacting with the operations personnel to ensure that they were familiar with the facilities and processes and that they were providing useful information to operators.
- Some controls were developed without sufficient involvement by operations personnel, and operations personnel did not always understand the basis for nuclear criticality safety limits and controls.
- The technical basis for criticality safety evaluations was not always adequately documented.
- Some contractor nuclear criticality safety self-assessments and program reviews were not sufficiently comprehensive or conducted with experienced personnel familiar with the application of nuclear criticality safety practices.
- Most of the five DOE field offices reviewed do not have sufficient nuclear criticality safety technical expertise or the formalized program needed to provide adequate line management oversight of the contractors.

The site-specific reports provided to the five sites identify the specific weaknesses applicable to each site and include opportunities for improvement that site management should consider to enhance nuclear criticality safety. The two safety issues noted above for the Y-12 Plant require a formal corrective action plan in accordance with DOE Order 414.1A. Corrective actions for the other weaknesses identified in the site-specific reports should be specified in the site nuclear criticality safety self-assessment reports that are being developed as another element of the Deputy Secretary's direction in his November 3, 1999, memorandum.

Viewed collectively, some weaknesses evident at multiple sites indicate a need for improved policy or guidance and/or increased Headquarters attention. For example, DOE has developed guidance for training and qualifying contractor criticality safety staff in DOE-STD-1135-99, *Guidance for Nuclear Criticality Safety Engineer Training and Qualification*, but has not established a specific requirement to implement that guidance. In its Implementation Plan for DNFSB Recommendation 97-2, DOE included a commitment to establish a contractual requirement to implement the guidance. However, DOE is overdue on this commitment, and a requirement to implement the guidance is not yet in place.

As another example, DOE developed and distributed criteria at the workshop "Your Mission and Nuclear Criticality Safety." Those criteria were endorsed by DOE field element nuclear criticality safety programs and senior DOE management. However, the criteria have not been implemented at the sites reviewed, and there is no formal requirement to do so. In this instance, DOE senior management expectations are not being met. Section 5 lists opportunities for DOE Headquarters to improve policy and programs.

8.0 Conclusions and Assessment of Risks

The overall conclusion of the Oversight review is that no imminent criticality safety hazards involving fissile solutions exist at the five sites but that additional management attention is needed to ensure identified weaknesses are corrected. Proper implementation of the four elements of the nuclear criticality safety program should ensure that the risk of a criticality accident remains low at the facilities reviewed. Additional management attention is needed to improve implementation of the ANSI/ANS-8 standards, which also provide an effective means for implementing most aspects of DOE integrated safety management in nuclear criticality safety. The standards also encompass program improvements from the more recent nuclear criticality self-improvement initiative.

Criticality Safety Evaluations

The criticality safety hazards in the areas reviewed at the five sites are understood and properly analyzed. The controls that were developed as a result of the nuclear criticality safety evaluations are appropriate and, if properly implemented, are sufficient to prevent a criticality accident. The sites have systems that translate the nuclear criticality safety controls into directions to the operators (e.g., procedure steps and postings).

Although the criticality safety documents (such as criticality safety evaluations, procedure steps, and postings) provide the foundation for an effective nuclear criticality safety program, some aspects of the program require additional attention:

- Controls will be effective only if implemented as required by the operators at the working level. At some sites, the process for developing nuclear criticality safety documents is not easy to understand, and the resulting controls are not easy for operations personnel to implement.
- There is considerable variation in facilities' approaches to establishing and implementing controls. Most sites use self-contained criticality safety evaluations to document fissile material limits and the contingency analysis, whereas others use two separate safety basis documents to establish limits and contingencies. Some sites consider the criticality safety evaluations part of the authorization basis, but most do not.
- Because of inconsistencies with national consensus standards (ANSI/ANS-8.1), DOE Order 420.1 does not provide clear and effective direction related to criticality safety evaluations. Some sites place most of their emphasis on a definition of the double contingency principle contained in DOE Order 420.1 and focus on identifying "the two" controls identified in the order. This emphasis is not consistent with the intent and requirements of ANSI/ANS-8.1, which focuses on ensuring that the process remains subcritical under all normal and credible abnormal conditions. The DOE order's excessive emphasis on implementing "double contingency" through multiple controls on a single parameter can lead to deterioration of other important process controls that are not "the two" but that are nevertheless relied on in the supporting criticality safety evaluation. The requirements in the order also have the effect of promoting the use of DOE "checklists" to document "the two" while ignoring other controls credited in the criticality safety evaluation.
- The limited availability of fully qualified and experienced nuclear criticality safety staff who understand operations, including process upsets and credible events, is a longstanding concern that requires continued attention across DOE. (This issue is being addressed through a five-year plan under the DOE Implementation Plan for DNFSB

Recommendation 97-2.) Staff attrition, particularly at sites such as Rocky Flats, can exacerbate the recognized shortages of qualified and experienced nuclear criticality safety staff. Some sites rely heavily on subcontracted nuclear criticality safety staff, some of whom lack an adequate understanding of fissile material operations in the facilities they support. DOE has developed guidance (DOE-STD-1135-99) to ensure that nuclear criticality safety staff are familiar with facilities and operations before they develop criticality safety evaluations, but DOE is delinquent in its commitment to the DNFSB to incorporate the training and qualification standard as a contractual requirement. Consequently, most of the sites have no formalized process for ensuring that nuclear criticality safety staff are familiar with operations prior to performing work.

Operator Understanding of Controls

At several sites, operators did not adequately understand the technical basis for the criticality safety controls they are required to implement, partly because they do not participate sufficiently in developing the criticality safety evaluations. Worker involvement and feedback in developing and implementing criticality safety controls is an important tenet of integrated safety management. Furthermore, at several sites, criticality safety engineers rarely interact with operators and do not spend significant time in the fissile material handling and processing areas. Despite an existing interface between the criticality safety engineers and the process engineers, there was little or no operator involvement during the development of the criticality safety evaluations and controls.

The variation in operator knowledge and understanding of controls highlights the importance of the regular presence of criticality safety engineers in the process area, interacting with and informally educating the operators about the importance and meaning of the criticality safety controls and limits. At sites where operators demonstrated a good understanding of nuclear criticality safety controls (e.g., LANL and Rocky Flats), the operators participate in the development of controls and know why the controls are in place. Conversely, at sites where criticality engineers did not spend significant time interacting with operators, the operators did not display a good knowledge of the technical basis for controls.

Several factors contribute to the insufficient coordination and interaction between nuclear criticality safety professionals and operating divisions. For example, because of the manner in which the nuclear criticality safety program is funded, criticality safety engineers often are required to work only on specific projects; there is no opportunity or funding for general activities, such as interaction with operators. In addition, line management and nuclear criticality safety department supervisors have not always established clear expectations for such interactions. To ensure effective and frequent interactions, criticality safety engineers need to spend a significant portion of their time in the process area interacting informally with operators while performing audits, participating in operator on-the-job-training, and becoming familiar with the fissile material operations in that area. Such interactions are unlikely to occur unless line management establishes clear expectations and ensures that appropriate direction and support (including funding mechanisms) are in place to allow frequent interaction.

Work Planning and Control

Processes for planning and controlling work varied in effectiveness. As a positive feature, some sites (e.g., Hanford, Rocky Flats, and LANL) have implemented criticality safety officer positions in the operating organizations. The criticality safety officers perform many useful administrative and liaison functions, such as preparing postings, attending pre-job briefings, and interacting daily with operators. These functions allow operations personnel to "own" the nuclear criticality safety program on the basis of technical data, input, and advice obtained from the nuclear criticality safety staff. Some important work planning and control elements have been implemented at all sites reviewed, such as pre-job briefings and facility configuration change control. However, weaknesses were identified at several sites in the document control practices related to procedures and nuclear criticality safety postings and evaluations. Work planning and control practices were deficient at the Y-12 Plant, resulting in numerous violations of nuclear criticality safety requirements.

Line Management Oversight

Another important factor in assessing the adequacy of the site's understanding of operations and criticality

risks is the adequacy of line management (both contractor and DOE) nuclear criticality safety oversight processes that provide feedback for continuous improvement. Rigorous self-assessments and feedback are required by the ANSI/ANS 8.19 standard and by DOE Policy 450.5. Further, effective feedback and continuous improvement constitute a fundamental component of the integrated safety management program.

DOE line management oversight of nuclear criticality safety programs lacks depth and consistency throughout the DOE complex, ranging from adequate to nonexistent. Most field offices have not implemented nuclear criticality safety oversight programs in accord with the criteria disseminated at the workshop "Your Mission and Nuclear Criticality Safety." For example, most DOE nuclear criticality safety programs do not have documented assessment plans or performance metrics. An additional factor contributing to deficiencies in DOE field office nuclear criticality safety programs is that DOE has not promulgated implementing requirements for developing DOE line management oversight of nuclear criticality safety. In addition, the capabilities of the field office nuclear criticality safety program managers vary widely.

There is a serious shortage of nuclear criticality safety staff in the field offices who have technical experience in criticality safety. Most of the nuclear criticality safety personnel at DOE field offices have not had hands-on experience as criticality safety engineers in nuclear processing facilities. Most field office nuclear criticality safety positions are limited to GS-12 or GS-13 levels. The proper implementation of nuclear criticality safety national consensus standards (required by DOE Order 420.1) can be accomplished only if there is a strong, experienced nuclear criticality safety presence in the DOE field office.

Problems with field element line oversight were most notable at LANL. The Albuquerque Operations Office and its Los Alamos Area Office are not providing effective line management oversight of the LANL nuclear criticality safety programs and are not meeting the expectations of DOE Policy 450.5, *Line Oversight of Environment, Safety, and Health*. The Los Alamos Area Office does not have a qualified nuclear criticality safety subject matter expert, and neither the Albuquerque Operations Office nor the Los Alamos Area Office has an ongoing program for nuclear criticality safety assessments. Although the LANL Building PF-4 nuclear criticality safety program is currently effective, the programs at other LANL facilities may not be as well implemented; Building PF-4 benefits from a relatively mature integrated safety management program and strong line management support. Thus, DOE line management may not receive the information it needs because of the absence of effective feedback from line staff.

With respect to contractor line management oversight, each of the site contractors has some form of a line management self-assessment and feedback process in its criticality safety program. However, the effectiveness of these activities varies. For example, LANL has an effective Criticality Safety Committee that reports to the Director of the Laboratory and is chartered to conduct annual appraisals of all operations that involve significant quantities of fissile materials. The committee oversees the annual assessments and ensures that issues are addressed and tracked to closure. This committee also provides technical advice to the Laboratory Director on criticality safety issues to enable sound decisions. However, some contractors (including the contractors at the Y-12 Plant and Hanford) have weak nuclear criticality safety self-assessment programs and do not make effective use of nuclear criticality safety committees/councils to provide input to senior management.

All five sites would benefit from self-assessment processes that systematically review the nuclear criticality safety program according to the ANSI/ANS-8.19 criteria. A major part of the Department's Criticality Safety Improvement Initiative is the implementation of effective contractor nuclear criticality safety self-assessments. Because of weaknesses in the self-assessment programs, senior contractor management may not be getting all the information they need in order to recognize weaknesses, make improvements, and ensure that corrective actions are effective.

4.0 DOE Site Opportunities for Improvement

At the DOE facilities reviewed, there was no evidence of major breakdowns in the criticality safety programs such as those that resulted in the criticality event at Tokai-mura, Japan. As discussed previously, the sites that were reviewed have established adequate controls, as well as programs (e.g., conduct of operations) designed to ensure that fissile material handlers and operators adhere to the established controls. While none of the identified weaknesses poses imminent criticality safety hazards, continued attention is needed to ensure that those weaknesses are addressed and that performance does not deteriorate.

This section identifies three general opportunities for improvement and related actions that DOE sites should consider to enhance their nuclear criticality safety programs. While some sites may already have effective practices in some of these areas, these opportunities for improvement are generally applicable to all five sites included in this Oversight review, as well as to other DOE sites that were not reviewed.

1. Ensure that criticality controls and their technical bases are understood.

In general, operators do not uniformly participate in the development and implementation of nuclear criticality safety controls, understand the basis for nuclear criticality safety controls, or interact with criticality safety engineers on a routine basis. Line management does not ensure that criticality safety engineers spend a large portion of their time in the fissile material areas learning the operations, performing on-the-job-training with operators, holding informal discussions, and conducting nuclear criticality safety audits and inspections alongside operators to improve operator knowledge and understanding. Actions to improve operators' understanding of the bases for criticality controls and their participation in implementing the nuclear criticality safety program include:

- Ensure frequent and effective interactions between nuclear criticality safety staff and operations personnel in accordance with ANSI/ANS 8.1 and 8.19 and DOE-STD-1135-99, *Guidance for Nuclear Criticality Safety Engineer Training and Qualification,* including "on-the-floor" assessments and on-the-job training of operators.

- Perform "on-the-floor" walkdowns of procedures, operations, and criticality safety evaluations and controls by teams of operators and nuclear criticality safety professionals to ensure that actual conditions meet established nuclear criticality safety requirements. Walkdowns should cover all areas on at least an annual basis.

- Ensure that nuclear criticality safety professionals who are thoroughly familiar with the facility and operations are accessible to answer questions from operators and respond to operations needs on a priority basis.

- Ensure that operations personnel, including operators and fissile material handlers, are involved in developing nuclear criticality safety evaluations and controls and that they understand the underlying basis for established controls and limits.

- Ensure that nuclear criticality safety staff understand facility operations, including process upsets and credible events, so that they can provide effective advice and develop practical controls to provide an adequate margin of safety against any single credible contingency.

- Promote contractor line management "ownership" of nuclear criticality safety program implementation by utilizing criticality safety officers within the operating groups to perform certain nuclear criticality

safety functions. Elements of the LANL, Rocky Flats, and Hanford Plutonium Finishing Plant nuclear criticality safety programs can be used to benchmark good practices in this area.

2. Ensure rigorous adherence to procedures and controls.

In the interviews conducted during this review, managers, supervisors, and workers generally indicated their understanding of the need to adhere to established nuclear criticality safety controls. However, the problems noted at the Y-12 Plant indicate that there are instances where controls are not fully and effectively implemented. Actions to enhance adherence to procedures and controls include:

- Continue to implement the DOE integrated safety management program to ensure that all work is performed safely.
- Emphasize and frequently reemphasize management expectations for effective conduct of operations, including procedure adherence and configuration control.
- Ensure that management expectations for stopping work when abnormal conditions are encountered and the priority of safety over production are communicated and understood at all levels of the workforce.

3. Improve feedback and improvement processes.

Some sites have weak nuclear criticality safety self-assessment programs and do not make effective use of nuclear criticality safety committees/councils to provide input to senior management. None of the five sites has a self-assessment process that systematically reviews the nuclear criticality safety program according to the criteria contained in ANSI/ANS-8.19. Suggested guidance was disseminated at the nuclear criticality safety workshop "Your Mission and Nuclear Criticality Safety." Because of the weaknesses in the self-assessment program, senior contractor management may not be getting all the information needed to recognize weaknesses, make improvements, and ensure that corrective actions are effective. Actions to enhance contractor management self-assessment include:

- Ensure that line management performs comprehensive self-assessments, tracks all findings to closure (including those from self-assessments, field element assessments, DNFSB reports, and Office of Oversight reports), and verifies the effectiveness of the corrective actions.
- Use a criticality safety committee, council, or advisory board consisting of technically qualified nuclear criticality safety personnel to provide advice to senior management, including periodic reviews of site programs such as operations, criticality safety documentation, and line organization self-assessments. This committee should periodically utilize external expertise. Best practices for criticality safety committees are exemplified by the LANL and Oak Ridge National Laboratory programs.
- Implement the self-assessment criteria based on ANSI/ANS-8.19 (disseminated at the workshop "Your Mission and Nuclear Criticality Safety") to ensure that all elements are assessed on an ongoing, periodic basis.

5.0 DOE Headquarters Opportunities for Improvement

Viewed collectively, several of the weaknesses evident at multiple sites indicate a need for improvement in policy or guidance and/or increased attention at Headquarters. For example, DOE has issued guidance for training and qualifying criticality safety staff but does not have a clear requirement to implement that guidance. In addition to site-specific opportunities included in the site-specific reports, the Oversight team identified several opportunities to enhance nuclear criticality safety programs across the complex. In some case (identified below), the effective practices evident at one or more of the DOE sites included in this Oversight review could serve as a benchmark for other DOE sites.

The DOE Nuclear Criticality Safety Program Management Team led by Defense Programs (DP-10) should take the lead in evaluating the opportunities for improvement listed below and determining an appropriate course of action. This Management Team should also take the lead in coordinating with the lead program secretarial offices and field elements as appropriate to ensure that enhancements are implemented at DOE sites.

1. Revise DOE orders and guidance to remove inconsistencies with national consensus standards, and promulgate needed requirements.

Actions to strengthen DOE orders, guidance, and requirements include:

- Revise DOE Order 420.1 to make the DOE application of the double contingency principle consistent with ANSI/ANS-8.1 and to eliminate the undue and potentially unsafe emphasis on implementing "double contingency" through two controls on a single parameter.

- Reexamine requirements and processes for including criticality safety evaluations in the authorization basis consistent with the ANSI/ANS-8 standards and best practices at LANL and Rocky Flats.

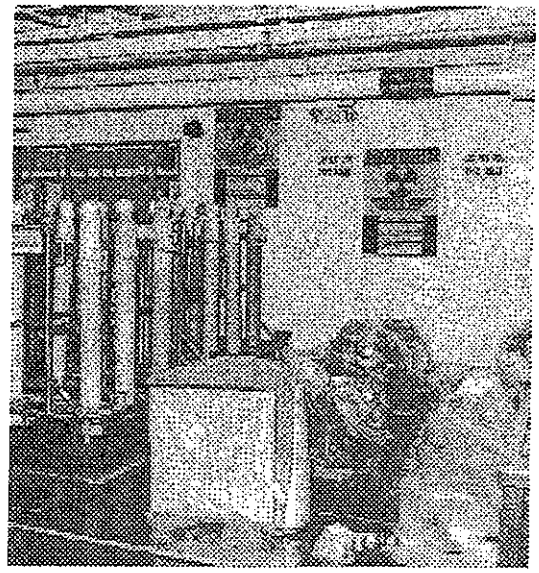
- Review and revise DOE-STD-3007-93 to clarify the purpose and content of criticality safety evaluations, emphasizing that they are stand-alone documents containing all the rationale and controls required to ensure subcritical operations.

- Establish a provision in DOE Order 420.1 that requires implementation of the training and qualification standard, DOE-STD-1135-99, for criticality safety staff.

2. Strengthen DOE field office nuclear criticality safety programs.

Actions to strengthen DOE field office programs include:

- Issue requirements for developing and implementing DOE line-management oversight of nuclear criticality safety programs considering the criteria issued at



Solution Storage Area at the Y-12 Plant

the workshop "Your Mission and Nuclear Criticality Safety."

- Provide guidance and expectations for having DOE field element nuclear criticality safety personnel spend sufficient time in the facilities to learn about the operations and equipment so that they have sufficient knowledge to perform effective line oversight.

- Monitor progress by DOE field elements to ensure that Federal personnel with nuclear criticality safety responsibilities are trained and qualified by December 2000 in accordance with the DOE commitment in the Implementation Plan for DNFSB Recommendation 97-2.

- Support activities that supplement the capability of DOE field elements, such as sharing technical staff or using the Criticality Safety Coordinating Team to share experience and lessons learned or to support periodic review of site programs.

- Promote hiring and retention of nuclear criticality safety staff who have technical experience as criticality safety engineers and encourage the use of such practices as hiring bonuses and excepted service.

APPENDIX A
REVIEW PROCESS AND TEAM COMPOSITION

Review Process

The review was conducted according to Office of Oversight protocols and procedures, including the validation of data throughout all stages of the process. The review included facility tours and interviews with DOE field office personnel and contractor personnel having responsibility for nuclear criticality safety, audits and assessments, work planning and control, configuration management, and authorization basis. The Oversight team reviewed a representative sample of operational criticality safety controls (e.g., criticality safety limits summarized in postings and stated in operating procedures), work control (e.g., other procedural and administrative controls governing normal work tasks, including maintenance, that affect criticality safety), change control, and audit/self-assessment practices. Selected criticality safety evaluations and other documents that formed the basis for these controls and practices were also reviewed.

In evaluating performance of the nuclear criticality safety programs, the Oversight team examined operational aspects of the safety management system in the areas specified by the Deputy Secretary: criticality safety evaluations and controls, work control, change control, and line management oversight. The evaluation criteria for these areas were derived from the national consensus standard ANSI/ANS-8.19 (which is required by DOE Order 420.1, *Facility Safety*) and DOE Policy 450.5, *Line Environment, Safety, and Health Oversight*.

The dates of the visits to the five sites are shown below. The composition of the Oversight team is set out on page 16.

SITE	DATES
Y-12 Plant	November 15-18, December 16, 1999
Los Alamos National Laboratory Building PF-4 at Technical Area 55	November 30 - December 2, 1999
Savannah River Site FB line facility and H-Area exterior tank storage	December 13-15, 1999
Hanford Plutonium Finishing Plant	January 10-12, 2000
Rocky Flats Building 371	January 18-20, 2000

Team Composition

The team membership, composition, and responsibilities are as follows:

Deputy Assistant Secretary for Oversight

S. David Stadler, Ph.D.

Associate Deputy Assistant Secretary for Oversight

Raymond Hardwick

Team Leader

Jerry McKamy, Ph.D.

Management Advisor to the Team

Ed Blackwood

Line Management Oversight Subgroup

Adolf Garcia
Jim Felty

Work and Change Control Subgroup

Bill Weaver
Gypsy Tweed

Criticality Safety Evaluations and Controls Subgroup

Steve Payne, Ph.D.
Ivon Fergus

Communications and Support

Cynthia D. Dorsey

Quality Review Board

Frank Russo
Raymond Hardwick
Thomas Davis
Thomas Staker

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FOR IMMEDIATE RELEASE
May 11, 2000

NEWS MEDIA CONTACT:
April Kaufman, 202/586-5806

Secretary Richardson Orders Series of Actions to Keep Nuclear Safety on Track at Energy Department Sites

Study of U.S. Nuclear Sites Finds No Similarities to Situations Surrounding Japanese Accident

Secretary of Energy Bill Richardson today released the results of a nuclear safety assessment of key Energy Department sites around the country. The study concludes that there is no imminent risk of a nuclear accident at the department's nuclear sites but also highlights steps that should be taken to improve nuclear safety programs and the professional expertise of those responsible for implementing nuclear safety precautions. The study was directed by President Clinton after the September 1999 nuclear accident in Japan.

"Safety is job one at all of our nuclear facilities," said Secretary Richardson. "I will make sure the Department of Energy takes every step to continually strengthen and improve the ways we ensure the safety of our workers, the public and the environment."

The report, titled "Nuclear Criticality Safety at Key Department of Energy Facilities," assesses the risk of an unplanned nuclear reaction – or nuclear criticality accident – at major sites in the department's nuclear weapons complex. The study finds that the risk of an accident similar to the one in Japan does not exist in the U.S., primarily because the Energy Department has adopted and adheres to national standards for operations and training specifically designed to reduce the risk of these types of accidents.

The report focuses on the department's Los Alamos National Laboratory in N.M.; Rocky Flats Environmental Technology Site outside Denver, Colo.; Hanford Site in Wash.; Savannah River Site in S.C.; and Y-12 Plant in Oak Ridge, Tenn.

The report noted major positive aspects of the nuclear criticality safety programs at five Department of Energy sites, including:

- At Los Alamos National Laboratory, Rocky Flats Environmental Technology Site and the Hanford Site, criticality safety personnel effectively ensure safety requirements are implemented by serving as liaisons between criticality safety staff and the operators who must make criticality safety a part of their jobs at all times;
- At the Hanford Plutonium Finishing Project, training sessions provide continuous professional development for nuclear criticality safety personnel and criticality safety representatives;
- At Rocky Flats Environmental Technology Site, the presence of nuclear criticality safety staff in the fissile material areas and interaction with operators improve operators' understanding

Department of Energy - News Release

and implementation of safety controls; and

- At the Savannah River Operations Office and Y-12 Plant, personnel have taken recent steps to improve safety by spending significant time in facilities, conducting periodic program assessments and evaluating contractor performance.

The report identifies two general areas for improvement at Department of Energy headquarters and three general areas for improvement at its sites. It recommends headquarters revise Energy Department orders and guidance to remove inconsistencies with national industry standards and strengthen nuclear criticality safety programs at sites. The report also recommends that all sites assess their safety programs and take any steps needed to ensure operators understand the controls and technical bases designed to prevent criticality accidents; ensure strict adherence to procedures and controls; and improve the processes for feedback and improvement.

In response to the report, Secretary Richardson has directed a number of immediate steps to improve and ensure the continued safety of American nuclear sites, including:

- Directing the development of corrective action plans that address how each site will improve in all areas noted in the report. The corrective action plans will need to be approved by the headquarters offices that focus on environmental issues and defense programs and reviewed by the department's safety and health office.
- Increasing the retention rate of criticality safety professionals by giving retention allowances and cash awards to experienced, high performing employees in this specialized field and using all available mechanisms to increase compensation to make the Department of Energy competitive in the current labor market;
- Finalizing within 30 days the job certification requirements for criticality safety experts by formalizing standards and necessary training;
- Strengthening existing staff by directing field offices to hire more experts and ensuring federal and contractor criticality staff meet the department's qualification standards for criticality safety experts; and
- Increasing the number of hours criticality engineers are on the floor where work is done and requiring them to report these hours to the department's headquarters safety and health office, as well as the program office responsible for the site. The department's Los Alamos National Laboratory has been successful in this approach, and Los Alamos' safety professionals will hold a two-day workshop to share their experiences with their counterparts throughout the department's nuclear weapons complex.

A team of experts, headed by Deputy Assistant Secretary for Oversight Dr. David Stadler and led by nuclear criticality safety expert Dr. Jerry McKamy, examined controls and processes at five key Department of Energy facilities. These sites were examined because they deal with fissile liquids, which are capable of causing an uncontrolled nuclear reaction if not handled properly. Fissile liquids have been involved in all but one criticality accident worldwide in the past 42 years. No criticality accident has occurred at a Department of Energy facility for more than 20 years.

Secretary Richardson has directed the team to return to each site in January to ensure thorough improvements have been made.

Last November, the Department of Energy directed comprehensive self-assessments at all nuclear facilities, including the Pantex Plant in Texas and other sites that handle or store other nuclear materials typically in stable forms. The assessments and corrective actions plans, if needed, are targeted for completion by June. Based on results to date, no immediate hazards have been identified.

A copy of the report is available on the internet at: http://www.eh.doe.gov.

- DOE -

R-00-133

NOTE TO EDITORS: Dr. David Michaels, Assistant Secretary for Environment, Safety and Health, and Dr. Jerry McKamy, nuclear criticality safety expert, will hold a conference call on this topic for interested media today at 1:15, Eastern Time. Call April Kaufman in the Department of Energy's press office for more information. 202/586-5806.

Department of Energy
Washington, DC 20585

March 17, 2000

MEMORANDUM FOR DISTRIBUTION

FROM: Ted Wyka
Director, Safety Management Implementation Team

SUBJECT: Corrective Action Plans for Identified Self-Assessments

The attached guidelines are provided for developing Corrective Action Plans (CAPs) for self-assessments of potential vulnerabilities in the nuclear criticality safety (ref A.) and High-Efficiency Particulate Air (HEPA) programs (ref B). The Safety Management Implementation Team was directed to develop these guidelines in the Deputy Secretary's memo of March 1, 2000 (ref C.).

Attachment 1 outlines the Department's Safety Issue Corrective Action Process, tailored for use with these two self-assessment efforts. This document does not contain new requirements; it merely provides a methodology to carry out secretarial direction regarding development of CAPs and corrective action tracking in the DOE CATS. If you have questions regarding this guidance, please contact Joe Hassenfeldt, co-Chair of the Integrated Corrective Action Management Team (I-CAM), at 202 586-1643.

Attachment

Refs.

A. Deputy Secretary Glauthier's memorandum to Heads of Departmental Elements, dated 11/3/99, re: Nuclear Criticality Self-Improvement Initiative.

B. Secretary Richardson's letter to Chairman Conway, dated 12/6/99, re: HEPA Filters Used in the Department of Energy's Hazardous Facilities.

C. Deputy Secretary Glauthier's memorandum to Distribution, dated 3/1/00, re: Action: Assess Potential Vulnerability Due to Degraded High-Efficiency Particulate Air (HEPA) Filters in Nuclear Facilities.

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SAFETY ISSUE CORRECTIVE ACTION PROCESS
For specific Line Management Self-Assessments

1. OBJECTIVE. To establish a uniform process to carry out the Secretary of Energy's desire to identify, correct, and track safety issues related to Self-Assessments of (1) HEPA filter vulnerabilities at Nuclear Facilities and (2) Nuclear Criticality Safety. This guidance contains no new requirements, but rather presents a way to develop Corrective Action Plans (CAPS) and track individual corrective actions in the Department's Corrective Action Tracking System (CATS) in response to these Line Self-Assessments. The following guidelines are adapted from Appendix 2 of DOE O 414.1A, *Quality Assurance*.

2. GENERAL REQUIREMENTS.

   a. DOE elements must correct safety issues (identified deficiencies) according to the importance of the problem and the work affected. Any Nuclear Safety non-compliances (under the Price Anderson Amendment Act) should be reported per existing procedures.

   b. DOE elements must develop and implement a corrective action plan (CAP) for safety issues.

   c. DOE Field/Operations Office Managers (Field Element Managers) must ensure that contractors within their purview implement the approved CAP, as appropriate. FEMs may assign responsibility for individual corrective action(s) to appropriate line managers. These Cognizant Line Managers (CLMs) are responsible to implement assigned corrective actions and keep the CATS updated on corrective action status.

   d. DOE elements must apply this process to safety issue identification, CAP development, and dispute resolution.

   e. DOE elements must use the DOE Corrective Action Tracking System (CATS) for CAP tracking and status reporting. Access to the CATS and password application can be obtained at: http://tis.eh.doe.gov/portal/ism/CATS.htm.

3. SAFETY ISSUE IDENTIFICATION AND RESOLUTION PROCESS.

   a. Safety Issue Identification. The Field Element Manager must perform Self-Assessments in accordance with the Deputy Secretary's 11/03/1999 memorandum (Nuclear Criticality Self-Improvement Initiative); and the Secretary of Energy's 12/06/1999 letter (HEPA Filters) and the Deputy Secretary's 3/1/2000 memorandum (HEPA Filters in Nuclear Facilities). Relevant due dates have been established in these documents.

(1) Describe each identified safety issue clearly in the assessment report. Safety issues will express the specific nature of the condition in a clear, concise, and direct manner that will allow line management to translate it into corrective actions.

(2) Verify the factual accuracy of the reported assessment findings with representatives of the assessed organizations.

(3) Submit the formal approved assessment report to the applicable Cognizant Secretarial Officer (CSO).

(4) FEM, or designee, will complete the "Report" and "Issue Information" data fields in the DOE CATS. The complete Data Dictionary and User's Guide for CATS is available at: http://tis.eh.doe.gov/portal/ism/cats.htm.

b. Corrective Action Plan Development. The Field Element Manager must prepare the CAP to address the safety issues raised in the self-assessment report by performing the following:

(1) Prepare a single, comprehensive CAP to address the safety issues contained in a given site-specific assessment report.

(2) The CAP must include actions to correct the safety issues (e.g., variance from established requirements), determine the causes of the issue, and prevent recurrence of the issue.

(3) The CAP must describe the basis for the disposition of each identified safety issue. If it is determined that no action will be taken in response to a given issue the CAP must describe the basis for this determination, demonstrating how safety will be maintained.

(4) The CAP must indicate the following for each safety issue requiring specific corrective actions: (Appendix A is an optional checklist/aid.)

- a root cause/causal factor determination,
- a description of the corrective action and which issues it addresses,
- a description of how the corrective action will preclude future recurrence of the problem,
- a deliverable which signifies action completion (report, new procedure or revision, calibration report, certification, etc.)
- a single, responsible individual who is held accountable for timeliness and effectiveness of the corrective action,
- the date the action is expected to be completed, and
- the mechanism to be used to independently verify action completion and to provide assurance the actions taken will prevent recurrence.

c. Corrective Action Plan Approval. The Field Element Manager must approve the CAP. The CLM must enter the "Corrective Action Plan" and "Corrective Action" data for the approved CAP in the DOE CATS. Again, the complete Data Dictionary and User's Guide for CATS is available at: http://tis.eh.doe.gov/portal/ism/cats.htm.

d. CAP Independent Technical Review. Self-Assessment is a Line Management function. Independent review of the associated CAPs is also a Line Management function. LPSOs will determine the method by which CAPs will be reviewed. An independent review will:

(1) Determine if the CAP provides timely or adequate corrective actions for all or part of the identified safety issues.

(2) Within 30 days of CAP approval, provide comments and their basis to the Field Element Manager and CLM when it is determined that the CAP does not provide timely or adequate corrective actions.

e. CAP Comment Resolution. The CLM, in consultation with the Field Element Manager, must perform the following to address review group comments.

(1) Determine if a CAP revision is needed.

(2) Revise the CAP appropriately.

(3) Inform the review group how their comments were dispositioned.

f. Dispute Resolution. The review group may choose to elevate their concerns regarding disposition of comments for dispute resolution in accordance with Paragraph 4, CAP 'Dispute Resolution Process'.

g. Deputy Secretary Briefing. The applicable LPSO must provide an opportunity for the Deputy Secretary (Department's Chief Operating Officer) or designee to be briefed by the Field Element Manager. The briefing may include identified safety issues, the CAP and planned corrective actions, and any associated resource issues.

h. CAP Implementation. The CLM must implement the approved CAP and complete the associated corrective actions.

(1) The CLM must track and report the implementation status of corrective actions. The status must be reported in the DOE CATS as the status changes or at least monthly, until the safety issue is closed.

(2) The review group may, at the direction of the LPSO, review the timeliness and adequacy of ongoing implementation of identified corrective actions.

i. CAP Verification. The Field Element Manager or CLM must conduct an independent assessment of all closed corrective actions. This verification must be performed by persons with sufficient independence from those who performed the work described in the CAP.

4. CORRECTIVE ACTION PLAN DISPUTE RESOLUTION PROCESS.

a. Disputes over the CAP or its implementation (such as timeliness or adequacy) must be resolved at the lowest possible organizational level. The organization that disagrees with the disposition of a given issue may elevate the dispute for timely resolution.

b. The organization that disagrees with the disposition of a given issue must elevate the dispute in a step-wise manner through the management hierarchy.

c. The dispute must be raised via a deliberate and timely dispute resolution process that provides each party with equal opportunity for input and a subsequent opportunity to appeal decisions up to the Secretary of Energy, if necessary.

Appendix A: Checklist for Reviewing Adequacy of Corrective Action Plans (CAPs)

No.:	Criteria	YES	NO
1	Has the Field Element Manager (FEM) prepared a single, comprehensive CAP to address all of the safety issues in the assessment report?		
2	Does the CAP clearly state the causes (the root cause(s) and causal factors) of the issue?		
3	Does the CAP describe the basis for the disposition of each identified safety issue?		
4	Does the CAP clearly state which corrective action(s) are responsive to the immediate condition/issue?		
5	Does the CAP clearly state which corrective action(s) are responsive to prevent recurrence of the issue?		
6	In the case that the FEM determines no action will be taken in response to a given safety issue, does the CAP describe the basis for this determination, and demonstrate how safety will be maintained?		
7	Does the CAP indicate for each corrective action the responsible individual (the Cognizant Line Manager [CLM])?		
8	Does the CAP indicate for each corrective action the expected date of completion?		
9	Does the CAP indicate for each corrective action the mechanism for the Line's independent verification of closure to ensure that the actions are appropriate to prevent recurrence?		
10	Does the CAP indicate for each safety issue the lessons learned for broader application?		

References:

1. DOE O 414.1A, "*Quality Assurance*"
2. DOE M 411.1-1A, "*Safety Management Functions, Responsibilities and Authorities Manual*"

Note: This checklist constitutes the minimum criteria for a CAP. Items 1 through 9 are based on requirements in reference 1; item 10 is based on requirements from reference 2.

別添資料9　東海村臨界事故に対するNRCの対応

NRC Temporary Instruction 2600/005 (10/12/99)
"Criticality Safety Programs at Fuel Cycle Facilities" 206
http://www.nrc.gov/NRC/IM/2600_005.html#_1_12

NRC Information Notice No.99-31 (11/17/99)
Operational Controls to Guard against Inadvertent Nuclear Criticality 209
http://www.nrc.gov/NRC/GENACT/GC/IN/1999/in99031.html

NEI Press Release, May 8, 2000
U.S. Nuclear Fuel Facilities are Operating Safely, Independent review Team Finds 211
http://www.nei.org/new/00-24.html

NEI Report 213
Http://www.bazley.net/NEIreport.html

Temporary Instruction - TI 2600/005

Issue Date: 10/12/99

NRC INSPECTION MANUAL NMSS

Temporary Instruction 2600/005

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Criticality Safety Programs at Fuel Cycle Facilities

Applicability: 2600

2600/005-01 Purpose

The purpose of this temporary instruction (TI) is to provide supplemental nuclear criticality safety inspection requirements for the resident inspectors at Category I fuel fabrication facilities and the two gaseous diffusion plants in response to early information learned from various sources concerning a criticality accident that occurred September 30, 1999, at a foreign fuel fabrication facility.

2600/005-02 Objective

The objective of this TI is to provide the resident inspectors with appropriate guidance to focus on licensee implementation of their criticality safety programs. Although the GDPs do not process moderate or high enriched uranium under NRC regulation, the resident inspectors at these facilities should use their discretion in applying the appropriate sections of this TI to similar operations at their sites.

2600/005-03 Background

A nuclear criticality accident occurred at a foreign facility that resulted in the exposure of three operators to extremely high levels of radiation, the extensive contamination of process areas, exposure of emergency responders and members of the public, and contamination of the environment. Preliminary indications are that the accident involved the dissolution of about 5 times the safe mass of uranium oxide (enriched to about 18%) by nitric acid in an "unfavorable" geometry vessel (e.g., the vessel was not designed to preclude a criticality for the enrichments encountered). The 18% enriched process was just restarted after a several year shutdown.

2600/005-04 Basic Requirements

Temporary Instruction - TI 2600/005

04.01 On a weekly basis, verify that the licensee has implemented appropriate measures to assure that moderate or high enriched uranium cannot be commingled in a LEU process when multiple enrichment categories are present onsite.

04.02 On a weekly basis, select at least one activity involving the manual transfer and processing of moderate or high enriched uranium and verify that the activity is conducted in accordance with NRC requirements and facility procedures and postings. Focus on the implementation of administrative controls. Conduct discussions with the operators involved to verify that they are aware of, and understand the safety requirements and what actions they should take if an off-normal condition arises or is observed. Review applicable records and verify that the operators have been properly trained and qualified for the above observed operations.

04.03 On a monthly basis, conduct a backshift inspection of an operation involving the manual transfer and processing of moderate or high enriched uranium and verify that the activity is conducted in accordance with NRC requirements and facility procedures and postings. Focus on the implementation of administrative controls. Conduct discussions with the operators involved to verify that they are aware of, and understand the safety requirements and what actions they should take if an off-normal condition arises or is observed. Review applicable records and verify that the operators have been properly trained and qualified for the above observed operations.

04.05 On a monthly basis, verify that new operators (or operators in a new assignment/position) have completed any prerequisite classroom training and receive appropriate oversight while in "on-the-job" (OJT) training status which is consistent with the plant manager's (senior ranking official onsite) expectations. Identify any situations where the plant manager's expectations are inconsistent with assuring that operators are appropriately trained.

04.06 Prior to the startup of any major new process or restart of a process that has been shutdown for more than one year, verify that the licensee has in place appropriate controls to ensure that the operations staff has been trained and updated in the operating procedures and safety limits and postings prior to the introduction of moderate or high enriched uranium into the process.

04.07 Within 45 days, review the facility emergency response procedures for a criticality accident and conduct discussions with shift operations management and health physicists to determine whether the procedures are up to date and technically adequate to provide reasonable protection for both onsite and offsite emergency response personnel from unnecessary radiation exposure and contamination should an event occur. Verify that the date of their last drill or exercise is consistent with plant procedures and review the status of any corrective actions that were identified as a result of these drills.

04.08 Within 45 days, review the maintenance and test records for the criticality accident alarm system and verify that the licensee is maintaining the system in an operable status.

04.09 On a monthly basis, verify that calibrations, testing, and maintenance of systems, structures, and components important to criticality safety are current and up-to-date.

04.10 Review the backlog of criticality safety maintenance items and access the safety impact to current operations.

04.11 Review the criticality safety corrective action log and access the safety impact of overdue items and review the effectiveness of implemented corrective actions.

2600/005-05 Inspection Guidance

General Guidance

The licensee is responsible for conducting specific safety evaluations for all activities involving the handling, storage or processing of special nuclear material; identifying the controls necessary to protect against the identified hazards; and taking appropriate measures to assure that those controls will be available and reliable. Safety controls are either active or passive engineered controls, or administrative controls. The licensee should use passive engineered controls as a first priority, where possible. Particular attention should be paid to the use of administrative controls to ensure that such controls are effective and reliable. Management control processes should assure that the identified controls flow down to the operators and technicians who are responsible for their operation and maintenance. Since the majority of nuclear criticality accidents have historically involved human error during the processing of moderate or high enriched uranium in liquid form, the inspector should focus on the implementation of administrative controls for similar processes at the licensee's facility. The inspector should challenge whether the administrative controls chosen by the licensee are appropriate for the complexity of the operation and its specific hazards.

Specific Guidance

Temporary Instruction - TI 2600/005

05.01 Any anomalies, questionable practices, or safety significant conditions identified by the resident inspector should be promptly discussed with headquarters nuclear criticality safety staff and with regional and headquarters management staff, as appropriate.

05.02 Moderate or high enriched uranium and materials should be physically separated from LEU processes and uniquely identified so as to minimize the possibility of human error that could result in the placement of moderate or high enriched uranium in an unapproved part of the process or plant. Operators should be aware of the material that they are authorized to handle, the specific limits involved, and the consequences of mishandling moderate or high enriched uranium. Where "downblending" operations occur, systems should be as described in the safety analysis and procedures followed verbatim.

05.03 For operators undergoing OJT, the licensee should have a method for determining what jobs they can perform unsupervised. The inspector should determine how the licensee assures that these operators have developed an adequate level of familiarization with the safety requirements of those jobs and an appropriate understanding and recognition of abnormal conditions or operations. This item should be a specific sign off step in the licensee's startup authorization process.

05.04 The inspector should specifically review those areas that handle, process or store enriched uranium in liquid form due to the greater challenge of preventing criticality accidents in this state.

2600/005-06 Reporting Requirements

All significant findings resulting from this Temporary Instruction (TI) will be orally communicated with regional and headquarters management in a timely manner and documented in routine inspection reports per IMC-0610.

2600/005-07 Completion Schedule

This inspection effort will be carried out during the routine resident inspector activities.

2600/005-08 Expiration

This TI will remain effective for 60 days from the date of issuance of this TI.

2600/005-09 Contact

Questions about the technical aspects of this TI should be addressed to Bill Troskoski, Fuel Cycle Operations Branch, at (301) 415-8076.

2600/005-10 Statistical Data Reporting

All direct inspection effort expended as a result of this TI should be charged against 2600/005 for RITS reporting.

10.01 Originating Organization Information

The Fuel Cycle Operations Branch (FCOB/FCSS/NMSS) initiated this TI.

10.02 Resource Estimate

The inspection effort necessary to complete this TI is included in current resources budgeted for routine inspections.

END

NRC Information Notice No. 99-31:Operational Controls to Guard Against Inadvertent Nuclear Criticality

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, D.C. 20555-0001

November 17, 1999

NRC INFORMATION NOTICE NO. 99-31: OPERATIONAL CONTROLS TO GUARD AGAINST INADVERTENT NUCLEAR CRITICALITY

- Addressees
- Purpose
- Description of Circumstances
- Discussion

Addressees

All NRC licensed fuel cycle conversion, enrichment and fabrication facilities.

Purpose

The U.S. Nuclear Regulatory Commission (NRC) is issuing this Information Notice (IN) to alert addressees to a recent nuclear criticality accident at a foreign fuel fabrication facility that resulted in a significant radiation exposure to workers and lesser radiation exposures to members of the public. Although an evaluation of the impact of this accident is ongoing, the NRC expects that recipients of this IN will review the information for applicability to their facilities and consider actions, as appropriate, to protect against a similar occurrence. However, suggestions contained in this IN are not

NRC requirements. Therefore, no specific action nor written response to this notice is required.

Description of Circumstances

On September 30, 1999, a nuclear criticality accident occurred at a facility in Japan that preliminary information indicates resulted in the exposure of three operators to extremely high levels of radiation, the extensive contamination of process areas, exposure of emergency responders and members of the public, and contamination of the environment. Preliminary indications are that the accident involved the dissolution of about 5 times the safe mass of uranium oxide (enriched to about 18%) by nitric acid in an "unfavorable" geometry vessel (i.e., the vessel was not designed to preclude a criticality for the enrichments involved). The 18% enriched process was just restarted after a several year shutdown.

Discussion

The Government of Japan has initiated a formal task force headed by the Prime Minister to thoroughly investigate the causes of the accident and determine any potential criminal liability. As information becomes available from the Government of Japan, NRC plans to conduct an in-depth review of the details surrounding the event to determine whether further improvements in the NRC regulatory program would be prudent. In the interim, a Temporary Instruction has been issued to NRC Resident Inspectors at the two high enriched uranium (HEU) facilities and the two gaseous diffusion plants regulated by NRC to focus inspection resources on criticality safety implementation at these facilities. NRC also plans to review the results of an industry initiative to assess their criticality programs. In view of the above accident, licensees are encouraged to review their policies and procedures and the results of safety assessments to assure that:

1. The possibility of commingling HEU and low enriched uranium (LEU) has been considered, where applicable, and appropriately rigorous controls are established to prevent the inadvertent introduction of HEU material into LEU plant areas and processes.

2. Operators who are authorized to handle special nuclear material (SNM) have received proper training/retraining with regard to the criticality safety rules and postings and that they understand the significance of the operating limits and what their expected response should be if any operating limit is exceeded.

3. Operations are conducted and administrative safety controls are implemented only in accordance with approved operating procedures and postings.

4. New processes and restart of processes that have been shut down for an extended period of time are covered by current safety assessments and an administrative process confirms that all applicable controls are established and

http://www.nrc.gov/NRC/GENACT/GC/IN/1999/in99031.html

implemented and operator training/retraining is completed prior to the introduction of SNM into the process.

5. Emergency plans contain appropriate provisions to ensure that both onsite and offsite emergency response personnel are made aware of criticality safety aspects of the facility, and receive proper health physics coverage and protection when responding to plant events.

6. Management provides an appropriate level of oversight of high risk operations to ensure that plant safety programs are effectively implemented and management expectations are being met.

Any further information developed as a result of the Japanese investigation will be reviewed by NRC to determine whether further action may be warranted.

This IN requires no specific action nor written response. If you have any questions about the information in this notice, please contact the technical contact listed below, or the appropriate NRC regional office.

Original signed by
Micheal F. Weber FOR

Elizabeth Ten Eyck, Director
Division of Fuel Cycle Safety and Safeguards
Office of Nuclear Material Safety and Safeguards

Technical contact: William Troskoski, NMSS
301-415-8076
E-mail: wmt@nrc.gov

Attachments:
1. List of Recently Issued NMSS Information Notices
2. List of Recently Issued NRC Information Notices

(ADAMS Accession Number ML993140347)

Press Release, May 8, 2000

U.S. Nuclear Fuel Facilities Are Operating Safely, Independent Review Team Finds

CHICAGO, May 8, 2000—U.S. uranium processing and fuel fabrication facilities are operating safely, according to a report released today by a special review team. The independent assessment, coordinated by the Nuclear Energy Institute, was requested by U.S. companies operating the facilities after last September's radiation accident that resulted in the death of two nuclear fuel plant workers in Tokaimura, Japan.

Engineering and procedural safeguards for blending uranium fuel that would prevent an incident, such as the one at Tokaimura, are in place and used at the 10 nuclear fuel facilities operating in the United States, the report concludes. Members of the team today briefed the U.S. Nuclear Regulatory Commission on the findings of their seven-month project.

"The U.S. nuclear fuel industry is operating on the assumption that an accident can occur. This provides a sound basis for the continuing vigilance and the safe operating practices that we observed," said John C. Brons, a Nuclear Energy Institute executive who presented the report, entitled "Assessment of Nuclear Criticality Safety and Emergency Preparedness at U.S. Nuclear Fuel Plants," to the agency.

The review was conducted by Brons, special assistant to the president at NEI; independent consultant Robert M. Bernero, who was director of Nuclear Material Safety and Safeguards at the NRC; and James R. Clark, a JAI Corp. vice president with considerable operating experience in the nuclear fuel industry.

"Safety in operating fuel facilities is the industry's overriding focus," Brons said. "Workers at these facilities understand that they have the authority to stop plant processes for safety reasons."

All U.S. uranium processing and fuel fabrication facilities are regulated by the NRC. Brons said the review team "believes that these regulations and standards are observed and provide for fundamental criticality safety."

Employees at the Tokaimura, Japan, fuel facility triggered the criticality, or nuclear chain reaction, on Sept. 30, 1999, by pouring excessive amounts of a liquid form of highly enriched uranium into a mixer. Radiation from the ensuing chain reaction has killed the two employees who suffered the most severe radiation exposure; a third employee also was injured. Hundreds of others, including residents immediately surrounding the Tokaimura facility, were exposed to elevated levels of radiation, though not at levels that would cause physical harm.

One of the contributing factors to the Tokaimura accident was insufficient training of workers on the potential for criticality-particularly when handling uranium enriched to 18.8 percent presence of the fissionable U-235 isotope-and its consequences. Neither of the operators who died had worked with the material before.

The report noted that processes are in place at U.S. fuel facilities to ensure that workers are experienced before being assigned to work independently. The report identified several opportunities to improve worker training, however.

In other areas that contributed to the Tokaimura accident, the review showed much stronger performance at U.S. facilities.

The facilities covered by the review are the five low-enriched uranium fabrication facilities operated by ABB Combustion Engineering in Hematite, Mo.; Framatome Cogema near Lynchburg, Va.; Global Nuclear Fuels in Wilmington, N.C.; Siemens in Richland, Wash., and Westinghouse in Columbia, S.C.

Press Release, May 8, 2000

Also, the team reviewed two high-enriched uranium fuel facilities owned and operated by BWX Technologies at Lynchburg, Va., and Nuclear Fuel Services in Erwin, Tenn. Also covered are the two gaseous diffusion plants owned and operated by U.S. Enrichment Corp. at Paducah, Ky., and Piketon, Ohio, and the uranium conversion facility in Metropolis, Ill., owned and operated by Honeywell.

Each assessment consisted of an on-site visit of one and one half to two days, preceded by the team's review of NRC inspection reports from the last two years. The review team focused on areas most important to criticality safety and emergency planning, including interviews with plant operators and other staff.

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Introduction

NEI Report

Introduction

On September 30, 1999, a criticality accident occurred at a uranium processing plant operated by the JCO Company, Ltd. in Tokai village, Ibaraki Prefecture, Japan. This report terms the occurrence as the Tokaimura event, or the Tokaimura accident.

Early information received from public sources reported that the Tokaimura event involved several factors of interest and concern to the uranium processing industry worldwide. Specifically, the criticality resulted in severe exposure to three individuals, involved the public and emergency planning considerations, and involved chemical processes that are in common use worldwide. In addition, the event was technically unusual in that it was of an extended duration, which required active intervention to terminate the criticality.

Senior managers responsible for the operation of commercial uranium processing facilities (facilities) in the United States met with the Nuclear Energy Institute (NEI) during the week of October 4, 1999. They concluded that it would be valuable to conduct on overall review of the facilities using experienced, independent observers in addition to any special or routine reviews done by the individual facilities. NEI was tasked with management of an industry initiative to review all U.S. facilities for susceptibility to the conditions understood to be factors in the Tokaimura event. There was no intention to develop an authoritative evaluation of the Tokaimura event. Rather, the intention was to use the early information available from public sources to develop a comprehensive assessment of U.S. facilities.

NEI discussed the industry initiative with the Nuclear Regulatory Commission (NRC) and with the Administration. Both agreed that the industry initiative was an appropriate response to the Tokaimura event. An expectation was set that the review would result in a publicly available report that describes the Team's assessment of overall industry conditions in the relevant areas. This report is the fulfillment of that expectation.

The facilities covered by the assessment are the five low enriched uranium (LEU) fabrication facilities owned and operated by ABB Combustion Engineering, Framatome Cogema, Global Nuclear Fuels, Siemens and Westinghouse and the two high enriched uranium (HEU) fuel facilities owned and operated by BWX Technologies and Nuclear Fuel Services. These facilities are licensed by the NRC under 10CFR70. The two gaseous diffusion plants (GDP) owned and operated by USEC, which are certified by the NRC under 10CFR76, were also included. In addition, the uranium conversion facility owned and operated by Honeywell was included at Honeywell's request. This facility is licensed by the NRC under 10CFR40. A brief description of each of these facilities is included in Appendix A.

The characteristics sought in the experienced, independent observers were focused on management level experience in operations, regulation and the conduct of assessments. After appropriate search and discussion with the facilities, a special assessment team (Team) was formed to conduct the facility review. The Team consisted of Mr. Robert M. Bernero, Mr. John C. Brons and Mr. James R. Clark. Resumes of the individual team members are in Appendix B.

Scope and Focus

The Tokaimura event involved the relatively infrequent handling of uranium enriched to the intermediate level of 18.8% U235. For U.S. commercial facilities, only the two HEU facilities are licensed for that level of enrichment. All other facilities are limited by their current licenses or certificates to lower enrichment levels. The Team concluded after a review of publicly available information that there were a number of other factors that were significant in shaping the environment for the Tokaimura event to occur appeared to be evident. They are:

Introduction

1. *A culture that permitted deviations from licensed procedures to respond to external pressures such as cost and schedule.* At Tokaimura, a set of procedures defining the process involved in the accident was approved during the licensing of the facility. Had these procedures been followed, the likelihood of a criticality would have been substantially reduced. During the licensed life of the facility, pressures to reduce costs led to adoption of management sanctioned procedures that were not in accordance with licensed conditions. The adoption of these procedures reflected a culture that was willing to sacrifice safety and regulatory due process for commercial expediency. At the time of the accidental criticality, the workers in response to schedule pressures employed a further shortcut over the unlicensed procedures, which greatly increased the risk.
2. *Tacit approval of procedural deviation by explicit involvement in unlicensed procedures and by routine willingness to deviate from "official" procedures.* Management and supervision created the initial set of inappropriate procedures but by practice did not insist that even those procedures be followed. Reportedly, operators frequently employed practices that were deviations from the promulgated procedures. Procedural use evolved to an "ad hoc" situation at Tokaimura.

3. *An insufficient criticality safety program, lacking appropriate use of the double contingency principle and maximum reliance on engineered controls.* The double contingency principle means that a criticality can occur only if two unlikely, independent events occur. Controls to prevent occurrence of such events are typically applied in a hierarchy of preference that values engineered controls over administrative controls. Engineered controls may be either passive or active but in either case are controls that are embedded in process hardware and do not require routine human intervention. Controls involving human intervention are termed administrative. At Tokaimura buckets were authorized in place of process designed vessels to dissolve the U_3O_8 powder; this eliminated some designed-in mass and geometry control but maintained the use of geometrically safe storage columns. Actual practice avoided the use of the safe geometry storage columns through use of the precipitator tank to accumulate a large batch in a single vessel. Ultimately, the practices in place when the accident occurred avoided mass controls and geometry controls and added in an unfavorable reflection factor.
4. *Insufficient administrative controls, including change control, procedures for starting/restarting infrequent operations and configuration management.* Review of the Tokaimura event did not indicate any administrative method for management to assure themselves that the procedures in actual use were those that they had sanctioned. It is not clear that the administrative mechanisms provided the operators with a way to know whether or not the procedures in use were authorized either. The event also disclosed that the various changes involved (substitution of buckets, elimination of safe geometry vessels, shift to an operation performed very infrequently) did not receive any special review to ensure that intended safety margins were maintained.
5. *Insufficient training to workers on the potential for criticality, the severe consequences of such an event and on adherence to procedures.* The actions of the operators indicated that they did not appreciate the impacts of handling material enriched to 18.8%. Results of interviews with the injured workers that were made publicly available indicated that they did not understand what criticality was and that they did not understand that many of the steps they had taken systematically eliminated barriers to criticality. Lacking this understanding, it is not surprising that they felt free to innovate to respond to schedule demands. It is normally expected that the operators actually performing work on the shop floor have experience to guide them in their understanding of procedures. In the case of this accident, neither of the operators had worked with this material before.

6. *Insufficient oversight, supervision or critical self-assessment, particularly with regard to*

inexperienced workers and unusual operations. It should be assumed in any organization that there may be times when the work force either misunderstands or for some other reason performs in a way that is contrary to management expectations. This assumption should result in the establishment of programs to oversee operations, to identify deficient equipment and practices, and to establish methods to ensure that effective action results from the observations. Although information regarding JCO's internal practices was not available to the Team, it was assumed that a robust program of this nature would be a helpful feature to reduce the probability of failure and may not have been a part of routine practice prior to the event.

7. *Insufficient instrumentation to monitor the potential for criticality or personnel radiation safety.* At Tokaimura initial indications of the criticality were derived from off-site monitors. Worker dosimetry was insufficient to establish actual exposure during the criticality.
8. *Inadequate emergency planning measures, particularly with regard to termination of an extended event, timely notification and care of exposed personnel.* Communication between the facility and appropriate governmental agencies after the event was very difficult and in some instances, untimely. Actions between governmental agencies were uncoordinated, and termination of the extended criticality was made more difficult by failure to provide prior consideration for such an event. The management of emergency care for the severely irradiated individuals resulted in three moves before they reached a facility properly equipped to treat them.
9. *Inadequate regulatory oversight.* The regulatory agency associated with licensing of the facility did not conduct regular oversight activities. Visits were infrequent and not focused on licensed operations.

Based on these considerations, the foregoing statements identified in italics defined the scope and focus of the Team's review. (Subsequent authoritative evaluations of the Tokaimura event did not disclose any additional areas for review.) The Team prepared a document entitled "Assessment of Nuclear Criticality Safety and Emergency Preparedness at U.S. Nuclear Fuel Plants" that provided this information to the industry. The Team also prepared a protocol for conducting the assessment at each of the facilities to ensure uniformity and thoroughness. Both of these documents were delivered to the industry by letter dated November 23, 1999. The documents are contained in Appendix C.

Assessment Methodology

The individual assessments were conducted in accordance with the protocol. Each assessment consisted of off-site preparation by the Team and an on-site visit of 1 ½ days to all facilities except for the two HEU facilities where the on-site visit was two days.

Prior to the on-site visit, the Team requested and received an advance package of information from each site that was used to provide specific background in a number of areas to be reviewed while the team was on-site. In addition, the Team reviewed NRC inspection reports for the two-year period preceding the Team's visit. These reports were available in the public document room.

The on-site portion of the visit was begun with a management presentation that covered a detailed list of questions and topics included in the protocol document. This presentation was conducted in a highly interactive format as the Team probed the information presented.

Following the management presentation the Team participated in a facility tour consisting of areas of interest from the standpoint of criticality safety and emergency planning. In addition, the Team conducted a number of individual interviews of facility staff, focusing heavily on operators and their immediate supervisors. Where possible the Team spoke to staff from more than one shift.

At the conclusion of the first day, based on its observations and interviews, the Team advised each

facility of three or more topics that individual team members would pursue in depth the following morning. The in-depth reviews allowed team members to "pull the string" on key issues to validate observations or view the "details" behind items presented on the first day.

After the in-depth reviews were completed, the Team prepared and delivered a debrief to the facility management.

Results – General

All uranium processing and fuel fabrication facilities in the United States are regulated by the NRC and committed to the same American National Standards Institute (ANSI) standards regarding the basic criteria for criticality safety. All of the facilities are committed to emergency planning under their specific regulations, 10CFR Parts 40, 70 and 76. The Team believes that these regulations and standards are observed and provide for fundamental safety. The Team was committed to report to senior plant management any conditions of safety urgency that required immediate attention observed during the course of the review. The Team did not observe any such conditions at any of the ten facilities. The Team concluded that the facilities reviewed are operating safely.

Results – Contributing Factors

The assessment conducted by the Team was focused on nuclear criticality safety and emergency preparedness as defined and limited by contributing factors evident from public information about the Tokaimura event. The basis of the Team's observation was not the threshold of regulatory compliance or standards compliance that provide an adequate safety baseline but rather a higher standard of "best industry practice."

At the outset of the review process, "best industry practice" was based on the Team's collective experience. As the review process continued, "best industry practice" became totally grounded in superior performance actually observed in the industry.

Note: Text in *italics* indicates a contributing factor that appeared to shape the environment for the Tokaimura event. The text in *italics* is not reflective of the Team's conclusions at U.S. facilities.

1. *A culture that permitted deviations from licensed procedures to respond to external pressures such as cost and schedule.*

   Observations

   Although all of the U.S. facilities maintain some level of awareness on the shop floor and within the office areas of pertinent business goals or objectives, the Team did not observe any instance of a culture that emphasized those goals or objectives above safety or anywhere near it. Most production employees viewed the display of business goals as informative and helpful to understand priorities, but no one ascribed any dominant performance pressure to them. Employees at all of the facilities expressed their right to stop the process if they had any safety doubts or concerns. Operators appeared very confident that management would be very supportive of any decision that they made to stop while a safety concern was resolved.

   Best Practices

At best practice facilities the Team observed a very positive culture in this regard, not just the absence of a negative culture. In the positive culture setting there was a high level of congruence between the expressions of management regarding safe work practices, use of procedures and the authority of the operators and the articulation of the same concepts by the operators and supporting management staffs.

2. *Tacit approval of procedural deviation by explicit involvement in unlicensed procedures and by routine willingness to deviate from "official" procedures.*

Observations

As a matter of first priority in this area, the Team tested the methodology used at each facility to ensure that the procedures in use flow down from the licensed conditions and supporting safety analyses. The methods used at all facilities employed sufficient rigor to provide reasonable assurance that the operating procedures in use are consistent with licensed conditions. The Team did not observe any instances of shortcut or unanalyzed procedures.

The Team found that senior management at all facilities expressed their will and intention that operating staff adhere to procedures. Several facilities insisted that their standard of adherence was one of "verbatim compliance." Others expressed varied views of what was intended by procedural adherence. A few facilities had defined a hierarchy of procedural use dependent on the process or the specific nature of the steps being performed.

The Team also found that it was the will and intention of the operating levels of the organizations to adhere to procedures. Frequently, however, the actual use of procedures in the course of operating the facility did not match the stated standards of use described by management.

The processes employed are generally repetitive and automated. The Team concluded that procedures are being followed and that both management and operating staff are concerned about doing the work in accordance with procedures. The processes in the main however do not lend themselves to step-by-step following of procedures or by "verbatim compliance" as the Team understands that term. The difficulties that arise in the use of procedures are more attributable to differences of understanding between the procedure writers and the procedure users on the degree of latitude that the operator has in any part of the process.

Best Practices

At best practice facilities, management has carefully defined and communicated its expectation on how procedures are to be used. The definition has accounted for the realities of the process and the ability of the operators to access or refer to the procedures during their work. The definition also describes different standards to be employed during especially critical steps or when the procedure is infrequently performed. In some cases, operator aids have been authorized to assist the operators in compliance with the expected standards. At these facilities there is a high level of congruence in the understanding of the operators and the expectations of management. It is clear that the expectations are reinforced.

3. *An insufficient criticality safety program, lacking appropriate use of the double contingency principle and maximum reliance on engineered controls.*

Introduction

Observations

All facilities have adopted the ANSI standards that employ the double contingency principle for processes involving special nuclear material (SNM). Some elements of process at the GDP do not permit application of this principle and the exceptions are recognized in their certificate. Specific focused requirements in the technical specifications applicable to these facilities compensate for any lack of ability to employ the principle in these areas.

Although all facilities adopt the ANSI standards for nuclear criticality safety (NCS), each individual facility has developed its own unique NCS strategy that is proposed in its license application for NRC approval. This case-by-case approach results in significant differences from plant to plant for reliance on mass or moderator control, in the application of mass thresholds for NCS calculations, and in the number of NCS controls for a process. Some facilities have an avowed policy of establishing "triple contingency controls" so that the least severe or most likely contingency occurrence would be an internally reportable event. The first level of reporting to the NRC would not be required until the second of three contingencies occurs.

Engineered controls are the expressed preference at all facilities. Most facilities have some process in place to systematically review administrative controls in use and where reasonable to replace them with engineered controls. Some facilities are using the integrated safety analysis (ISA) process very effectively to accomplish this goal of minimizing administrative controls.

Those facilities that have developed the ISA process more extensively report success, not so much in discovery of previously unrecognized risks, but in establishing a coherent consolidation of the safety design basis. It is this coherent design basis that can be used to weigh enhancements of safety controls and to assure that safety controls are systematically flowed down into operations.

Postings are used at all facilities to provide reminders at the point of need of criticality safety restrictions important to the operators and to the processes. Some facilities use them extensively. The Team noted that the impact and effectiveness of the postings is highly dependent on the care used in their preparation, the size print used, the language clarity and the location chosen.

Some facilities are reporting large numbers of "reportable" items under NRC Bulletin 91-01, which leads to a perception that criticality safety programs may be lax. In the Team's view, the real driver for the large numbers of items is the application of an overly conservative standard used to determine the scope and reportability of items.

Best Practices

Best practice facilities are staffed with an adequate number of criticality safety engineers with job responsibilities that are undiluted by significant collateral duties. They are highly visible in the operating areas of the facility and well known to the operators and their supervision. Criticality safety surveillance is enhanced by cross training radiation protection personnel on shift to perform some nuclear safety surveillances. Any administrative controls in use are systematically challenged based on priorities established through aggressive use of the ISA and internal problem reports or operator input. Internal control limits are established that provide early warning of process deviations reportable under Bulletin 91-01. These early warning issues receive aggressive follow-up using the full range of the facility corrective action program. Postings are determined by the nuclear safety department and turned over to the operations department which takes

complete ownership for preparation and placement of the postings. External events such as the Tokaimura event result in a thorough review of the facility for applicability and lessons learned.

4. *Insufficient administrative controls, including change control, procedures for starting/restarting infrequent operations and configuration management.*

Observations

All facilities employ some method to identify authorized changes to operating procedures and to assure that procedures in use are the latest revision. The Team observed varying degrees of rigor to be certain that operators are aware of the change and that outdated versions of the procedure are no longer available. Some facilities use primarily paper copies of procedures and control methods that are suitable to paper. Other facilities use computer based systems and are moving toward elimination of "hard copy" procedure use. At most facilities changes are highlighted or marked in some distinctive way to facilitate recognition and awareness of change content.

Each facility has a satisfactory process for controlling changes to the physical plant and for start-up of new processes. In some instances the change control process is not "user friendly" in that it is difficult to verify and validate the entire record of change. Most facilities also re-initiate the change control process for previously approved systems that have been idle for extended periods or for processes that are used infrequently. Although this practice, which is commonly used in the facilities, is not required at most facilities, the Team believes that the probability of the Tokaimura event would have been reduced if it had been employed there.

Best Practices

Best practice facilities employ a centrally administered change control process for operating procedures that assures that old copies of the procedure are no longer available to operators once a change has been issued. Positive controls are in place to be confident that operators are informed of changes and trained in their significance before they are permitted to operate a process affected by change.

Best practice physical plant change control operates under an umbrella policy that specifies applicability to all equipment and processes related to nuclear safety. The policy also specifies that the change control requirements also apply to any previously approved system, even if unchanged, if it has been "out-of-service" for more than a designated time. The process is administered with a structured checklist that accompanies a proposed engineering change through a pre-established multi-disciplinary review and approval process that includes:

- an integrated safety analysis of the proposed change

- verification and validation of the change prior to implementation

- training of the appropriate personnel prior to initiation with SNM

- controlled distribution of revised procedures.

Document control is maintained on the entire record of the change and management oversight review of proposed engineering changes at the onset, during project development and near completion is included.

5. *Insufficient training to workers on the potential for criticality, the severe consequences of such an event and on adherence to procedures.*

Observations

All facilities provided information to their workforce about the Tokaimura event; as a result there was general awareness of the accident and its consequences. Only a few facilities, however, used the event and the potential lessons learned aggressively to reinforce management expectations and standards. In general, interviews conducted by the Team revealed a weak understanding of the term criticality and an equally weak understanding of its consequences. Many operators understood criticality to have dire, life-threatening consequences but erroneously equated the cause of these consequences to an explosion. Operators were uniformly aware of the restrictions and controls under which they operate and were adamant in their need to adhere to those controls, but the training program had not provided sufficient understanding to retain the reasons for the controls. A few facilities were significant exceptions to this in that their work force exhibited a strong understanding of these key concepts.

General training is conducted at all facilities for all new employees shortly after the time of hire, and generally, the training is repeated or updated on a mandatory annual basis. In some cases the material presented for these general training courses was inordinately detailed and scientific. In other cases, the material used provided minimal understanding of the technical concepts. In the case of the few facilities where a strong understanding of key concepts exists, the information appears to have been acquired from sources other than the general or annual retraining such as handbooks or formal job specific criticality training.

About half of the facilities conduct more detailed training in the classroom on a task specific or job qualification specific basis.

Training is the responsibility of the training department at some facilities. Those facilities that have training departments usually conduct training on a more formal basis using learning objectives, lesson plans and objective measures to gauge success. Training staff tend to be beneficially engaged in the qualification process as well. In other facilities, training is a collateral responsibility of supervision, engineering or the criticality safety department.

Most of the qualification programs are relatively informal. The most common qualification process for operators involves on the job training (OJT), observation and approval/qualification by the first line supervisor. Some facilities use a much more formal process involving qualification cards, written tests, independent observers and practical factor check-offs. The Team was not able to discern any substantial differences in performance between the two systems. All but one of the facilities that used written tests as a part of the qualification process administered them as "closed book" even though all expected the procedures to be used during the course of operation. This appeared to the Team to represent inconsistent thinking. If the procedures are expected to be in active use during operations then the testing should be open book. If procedures are expected to be used only when some uncertainty exists, then closed book testing may be appropriate.

Some facilities assign permanent employees as the majority of the work force and rely on temporary employees for the remainder. The Team observed some uncertainties in the training

and qualification management for temporary employees as compared with permanent employees.

Best Practices

The best practice facilities used the Tokaimura event aggressively to reinforce management expectations. The work force understands the physical phenomenon called criticality and is thoroughly aware of its severe consequences and how they occur. The work force also understands the physical principles associated with the various control factors in use at the facility.

Training is conducted to predetermined training objectives, and training results are measured to validate the achievement of objectives. Initial general training is backed up in six to eight weeks in recognition of the fact that, for a new hire, initial training is somewhat like " drinking from a fire hose." Annual retraining advances the general skill of the workforce rather than maintaining the entry level knowledge.

Qualification processes engage process engineers with the trainers and supervision to produce a quality product. Individuals assigned to observe OJT are themselves trained to observe the qualification process and act independently of any possible pressure to qualify people. Training material provided for operators captures potential operating lessons learned from the facility's own history and the industry at large. Individuals selected to train new operators are chosen for their training skills as well as their qualification credentials.

6. *Insufficient oversight, supervision or critical self-assessment particularly with regard to inexperienced workers and unusual operations.*

Observations

Strong, beneficial involvement by first line supervision in operations was evident at all facilities. At most facilities, day-to-day close involvement of the criticality safety engineering staff with plant operations was also evident. At some facilities, process engineers and radiological technicians contributed to a healthy oversight process by involvement in various oversight roles such as conducting periodic surveillances of compliance with criticality safety postings.

All facilities conducted periodic audits related to criticality safety and operations as required by their licenses or certificates. At many facilities, however, the distinctions between oversight techniques that test compliance and those that seek opportunities for improvement or adherence to expectations were poorly defined. Requirements that would be better satisfied by formal compliance-based audits were frequently performed in an informal manner. Programs aimed at improvement opportunities were often conducted by the same individuals, month after month. The observations derived from these reviews frequently fit a predictable mold of benign deficiencies and seldom led to substantive opportunities for improvement.

Administrative corrective action programs are employed at all facilities to trend observations and to track items to closure. Many of the programs were highly compartmented, however. For example, NRC observations would be tracked in one program while a different program was used for internal observations. In some cases there were several corrective action programs tracking items derived by various sources. Often more attention and emphasis was given to NRC observations than those derived internally or independently with less regard for the significance of the observation. The diffuse nature of these programs tended to reduce their effectiveness.

Introduction

Best Practices

Best practice facilities exhibit a substantial involvement by first-line management on the shop floor every day. This is supplemented by the active engagement of process and maintenance engineers and others such as the radiological technicians who have been specially trained to make observations regarding quality and safety of operations. Where appropriate, check lists are provided to guide these observations.

A balanced mix of audits, which formally test compliance; surveillances, which test conformance to expectations; and management walk-throughs, which seek opportunities for improvement, is employed. The results of these efforts together with those of outside agencies and other independent sources are tracked and trended in a comprehensive system. In addition, all individuals at the facility are free to contribute observations or identify problems. High percentages of the observations are identified by people actually involved in the process. Programmatic results are analyzed by management for the effectiveness and timeliness of prior corrective actions

7. *Insufficient instrumentation to monitor the potential for criticality or personnel radiation safety.*

Observations

Both instrumentation to monitor for criticality and personnel dosimetry are appropriate. On-site instrumentation provides proper coverage of all areas on site handling SNM to detect criticality. Alarm condition notification is accomplished by both audible and visual means. Dosimetry provided to workers is appropriate to monitor for routine exposure and also contains the ability to record accident exposures.

Instrumentation to monitor for criticality is available at most emergency control facilities in the form of instrument location and alarm/not alarm condition. Facilities rely on trained monitoring teams with hand-held instruments to monitor post alarm conditions. One facility has the capability to monitor criticality accident alarm system instrumentation for continuous readings after it has alarmed.

8. *Inadequate emergency planning measures particularly with regard to termination of an extended event, timely notification and care of exposed personnel.*

Observations

All facilities have active emergency plans, which are exercised routinely on site and periodically with support organizations off site. The exercises cover the full range of site emergencies including criticality (except, of course, at Honeywell where no risk of criticality exists). Written agreement with local emergency organizations, fire, police, and hospitals are in place to support emergency operations. Facilities on site to coordinate activities and communicate with off-site agencies and organizations are in place. Some facilities are very elaborate. On-site work force

and visitors are trained in actions to be taken in response to various site emergency conditions.

Most facilities have relatively large sites that result in very low risk to the public especially with respect to a criticality. Risk to the off-site public is typically process or chemical risk. The principal risk at these facilities is to the on-site workers, radiation risk mostly from accidental criticality and process safety risk mostly from chemicals. Appropriate emphasis is given in emergency plan drills and exercises to risks associated with criticalities, chemical upsets or fire on site.

Some facilities include extended criticalities in their repertoire of drills; others do not. Few facilities have given full consideration to options that may be used to terminate an extended criticality and the logistics to employ them. All facilities have considered the medical management of contaminated individuals but few have considered the management of highly irradiated individuals and the logistics to deliver them to appropriate facilities.

Best Practices

Best practice facilities maintain an active emergency planning organization that works closely with community emergency organizations on a mutual support basis. These arrangements are documented in written agreements and include a scope of services that encompasses the worst-case support situations. Arrangements are in place to guide community assistance forces who respond to plant emergencies on an off-hours basis. Community forces have been trained in special circumstances that may apply, such as fire fighting without the use of water in certain areas. Drills and exercises span the full range of emergency situations that may be encountered on-site, and full consideration of the worst-case situation has been applied. Routine training and drills emphasize events with the highest probability.

Emergency planning facilities are equipped with all necessary communication equipment, and backup equipment is available and tested. Meteorological information and accurate maps of the surrounding community are available. The emergency control facility itself will be habitable during an extended criticality, or an alternate site is available. Appropriate facility drawings are available at the emergency control center to allow planning of remedial actions in the event of an accident that renders access to the scene dangerous.

9. *Inadequate regulatory oversight.*

Observations

All of the facilities reviewed receive adequate regulatory oversight from the NRC. The regulatory presence varies appreciably from one facility to another. The two HEU facilities have a single resident inspector as well as periodic inspections by NRC headquarters and regional staff. The two GDP have two resident inspectors each, and are frequently inspected by NRC headquarters and regional staff. The five LEU fuel fabrication plants do not have permanent resident inspectors but are periodically inspected by NRC headquarters and regional staff in a consistent pattern with changes to reflect unique conditions such as start-up of a new process. The single uranium conversion plant receives more than adequate regulatory oversight, roughly equivalent to the level applied to a fuel fabrication plant. NRC oversight is responsive to special circumstances such as the installation of new processes or labor disputes.

A healthy, respectful relationship with the regulators was apparent at all of the plants reviewed, especially with the resident inspectors at the four plants that have them. The GDP seem to receive the most intense level of regulatory oversight. The Team recognizes that these very large facilities came under NRC regulation only in the past several years of their very long operating lives, a basis for intense

effort to establish the regulatory system under Part 76, unique to these plants. With the management systems now in place at the GDP, the continued intensity of regulation may be disproportionate to risk.

The evolution of NRC's licensing (and certification) process is evident. There is gradual adoption of ISA and the longer, 10-year license term. The scope and content of license conditions vary from plant to plant. Individual licensees are developing improvements in safety management systems, such as graded criticality safety limits, use of performance indicators, etc. The unique characteristics of these plants, even within a class, pose a challenge for evolution of a balanced regulatory regime that will require a continuing cooperative effort between the industry and the NRC.

Results – Integrated

The review process brought about by the Tokaimura event provided what appears to be a unique opportunity for a small group of people, the Team, to have full and very cooperative access to all commercial domestic fuel cycle facilities in one relatively short window of time. This was a unique opportunity to conduct a safety review at all of these facilities using the same scope and approach. The Team is quite conscious of the limited scope of its reviews and the short time for conducting each one. The typical review had the Team spending only about 15-20 hours in each plant. Nevertheless, this unique opportunity has enabled the Team to form some observations and conclusions that go beyond the scope of the review process itself. These additional observations are offered by the Team, conscious of our limitations, in the hope of providing further value to the ten facilities and to the NRC.

Competition and Consolidation

Portions of the industry were once a monopoly; the government run GDP were at one time virtually the only source of uranium enrichment. Other portions have long been independent competitors. The former monopoly portions are now challenged by available product from new sources, imposing competitive pressures where none previously existed. The competitive portions are participating in a global consolidation effort that provides new pressures. Overall, the industry is of strategic interest to the country. The time of transition is one for caution and clear focus on fundamentals.

Proprietary considerations have caused the facilities to be very guarded in sharing operating practices. To some extent that notion is reinforced by various securities and exchange rules in effect in the present context because of merger and acquisition activity. This report refers to a number of "best practices." It is interesting to note that each facility visited contributed in some way to the best practices mosaic. The Team believes that the best practices cited in this report do not have anything to do with proprietary processes.

The Team believes that competition, consolidation, efficiency, safety and the strategic national interest will be served well if the facilities can find some way to share best practices and permit benchmarking in ways that do not betray proprietary interests.

The Facilities

The fuel cycle facilities reviewed cover the front end of the nuclear fuel cycle from the receipt of natural uranium oxide (U3O8) at the conversion facility to the shipment of completed fuel assemblies to the reactor users.

The conversion facility converts the natural U3O8 to natural UF6; it does not handle enriched uranium

(SNM). Although no risk of criticality exists, this facility was included in the review at its request because the chemical risks involved require emergency plan considerations. The other nine facilities accomplish the enrichment process, production of enriched uranium oxide powder, formation of the powder into ceramic pellets, loading of the pellets into fuel rods and, finally, assembly of the fuel rods into completed fuel assemblies for use in reactors. Facility product from the enrichment plants is typically in the form of UF6. Fuel fabricators may deliver product in powder, pellet or fuel assembly form. All must maintain careful batch control for the enrichment assay to meet customer specifications and to maintain close Material Control and Accounting (10CFR Part 74).

The fuel fabricators often hold substantial batches of material in interim storage for product blending and control. Product assay and quality receive great emphasis, as they should, but it takes additional effort to maintain comprehensive quality assurance for management and operations. These facilities are each a part of a worldwide network of nuclear fuel production that requires careful accounting for the condition of the supply materials received and the products shipped, as well as the containers used. The UF6 and other products must be shipped in certified containers that require close surveillance and testing to meet requirements.

Risk and the Regulatory Process

The processes at these facilities are both chemical and physical. The conversion plant uses a chemical process to convert oxide to the UF6 form. The enrichment plants use a physical process of pumping for pressurized selective diffusion of the UF6 gas. The fabrication plants use chemical processes to produce the enriched oxide powder from the UF6, and a succession of mechanical processes thereafter. Many of these mechanical processes are highly automated and, when viewed step-by-step, are relatively simple. Human involvement at any given stage tends to deal with a focused, repetitive portion of the process and is provided mainly for safety oversight, quality oversight, dealing with process upsets and handling of process input and output materials.

The principal accident risks at the conversion plant lie with potential release of large quantities of hazardous chemicals. At the enrichment plants, the hot UF6 gas reacts vigorously with water, even moisture in the atmosphere, releasing hazardous chemicals, HF and UO2F2. If the UO2F2 particulate collects in one place, a critical mass may form. Criticality is avoided at these plants by controlling the size of the cylinders used to hold the UF6, by controlling the possible buildup of deposits within the enrichment process and by avoiding collection areas where accidental UF6 releases might collect. The fuel fabrication plants have risks associated with both the failure of the chemical processes and the possibility of criticality accident with large quantities of material in interim storage or the possible collection of process scrap residues to form a critical mass. Considering these risk characteristics and the layout of these plants, in the Team's view, risk to the off-site public is low, and is typically process or chemical risk. The principal risk at these facilities is to the on-site workers, radiation risk mostly from accidental criticality and process safety risk mostly from chemical hazards. The harmful range of radiation from an accidental criticality is so limited that such an emergency can be managed at the site without major off-site protective measures. The risk profile is distinctly different from that of a nuclear reactor where risk to the off-site public from radioactive releases is the dominant concern.

The Team was surprised to find an apparent tendency to manage and to regulate these facilities as similar to reactors by both the management and the NRC. On the facility side, the Team observed emulation of reactor programs in administration of training and qualification, intentions for the use of procedures and elsewhere. On the regulatory side, the Team observed evidence of regulatory initiatives apparently modeled on reactor programs, such as the development of standard performance indicators. The regulatory process for these facilities is evidently evolving. The ISA is being introduced; license terms and application sequences are changing. Major licensee performance evaluations are being

conducted by the NRC. Yet some of the licenses are still laden with special conditions as they were in the past. These license conditions are not always consistent. For example, some licensees are required to obtain a periodic external audit of their criticality safety program, while others are not. The direction and basis for risk informed regulation of these facilities is not yet clear. There is, however, a clear opportunity for the industry and the NRC working together to enhance the regulatory paradigm as the NRC moves into risk informed regulation in the fuel cycle area.

In the Team's view, it is important that the facilities be recognized and treated as they are, unique facilities with low and unique risk profiles. Expectations and programs should be directed at the realities of the processes being employed. Efficiency and safety will both be enhanced if the imposition of elaborate measures better suited to other enterprises is avoided. As much as each of these facilities is similar to the others, it is also sufficiently unique so that few "one size fits all" solutions are applicable.

Conclusions

The Team did not observe any conditions during the course of its reviews or on-site visits of safety urgency requiring immediate attention.

During the course of its review the Team observed a number of instances at each facility where actual performance fell short of management expectations or of a standard that would be described as best practices. In each instance, the Team provided its observations to the facility involved for its consideration and potential resolution or adoption. Similarly, as previously noted, each facility visited contributed in some way to the virtual mosaic which ultimately could be described as the "Best Practice" facility. Shortcomings and strengths considered, the Team did not encounter any deviation, practice or condition that compromised the nuclear safety of the facility.

Throughout its review process the Team observed a common belief on the part of the regulators, the managers, the engineers and the operators that a criticality is possible and that it can happen "here." This is a positive contribution to continuing safety.

The prevailing view at the outset of this review was that the fuel cycle industry in the United States was regulated and operated on a firm safety foundation. Within the scope of its review as developed by a focus on the perceived contributing factors to the accident at Tokaimura, the Team affirms that view.

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別添資料10　NCS Procedural Infractions

Sample Page of Source Publication for
Operating Experience Weekly Summary (OEWS) NCS Procedural Infractions
DOE サイトにおける臨界安全手順の違反事例 （仮訳）

Sample Page of Source Publication for
Operating Experience Weekly Summary (OEWS) NCS Procedural Infractions
臨界安全手順に係る違反事例 （仮訳）

事象－1
1. 年月日 ； 1999年 8月24日
2. 場所 ； RFETS
3. 概要 ；
正確な貯蔵位置の連絡がうまくいかかったため、隔離距離の条件を守れず、臨界安全の裕度を減少させる結果になった。現場調査員は、「電算機上の場所名と現場のグローブボックスの場所名は、文字による識別名が異なっていた。また、現場監督者は、核物質を収納した缶の貯蔵場所を工程のスペシャリストに伝える時英数字を組み合わせた識別名を使用していた。」ことを確認した。(99－

事象－2
1. 年月日 ； 1999年 4月12日
2. 場所 ； RFETS
3. 概要 ；
臨界安全に係わる運転制限条件を満たすことができず、臨界安全の裕度を減少させる結果になった。この事象が発見される3日前に、濡れた可燃物の詰め替え作業をするグループが、可燃物をグローブボックスに搬入する際の条件を確保するために、防火用毛布を据え付けたが、臨界安全のためのドレインが詰まっていないことを確認しなかった。(99－

事象－3
1. 年月日 ； 1999年 5月 6日
2. 場所 ； RFETS
3. 概要 ；
臨界安全に係わる運転制限の条件を満たすことができず、臨界安全の裕度を減少させる結果になった。作業員は、Pu の制限値が 200g の 55 ガロン(約 200 リッター)・ドラムに、275g の Pu を収納し、JH-98ドラムの間隔をあける保管条件に違反する24インチ(約61センチメートル)以内に 55 ガロン・ドラムを保管した。その 55 ガロン・ドラムは、他の施設から搬入した物であった。そのドラムは新しい施設の中で移動され、新しい場所で他の作業員が詰め替えも自分の作業の一部であると誤認してそのドラムの詰め替えを行った。(99－

事象－4
1. 年月日 ； 1999年 2月18日
2. 場所 ； RFETS
3. 概要 ；
臨界安全に係わる運転制限の条件を満たすことができず、臨界安全の裕度を減少させる結

果になった。200g Pu以上を収納したドラムが、共通の壁で仕切られた2つの部屋に貯蔵されていた。異なった2つの組織は、各部屋の原子力施設の安全について管理を行う義務があったが、組織間では部屋の仕様又は貯蔵の必要条件に係わる情報の共有化がなされていなかった。また、その部屋の1つには、核物質を貯蔵をしてはならない旨の標示があったが、目の高さよりも上にあったので、その標示に気づかなかった。(99−

事象−5
1. 年月日 ; 1998年 9月10日
2. 場所 ; RFETS
3. 概要 ;

臨界安全に係わる運転制限の条件を満たすことができず、臨界安全の裕度を減少させる結果になった。汚染したセルにドラムを搬入する作業員は、ドラムを搬入する前にドラム内のPu量がセル内の取扱い量の範囲内にあることを確認しなかった。4リッター容器に限定されているカートの上に、6リッターの容器が乗っていた。地下貯蔵庫の棚に貯蔵されている核物質は、棚の質量制限値を超えていた。運転員は、間違った臨界安全手順を使ってサンプリングを行っていた。(98−

事象−6
1. 年月日 ; 1998年 8月11日
2. 場所 ; LANL／LACEF
3. 概要 ;

核分裂性物質の質量制限値に違反すると、大きく臨界安全の裕度を損なうことになる。臨界安全の訓練コースのためのデモ試験を準備している時に、核物質の質量をカートの上の他の核物質に追加して、単一貯蔵区域の許容される質量制限値を超えてしまった。1人目の作業員は、デモ試験のために3個の核物質を用意し、その内の1個は、デモ試験時には気づかなかったが、劣化ウランの代わりに10%の濃縮ウランであった。2人目の作業員は、10%の濃縮ウランを劣化ウランと信じて、その
10%の濃縮ウランをカートの上に乗せて、一時的ではあるが質量制限値を超えてしまった。(98− ／5)

事象−7
1. 年月日 ; 1998年 7月 8日
2. 場所 ; LLNL
3. 概要 ;

手順書を守らなかったので、質量制限値を超える結果になった。作業区域において、268gPu が見つかり、これは古い制限値 2,500gPu から変更した新しい制限値 220gPu を超えていた。管理者は、制限値が変更になった連絡を受けていたが、臨界安全に係わる手順書を変更しなかったか、或いは、古い手順書が廃止された時に核物質を作業区域から移動させなかった。(98−

事象－8
1. 年月日 ； 1998年 6月 2日
2. 場所 ； Hanford
3. 概要 ；
核分裂性物質の取り扱いに係わる条件を満たすことができなかったので、HPFP における臨界安全の裕度を減少させる結果になった。未熟な作業員が、必要な管理を行わずに核分裂性物質を移動した。作業員間の連絡が不十分であった。コンテナー間の隔離距離の制限値が守られていなかった。輸送コンテナーの標識が不十分であった。DOE は、承認無しに核分裂性物質を移動したことについて、報告を受けていなかった。グローブボックスの差圧計の校正に係わる有効期間がきれていた。グローブボックスから移動する核分裂製物質の質量を決めるための明確な指針(或いは承認された技術的根拠)がなかった。 (98－24／3)

事象－9
1. 年月日 ； 1998年 5月 4日
2. 場所 ； RFETS
3. 概要 ；
臨界安全の制限値に違反することにより、臨界安全の裕度を減少させることになった。塩を処理する際の臨界安全制限値を定める時に、不確かさについて非安全側(保守的でない)の前提を設けて評価していた。砂、スラグ、るつぼの運転員は、抜き出し運転時に、運転手順書により要求されている Pu の質量を管理しそこなった。運転員は、各々の缶について臨界上安全な値の代わりに Pu の推定グラム数を記録した。
(98－19／1)

事象－10
1. 年月日 ； 1998年 1月 7日
2. 場所 ； Commerc'l
3. 概要 ；
認可を受けた事業者は、核物質の処理を含む施設の運転が安全の条件を遵守して実施されることを保証する全体的な計画を運用しそこなった。ウラン粉末のホッパーの体積が、臨界安全の解析で設定したものより大きく、臨界防止のための体積管理ができなくなる結果になった。
(98－02／4)

事象－11
1. 年月日 ； 1997年11月 5日
2. 場所 ； RFETS
3. 概要 ；
隔離距離と取扱いに係わる条件を満たすことができず、臨界安全の裕度を減少させる結果になった。2つのコンテナーが、指定された所定の場所に貯蔵されていなかった。臨界安全評

価をせずに、或いは臨界安全制限値を決めずに、核物質がドラムからコンテナーに移された。(97－46／6)

事象－12
1. 年月日 ； 1997年 7月 1日
2. 場所 ； Fernald
3. 概要 ；
濃縮され制限された核物質を収納した5つのドラムと2つのコンテナーは、承認された書類無しに移動が行われた。また、担当管理者は、核分裂性物質を取扱う管理者としての訓練を受けていなかった。(97－28／1)

事象－13
1. 年月日 ； 1997年 4月21日
2. 場所 ； Hanford
3. 概要 ；
臨界安全についての標示内容を遵守しそこない、安全の裕度を減少させる結果となった。グローブボックス内のコンテナーに貯蔵されている核分裂性物質の量は、臨界安全についての標示された量を超えていたが、臨界防止上の設計値は守られていた。標示内容は、設計値と一致させるように変更することになっていたが(核物質を移動した後で)、実際には実施されなかった。(97－18／1)

事象－14
1. 年月日 ； 1997年 2月12日
2. 場所 ； RFETS
3. 概要 ；
手順書は、臨界安全に関係する溶液のサンプリング及び移送について十分に記載していなかった。硝酸プルトニウム溶液を抜き出す工程のタンクをスパージングしている時に、バルブが間違った位置にあることに気付いた。そのバルブは、タンクから液抜きをする手順の中では確認することになっていなかった。そのバルブが開だったので、タンク内の負圧が減少し、スパージングに影響を与え、溶液中の核分裂性物質の分布状態に悪影響を与えた。(97－08／5)

事象－15
1. 年月日 ； 1996年 4月 2日
2. 場所 ； PNNL
3. 概要 ；
脚注に記載された条件が守らていなかったので、臨界安全の条件に違反する結果になった。臨界安全設計書を検討している時に、幾つかの作業エリアの位置は反射材に係わる脚注の内容を守っていないことが確認された。調査した結果、該当する2つの部屋の貯蔵状態は臨界安全の条件に違反していることが確認された。スタッフはこの事に気がついていたが、記載内容

が自分達の業務に適用されるものだとは思わなかった。(97－07／3)

事象－16
1. 年月日 ； 1997年 1月31日
2. 場所 ； Fernald
3. 概要 ；

手順書を守らなかったので、臨界に係わる安全の裕度を減少させる不測の事態を引き起こす可能性が生じる結果になった。手順書が守られずに、濃縮され制限された核物質を収納した1個のドラムが、許可を受けずにある施設から他の施設に移された。幾つかのドラムは詰め替えが行われたが、作業員は、1つのドラムについては、物質が凝固していたのでドラムの詰め替えはできなかった。その管理者は、最初の指示及び承認で十分であると考えたので、安全運転に係わる承認を取らずに、そのドラムを元の施設に返却した。(97－06／1)

事象－17
1. 年月日 ； 1996年12月30日
2. 場所 ； RFETS
3. 概要 ；

臨界安全の管理上の条件に違反することにより、臨界安全の裕度を減少させることになった。グローブボックスの中に貯蔵されているエア・フィルターは、隔離距離の条件を満足していなかった。2つのカートは、核物質安全制限値を守れなかった。また、最近のドラムの移動制限に係わる条件が記載されていなかった。(97－02／2)

事象－18
1. 年月日 ； 1996年12月31日
2. 場所 ； Hanford
3. 概要 ；

隔離距離と取扱いの条件を満たすことができず、臨界安全の裕度を減少する結果になった。未確認のフード廃棄物を収納した隔離された輸送コンテナーが、167gPu を収納し配列が固定化されたワゴンから約2フィート(約61センチメートル)の所にあった。Pu 量が未確認の核物質と Pu を 100g 以上を含む核物質の隔離距離は、最低3フィート(約92センチメートル)必要とされていた。管理者は、手順書により隔離距離が必要とされていたが、壁の反対側の部屋に貯蔵されている核分裂性物質を確認せずに、配列が固定化されたワゴンを非隔離壁(中性子遮蔽がない壁)の近くに置いた。また、配列が固定化されたワゴンは、核分裂性物質を貯蔵可能な仕様になっている部屋から他の部屋に移された。(97－02／3)

事象－19
1. 年月日 ； 1996年12月11日
2. 場所 ； RFETS
3. 概要 ；

承認されていない設備改造は、運転員に不測の事故を及ぼす可能性がある。55ガロン(約200 リッター)の配管とそれに接続したサンプ・ポンプは、凝縮液を核分裂性物質用のタンクに送れるように改造されたが、タンクへの誤移送を防止するための装置がついていなかった。臨界安全の技術者は、配管とポンプの構成を検討せずに、また、その使用に関しては安全上の制限を文書で提示していなかった。

(96－51／1)

事象－20
1. 年月日 ； 1996年12月 2日
2. 場所 ； RFETS
3. 概要 ；

管理方法が守られず、臨界安全の裕度が減少した。臨界の危険がある核物質を収納した2つの輸送カートが移動された。そのカートは移動禁止になっていたが、その禁止標示が貯蔵庫のドアについており、作業のためドアが開放状態にあったのでその禁止標示が見えなかった。6つのドラムが、移動禁止標示に違反して、2つの施設間で移動され、質量制限値を超える危険があった。(96－49／6)

事象－21
1. 年月日 ； 1996年10月30日
2. 場所 ； RFETS
3. 概要 ；

禁止事項に関わる不明確な指示や非安全側の仮定(保守的でない)が、臨界安全のルールに違反する原因となった。グローブボックス内の核物質が、そのエリアにおいて臨界安全のルールに違反するような方法で移された。過去に起った2つの違反事例に関するガイドが2つの現場指示という形で出されていたが、技術アドバイザーはそのガイドの真意を理解しなかった。その結果、不安全で不正確な指示書が出された。(96－45／5)

事象－22
1. 年月日 ； 1996年10月17日
2. 場所 ； RFETS
3. 概要 ；

臨界に係わる排水口が、密閉された部屋の中でテープを巻いて塞がれてあった。工程配管が核分裂性物質を密閉された所に排水したならば、核分裂性物質が排水の穴に貯まって臨界上の問題を引き起こすことになる。また、密閉された部屋の臨界安全に係わる操作制限値は、時代遅れの評価方法を使って決めらていた。放射線管理の現場監督者は、テーピングにより空気汚染を防止するような放射線管理を指示していた。(96－43／1)

事象－23
1. 年月日 ； 1996年 8月22日

2. 場所　　; RFETS
3. 概要　　;

違反の恐れのあるドラムの移動により、臨界事故になる可能性が生じた。減速材と核分裂性物質の比のモデル化が不十分であり、核分裂性物質を200g以上含む減速材の量が不正確だったので、1組のドラムは違反することになった。貯蔵室では、200g 以上の核分裂性物質と減速材をいっしょに収納している55ガロン(約 200 リッター)のドラムが貯蔵してあれば、「臨界安全の制限値を超えている可能性あり」との標示をすることになっていた。この違反を補う措置として、ドラムの再分析が終了するまで、貯蔵庫の中の全ての物質の移動を禁止した。しかし、この措置は守られず、31個の廃棄物が混入しているドラムは、建屋内の操作に係わる指示が臨界安全に違反していることを正確に伝えていなかったので、承認を得て貯蔵庫から搬出された。
(96－35／2)

事象－24
1. 年月日 ; 1996年 7月 3日
2. 場所　　; RFETS
3. 概要　　;

臨界安全の操作制限に違反し、質量及び形状寸法の安全裕度を減少させ、不測の臨界事故が発生する可能性が生じた。幾つかの4リッター以上のビニールバックにはスリットがなかったが、開口部のあるビニールバッグは未処置のままであった。これらのビニールバックを使用する清掃作業を割り当てられた請負業者は、臨界安全制限について訓練を受けていなかった。
(96－28／2)

事象－25
1. 年月日 ; 1996年 6月25日
2. 場所　　; RFETS
3. 概要　　;

不適切な安全制限及びコンテナーの内容物を示す統一していない用語は、臨界安全の制限に違反する原因となった。10ガロン(約38リッター)のコンテナーを開封している時に、コンテナー内の物質重量が、臨界安全の最も厳しい操作制限量 1000g(核分裂性物質量＋非核分裂性物質量)を超えていることが確認された。不適切で混乱を招く用語－ 正味重量」、「Pu の正味重量」、「正味物質重量」－　　なった。(96－28／3)

事象－26
1. 年月日 ; 1996年 6月12日
2. 場所　　; RFETS
3. 概要　　;

核物質の取扱いルールに違反し、臨界が懸念される結果となった。工程の運転員が、核物質の移動中に、2つの10ガロン(約38リッター)のドラムを積み重ねて、臨界安全の操作制限に

違反することになった。その工程の運転員は、作業前に現場監督者から説明された指示に従って作業を行わなかった。(96－25／2)

事象－27
1. 年月日 ； 1996年 5月 2日
2. 場所 ； RFETS
3. 概要 ；
核物質を出荷する際に、事前に建屋内の核物質の収納制限値を確認していないと、不測の臨界事故を招くことになる。出荷用の8802キャニスターの中の8801内容器が開封され、酸化ウラン試料が入った18個のバイアルが発見された。その建屋の臨界安全に係わる最大制限値は、10バイアルであった。(96－19／2)

事象－28
1. 年月日 ； 1996年 3月20日
2. 場所 ； Hanford
3. 概要 ；
Puを収納した2つのコンテナが、炉の中のPuを収納した3つ目のコンテナとの距離が10インチ(約26センチメートル)以内の所に置かれて、臨界防止措置が破られる結果となった。この時、二重偶発性の原則は維持されたが、核分裂性物質は3番目の防止対策に違反した配置に置かれた。この事象の原因は、以下のように2つあった。；
(1) この工程で通常使用されるコンテナーの大きさがより大きく変更になったので、グローブボックス内の利用可能な空間が減少した。
(2) 運転員は、炉を工程設備の一部と考え、隔離距離の条件の1つの対象であるとは考えなかった。(96－13／2)

事象－29
1. 年月日 ； 1996年 2月 1日
2. 場所 ； RFETS
3. 概要 ；
開口部があり道具を入れるビニールバックが、核分裂性物質の溶液ラインの下に置かれており、もしラインから溶液が漏れたならばビニールバックの中に核分裂性物質の溶液が貯まり、臨界上不安全な形状寸法になる可能性が生じた。そのビニールバックは、配管作業を行うため、保守を行う配管工によって残したものだった。

(96－06／6)

事象－30
1. 年月日 ； 1995年 9月28日
2. 場所 ； Paducah
3. 概要 ；

機械工は、臨界防止バリアの1つを除いてしまう位置に、核分裂性物質を知らずに置いてしまった。核分裂性物質を含む構成部品は、臨界上の隔離距離の条件に違反する位置に保管された。機械工は、以前に保管した延長継ぎ手から約14インチ(約36センチメートル)離れた位置に、U235 の濃縮度1%以上の核物質を含む延長継ぎ手を保管した。必要な最小限の隔離距離は、24インチ(約61センチメートル)であった。

(95－40／4)

事象－31

1. 年月日 ； 1995年 8月31日
2. 場所 ； Paducah
3. 概要 ；

臨界安全に関して認可された内容から運転状況が乖離していることが、以下の3つのケースの場合に確認された。

(1) 真空モーターのヘッドが、核分裂性物質の貯蔵エリア内に無造作に置かれていた。
(2) &(3)3つの5ガロン(約 19 リッター)の廃棄物ドラムが、核分裂性物質量を明記したタグを付けないまま、核分裂性物質中間貯蔵エリア内に貯蔵されていた。

最初のケースでは、作業員は標示の記載内容を無視した。

2番目と3番目のケースでは、2つの異なる部門から来た作業員らは標示の記載内容を無視した。(95－36／1)

事象－32

1. 年月日 ； 1995年 6月26日
2. 場所 ； Paducah
3. 概要 ；

ピットの液位が制限値を超えた場合を考慮して、臨界安全確保のために中性子を吸収するPVC 製の格子が設置されていたが、その格子から管理者が1枚の板を外してしまい、二重偶発性の原理による臨界安全措置に違反してしまった。対応処置を講じないで横板を取り除くことは、施設の手順書及びそのピットに係わる臨界安全の評価内容に違反することになった。残りの横板でも、臨界安全に係わる評価の制限内の安全裕度を保つための十分な量と寸法形状を有していた。その管理者は、未臨界液位の警報故障の原因を調査するためにサンプ・エリアを見ようとして、その横板を取り除いた。その管理者は、その横板を取り除いても臨界になる可能性はないことを知っていたが、事前に臨界安全評価グループに通知しなかったので、手順書に違反することになった。(95－26／2)

事象－33

1. 年月日 ； 1994年 6月22日
2. 場所 ； Various
3. 概要 ；

DNFSBの調査結果。

Y－12:ドラム貯蔵に関する臨界安全認可事項の違反についてDNFSBから指導を受けた時、施設の運転員はエリアの管理ができていなかった。;他にも同様な違反が確認された。
RFETS:運転員は、タンクから配管により核分裂性物質を含む溶液の認可されていない液抜きを行い、二重偶発性の条件に違反した。;この事象は、臨界事故になる可能性があり重大な事象であった。

他にも、臨界安全認可事項に違反した例があった。
Y－12:1344件の違反に対して872件の臨界安全認可事項が検討された。
K－25:372件の違反に対して19件の臨界安全認可事項が検討された。
Paducah:26件の違反に対して2件の臨界安全認可事項が検討された。
Portmouth:213件の違反に対して2件の臨界安全認可事項が検討された。

(94－42／2)

事象－34
1. 年月日 ; 1994年10月 7日
2. 場所 ; RFETS
3. 概要 ;

運転員は、核分裂性物質を含む溶液をタンクから配管を使って認可されていない液抜きを行い、臨界事故が発生する可能性を引き起こす結果となり、二重偶発性の条件に違反することになった。(事象－33参照) 運転員は、初期のバルブ状態、タンク内最大濃度 5g／l、二重偶発性の原則の確保に基づいた手順に従って、核分裂性物質を含む溶液をタンクから55本の4リッターのボトルに液抜きした。そのタンクの液抜きの後、認可されていないタンクからの液抜きを行ったが、この作業は手順書の範囲外の作業であった。その液抜きの結果、5本のボトルの溶液内の核分裂性物質濃度が、そのタンクの濃度よりも高くなった。交代勤務に入っていた当直長と技術アドバイザーは、追加された液抜き作業の前にも後にも、この事象に気づいていなかった。1週間後、当直長の承認を得ずに、製造マネージャーの指示により、ボトルの1本からサンプルが採取され、分析した結果、5g／l の制限値を超えていた。そして、製造マネージャーは、当直長に追加の液抜き作業について通知した。(94－41／1)

事象—35
1. 年月日;1994年9月22日
2. 発生場所 ;Y－12
3. 概要;

中性子吸収材を含む核兵器の構成部品を収納したドラムが、臨界安全に係わる承認手続きを取らずに積み重ねられていた。これは、核分裂性物質コンティナー貯蔵エリア内の核分裂性物質の貯蔵に関して違反するものであり、DNFSB職員の巡視により確認された。管理者は、手順書により要求されている、そのエリアの適切な管理及び臨界安全を担当している部署への速やかな報告を怠っていた。(94－39／1)

事象—36

1. 年月日;1994年7月26日
2. 発生場所 ;B&W NNFD
3. 概要;

運転員は、燃料の質量が超えたことを示すコンピューターの警報に対応しそこなって、U235の管理質量制限値を超えてしまった。運転員は、コンピューターの画面に表示された警報に気づかなかった。コンピューターの画面に表示される工程の状況と警報は似ていた。重量を測定する場所からは、運転員は、コンピューターの画面に表示される工程の状況を読みとることができなかった。コンピューターは、重量を測定している間、警報を出し続けていた。(94－31／7)

事象―37

1. 年月日;1993年5月14日
2. 発生場所 ;ICPP
3. 概要;

研究炉から搬出された使用済燃料を収納した2つのステンレス製バケットが、空であるとおもわれていた燃料貯蔵ラックに貯蔵されていた。また、燃料の二重装荷を防止するための臨界防止策が講じられておらず、空の燃料貯蔵ラックは空と思われていたラックの上を移動していた。根本的な原因としては、管理者が十分な訓練の実施を確保していなかったこと、及び、手順書の遵守を推進していなかったことが挙げられる。直接的な原因としては、運転員と管理者が目視により燃料の移動前にラックが空であること、及び、その燃料が正しい場所に移動されていることを確認していなかったことが挙げられる。 (94－23／3)

事象―38

1. 年月日;1994年3月13日
2. 発生場所 ;ICPP
3. 概要;

異なる燃料を収納した2つのヨーク(yokes)が互いに隣接して貯蔵されており、空のヨークにより異なる種類の燃料を離して貯蔵することを要求している手順書に違反することになった。この隔離距離は、臨界防止のための安全余裕を与える。

(94－11／3)

事象―39

1. 年月日;1994年2月25日
2. 発生場所 ;Fernald
3. 概要;

濃縮され制限された核物質を収納したドラムの配列は、13～22インチ(約33～56センチメートル)離して貯蔵されていたが、手順書は24インチ(約61センチメートル)以上離して貯蔵することを要求していた。また、幾つかの標示されていた内容は不十分であり、幾つかのドラムのラベルは読めなかった。(94－9／1)

事象―40
1. 年月日;1993年11月1日
2. 発生場所 ;RFETS
3. 概要;
30ガロン(約114リッター)のプラスチック製バックが、核分裂性物質を内蔵しているタンクに付いている計測器のドライレッグ(dry leg)に接続されていた。このバックには、安全制限値を超えて核分裂性物質が溜まることを防止するために、臨界安全上要求されるスリットが付いていなかった。同様な事象が、1週間前に発生しており、過去においても発生していた。(93－44／1)

事象―41
1. 年月日;1993年9月22日
2. 発生場所 ;Fernald
3. 概要;
1. 25%の濃縮ウランを収納している30ガロン(約114リッター)のドラム30基が、臨界安全上必要とされる隔離距離2フィート(約61センチメートル)以下の距離で貯蔵され、二重偶発性原理に違反することになった。この違反の原因は、そのドラムを移動することを指示された作業員がお互いに十分な連絡をしていなかったためである。

(93－39／3)

事象―42
1. 年月日;1993年9月24日
2. 発生場所 ;Pantex
3. 概要;
マガジンに装荷している時に、プルトニウムの質量制限値を超えてしまった。運転員はマガジンに装荷するプルトニウム量を誤って設定した結果、作業員がマガジンに過剰に装荷してしまい、そのプルトニウム量は17Kg となった。交代勤務している当直長がいなかったので、運転員は作業員に抜出しを行う指示書を渡したが、管理制限値のチャートを間違って読んだために、運転員は誤った情報を作業員に流してしまった。この間違いは、約5時間後に確認され、正常に復帰された。(93－39／4)

事象―43
1. 年月日;1993年9月24日
2. 発生場所 ;B&W
3. 概要;
U235 の最大質量制限値を350g で管理している部屋で、436g の U235 が見つかった。1つのドラムに異なる2種類の溶液(各溶液の個別の質量が記録されている。)が収納されており、

混合した廃棄物を化学的に分離している時に、この事象が発生した。送られてきた記録は正しかったが、処理をした後、送った2つの値は1つしか入力されていなかった。(93—38／4)

事象—44
1. 年月日;1993年8月27日
2. 発生場所 ;RFETS
3. 概要;
貯蔵タンク内のラシヒリングは、必要とされている定期的な検査をしていなかった。Rocky Flats の運転停止から再開までの間、システムの配置の制限より、検査の実施ができない状態であった。(93—35／2)

事象—45
1. 年月日;1993年6月22日
2. 発生場所 ;SNL
3. 概要;
核物質の貯蔵に使用されていたキャビネットは、標示されている制限値700gU235より17g多い核物質を貯蔵していた。1人の技術者が、核物質の量をログシートに正しく記載しないで、核物質をキャビネットに入れてしまっていた。(93—27／5)

事象—46
1. 年月日;1993年5月20日
2. 発生場所 ;NFS
3. 概要;
廃棄物回収タンクにおいて、臨界安全制限値を超えてしまった。そのタンクにおける濃縮度97%のU235の制限値は、350gの代わりに、570～600gの範囲で管理することに決められていた。年1回のタンク洗浄の結果、この決定がなされていた。
(93－21／2)

事象—47
1. 年月日;1993年5月14日
2. 発生場所 ;ICPP
3. 概要;
事象—37に同じ。

事象—48
1. 年月日;1993年5月6日
2. 発生場所 ;RFETS
3. 概要;
4基のコンテナーに収納された核分裂性物質の量が、標示されている許可された臨界安全

制限値を超えてしまっていた。超えた原因は、質量を決定するために新しくより正確な分析方法を使ったためである。(93—19／5)

事象—49
1. 年月日;1993年4月26日
2. 発生場所 ;RFETS
3. 概要;
グローブボックスの中で、核物質を収納した不適切な形状のキャニスターが見つかった。このキャニスターは、グローブボックスに標示された形状に違反していた。
(93—17／1)

事象—50
1. 年月日;1993年4月16日
2. 発生場所 ;B&W
3. 概要;
標示された U235 濃度に関する管理制限値を守っていることが実証できなかったので、臨界安全制限値を守っていることが証明できなかった。燃料の洗浄作業により、燃料の物理的な変化が確認され、標示されている管理制限値が守られていることを確認することが不可能になった。その事象については記録されておらず、管理者が手順書の各手順が適用できなくなったと連絡を受けた後、作業停止の措置が取られなかった。(93—16／8)

別添資料11　Regulatory Activity Status

Proposed Page Change for DOE O 420.1, Section 4.3　243

Implementing Instructions to Accompany Page Change to DOE O 420.1, Facility Safety (draft)　249

Regulatory Activity Status of the Rule (10CFR Part 70) & the U.S. NRC Draft Standard Review Plan (NUREG 1520)　250

Session VIII. Regulatory Activity Status: The Guide (DOE G 421.1-1) and the Order (DOE O 420.1; the Rule (10 CFR Part 70) and the NRC SRP (Chapter 5 of NUREG 1520)

1. Revision Plans for the Good Practices Guide and the Order

Burton Rothleder (DOE-HQ/EH-31)

Proposed Page Change for DOE O 420.1, Section 4.3

Attachment 1

Proposed Page Change to DOE O 420.1, Facility Safety
Section 4.3.3, Specific Requirements

DOE O 420.1
10-13-95

15

h. It is acceptable to DOE to follow DOE-STD-3007-93 (Guidelines for Preparing Criticality Safety Evaluations at Department of Energy non-Reactor Nuclear Facilities) when preparing Criticality Safety Evaluations.

For DOE application, the following sections of DOE-STD-3007-93 shall be read as follows:

(1) **II. DEFINITIONS.** The definition of "BIAS" should be interpreted as discussed in paragraph 4.3.3.d.(3).

(2) **4.0 METHODOLOGY.** When computer neutronics calculations are used, the type of computing platform should be stated along with relevant code configuration control information and code development and user documentation.

i. DOE Elements shall ensure that the contractor shall have a program to detect inadvertent accumulation of significant quantities of fissionable material.

j. Transportation Requirements for Fissionable Material.

(1) The requirements of this Section shall apply to all activities where fissionable material is transferred from one operation to another within a facility and from one on-site location to another.

(2) The requirements of DOE O 460.1 (Packaging and Transportation Safety, 9-27-95) shall be complied with regarding off-site shipment of fissionable material.

DOE O 460.1 (Packaging and Transportation Safety, 9-27-95) shall apply to the safe transportation of weapon components and special assemblies shipped in national defense.

k. Guidelines for Fire Fighting

The fire protection program (Section 4.2.1) shall establish guidelines for fire fighting within, or adjacent to, moderation controlled areas. These guidelines shall be based on comparisons of risks and consequences of a criticality accident with the risks and consequences of postulated fires for the respective area(s). Risk and consequence comparisons may be a qualitative evaluation. The basis for the guidelines shall be documented.

Attachment 1

Proposed Page Change to DOE O 420.1, Facility Safety
Section 4.3.3, Specific Requirements

DOE O 420.1 16
10-13-95

1. Training and Qualification

A program for training and qualifying nuclear criticality safety staff shall be implemented. DOE-STD-1135-99, "Guidance for Nuclear Criticality Safety Engineer Training and Qualification," provides guidance to assist DOE contractors in developing a program to meet these program requirements. DOE Federal staff shall follow the requirements in DOE O 360.1, "Federal Employee Training," and DOE M 426.X-1, "Federal Technical Capability Manual." The training and qualification program should be implemented using a graded approach. This graded approach should be based on the duties and responsibilities of individual nuclear criticality safety engineers and should establish priorities that are appropriate to insuring all aspects of nuclear criticality safety.

Attachment 1

Proposed Page Change to Contractor Requirements Document for DOE O 420.1, Facility Safety Section 4.3.2, Specific Requirements

DOE O 420.1
10-13-95

Attachment 2
Page 13

h. It is acceptable to DOE to follow DOE-STD-3007-93 (Guidelines for Preparing Criticality Safety Evaluations at Department of Energy non-Reactor Nuclear Facilities) when preparing Criticality Safety Evaluations.

For DOE application, the following sections of DOE-STD-3007-93 shall be read as follows:

(1) **II. DEFINITIONS**. The definition of "BIAS" should be interpreted as discussed in paragraph 4.3.3.d.(3).

(2) **4.0 METHODOLOGY.** When computer neutronics calculations are used, the type of computing platform should be stated along with relevant code configuration control information and code development and user documentation.

i. The contractor shall have a program to detect inadvertent accumulation of significant quantities of fissionable material.

j. Transportation Requirements for Fissionable Material.

(1) The requirements of this Section shall apply to all activities where fissionable material is transferred from one operation to another within a facility and from one on-site location to another.

(2) The requirements of DOE O 460.1 (Packaging and Transportation Safety, 9-27-95) shall be complied with regarding off-site shipment of fissionable material.

DOE O 460.1 (Packaging and Transportation Safety, 9-27-95) shall apply to the safe transportation of weapon components and special assemblies shipped in national defense.

k. Guidelines for Fire Fighting

The fire protection program (Section 4.2.1) shall establish guidelines for fire fighting within, or adjacent to, moderation controlled areas. These guidelines shall be based on comparisons of risks and consequences of a criticality accident with the risks and consequences of postulated fires for the respective area(s). Risk and consequence comparisons may be a qualitative evaluation. The basis for the guidelines shall be documented.

Attachment 1

Proposed Page Change to Contractor Requirements Document for DOE O 420.1, Facility Safety Section 4.3.2, Specific Requirements

DOE O 420.1
10-13-95

Attachment 2
Page 14

1. Training and Qualification

A program for training and qualifying nuclear criticality safety staff shall be implemented. DOE-STD-1135-99, "Guidance for Nuclear Criticality Safety Engineer Training and Qualification," provides guidance to assist DOE contractors in developing a program to meet these program requirements. The training and qualification program should be implemented using a graded approach. This graded approach should be based on the duties and responsibilities of individual nuclear criticality safety engineers and should establish priorities that are appropriate to insuring all aspects of nuclear criticality safety.

Attachment 2

Summary of Proposed Page Change to DOE O 420.1, *Facility Safety*

The proposed page change to DOE O 420.1, *Facility Safety,* formalizes requirements to implement a training and qualification program for nuclear criticality safety engineers. The program requirements satisfy a commitment under the Department's Implementation Plan in response to Defense Nuclear Facilities Safety Board Recommendation 97-2, *Criticality Safety.*

Currently, training and qualification programs for nuclear criticality safety engineers vary widely in formality and rigor. Under the 97-2 Implementation Plan, the Department committed to develop and implement guidance to improve the standards used in training and qualifying criticality safety engineers. The proposed page change satisfies that commitment and ensures that nuclear criticality safety staffs have a sufficient level of knowledge and familiarity with criticality safety concepts, methods and practices.

The proposed page change was developed by a working group of individuals from various Headquarters and Field organizations. Some of the individuals are also part of the Nuclear Criticality Safety Program Management Team and the Criticality Safety Support Group, both formed under the 97-2 Implementation Plan. Individuals who participated in the development of this page change include:

Roger Dintaman, DP
Emil Morrow, DP
Jim Felty, DP
Richard Stark, EH
Burton Rothleder, EH
Jerry McKamy, EH
Richard Serbu, EH
Adolf Garcia, DOE-ID
Mike Mikolanis, S-3.1
John Evans, S-3.1

The requirements of the page change were initially submitted to the Field Management Council on February 28, 2000 as a proposed new DOE N 420.1, *Nuclear Criticality Safety Engineer Training and Qualification*. After an initial review of the Notice by the FMC Secretariat and subsequent discussions with Craig Wisooker, MA-411, it was decided that placing the requirements in a page change to DOE O 420.1 would be more appropriate.

If the page change should receive a favorable review by the FMC, and after all comments from the coordination period are resolved, the intention is to release the page change accompanied by implementing instructions. These instructions will specify that nuclear criticality safety engineer training and qualification program plans be submitted to DOE Field Elements for review within 60 days after the effective date of the page change. The program plans should include dates when appropriate criticality safety staff are scheduled to complete qualification. DOE Field Elements would then review and approve the program plans.

Questions or comments on this proposed page change may be directed to Burton Rothleder at (301) 903-3726 or Burton.Rothleder@hq.doe.gov.

DRAFT

Implementing Instructions to Accompany Page Change to DOE O 420.1, FACILITY SAFETY

1. **PURPOSE.** These implementing instructions are provided for review and comment along with the proposed page change. These instructions are separate from the page change and describe the requirement to develop and submit nuclear criticality safety engineer training and qualification program plans.

2. **IMPLEMENTING INSTRUCTIONS.**

   a. Within 60 days of the effective date of this page change, program plans for nuclear criticality safety engineer training and qualification should be developed and submitted to DOE Field Elements for review and approval.

   b. These plans should include dates when appropriate criticality safety staff are scheduled to complete qualification.

   c. DOE Field Elements should provide copies of the approved plans to their Lead Program Secretarial Officers and to the Responsible Manager (Assistant Deputy Administrator for Research, Development and Simulation, DP-10) for the Department's 97-2 Implementation Plan on criticality safety.

   d. The training and qualification program plans should be updated in accordance with established schedules that are part of the overall training program.

DRAFT

Regulatory Activity Status of the Rule (10 CFR Part 70) & the U.S. NRC Draft Standard Review Plan (NUREG 1520)

JNC TN8200 2000-006 (2/2)

March 29, 2000

Harry Felsher, U.S. NRC
Telephone: 301/415-5521, E-mail: hdf@nrc.gov

March 2000 U.S. DOE Nuclear Criticality Technology Safety Project Workshop

Proposed Rule for Nuclear Fuel Fabrication Facilities

Characteristics of Draft Revisions to 10 CFR Part 70

- Pre and post licensing changes
- Risk-informed, performance-based
- Covers major accidents only - Part 20 addresses safety for normal operating conditions/upsets
- Requires "integrated" look at accident safety
- Consistent & compatible with OSHA and EPA process safety rules
- Explicit accident standards for worker, public, & environmental safety

JNC TN8200 2000-006 (2/2)

Standard Review Plan (SRP)

Structure

http://techconf.llnl.gov/cgi-bin/topics, select "Draft Standard Review Plan and Guidance on Amendment to 10 CFR Part 70" & then select "Document Library" -- (7/16/1999)

- Abstract, Introduction, Acronyms, Glossary, General Information, Organization & Administration, and Integrated Safety Analysis
- Radiation, Nuclear Criticality, Chemical Process, and Fire Safety
- Emergency Management, Environmental Protection, Decommissioning, and Management Measures
- Purpose, Responsibility, and Areas of Review
- Acceptance Criteria
- Review Procedures, Evaluation Findings, and References

JNC TN8200 2000-006 (2/2)

Future Actions on the Rule and the SRP

- On 1/28/2000, NRC staff's proposed resolutions of the comments made on the SRP chapters were placed on the website and starting 3/13/2000, revised drafts have been placed on the website

- A public meeting is scheduled for 4/18-19/2000, at the NRC TWFN Auditorium to discuss comments on the revised SRP chapters and you are encouraged to provide written comments on these revised drafts, as much in advance of the meeting as possible

- To the extent practical, these comments will be considered by staff in further revisions to the SRP chapters before the entire Rulemaking package is forwarded to the Commission in early May for its consideration [Public comment period on the Rulemaking itself expired 10/13/1999]

JNC TN8200 2000-006 (2/2)