April 4, 2016

To: J. N. McKamy, Manager, US DOE Nuclear Criticality Safety Program (NCSP)

From: David Erickson, Chair, US DOE NCSP Criticality Safety Support Group (CSSG) dge

Subject: CSSG Tasking 2016-01 Response

In Tasking 2016-01 the CSSG was directed to provide a Review of the US DOE NCSP T&EP Hands-On Training and Education Course for Criticality Safety Professionals.

The CSSG Subgroup Review Team assigned to the Tasking were:

- Calvin Hopper (CSSG Emeritus, team lead)
- Mikey Brady Raap
- Kevin Kimball
- Fitz Trumble

Per the tasking the three elements of the directed review were:

1. The consideration of the effectiveness of presentations and balance of the course material and content and also the degree and appropriateness of any course content creep relative to the CSSG Response to Tasking 2009-03, "Recommendations for the Future DOE NCSP Training and Education Infrastructure Program."
2. The evaluation of the consistency of the course with the "2014 - 2023 NCSP Mission and Vision."
3. The consideration of realistic circumstances that are, or may reasonably become, prevalent regarding necessary resources to address the course criteria (e.g., availability of facilities, training materials, personnel, fiscal support, calendar dates, student support/schedules).

The attached report addresses the first and second elements. The third element was not fully completed due to the limitation of time and knowledge of circumstances including available resources of DOE programs and facilities. It is recommended that the third element of the review be undertaken by individuals with a broad and in-depth knowledge of those potential programmatic circumstances and resources.

It is further recommended that a mechanism be established within the NCSP T&EP to track and report the resolution of the Review recommendations to the CSSG.

The attached response was reviewed by the entire CSSG and all relevant comments to the CSSG Subgroup's observations were addressed and incorporated into the final report.

cc: CSSG Members
D. G. Bowen (NCSP T&E Manager)
A. S. Chambers (NA-511)
M. E. Dunn

Attachment: CSSG Tasking 2016-01 Response

Review of US DOE NCSP T&EP Hands-On Training and Education Course for Criticality Safety Professionals

CSSG Tasking 2016-01 Response
31 March 2016

Overview

The Criticality Safety Support Group was directed, via Tasking 2016-01[1], to review the US Department of Energy (DOE) Nuclear Criticality Safety Program (NCSP) Training and Education Program (T&EP) Hands-On Training and Education Course (HTEC) for Criticality Safety Professionals. The review included both the HTEC Nevada Field Office (NFO) classroom presentations followed by the hands-on subcritical and critical measurements at the US DOE Sandia National Laboratory (SNL) Critical Experiment (SCX) facility and at the National Criticality Experiments Research Center (NCERC). The scope of the review was to consider three elements:

1. the effectiveness of presentations and balance of the course material and content in addition to the appropriateness of any course creep relative to the Criticality Safety Support Group (CSSG) Response to Tasking 2009-03: Recommendations for the Future DOE NCSP Training and Education Infrastructure Program[2],

2. the consistency of the course with the 2014-2023 NCSP Mission and Vision[3], and

3. the realistic circumstances that are, or may reasonably become, prevalent regarding necessary resources to address the course criteria (e.g., availability of facilities, training materials, personnel, fiscal support, calendar dates, student support/schedule).

This review report covers the first and second elements. The third element was not fully accomplished due to the limitation of time and knowledge of circumstances including available resources of DOE programs and facilities. It is suggested that the completion of this element of the review be undertaken by individuals with a broad and in-depth knowledge of those potential programmatic circumstances and resources.

The CSSG Subgroup Review Team consisted of Calvin Hopper, CSSG Emeritus and Team Lead, and CSSG members, Mikey Brady Raap, Kevin Kimball and Fitz Trumble. Team assignments were made to cover the three components of the 2-week course: Hopper and Brady

[1] Review of US DOE NCSP T&EP Hands-On Training and Education Course for Criticality Safety Professionals, CSSG TASKING 2016-01, 12/22/2015, http://ncsp.llnl.gov/cssg/taskandresponse/2016/CSSG_Tasking_2016-01.pdf.
[2] CSSG Response to Tasking 2009-03, Recommendations for the Future DOE NCSP Training and Education Infrastructure Program, October 16, 2009, http://ncsp.llnl.gov/cssg/taskandresponse/2009/CSSG-Response-to-2009-03-FINAL-091016.pdf.
[3] The Mission and Vision of the United States Department of Energy Nuclear Criticality Safety Program for the Fiscal Years 2014 – 2023, http://ncsp.llnl.gov/NCSP_MISSION_VISION_FY14-23.pdf.

Raap were assigned to observe the classroom portion of the course given at NFO; Hopper and Trumble to observe the hands-on portion given at SCX; and Brady Raap and Kimball to observe the hands-on portion given at NCERC. These assignments assured that one reviewer for each of the HTEC classes had been present at the classroom portion. The team members were assigned the task of reviewing and commenting on HTEC printed slides and presentations of the slides by HTEC instructors.

This review was the first conducted since the August 2011 pilot course. Outbriefs were held at the end of the week for each portion of the three classes. Both preliminary Observations and *Recommendations* were discussed at outbriefings. At the close of the classroom portion, Hopper and Brady Raap met with Doug Bowen and Lori Scott. The outbriefing for the NCERC hands-on training was held with Doug Bowen and Catherine Percher and observers Kimball and Brady Raap. At SNL, the outbriefing included Gary Harms with Hopper and Trumble.

The draft of this report was provided for factual accuracy reviews by the T&EP course coordintor and the points of contact POCs at Lawrence Livermore National Laboratory (LLNL), NCERC, and SNL. Corrections were performed and comments addressed.

This report provides the Team's high level Observations and *Recommendations* in the main body of the report. Detailed Observations and *Recommendations* are provided in Appendix A of the report. The Observations and *Recommendations* are focused on the logistics, content, teaching methods, student reactions and identified opportunities for integrating course content more closely across the modules with suggested and recommended additional content that may be of benefit to the HTEC and criticality safety professionals.

In various instances the Team learned that many of their *recommendations* have either been considered or are in a state of development.

1. High level Observations and *Recommendations* regarding effectiveness of presentations and balance of the course material and content in addition to the appropriateness of any course creep relative to the CSSG Response to Tasking 2009-03

In general, the US DOE NCSP hands-on training and education course objectives recommended by the CSSG 2009-03 Tasking Response were addressed (***exceptions/additions noted***) as follows:

Classroom Training and Education at NFO (Nevada Field Office)

1. Nuclear criticality safety fundamentals
2. Standards – including regulations
3. Criticality safety evaluation development
4. Criticality accident discussions

(*No access to fissile handling facilities/mockups were available.*)

Hands-on Experiments Training and Education atNCERC (National Criticality Experiments Research Center)

1. The experiments/training exercises involved the same assemblies as used in prior courses.
2. The Los Alamos National Laboratory (LANL) training included Flattop and the 93%-enriched polyethylene-coated U foils/Plexiglas™ plates, Planet and Godiva.
3. The Training Assembly for Criticality Safety (TACS) shell experiments were included in the suite of experiments.
4. One or more experiments representing over-moderated configurations were included.
5. The training included the demonstration of student competency.

(*No non-security-cleared students participated in the class. It is understood that the logistics for enabling non-security-cleared student access uses more resources, hence it is more costly (i.e., 1 escort per 3 uncleared versus 1 escort versus 5 cleared). Also, having non-security-cleared students in attendance could limit discussion on some sensitive topics that may arise as part of discussions with students.*)

(*Though the CSSG 2009-03 Tasking Response made no recommendation for hands-on subcritical demonstrations with the BeRP Ball and 237Np sphere they were performed*.)

SCX (SNL Technical Area V Critical Experiments Facility)

1. Critical conditions were based on variable fuel loadings and water level control.
2. The training included the demonstration of student competency.
3. Non-security-cleared students were accommodated.

(One or more experiments representing over-moderated configurations have not been included – a current safety basis restriction.)

(An assembly using 19%-enriched U plates/foils has not been included – currently fiscally constrained.)

No course creep was observed regarding the HTEC Objectives specified by the CSSG 2009-03 Tasking Response.

The same fundamental learning objectives for hands-on training generally were addressed at both sites (NCERC and SCX) regardless of the exercises performed or the particular assemblies used for the exercises. However, it was not apparent that the developers of the three-venue training and education sites (i.e., NFO, NCERC, and SCX) collaborated during the T&EP development and/or the evolution of the course to ensure agreement on the specific learning objectives and to ensure that the final training modules addressed those objectives with limited redundancy.

The following bulleted items are Observations and *Recommendations* regarding each of the three-weeks courses (i.e., NFO, SCX, and NCERC).

General Observations

- The CSSG reviewers were unanimous in the value provided by the course. The content of the course, and the unique student interactions with critical and subcritical assemblies is of significant value.

- The T&EP group has worked very hard to encompass the guidance provided in the CSSG 2009-03 response and to meet a number of the 5-year mission goals.

- This review itself is a testament to the values of continuous improvement and transparency embraced by the NCSP.

- It was not apparent that the developers and lecturers of the three-week/venue training and education sites (i.e., NFO, NCERC, and SCX) collaborated during the T&EP development and/or the evolution of the course to ensure agreement on the specific learning objectives and to ensure that the final training modules addressed those objectives with limited redundancy and consistency of format. *Have the two-week course developers scrub each other's slide presentations for content to avoid redundancy.*

- There were several missed opportunities to utilize and/or reference the NCSP products like heritage videos and CSSG tasking responses in both the classroom and hands-on courses. *Every effort should be made to actively integrate as much information as possible from the NCSP website (e.g., in live-time, or simulated-live-time, access NCSP website resources directly on class screen displays).*

- As shown on introductory slides, the ground rules metric for pass/fail is not consistent among the SCX, the NFO and NCERC regarding passing written test(s) and active classroom participation. The SCX expectation is that 70% of a written test and 30% of student participation are summed to determine a passing grade of 80% (e.g., 50% written test score plus 30% participation score could be passing). *Resolve expectations of the NCSP.*

1st Week NFO Classroom Course

- The classroom/facility space available at the NFO location was excellent. From a facility standpoint only the issue of audio/visual equipment and support were noted as negatives.

- The instructors come from diverse intellectual, academic and experiential backgrounds. This provides for a wide range of exposure by the students to members of the community.

- There were instances of slide content/words not being consistent with ANSI/ANS-8.xx language. *Review and correct all slides for precise and consistent language with **<u>current</u>** ANSI/ANS-8.xx and DOE document requirements and their relevance to the topic of discussion.*

- Occasionally, instructors would provide anecdotal examples to emphasize a subject or topic of discussion by expressing opinions, actions, judgments and/or facility practices at a specific facility. Also, several slide sets seem to have organizational influences in addition to personal opinion. *Limit the use of facility-specific references or anecdotes depicting good or bad behaviors or judgments but positively specify DOE expectations regarding episodes such as found in the DOE Occurrence Reporting Processing System (ORPS) system in order to avoid endorsing or criticizing differences among DOE facilities.*

- No reference or review of anomalies were addressed. *Provide a module, with reference to the Clayton anomalies report near the conclusion of the classroom course that will be instructive to students as a caveat to over reliance on "rules of thumb" and frequent intuitive mistakes*.

- No comprehensive explanation about the NCSP website is provided. *Present the suite of resources/products available from the NCSP website including heritage videos, Nuclear Criticality Safety Engineer Training (NCSET) modules, CSSG tasking reports, experiment requests, specific references cited in presentations, etc. Try to weave these products into examples throughout presentations*.

- The process analysis portion of the course was stunted from not having access to an operating facility (e.g., LANL PF-4) for the Nuclear Criticality Safety Evaluation (NCSE) Workshops and Process Analyses. Also, small groups (3-4 students) were very important to engaging all the students. However, the disadvantage was that each "supervisor" (instructors were considered process supervisors for this exercise) had to repeat everything twice regarding an imagined facility. In the absence of using actual fissionable material processing facilities it would be beneficial to use some sort of a mock facility with relational objects (e.g., materials, geometries, spacing, personnel and equipment interactions and limitations represented by tables, tape on the floor, and cardboard could be used for a simulation that would engage the students; 3-D computer mockups could also be considered but may be too costly compared with the "benefit"). *Provide videos, pictures, and/or props to support the NCSE Workshops and Process Analyses.*

- Some mixed messaging with respect to using a systematic approach to performing evaluations. Steps are presented in lecture materials and NCSET modules but not carried through to exercises. *Carry through in exercises.*

- Some anecdotal discussions confuse the student as to what/who the reference/authority is on NCS interpretations and/or applications. *Ensure that module learning objectives are linked with or supported by ANSI/ANS-8.26-2007 and the US DOE NCSP expectations and distinguish between opinions, best practices and examples. The recommendation relates to the use of the ANS Enquiry Process and DOE Headquarters (HQ) documents and Field Office (FO) guidance.*

- Various definitions and the statement made on the treatment of "positive bias" are not consistent with ANSI/ANS-8.24-2007. *Correct definitions/statements in NFO Module 08 to be in line with the standard; consider engagement with some of the 8.24 standard members to review the module*.

- Sensitivity/Uncertainty (S/U) methods are a powerful tool when used appropriately. It is judged that the typical NCS engineer performing validations and safety evaluations may not have adequate training/understanding of these methods to understand the potential pitfalls and to apply them correctly. *Remind students that the use of S/U requires training and understanding of the methods used and the ability to adequately interpret the data provided.*

- Hazard and operability (HAZOP) methods and instruction are limited to mostly "What If". *Consider including greater detail and instruction/references to additional methods*.

- Much of the information, data, and graphics is plutonium-centric. *Include information, data, and graphics, where appropriate, for* ^{235}U, ^{233}U, *LEU, MOX, etc., and expand to provide a different graphical perspective*.

2nd Week SCX Hands-on Course

- Significant improvements in the class room portion of the facility have been made and more are planned. Reduction of the background noise via improvements in HVAC and the planned "false floor" improve the interactions between the students and the instructors as well as reducing potential tripping/equipment damage issues.

- All materials necessary for the students to perform the experiments, data collection and evaluation were provided to the students in the classroom. *It may be beneficial to let the students know this in advance so they are not tempted to pack these materials.*

- Instructors projected a passion for the material and a genuine interest in the students. This kept the students engaged throughout the week.

- Some discussions about the implications of experiments and lattice criticality accidents regarding the safety of DOE fissionable material operations were weak with a focus on reactor lattices as opposed to the experiment accidents' similarity to non-reactor nuclear facility fissionable material operations. *Work to relate lattice experiments and discussion about accidents to DOE non-reactor nuclear facility operations (e.g., PF-4, Y-12, Savannah River Site).*

- Several modules (modules 23-25) were of very limited value. These were focused on light water reactor (LWR) reactor cores, and, while interesting, the time in the class room could be more effectively utilized by covering other material (greater discussion of criticality accidents relevance to criticality safety, the suggested added module on Clayton's Anomalies).

- Only a partial description of detectors in general was provided and it seemed to be missing the tie-back to what could go wrong to give bad data. *Provide examples of detector issues that could/has gone wrong to provide bad data.*

2nd Week NCERC Hands-on Course

- The logistics of entry/exit to Device Assembly Facility (DAF), escorts, rad con, etc., worked smoothly. Training rooms were well equipped and comfortable.

- The conduct of the experiments was professional and the information is of significant value in training nuclear criticality safety engineers. *Tie the process analysis methods back to the experiment portion of the training to re-enforce the classroom portion.*

- It was noted that the lead instructor on the TACS module, sat through the other modules. This is a positive Observation in that it showed some cross transfer of information. It is unknown if the other instructors have been through the TACS module. *Have all instructors be knowledgeable of what is being taught in all modules to ensure consistent instruction.*

- Some portions of the training were of questionable value. In particular, Module 6 on the BeRP Ball and Np Sphere. This was mainly a "show and tell" type of presentation that, while interesting, required many NCERC personnel to accomplish and did not directly tie to the ANSI/ANS-8.26-2007 objectives. *Re-evaluate the value of that activity relative to expanding on other training related to the experiments and/or performance of NCSEs/procedures for the demonstrations.*

- It was interesting to observe the difference in the teaching approach between Module 3/4 (TACS) and Modules 5 (Planet), 7 (Flattop), and 8 (Godiva-IV). The hands on portion for Module 3/4 was less formal; that is, it was not performed to an in-hand procedure nor was the procedure for the experiment provided to students. They performed the experiment directly from the workbook. In addition, assembly steps changed during the course of the experiment (i.e., some assembly was being performed outside of the experimental apparatus). The other modules, however, were more formally performed with an in-hand procedure. There was a clear connotation that the experiment in Module 3/4 could not achieve a critical state and that upfront belief resulted in an informality of conduct of operations. However, the knowledge that the experiment set could not achieve a critical state was not derived through training by the students. Conversely, there was a clear expectation that the remaining experiments would achieve a critical state and the performance of the experiments was more formal, slow, and deliberate. *Address the missed opportunity in performing Module 3/4 by showing the students how preconceived knowledge of "assured" subcriticality and notion for the degree of safety affects operations at the student's facilities and by demonstrating the relationship of "Formality of Operations" and "Formality of Conduct of Operations." Explain how ANS-8.1 requirement for written instruction is met.*

- There was a tendency to "staff" positions by the instructors where students could do the job (e.g., reading through the procedure, overseeing calculation results or otherwise doing the work for the student). This missed an opportunity to involve students in every aspect of the conduct of operations. *Look at all roles in the training and involve students in as many roles as possible.*

- Many questions asked by instructors were yes/no type questions, questions that hinted as to the answer or questions were the answer was quickly confirmed. Engaging students to think is the most important part of this process. If another student had a different answer, they were often not given an opportunity to explore that answer. *Train instructors on how to ask open ended questions and how to draw other students into the question session.*

- A significant amount of time was spent on teaching experimental methods, including the attempt to distinguish an operation from ANS-8.1 space to ANS-1 space. This was at times confusing. Because the content of the training was focused primarily on how to do an experiment rather than on the ability to "relate the results…to facility operations for which they prepare NCSEs." This Observation is reinforced by the stated objectives in Modules 2, 3, 5, 6, 7, and 8, as well as the exam. Those elements focus on methods to approach critical, use of basic nuclear equations, and specific property effects on reactivity. The students left with a good sense on how to conduct an experiment and the associated nuclear physics responses, but not necessarily on how to relate experiments and data to facility operations at their site. In other words, there was a missed opportunity to have the students relate what was observed through the experiment to actual field issues they deal with day in and day out and how they write evaluations. *Relate the experiment conditions and observed factors to non-reactor nuclear facility criticality safety and operations and keep the focus on applicability to the ANS-8 series, which is where the NCS engineer lives.*

- *Specific "take aways" should be identified for the experiments. Clarify the "take away" for the practitioner regarding the Flattop Free-Run Demonstration to promote the concept of critical thinking to encourage a questioning attitude and to challenge the concept of using the "most conservative" conditions for example.*

2 High level Observations and *Recommendations* regarding the HTEC consistency with the 2014-2023 NCSP Mission and Vision for Training and Education

By virtue of this CSSG review it is concluded that certain 5-year "high priority" aspects of the 2014-2023 NCSP Mission and Vision (M&V) Technical Priorities are being addressed by the HTEC, which addresses the requirements of ANSI/ANS-8.26-2007[4] national consensus standard. In particular, the following "High Priority" "Attributes" and "Goals" of the M&V for the the T&EP HTEC are being addressed as follows.

[4] Criticality Safety Engineer Training and Qualification Program, ANSI/ANS-8.26-2007, American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60526 USA.

Attributes	Goals
Access to an integrated, coordinated, and consistent compendium of criticality safety training and education resources that provide effective training commensurate with need	A sustainable process to identify and communicate available training classes and education resources in the national and international communities – *is accomplished by the continued and updated postings on the US DOE NCSP website regarding the announcement of the T&E HTEC for professional nuclear criticality safety engineers. Other training courses regarding the development and use computer codes are publicized via the NCSP sponsored ORNL Radiation Safety Information Computational Center as well as Nuclear Criticality Safety Engineer Training modules. As noted there is a further opportunity to integrate the HTEC with the other materials on the NCSP website.*
	A gap analysis of training needs based on an assessment of available training and education resources in the national and international communities – *is addressed by the current CSSG review of the extant US DOE NCSP T&E Program regarding the HTEC program.*
	A sustainable process to obtain and incorporate feedback to expand or improve training course(s), training modules, or NCSET modules – *is addressed by the the student evaluation forms from each class and feedback of the CSSG review of the extant US DOE NCSP T&E Program. Those data should be reviewed annually for trends that could identify needed clarifications on messaging.*
Provider of criticality safety training not readily available from other sources	The existing and unique training provided by the NCSP, e.g., classroom and hands-on experiment training, and NCSET modules, remains a high priority – *and is judged so by the current CSSG review of the extant US DOE NCSP T&E Program.*

The following remaining 5-year "high priority" aspects of the 2014-2023 NCSP Mission and Vision (M&V) Technical Priorities were not verified but are understood to be in-process or under development.

Attributes	Goals
Provider of criticality safety training not readily available from other sources	Sustain a training course for managers, supervisors, criticality safety officers, or criticality safety representatives, and DOE facility representatives – *it is understood that those courses have not been piloted or reviewed for consistency with NCSP objectives.*
	Develop a mobile CAT 1 criticality hands-on critical or near critical demonstration capability.

The following 5-year "medium priority" aspects of the 2014-2023 NCSP Mission and Vision (M&V) Technical Priorities were reviewed with the following results.

Attributes	Goals
Collaborative environment between national and international communities	Sustainable program (internship, rotational assignments, etc.) to facilitate collaborative training and education opportunities (national and international) – *this goal is in its infancy but has been initiated with a collaborative agreement since 2014 resulting in Institut de radioprotection et de sûreté nucléaire (IRSN) personnel visiting SNL, LANL, and NCERC and learning about NCS training and practices in the US. There has been an exchange of an LLNL employee with* Atomic Weapons *Establishment (AWE) under a continuing mechanism for exchanges between NNSA and AWE, however it has not yet become a sustainable program.*

Other 5-Year 2014-2023 NCSP Mission and Vision (M&V) Technical Priorities for Training and Education were judged to be outside of the scope of the US DOE NCSP hands-on training and education course.

3 Realistic circumstances that are, or may reasonably become, prevalent regarding necessary resources to address the course criteria (e.g., availability of facilities, training materials, personnel, fiscal support, calendar dates, student support/schedules).

This was only lightly touched on by the team during this review due to the limitation of time and knowledge of circumstances including available resources of DOE programs and facilities. It is suggested that the completion of this element of the review be undertaken by individuals with a broad and in-depth knowledge of those potential programmatic circumstances and resources.

The following Observations are provided:

- On a positive note, the training materials and course content were judged to be very good and well put together, and use of students' time in the course was good.

- Given the 5+ years of offering the class, attendance at the classes appears to continue to be strong. As the potential needs diminish, T&E should continue to monitor and make suggestions as to the optimum number of classes to be held each year.

- The goal of having a "mobile version" of the classs, perhaps using TACS, that could come to the individual sites, has not been realized. Relating changes in process parameters to effects on criticality in a real world setting is a significant value that this class could provide to both criticality safety engineers and operators. *T&E should evaluate necessary plans/procedures/funding necessary to create a mobile version of the class and present that to the NCSP as an option.*

- Due to unforseen events at LANL regarding the loss of criticality safety staff, and the PF-4 restart efforts, the classroom portion of the training was moved to NFO starting in CY16. While this had some logistical advantages for those continuing on at NCERC, the loss of actual fissile operations to review as part of NCSE development was a detriment to the class. *Investment by the NCSP into T&E in the area of developing simple mockups using "standard equipment" should be strongly considered if the intent is to continue to* *hold the classroom portion away from an actual operating site. Alternatively, consideration should be given to using walk down/assessment and NCSE development at both NCERC (vault storage, handling, etc.) and SNL (drum/material storage, handling, etc.) thereby giving the cleared and uncleared students somewhat of an environmental appreciation for some operations.*

- There were some comments by the students that packing for the consecutive two weeks of the class (often in multiple locations) was difficult. *A continued discussion within the T&E, reflecting on any student feedback on the survey evaluation forms, should be undertakent to determine the cost/benefit associated with the two weeks of the class being contigious vs being separated by several weeks.*

- Now that the class content is fairly well stabilized, the use of "alternate" teachers for the class has been undertaken. Since multiple instructors may be used over multiple classes to teach a module, the importance of speakers notes and speaker preparation is very important. *Course content leads should ensure that a set of speaker notes is available for the slides of each module. They should aslo ensure that instructors are expected, and provided time, to prepare for module instruction if they have not taught that module before.*

General and Detailed Observations - *Recommendations*

General and detailed specific review positive acknowledgments, Observations, comments, *Recommendations*, suggestions, and missed opportunities, regarding the HTEC classroom and hands-on lectures, slides, workshops and sub-critical and critical experiments training and education are provided in Appendix A to this report.

Appendix A

US DOE NCSP Hands-on Training & Education Course Review

General Overall Course Observations

In general, the US DOE NCSP hands-on training and education course objectives recommended by the CSSG 2009-03 Tasking Response were addressed (***exceptions/additions noted***) as follows:

Classroom Training and Education at NFO (Nevada Field Office)

1. Nuclear criticality safety fundamentals
2. Standards – including regulations
3. Criticality safety evaluation development
4. Criticality accident discussions

(*No access to fissile handling facilities/mockups were available.*)

Hands-on Experiments Training and Education at NCERC (National Criticality Experiments Research Center)

1. The experiments/training exercises involved the same assemblies as used in prior courses.
2. The LANL training included Flattop and the 93%-enriched polyethylene-coated U foils/Plexiglas™ plates though Planet.
3. The TACS shell experiments were included in the suite of experiments.
4. One or more experiments representing over-moderated configurations were included.
5. The training included the demonstration of student competency.

(*No non-security-cleared students participated in the class. It is understood that the logistics for enabling non-security-cleared student access uses more resources, hence it is more costly. Also, having non-security-cleared students in attendance could limit discussion on some sensitive topics that may arise as part of discussions with students.*)

(*Though the CSSG 2009-03 Tasking Response made no recommendation for hands-on subcritical demonstrations with the BeRP Ball and 237Np sphere they were performed.*)

SCX (SNL Technical Area V Critical Experiments Facility)

1. Critical conditions were based on variable fuel loadings and water level control.
2. The training included the demonstration of student competency.
3. Non-security-cleared students were accommodated.

(*One or more experiments representing over-moderated configurations have not been included – a current safety basis restriction.*)

(*An assembly using 19%-enriched U plates/foils has not been included – currently fiscally constrained.*)

No course creep was observed regarding the HTEC Objectives specified by the CSSG 2009-03 Tasking Response.

Review Observations - *Recommendations*

The same fundamental learning objectives for hands-on training generally were addressed at both sites (NCERC and SNL) regardless of the exercises performed or the particular assemblies used for the exercises. However, it was not apparent that the developers of the three-venue training and education sites (i.e., NFO, NCERC, and SCX) collaborated during the T&EP development and/or the evolution of the course to ensure agreement on the specific learning objectives and to ensure that the final training modules addressed those objectives with limited redundancy. *Have the two-week course developers scrub each other's slide presentations for content and to avoid inappropriate redundancy from the first week course and the second week course.*

Based upon the review of NCERC and SNL classroom slides and presentations there appear to be similar fundamental learning objectives for hands-on training but there are remarkable redundancies with the 1st-week classroom training and education objectives with limited inconsistencies. It is not clear that there has been a refereed and moderately directed collaboration among the classroom, NCERC and SNL course materials and lectures. Examples include:

Nuclear criticality safety fundamentals

Standards – including regulations

Criticality safety evaluation development

Criticality accident discussions

Ensure that the primary developers for each of the three two-week courses (i.e., classroom, SNL, and NCERC) have reviewed and/or attended lectures for all three courses to ensure consistent and intended progressive training and education from the 1st to 2nd week courses.

There is general uncertainty that students have actually considered the identified prerequisites recommended by the CSSG Response to Tasking 2009-03 (e.g., NCSET Modules). Student feedback was that the information was too much to read. *Develop some sort of pre-course simple student exercises in the use and familiarity of the NCSP.LLNL.GOV and NCSET Modules to be completed as part of their pass/fail criteria for the course and/or provide in Module 00 a table cross referencing salient information and location on the NCSP website as appropriate.*

There were several missed opportunities to utilize and/or reference the NCSP products like heritage videos and CSSG tasking responses in both the classroom and hands-on courses. *Every effort should be made to actively integrate as much information as possible from the NCSP website (e.g., in live-time, or simulated-live-time, access NCSP website resources directly on class screen displays).*

As shown on introductory slides, the ground rules metric for pass/fail is not consistent among the SCX, the NFO and NCERC regarding passing written test(s) and active classroom participation. The SCX expectation is that 70% of a written test and 30% of student participation are summed to determine a passing grade of 80% (e.g., 50% written test score plus 30% participation score could be passing). *Resolve expectations of the NCSP.*

Modules, Sections, Parts, and Supplemental Information labeling is not consistent throughout the slide presentations and students occasionally lose their place when instructors flip backwards or forwards in the slides. *Identify in a header or footer, each instructional slide with its module, section, part, supplemental information, or other unique identifier.*

Statements of Module Objectives and a concluding slide review of Module Objectives are not provided for many modules. *State the learning objectives on the introductory slide for each module and verify/recap the objectives in the terminal slide(s) for each module.*

Various slides presented equations without defined parameters that were verbally referenced. Students missed or misunderstood the meaning of some of the verbally mentioned parameters. *Include equation parameter and/or abbreviations definitions used in equations.*

Only one or two modules had lecture notes provided on the "raw" MS PowerPoint, pdf slides to be used by the originator or substitute lecturers and for updating/improving the course and slides. *Provide and update lecture slide notes with subsequent course classes.*

On occasion, subject matter instructors would not be present during a testing period. *Instructors should be prepared to be present in the room for the duration of testing should questions arise.*

Provide gamma and neutron radiation <u>dose</u> and <u>dose rate</u> meters at/near the location of critical assemblies, such as an operator position, for students to observe the radiation fields during the complete evolution of the experiments, especially the decay following shutdown from critical. Also, provide conversion factors to the students for their estimating the dose to a nearby person as a function of a typical accident fission yield.

1st Week NFO Classroom Course

General Observations – *Recommendations*

Logistics/Structure:

The diversity of instructors was good.

Perhaps, due to this being the first presentation of the classroom portion of the course at NFO there were various logistic challenges including the following:

- The delayed in-processing of personnel without Homeland Security Presidential Directive (HSPD)-12 badges (~40 minutes). Include an approved image of an HSPD-12 badge on the website and course registration/description materials for clarification (badging delays caused by student not knowing they did NOT have an HSPD-12 badge).

- Inadequate audio-visual capabilities for some presentations.

- Intermittent to mostly non-existent Wi-Fi internet capabilities for presentations (subsequently worked around with retrieved video files on the presentation computer with no audio).

- Need for the required use of a lapel microphone (some instructors were too soft spoken to hear/understand), likely should be required use of all instructors to avoid failure of usage.

Continue to predict and address logistic challenges.

Aside from issues with the audio visual services, the NFO classroom environment was excellent for the size of the class. Desk and seating spacing provided good working/writing surface for each student and provided sufficient spacing between students to discourage neighbor conversations during the lectures. *Attempt to maintain classroom layouts similar to that experienced at NFO.*

The diversity of instructors was good. *Maintain diversity.*

There is no clearly stated introductory link provided between ANS-8.26 and the objectives of the class. *Clarify the purpose of course to provide a link between ANS-8.26 and students, e.g., to provide basic knowledge, access to specific resources/reference materials and identify good habits that will aid the criticality safety practitioner to understand and satisfy the requirements from national standards and DOE expectations*.

Several slide presentations were not consistent (the outlines/objectives do not always match presentation content. *Update to current version of standards and references.*

Most slides were displayed with full content thereby facilitating students' reading ahead rather than focusing on an instructional point. *Consider using animation in slides to help students focus on one point at a time rather than reading ahead.*

There were instances of slide content/words not being consistent with ANSI/ANS-8.xx language. *Review and correct all slides for precise and consistent language with* ***current*** *ANSI/ANS-8.xx and DOE document requirements and their relevance to the topic of discussion.*

There was inconsistent verb tense/perspective on "course content" slides. *Choose either lecturer or student, don't mix.*

Some presentation slides make reference to information available on the NCSP website but give no http link. In other instances, some slides attempt to provide a link but it is too general in nature (i.e., http://ncsp.llnl.gov). *Provide* ***specific*** *links to referenced and useful information (e.g., http://ncsp.llnl.gov/cssg/taskandresponse/2014/2014-02_Response_on_Validation_with_Limited_Data_09-21-15.pdf).*

Occasionally, instructors would provide anecdotal examples to emphasize a subject or topic of discussion by expressing opinions, actions, judgments and/or facility practices at a specific facility. Also, several slide sets seem to have site specific influences in addition to personal opinion. *Avoid the use of facility-specific references or anecdotes depicting good or bad behaviors or judgments but positively specify DOE expectations regarding episodes such as found in the DOE ORPS system in order to avoid endorsing or criticizing differences among DOE facilities.*

On various occasions, instructors in the audience would interrupt, correct, or challenge a lecturer during their presentation to the students. That action may confound students about the validity of the presentations or may create a student's sense that they are being given correct and up-to-date information in an informal and knowledgeable manner. C*onsider the value of such interruptions versus offering information to the lecturer in private.*

Following the presentations of all accident lessons learned a seemingly impromptu presentation/module was given about process accident contributors. A more formal, referenceable, and meaningful module could have been provided. *Provide a summary module about process criticality accident contributors as identified in LA-13638, Section C. OBSERVATIONS AND LESSONS LEARNED FROM PROCESS CRITICALITY ACCIDENTS.*

Opportunities:

No reference or review of anomalies were addressed. *Provide a module, with reference to the NCSP anomalies report near the conclusion of the classroom course that will be instructive to students as a caveat to overreliance on "rules of thumb" and frequent intuitive mistakes*.

No comprehensive explanation about the NCSP website is provided. *Present the suite of resources/products available from the NCSP website; include heritage videos, NCSET modules, CSSG tasking reports, experiment requests, specific references cited in presentations, etc. Try to weave these products into examples throughout presentations*.

The guidance for performing a criticality safety evaluation and the exercises focuses on existing processes and facilities. *Discuss/contrast this process with an evaluation for a proposed process/facility could be informative (e.g., discuss example of a new vault for material storage and then confirm approach when viewing the vault at the NCERC).*

The presentation on nondestructive assay (NDA) focused strongly on the techniques and issues associated with the methods. There was little information or encouragement to consider these techniques to enhance a criticality safety program. *Consider providing more examples of in practice use of these techniques to support criticality safety to possibly encourage the next generation NCE to look for practical ways to incorporate these techniques into their criticality safety control strategy…as either primary or defense in depth controls.*

ARH-600 as a handbook reference was mentioned but no specific use/example provided in the workshop for hand calculations relative to the 2nd week hands-on course. *Provide a review of content and potential use of ARH-600.*

Workshops:

The workshops were well executed and successfully engaged the students.

The mock processes were simple and well-suited for the exercise.

The process analysis portion of the course was stunted from not having access to an operating facility (e.g., LANL PF-4) for the NCSE Workshops and Process Analyses. Also, small groups (3-4 students) were very important to engaging all the students. However, the disadvantage was that each "supervisor" (instructors were considered process supervisors for this exercise) had to repeat everything twice regarding an imagined facility. In the absence of using actual fissionable material processing facilities it would be beneficial to use some sort of a mock facility with relational objects (e.g., materials, geometries, spacing, personnel and equipment interactions and limitations represented by tables, tape on the floor, and cardboard could be used for a simulation that would engage the students; 3-D computer mockups could also be considered but may be too costly compared with the "benefit"). *Provide videos, pictures, and/or props to support the NCSE Workshops and Process Analyses.*

Workshop and lecture did not address documentation of items/scenarios considered but were dismissed because they were judged not to impact criticality safety. In unreviewed safety question reviews, knowing what was considered may be helpful in understanding if a condition is truly unanalyzed versus judged to have no impact. *Provide instruction regarding the documentation of items/scenarios considered but dismissed as inconsequential to criticality safety*.

Some students struggled with reference materials and their applicability to the "processes" they were evaluating (including hand calculations, subcritical values from ANS-8.1 and tables and charts from LA-10860). *As may be possible, provide more engaging/instructive use of the reference materials.*

There was good integration of human factors considerations in the control selection portion of the exercise.

The relationship between NDA and the criticality safety limits/assumptions/controls was unclear and appeared attempted to be used to define upset conditions. *Integrate NDA discussions into the exercise with something like a "best in class NCSE" example.*

Some mixed messaging with respect to using a systematic approach to performing evaluations. Steps are presented in lecture materials and NCSET modules but not carried through to exercises. *Carry through in exercises.*

There was active participation by students. Good lines of inquiry from students were sometimes "steered" away because of limited time and desire to have a "result" to present. Some of this could be mitigated by providing dummy materials like procedures and/or access to "operator" for walk down interview and consistent information for each example or dummy process. *Avoid dismissing student questions for expediency or to avoid embarrassment.*

Maintenance activities in the "what-if" analysis were not noted and could present credible conditions not otherwise anticipated. *Include maintenance activities as credible influences.*

Note the value of reviewing ORPS reports for lessons learned can be very informative with respect to evaluating how robust or effective proposed controls will be.

High Priority Comments by Module:

Module 00: Where possible, tie the course content discussions to ANS-8.26 and/or appropriate NCSET modules.

- Module 00 Section 02; Module 03; Module 09; and Module 10 all address "DOE Requirements and National Standards and the National DOE Nuclear Criticality Safety Program."

- Learning objectives for this material need clarification; title and materials should be consistent with objectives.

- Much overlap, some missing information (e.g., Defense Nuclear Facilities Safety Board (DNFSB) info is advertised but not provided).

- ANS 8.1 is misquoted; verify that all information purported to be from standards is correctly quoted from the current revisions.

- Observed difference of opinions expressed by individual lecturers may cause doubt that the standards are "concise and clearly stated."

- Is one objective to develop a questioning attitude among practitioners to challenge when procedures require efforts that are far more cumbersome or restrictive that the Standards and Orders?

- Ties to DOE-STD-3009 are not discussed.

- Several slides related to the standards stressed what words like credible did NOT mean. A positive spin describing DOE's expectations would be more useful (other examples in addition to credible include safety margin and unlikely).

- Clarify if DOE requirements include addressing natural phenomena hazards (NPH) in the criticality safety assessment as part of the ANS-8 standards' mandate that all hazards be considered in a risk/benefit manner.

Module 02:

- Discussion of Time Behavior of Criticality Accidents is more relevant to the follow-on week and should have priority over the discussion of cross-sections. This material was treated as "if it fits/if we have time."

Module 04:

- Link learning objectives to requirements of ANS-8.26.

- Suggest provide reference sheet of methods and their applicability/restrictions.

- Look for opportunities for linking to NCERC, TACS and SNL experiments. Done informally for Planet experiment at NCERC.

- The module needs to ensure that students understand that the hand calculations are very useful for scoping and estimating critical/subcritical systems but should not be used as the basis of a NCSE without verified and validated "touch-stone value(s)" The presented results of exercises rightfully demonstrate good answers, thereby, giving the students confidence for use without "touch-stone value(s)."

- Look for opportunities to compare hand calculations to code results when appropriate. If hand calculation method based on k=0.9, code calculation should also be to k=0.9, not k=1.0.

Module 05:

- Ties back to ANS-8.19 in discussion of procedures were excellent.

Module 06:

- Discussion and process aligned with existing facilities, enhance by contrasting with situation regarding new/proposed facilities/operations.

- Guidance relative to use of checklists confusing. Discussion of systematic approaches that can be tailored to individual process analyses should be considered.

Module 07:

- Relationship to criticality safety not clear and should be enhanced. NDA techniques clearly important to criticality safety evaluations for waste operations.

- Seek to provide additional examples beyond waste drums where NDA and criticality safety are integrated.

Module 08:

- Learning objectives should be more directly related to the requirements of ANS-8.1 and ANS-8.24.

- Talking points are strongly urged for this module, primarily to distinguish between requirements, opinions, best practices and examples.

- An impression was given that "code-to-code" validation is permitted. In fact, the lecturer was clearly surprised to learn that code-to-code validation will not satisfy the requirements of ANS-8.24.

- The discussion of computational method should include the contribution of the human element, i.e., the user, as part of a quality assurance program for Verification & Validation (V&V).

- There was some verbal discussion of systematic bias but no specific example was given.

- Discussion of margin of safety needs to be integrated with ANS-8.1 and 8.24 requirements. The terminology needs to be cleaned up with respect to minimum subcritical margin, administrative margin, and margin of safety.

- The value of the data adjustment analysis is questionable. It would not be advisable for the general criticality safety analyst.

- Comments made on the treatment of "positive bias" are not consistent with ANS-8.24

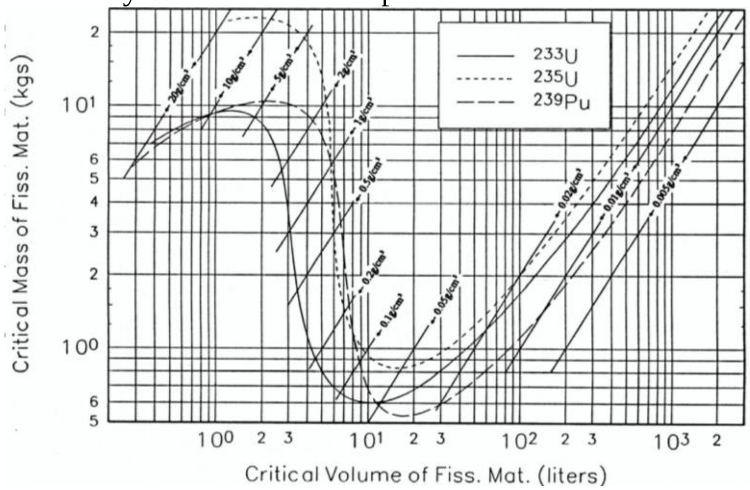
Detailed Module/Slide-specific Observations – *Recommendations* (most are nits):

(These notes use the format MM:SS:ss where MM is a 2-digit integer for the module number, SS is the section number and ss is the slide number from the printed books.)

00:00:05	*Revise to include metric for participation.*
00:00:10	Revise final bullet to be class exercises and observations. Add bullet to evaluate course effectiveness with quizzes and closed-book exams.
00:01:02	Title provides welcome to LANL. Change to a *"Welcome and Introduction to the NCSP T&EP Two-Week Hands-on Course" or something to that effect*.
00:01:07	There is frequently a difference between facility expectations and regulatory expectations that need to be moderated and resolved. Not doing so is the cause of safety program disconnects that fester. *Purposefully state that the students are encouraged to challenge any of the messages or information presented in the course materials and presentations. This should be an opportunity for students to resolve discrepancies between what they are obliged to do at their job and what the DOE NCSP expectations are.*
00:01:09	HAZOP methods and instruction are limited to mostly "What If." *Consider including greater detail and instruction/references to additional methods.*
00:02:20	Follow this slide with word slide elaborating function of components/tasks of NCSP.
00:02:21	*Suggest move this slide ahead of figure in previous slide. Also add slide about NCSP.LLNL.GOV website.* The intent is to convey to the new or prospective criticality safety professional the concepts and applications of the DOE Orders and Standards. *Work to avoid personal perspectives and philosophies that can be perceived as "wishy-washy" and have limited regulatory value leaving open-ended arguments.*
00:02:22	*Reinforce the notion that there is value in the consistent application of safety across the DOE complex such as the identification of the character of controls, the establishment of normal process and control limits, and subcritical limits.*
00:02:26	*Improve examples of "Program Values" bullets to explain HOW this value is implemented.*
01:00:14	Although no physical damage to processing equipment or facilities, there have been situations where process rooms were so significantly contaminated that operations could no longer continue in those areas. *This should be noted not just spoken. Also, the potential for damage should be related to accidents in experimental facilities.*
01:00:38	*Note that no criticality accident alarms were installed because criticality had been evaluated as not credible for the ongoing operations at the facility. Provide the DOE NCSP expectations for what constitutes a CAAS needs analysis and how a trivial/non-trivial determination is made with respect to the facility overall NCS risk.*

01:02:34 Much of the information, data, and graphics is plutonium-centric. *Include information, data, and graphics, where appropriate, for ^{235}U and ^{233}U and expand the graphics to provide a different perspective. An example could be something like the following for*

Fully Water Reflected Sphere Mass vs. Volume



01:02:36 A typical "rule of thumb" is that it requires ~10^{17} fissions to vaporize 1-liter of water originally at room temperature without condensation. Observations of actual solution accidents have demonstrated that a typical first "spike" yield of ~10^{15} fissions per liter occurs with solution accident. That was not discussed. *Relate the rule of thumb and observation as they may or may not relate to later accident reviews.*

01:02:41 The slide does not provide relative dimensions in the photo for the location of the accident, construction of the buildings, the plant boundaries referenced on later slide and location of facilities that were alarmed. *Provide dimensional information to sensitize students to the circumstances of the accident.*

01:02:43 States that that the processing operation was the "Ninth time in the facility history" without specification. *Specify years of facility history if possible.*

01:03:44 Provides no relative facility dimensions. *Provide approximate dimensions of facility*.

01:03:49 There are no indications of buildings that did alarm. *Provide a plat map of buildings that alarmed and at what level of radiation thresholds they alarmed. That would give students an appreciation of the broad range that such an accident MIGHT be detected*.

01:04:58 *Though not a Process Facility Solution Criticality Accident, ensure that the Siberian Chemical Combine, 13 December 1978 accident and the US Nuclear Regulatory Commission (NRC)-licensed facility incident with a mound of "dry" uranium oxide are discussed to sensitize students to the possibilities of such accidents though remote.*

02:00:02 Relate learning objectives with those of the overall class and ANS-8.26.

02:01:04 Does not include information that in October 1943 the Oak Ridge X-10 Graphite Reactor went critical and provided the proof of principle for production and chemical separation of plutonium and further design parameters for Hanford Plutonium Production. *Include a table entry about the Graphite Reactor in 1943 prior to the Hanford Plutonium Production reactor design and construction.*

02:01:05 Are there values for early estimates of critical masses of 235U and 239Pu that could be compared with current values? If "Plants were designed conservatively" why did criticality safety accidents occur?

02:01:06 Reference to "simple computations did exist." *Elaborate if referring to hand calculations, diffusion theory, etc.* The statement, "Required to do whatever they needed to ensure safety of the workers." *Recognize that the timely success of the project depended upon accident avoidance.*

02:01:07 *Relate back to introduction in Module 01 of criticality accidents*. The statement, "Led to developing remote assembly capabilities at TA-18." *Include the portion of the ORCEF Heritage Video discussion by Dixon Callahan, Alvin Weinberg and Ray Murray regarding Slotin's accident and character.*

02:01:08 Link to lessons learned from criticality accidents codified in ANS-8.1 and assignment of responsibilities

02:01:09 Tie "educated judgment" to requirements of ANS-8.26

02:01:11 The quote could lead to "unimagined" safety regulatory approaches. *Carefully balance the discussion about flexibility and constraints on operations.*

02:01:18 Relate ways to start chain-reaction to the control parameters to be addressed in NCSEs as described in DOE-STD-3007(2007)

02:01:42 Switch/revise with information from slide 02:01:48. Discussion of k here is more about chain reactions. Relating k to "generations" fits better with slides 02:01:49 and 50.

02:01:58 *Errors on slide; definition of fissile is only slow neutrons, fissionable includes both thermal and fast, referred to here as "threshold." There are some fissionable isotopes with a threshold at High energies (greater than 2MeV).*

02:01:62 Formatting issue. *Fix.*

02:01:64 Mass units in table are different. Use consistent units for mass (e.g., kg)

02:01:88 The rate of change of prompt neutrons is shown by dn/dt rather than n(t). *Assuming the first generation is at critical and the next generation is at* k_p *this can be written as dn/dt= change in prompt neutron population between generations/mean prompt neutron generation time; delta k/* l_p*; going to prompt critical delta k=* k_p*-1 Therefore* $dn/dt=(k_p -1)/ l_p$*. The time dependent behavior, not rate, of prompt neutrons is* $n(t)=n_0e^{(k_p-1)/l_p}$*.*

02:01:89/90 Projected slides had a lamda rather than a script, ℓ_p. *Correct projected slide.*

02:01:94	This slide makes a point that it is a common belief that k_{eff} is a measure of safety margin. Verbally stated that delta k is NOT safety margin, later referred to delta k as a safety margin. *Clarification needed. Can delta k be a measure of safety margin? If delta k is not safety margin, what is? What are caveats? Is safety margin qualitative or quantitative? Relate to the "k-safe" term that is used a lot.*
02:02:16	"Large energy release, in the form of radiation, is possible" is a limiting concept. *Modify to "Large [kinetic] energy release, in the form of [fission fragments and] radiation, is possible"*
02:02:21	"…proton/neutron…" is a ratio. *Specify that the mass of a proton and a neutron is arbitrarily assigned an integer mass of ≈ 1 for nuclide identification*.
02:02:24	"Should be easier of ^{239}Pu than for ^{235}U" *Modify "Should be easier for ^{239}Pu than for ^{235}U"*
02:02:30	Slide describes cross-sections as area only. *Also, relate neutron cross sections to probabilities of reactions as well as area.*
02:02:40	Slide limits non-fissionable nuclei reactions. *Include brief statements and examples of n-n, n-2n and consider identifying α-n, γ-n reactions and their potential role in NCS.*
02:02:41	Grammar, *change "it" to "they"*
02:02:43	Verbal presentation stumbled on the notion that k_{eff}, or k_{∞}, might be as high as 4.0 for a faulty calculation. *Ensure students understand that the neutron multiplication factor cannot exceed nu-bar.*
02:02:62	Formula does not display correctly in student slides handout. *Fix all slides that display formulae incorrectly.*
02:02:67-70	Slides do not specify geometry of systems. *Change graph title to include "Spherical"*
02:02:77	Time Behavior of Criticality Accidents has no Module or Section number. *Fix.*
02:02:83	No description is provided for "neutron lifetime." *Students do/will hear of "neutron lifetime" so give some relative description.*
02:02:86	Slide does not differentiate which βeff is for 235U, 239Pu. *Identify the βeff for 235U, 239Pu, and include 233U.*
02:02:88	"Time Behavior of Criticality Accidents" had a very brief presentation. Slide 88 refers to rate of change but presents equation for prompt neutron population as a function of time rather than dn/dt (production – loss). *Provide the relationship for n(t) and dn/dt.*
02:02:93	Safety Margin – No Module or Section number. *Fix.*
02:02:99	Subcritical Multiplication & Reactor Period – No Module or Section number. *Fix*.
02:02:100	Slide does not differentiate which β_{eff} is for ^{235}U, ^{239}Pu. *Identify the β_{eff} for ^{235}U, ^{239}Pu, and include ^{233}U.*

03:01:02 The title and objectives do not align with specific material in this presentation but actually discusses the role of standards and DOE as required by law, and also addresses the ANSI consensus standards process. *Align Objectives with slides or modify module.*

03:01:09 *Needs to strengthen or give examples to support statement that* “Standards recognize this relationship”

03:01:10 The “Categorization” in 3 groups may represent the ANS-8 series but is not generally applicable. *This slide should be revised to illustrate how the ANS-8 series of standards has been developed*

03:01:11 *Reconsider the characterization of the standards and/or justify the characterizations of standards like ANSI/ANS-8.20, -24, -26 as not being “Application Specific.”*

03:01:14 *Title of 8.15 should be updated.*

03:01:17 The statement from the introduction of the 8.1 standard is misquoted, “good safety practices “should”“ rather than “must”. *Fix if inconsistent with DOE expectations.*

03:01:18 The statement is made that “accidents without human consequence are not bound by the standards” is misleading. If the unmitigated accident is without human consequence then generally the facility is designated exempt. If there are no human consequences by virtue of process or control assumptions, these must be identified and protected and the standards would still apply. *Clarify and avoid innuendo.*

03:01:19-22 *Consider moving this slide up earlier in the discussion of standards. Enhance “say what they mean and mean what they say” by stating standards provide specific definitions for terms which they believe may be subject to misinterpretation*.

03:01:21 “…an official inquiry should be made” - *The understanding of this statement needs to be elaborated to explain that any doubt or misunderstanding about the textual meaning of a standard must be resolved by a direct inquiry to the ANS Standards Administrator. A regulator may choose to impose independent interpretations or conditions from ANSI standards, in which case they are obliged to justify the regulator position. (ref. PL 104-113, SEC. 12. STANDARDS CONFORMITY. (d)(3)). A fun, but serious, question for the course developers would be, “Has DOE or NRC filed their exceptions to ANSI/ANS-8.1-2014, or any other ANSI/ANS-8.xx-xxxx standards, with the Office of Management and Budget as required by PL 104-113?”*

03:02:07 Did not provide the evolution from ASA to ANS standards though slide 03:02:05 video might have. *Ensure 03:02:05 video can be played (e.g., stored on a computer for playback).*

03:02:27	A verbal statement about the slide was that "Single Parameter Limits" developed and published for operations use and consideration. *Reconsider the verbal statement that ANSI/ANS-8.1 had "Single Parameter Limits" developed and published for operations use and consideration. Possibly replace the verbal statement with the concept that ANSI/ANS-8.1 was developed for applications by a facility NCS Program and it includes safely subcritical consensus values.*
03:02:31	"1990 to 2003 at LANL responsibility had shifted from operations to the NCS group." Is this the message that is wanted to be conveyed? Perhaps. *Either remove this reference or statement about LANL or provide reference to documents supporting this position and the absolute shift in responsibilities in 2003. All may not be well yet. Perhaps the same message about responsibilities can be made without finger pointing or making declarations that all is well.*
03:02:34	"Combustible loading may be determined by fire safety professionals but they don't monitor the combustible levels" may be too strong a state. *Reconsider the statement. Not a good analogy.*
03:02:38	*Extend need to collaborate with experts to include specifically fire safety and process engineering/supervision*
03:02:42	Don't understand why ASA-N6.1 is presented here. *If included, clarify it as a piece of history but not CURRENT consensus statement. Slide could lead to the assumption that all risk is trivial.*
03:02:45	The statements appear to switch between ASA-6.1 (slide 42) to ANSI/ANS-8.1-2014 "Only one applies in all situations, i.e., 4.2.1"? *Elaborate the verbal explanation of the concepts.*
03:02:48-57	*These slides should explain more what terms do mean regarding DOE expectations rather than what they do not mean. Clarify.*
03:02:58	*Statements seem to be conflicting (i.e., "If an inadvertent departure from procedure results in a critical system, it must not be a credible abnormal condition" and "Don't rely on a single departure from procedures as having to be incredible (defense-in-depth)"). Clarify.*
03:02:59	Grammar. *Correct grammar to "they had counted to two and stopped". Also, make the point that the identified, but limited, controls were not followed.*
03:02:60	*Consider the circumstances at the WTP.*
03:02:66	*Ensure that the slide content is consistent with DOE expectation.*
03:03:71-75	*Provide discussion regarding the "margins of subcriticality" of the subcritical limits, the material characteristics and how those characteristics relate to "margins of safety". That is reinforce the difference between "margins of subcriticality" and "margins of safety."*
04:01:03	Relate to TID-7016. *Suggest including summary table that lists methods and their applicability.*
04:02:19	Only provides core density relationships for bare spheres. *Include core density relationships for bare cylinders and slabs.*

04:02:24 *Provide specific reference for "look up value"*

04:00:25 *Provide specific reference*

04:00:32 *Verbally provided example related to anticipated Planet experiment for following week. Recommend formally integrate into presentation. Those going to SNL and not NCERC will still benefit by seeing the difference in critical mass for bare and moderated systems*.

04:02:35 A verbal statement (misheard?) was made that the Array Methods were developed for supervisors (operations?). *Reconsider the verbal statement that the array methods were developed for supervisors (operations?) or cite the reference(s) that support that statement.*

04:02:37 Elaborate on "Thomas data" and provide reference and include reference or link to Y-CDC-13 and consider providing Y-CDC-13 in the NCSP.LLNL.GOV NCS Information link.

04:02:52 Does not relate the relative k_{eff}s of the tabulated data thereby creating an impression of imprecise methods. *Elaborate on comparison of hand calculations and code results, not all represent k=1.*

05:00:01-05 This is a good format for introducing the materials. *Consider using similar format for other modules.*

05:00:11-14 The SMEs for HF/Reliability in the complex is a much larger set than just those listed. *Expand on the list of SMEs.*

05:00:12 Insert identifies "Mission and Vision for FY09-18". *Change "Mission and Vision for FY09-18" to "FY14-23."*

05:00:18 Good practice to show relationship back to guiding standards.

05:00:20 Describes error pathways that typically occur as the result of poor or less than adequate management oversight. *Acknowledge the influence of poor or non-existent management oversight*.

05:00:21 Procedures: Real-World Example. Consider including a recommendation to perform a "dry-run" of the procedure before actual operations.

05:00:39/40 Nice references. *Consider developing a NCSP.LLNL.GOV module that is more comprehensive than the tables and available/referenceable - not to make PRA experts but to provide a few more approximate values of equipment reliability.*

05:00:47 The slide has limited data *Provide a reference that is readily available like Swain's contribution to Human Factors information*.

06:00:03 Slide does not include the pursuit of the DCP "Should". *Include both PA and DCP a clearer distinction between the required "Process Analysis" and the recommended "Double Contingency Principle."*

06:00:04	The statement "with due reliance on Formality of Operations • Conduct of operations • Conduct of training • Configuration Management" is weak with the implication that "due reliance" is customary acceptance. *Prefer changing the word, "due", to "appropriate" or "due reliance on demonstrated quality Formality of Operations."*
06:00:10	*These "steps of a criticality safety evaluation" should relate to or reflect some guideline such as the NCSET module rather than introduce a unique set.* Instructor pointed out that step 9 "approve the evaluation" is not performed by the supervisor at LLNL. Do any of the Standards or formal DOE require the Supervisor to approve? Be clear between requirements and recommendations/opinion.
06:00:18	Common mistakes can include not preparing for supervisor absence/replacement. *Include need for replacement supervisor guidance.*
06:00:27	*Include reference to using knowledge from other facilities'/sites' credible failures and ensure that the machining example does not reflect unattended automated processes (like machining) as not "making sense."*
06:00:28	"Are you comfortable with the margin if a criticality accident result if there is inadvertently" *Fix Grammar.*
06:00:35	The quote is from the old ANSI/ANS-8.1-1998 and does not exist, per se, in the current 2014 version of 8.1. *Explain the reason for using the quote instead of the 2014 version and/or proper reference.*
06:00:37	This and several prior slides are missing numbers; update references. *Fix.*
06:00:38	The 2011 issue of the IHECSBE is displayed. *Update image to 2015 issue.*
06:00:39	Table does not include Y-1272, Y-12 Plant Nuclear Safety Handbook, as an important industrial nuclear safety guide. *Include Y-1272 and request its inclusion in the NCSP website information resource.*
06:00:41	Is the statement, "This methodology has limitations which may not allow analysis of all upset conditions" supposed to relate to all of the above methods? *If so, clarify statement.*
06:00:46	Hmmmm - words. Does this slide mix the terms and meanings of process "conditions" and "parameters"? *Clarify with actual meaningful examples.*
06:00:47	Example of how "talking points" in Notes would be helpful. Instructor gave inaccurate example related to Raschig rings as easily broken. *Correct "talking points."*
06:00:49	Slide omits the ability to monitor the condition of a control during its life. *Add a bullet that includes the word, "monitorable."*
07:00:02	*Update to delete references to PF4 walkthrough: add information regarding relevance to criticality safety, for instance NDA used for waste drums especially segmented gamma scanner (SGS).*

07:00:46 Table does not provide <u>example</u> measurement methods and typically representative ranges of uncertainties for the listed holdups. *Include additional information with a caveat that the data is not absolute but merely relative estimates/examples.*

07:00:all Opportunity to *provide examples of NDA technologies in use for criticality safety purpose or present how different types could be used for criticality safety*.

08:00:03 *Remove first bullet*.

08:00:06 *Contrast subcritical limit to margin of safety in this discussion; use talking points to avoid introducing the mis-perception that code-to-code validation is acceptable unless negated by DOE*.

08:00:09 List is silent on the impact of the user as a contributor to the "computational method". *Include comment regarding user qualification/validation.*

08:00:10 "Critical experiment description errors!!" Discussion charges evaluators as code/data manipulators to match experiment critical/subcritical k_{eff}. The IHECSBE states, in part, "Sample input listings are not intended to be used directly for validation efforts and should be verified by the user… The user of any code system has the responsibility to ensure that the particular calculational tools and options used to solve a problem are properly validated. It is the responsibility of the user to ensure that use of these listings for any other purpose is consistent with proper criticality safety practices." Also, the D.I.C.E. utility specifically states, "Much of the data in D.I.C.E. were entered independently and are subject to data entry errors and, in some cases, approximations." *Correct.*

08:00:16 *Revise consistent with ANS-8.1 to indicate the preference to derive subcritical limits from experiments.*

08:00:19 States that WHISPER (a nascent code) and TSUNAMI <u>should be used, where practicable</u>, for the selection of experiment benchmarks having relevance to the validation of computations for nuclear criticality safety benchmarks. *Recommend acknowledging there are multiple methods of selecting benchmarks (e.g., DICE, S/U) and that use of S/U for benchmark selection requires appropriate training and understanding. Should acknowledge that WHISPER has not yet been released by LANL (consistent with later slides in this section) and that training is currently in development*

08:00:21 Verbally discussed possibility of systematic bias being present, provide additional details on how to identify this potential bias

08:00:22 The slide appears to be inconsistent with the standard. *Re-evaluate the terminology in the slide as compared to the verbatim language in the ANSI/ANS-8 standards and the US DOE NCSP expectations. Also, provide a graphical demonstration for the students.*

08:00:24	Last bullet is not explicit to ANSI/ANS-8.24-2007 and strongly implies that "…positive biases…are not to be credited…" *Quote ANSI/ANS-8.24-2007 (see footnote 3 on p. 1)* ***6.1.2*** *If a positive bias is used in the determination of the calculational margin, its use shall be justified based on an understanding of the cause(s) of such a bias." i.e., footnote 3 states "The sign of the bias is arbitrary. For the purpose of this standard, it has been defined to be positive when the calculated values exceed the experimental values, but it could be defined otherwise." then relate to common practices. Clarify – don't state absolutely!* Fourth sub-bullet identifies WHISPER (a nascent code) as a tool for calculating bias and bias uncertainty. *Recommend removal of sub-bullet or acknowledge that WHISPER has not yet been released by LANL (consistent with later slides in this section). Another good place to acknowledge that use of S/U in determining bias and bias uncertainty requires appropriate training and understanding.*
08:00:32/34	Margin of Safety is related to minimum subcritical margin. *Elsewhere in the course a point is made that a calculated value of k_{eff} is often misconstrued as a margin of "safety" as opposed to a margin of "subcriticality". It is strongly suggested that the terminology be consistent throughout the HTEC course to convey the very different meanings! Slide 34 exacerbates the misconception. Fix.*
08:00:32	MSM and MOS is a mix of terms. The lecturer frequently referred to "margin of safety (MOS)". *That phraseology needs to be scrubbed.*
08:00:33	The Margin Of Safety (MOS) is directly related to Δk! - *Correct that thinking or verbalizing!*
08:00:34	*Revise slide to be consistent with the language in 8.24 on positive bias.*
08:00:35	*Final bullet suggests that it is common practice to reject data. Provide an example of rigorous method that could be used? Another good place to quote from 8.24 about data rejection.*
08:00:39/41	*Too busy, need to simplify to focus message*
08:00:43	*Due to the current level of data fidelity and the lack of adequate experience, Data Adjustment Analysis is probably not a good practice for the general criticality safety engineer, suggest re-evaluating presenting this slide.*
08:00:44	*Distinguish between requirements for documentation and recommendations/best practice. Being too descriptive may create inconsistencies with site practices.*

09:00:19 ***A global suggestion*** *is that all NCSP T&EP slides be scrubbed for the use of "uncertain" and "unofficial" pronouns (i.e., they, we, it, that, those, etc.) by appropriately replacing uncertain or unofficial pronouns with specific nouns such as DOE, DOE staff, Contractor, Licensee and other references.*
It would be instructive for the presentation to reference any examples of DOE's departures/exceptions from ANSI standards statements that are documented with the OMB as required by PL 104-113, SEC. 12. STANDARDS CONFORMITY, para (d)(2) and (d)(3). The exceptions could be related to NCS or any ANSI topical standard or ISO standard for that matter. Such an example could show the thought processes that have been applied to deviate from private consensus organization standards (i.e., ANSI and ISO).

10:00:02 Role of DNFSB was not included in presentation materials.- *Consider providing the DNFSB role.*

10:00:11 "is 50/N**a** where N_a" *Fix typo.*

10:00:13 *Reference 49 CFR §173.447, Storage incident to transportation—general requirements*.

10:00:19 *Use the PL 104-113 language, i.e. "standards developed by private, consensus organizations". Also, reiterate that organizations that qualify as private, consensus organizations are ANSI and ISO. IAEA is a regulatory-consensus organization much like NRC or DOE*.

2nd Week SCX Hands-on Course

General Observations – *Recommendations*

Though students were prompt for the 8 February in-processing at 7:15AM, class was not begun until 9:20AM followed with further 20 minutes of in-processing training. *Continually strive to pressure the in-processing and badging process to streamline and shorten the time necessary to eliminate the large block of lost training and education time*.

The classroom environment has been substantially improved regarding the reduction of HVAC background noise and audio visual features. *Continue with the proposed installation of a false floor could do much for damping noise in the classroom and protecting detector signal cables.*

The tank assembly for fuel rod lattice experiments has been modified and is used to allow control of the critical conditions based on water level control. *Evaluate modification of operating specifications to permit attaining critical conditions with water height for overly-moderated cores.*

There were good presentations and exercises providing hands-on training addressing important characteristics of neutron multiplying systems along with discussions on the theory of sub-, super-, and prompt-critical systems. *Continue.*

Though quite interesting to the students the streaming video feed of the assembly loading/unloading/flooding during lectures was distracting. *Use an initial video streaming as the subject of a portion of a lecture and then turned off for lecture/instruction and then again steam video for specific lecture information.*

Some discussions about the implications of experiments and lattice criticality accidents regarding the safety of DOE fissionable material operations were weak with a focus on reactor lattices as opposed to the experiment accidents' similarity to non-reactor nuclear facility fissionable material operations. *Work to relate lattice experiments and discussion about accidents to DOE non-reactor nuclear facility operations.*

There has been no success, perhaps limited effort, to obtain 19%-enriched U plates/foils/rods for a critical assembly. *Re-evaluate the CSSG 2009-03 Tasking Response Recommendation for obtaining such materials. There may be no realistic opportunity to obtain such fuel*.

The course was very engaging of students by providing experiences in neutron multiplication and critical experiments. *Continue.*

Hand calculations were not used in the SCX course. *Develop a hand calculation exercise to demonstrate its relevance to estimating critical parameters based upon SCX information*.

In general, the instructors projected, by experience, knowledge and demeanor, the students' sense of respectful interest and acceptance of the classroom and experiments training and education. However, an instructor commented that he was seeing some lecture materials for the first time. It appeared that the instructor was not prepared for the lecture and that there were no lecturer notes to guide them, nor that they had prepared for the presentation. *Ensure lecturers are knowledgeable and prepared course materials.*

Students remained seated in same relative positions to other students during the course. *Consider the potential value of having class members "move about" and work with other members on the teams to better facilitate interaction and data sharing between participants*.

Module 17 split core made good use of the comparison with real world criticality with good discussions regarding interpolation and intuition applied to areas where you don't have data - and the dangers there-in. *Develop an experiment with near optimum moderation of core halves to demonstrate approach to critical without an optimum slit core separation. Also, consider using this module as segue to a module on Clayton's Anomalies of Nuclear Criticality*.

The tour of ACRR was a welcome break from the class room and permitted the students to observe, by video, an actual critical pulse resulting in a flash of Cherenkov radiation. *Continue.*

Students felt very well taken care of. *Continue.*

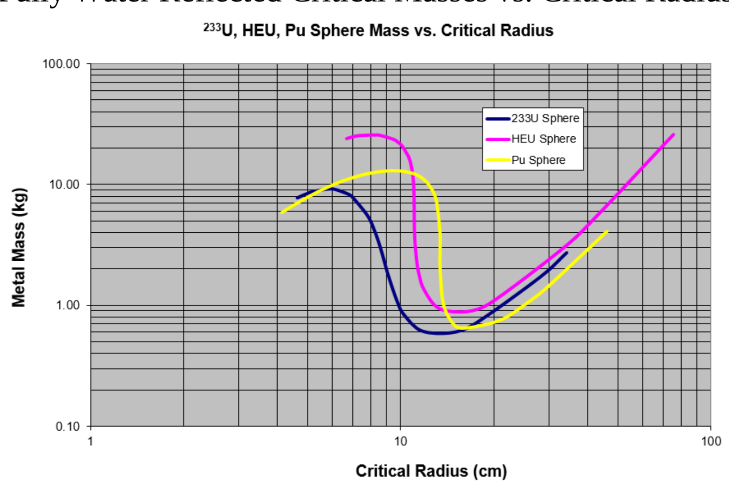
Several modules (modules 23-25) were of very limited value. These were focused on LWR reactor cores. *While interesting, the time in the class room could be more effectively utilized by covering other material (e.g., greater discussion of criticality accidents' relevance to criticality safety, the suggested added module on Clayton's Anomalies).*

Detailed Module/Slide-specific Observations – *Recommendations* (most are nits):

01:00:xx The module primarily relates to U and Pu. *Consider expanding to include ^{233}U systems.*

01:00:13-18 Module provides individual critical systems for individually separate fissile systems and does not easily demonstrate the relative geometric sensitivity of different fissile species. *Include slide(s) that simultaneously relate critical values for ^{239}Pu, ^{235}U, and ^{233}U, in the SCX and perhaps the 1st week classroom and NCERC courses, e.g.,*

Fully Water Reflected Critical Masses vs. Critical Radius



01:00:02/41 The discussion about Module Objective did not elaborate on the distinction between concentration and density. *Include the concept of acid concentration, molarity, fissile nuclide density as part of the words, concentration and density.*

01:00:05/07/10 The specific data should be consistent with the 1st-week classroom and NCERC courses. *Ensure no inconsistent data is presented among the three courses.*

01:00:08 Moderation did not include solid moderators. *Include identification of solid moderators such as plastic, etc.*

01:00:11 No reference made to ANSI/ANS-8.xx standards. *Reference ANSI/ANS-8.5-1996, -8.14-2004, -8.21-1995.*

01:00:xx Module did not provide examples of reflector effectiveness. *Incorporate a brief slide/discussion on reflector effectiveness from LA-10860 and also in Module 2 Slide 3. e.g.,*

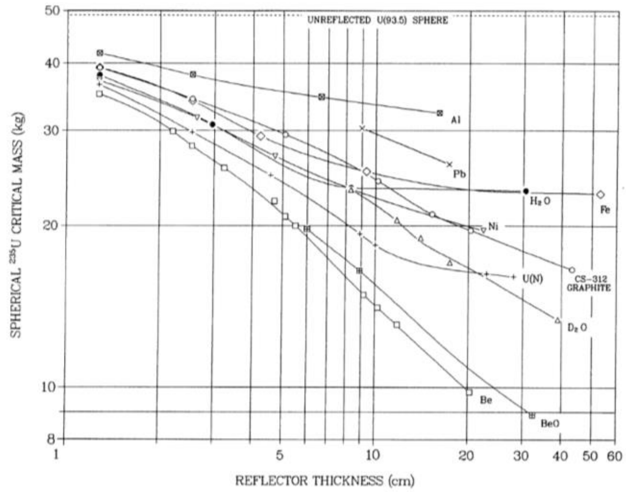


Fig. 42. Critical masses of U(93.5) metal spheres in various reflectors. Uranium density = 18.8 g/cm³.

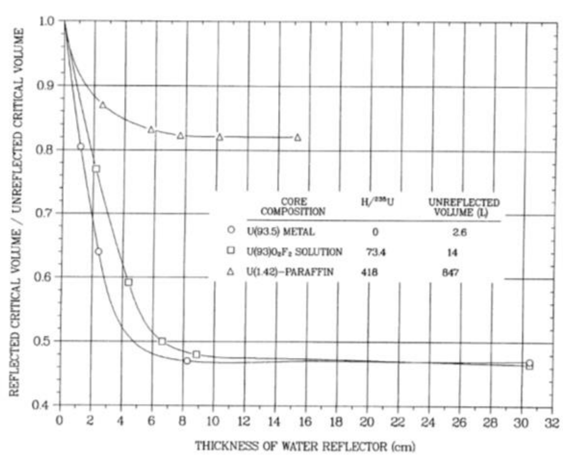


Fig. 45. Ratio of water-reflected to unreflected spherical critical volumes vs reflector thickness for enriched uranium.

01:00:12 Did not include neutron absorbers as reflectors. *Include the possibility of neutron absorbers as reflectors.*

01:00:13-18	Discuss the relevance among the words, “concentration” and “density”. *Clarify the meanings and applications of the words, “concentration” and “density”.*
01:00:30	The four-factor formula was verbally referenced. *If reference to the four-factor, six-factor formula, or other methods are to be verbalized, include their descriptions/meanings in the lecture otherwise drop from verbalization unless the instructor is “fishing” for the students’ degree of understanding about nuclear criticality*.
02:00:18	Did not identify “interpolation” and hazards of “extrapolation”. *Consider discussing hazards of interpolation and extrapolation of experimental results.*
04:00:30	Student asked, “What was special about the data from the LANL water boiler that allowed a projected critical mass to be 580 grams for 235U when we were provided a minimum critical 235U mass of about 820 grams as shown in a figure [Fig. 10, LSA-10860]? The instructor did not explain the inconsistency with earlier course information. *Ensure that instructors are knowledgeable of information they are to present.*
06:00:01-16	Good exercise on critical by rods. *Continue*
07:00:07	Good discussion about Con Ops. *Strongly emphasize that if Con Ops has failed, then no matter how good the NCS program is, safety cannot be assured.*
08:00:xx	Was only a partial description of detectors in general and seemed to be missing the tie-back to what could go wrong to give bad data. *Provide examples of detector issues that could/have gone wrong to provide bad data.*
09:00:xx	Was a good “pick up sticks” description of the accident but missed the opportunity to relate to an “on the floor” accident. *Relate the accident to poor designs/operations considerations at DOE non-reactor nuclear facilities that might impact geometry and moderation.*
10:00:03	Blew past some terms like fertile conversion – not likely to be understood by many students without some description. *Provide more description about “Fertile conversion.”*
10:00:32	Exercise on the effects of moderator density on various parameters was good and was a welcome break. However, various students misunderstood initial conditions and constraints on the conditions of the exercise. *Provide more explicit descriptions of the initial conditions for the exercise and consider moving the exercise somewhat earlier in the module.*
11:00:xx	The module was taught before Module 10 thus making it seem a little out of place and was taught at a very high level. *Consider moving before Module 10 and renumbering.*

12:00:xx	Very good experiment but missed some opportunities to tie back to criticality safety on the floor. *(1) Emphasize that the importance of the experiment is not so much the specific experiment, but student understanding of the sensitivity of the parameter being studied for effect on reactivity of the system (difference in water height between critical and subcritical was less than a cm). (2) Discuss the impact of not having a neutron source present during an on-the-floor mishandling of fissionable materials.*
12:00:07	Discussion on the origin of the "half-way rule" was missing. *Provide a brief discussion on the origin of the rule and perhaps extract a brief video from the Heritage Videos about the background of the rule if it is available.*
12:00:08	The approach to critical for the experiment took inordinately long and many approach steps due to a pair of students' misunderstanding of the math. *Intervene to correct student errors to streamline an approach to critical and avoid limited learning with rote repeats of the process.*
14:00:07/08	Were good and should be discussed but were confounding to many students. *Provide an extended discussion on the example presentations.*
14:00:xx	Exercises 2 & 3 had an issue with the way contingencies were treated. It appeared from the supplied answers that the expected results were to combine all the listed contingencies (such as full reflection and double batching) when determining the process limits. That does not seem appropriate. For example, if normal conditions are nominal reflection and control of mass it would appear that taking the nominal mass and dividing it by two (to account for double batching) or taking the nominal reflection and defining the condition for full reflection should be done and the smaller value selected. By taking both full reflection and double batching this seems like it has left the realm of "double contingency". *Reconsider the presentation of the exercises.*
15:00:xx	Was a good discussion about the ICSBEP but missed opportunities to discuss the Uncertainty Guide, DICE, Sensitivity Files, and Spectral Indices. *Include brief description/value of the Uncertainty Guide, DICE, Sensitivity Files, and Spectral Indices files.*
15:00:02	Instructor emphasized that the example inputs for Results of Sample Calculations should not be used for validation back at the student's facility but there was an implication that the instructor had used inputs in the past. *Avoid admitting to having used the inputs for anything except maybe trying to understand errors in the Sample Calculation Results.*
16:00:xx	Good overview of SCX experiments performed that may stimulate future student questions/proposals for experiments. *Value of the overview may need to be reconsidered.*

16:00:18	The instructor discussed the value of computations for rod(s)/hole(s) sensitivities for projection to critical. In the discussion it was stated that any computational biases would cancel when subtracted for the purpose of determining the sensitivity/worth of rod(s)/hole(s). *A caveat should likely be included in the statement to exclude circumstances where core parameters have large step changes (e.g., moderation, mass, interaction, etc.).*
18:00:29	The Scenario – Reconstruction was cryptic but slide 18:00:20 promised to provide the complex process of neutron-poison rod movements leading to the accident. *Remove slide 18:00:20, include the sequence of movements, or provide the reference that does provide the sequence (LA-13638?). Focus should be on what failed and how they got to the point of the accident*.
18:00:49	Was a missed opportunity to engage students about the possible omission of Causal Factors of the accident. *Challenge the students to identify other possible causal factors*.
19:00:19-20	Does not provide a schematic of the steps for the separation of the assembly and slide 20 confound the understanding of the disassembly process. *Provide a schematic or graphic of the piece removal of the critical assembly.*
19:00:22/23	Provides the description of the protracted criticality accident power oscillations but provides no explanations about the degree of super-prompt reactivity or subsequent sub-prompt criticality. Some personnel have heard that no criticality accident alarm is necessary for a metal accident because it will only occur as a single spike burst thereby self-terminating. *Provide an explanation of the typical reactivity addition rates/magnitudes that are required for self-terminating or protracted ^{235}U and ^{239}Pu metal accidents and why it is hard, or easy, to accidentally cause such accidents.*
20:00:21	Only identified "Moderation [only] due to experimenter thumb and body position body position may have caused accident". *Include "Reflection" as likely contributor to the cause of the accident.*
23-25:xx:xx	Modules about LWR Paradigms, Designs, and Depletion/Burnup have very limited relevance to DOE non-reactor nuclear facility NCS programs/issues aside from limited application to spent nuclear fuel transportation and disposition. *Remove modules or create an abbreviated, and perhaps consolidated, module as incidental information and references for students' self-study interests.*

2^{nd} Week NCERC Hands-on Course

General Observations – *Recommendations*

Generally, the students were engaged and gave very good feedback on the course.

The TACS and NCERC exercises clearly satisfy the ANS-8.26 requirement for criticality safety to have experience *"in the conduct and interpretation of critical experiments in hands-on classes that demonstrate how varying the properties of a fissionable material system can affect neutron multiplication"*.

The logistics of entry/exit to DAF, escorts, rad con, etc., worked smoothly. Training rooms were well equipped and comfortable.

The conduct of the experiments was professionally done and the information is of significant value in training nuclear criticality safety engineers. *Explore additional opportunities to tie the experiment portion of the training back the process analysis methods to re-enforce the classroom portion.*

Some portions of the training were of questionable value. In particular, Module 6 on the BeRP Ball and Np Sphere. This was mainly a "show and tell" type of presentation that while interesting, occupied many NCERC personnel to accomplish and did not directly tie to the ANS-8.26 objectives. *Re-evaluate the value of that activity relative to expanding on other training related to the experiments.*

It was interesting to observe the difference in teaching approach between Module 3/4 (TACS) and Modules 5 (Planet), 7 (Flattop), and 8 (Godiva-IV). The hands on portion for Module 3/4 was less formal; that is, it was not performed to an in-hand procedure nor was the procedure for the experiment provided to students. They performed the experiment from the workbook directly. In addition, assembly steps changed during the course of the experiment (i.e., some assembly was being performed outside of the experimental apparatus). The other modules, however, were more formally performed with an in-hand procedure. There was a clear connotation that the experiment in Module 3/4 could not achieve a critical state and that upfront belief resulted in an informality of conduct of operations. However, the knowledge that the experiment set could not achieve a critical state was not derived through training by the students. Conversely, there was a clear expectation that the remaining experiments would achieve a critical state and the performance of the experiments was more formal, slow, and deliberate. *Address the missed opportunity in performing Module 3/4 by showing the students how a preconceived knowledge of "assured" subcriticality and notion for the degree of safety affects operations at the student's facilities and to demonstrate the relationship of "Formality of Operations" and "Formality of Conduct of Operations". Explain how ANS-8.1 requirement for written instruction is met and consider providing training in the development of a NCSE for the conduct of the experiment.*

There are opportunities to more closely integrate the NCERC and TACS portions with the first week course materials. A lack of coordination between TACS and NCERC was apparent. Improving this could benefit the class and free up time for additional exercises that could more actively engage the students in the lecture/analysis part of the class. As in the first week observations there is substantial overlap in the presentation material. The workshops during the first week provided ample opportunity to engage students in the thought processes and behaviors expected of criticality safety engineers. There were fewer opportunities at DAF largely because of schedule constraints. *Develop and execute a plan to ensure that the training POCs for each of the three week courses collaborate in revising course materials to avoid overlap and redundancy of training materials.*

Primarily, comments are related to clarifying the relevance of course materials to the ties to ANSI/ANS-8.26 and the daily tasks and expectations of NCS Engineers.

ANSI/ANS-8.26-2007, "Criticality Safety Engineer Training and Qualification Program", specifies in Sections 7.3 and 7.4 the objectives regarding training with critical experiments. Specifically, the sections state:

> *7.3 Critical experiments and data*
> *Criticality safety engineers shall be able to relate the results of critical and subcritical experiments, available nuclear data (e.g., cross sections), and lessons learned from past criticality accidents to facility operations for which they prepare NCSEs.*
>
> *7.4 Hands-on experiments*
> *Criticality safety engineers shall participate, or shall have participated in the past based on education, experience, or training, in the conduct and interpretation of critical experiments in hands-on classes that demonstrate how varying the properties of a fissionable material system can affect neutron multiplication. These hands-on classes may be held, or may have been held in the past, either at a critical experiments facility or at a research reactor.*

The content of the course contained sufficient information to achieve the above objectives. There was sufficient information to teach "how varying the properties of a fissionable material system can affect neutron multiplication"; however, meeting this objective could be improved through application of different teaching techniques (see comments on teaching methods).

A significant amount of time was spent on teaching experimental methods, including the attempt to distinguish an operation from ANS-8.1 space to ANS-1 space. This was at times confusing. Because the content of the training was focused primarily on how to do an experiment rather than on the ability to "relate the results …to facility operations for which they prepare NCSEs." This Observation is reinforced by the stated objectives in Modules 2, 3, 5, 6, 7, and 8, as well as the exam. Those elements focus on methods to approach critical, use of basic nuclear equations, and specific property effects on reactivity. The students left with a good sense on how to conduct an experiment and the associated nuclear physics responses, but not necessarily on how to relate experiments and data to facility operations at their site. In other words, there was a missed opportunity to have the students relate what was observed through the experiment to actual field issues they deal with day in and day out and how they write evaluations. *Relate the experiment conditions and observed factors to non-reactor nuclear facility criticality safety and operations and keep the focus on applicability to the ANS-8 series, which is where the NCS engineer lives.*

Comments - ***Recommendations*** **are organized in three categories: Teaching Methods, Infrastructure and Content.**

Teaching Methods:

All instructors were very knowledgeable of their experiment set and were very responsive to questions from the students. The interaction was very good.

The teaching style tended to be a classical engineering method of teaching, which is expected because the subject matter experts are not professional trainers. With some coaching, the training style and approach could be modified to a method that would enhance student engagement, retention of the material being presented, and leave the students with the means to continue their education. Specific Observations and *Recommendations* are provided in the following section.

There was a tendency to "staff" positions by the instructors where students could do the job (e.g., reading through the procedure, overseeing calculation results or otherwise doing the work for the student). This missed an opportunity to involve students in every aspect of the conduct of operations. *Look at all roles in the training and involve students in as many roles as possible.*

Many questions asked by instructors were yes/no type questions or questions that hinted as to the answer or were quick to confirm an answer by a student. Engaging students to think is the most important part of this process. If another student had a different answer, they were often not given an opportunity to explore that answer. *Train instructors on how to ask open ended questions and how to draw other students into the question session.*

The involvement of the students was significant in two areas: physical manipulation of material and computation of 1/M plots, reactivity equations, etc. However, there was little to no exercises related to evaluating changes in process conditions. *Include exercises where students exercise skills in process hazard analysis for the experiments.*

The experiments had missed many opportunities to do practical exercises related to the process analysis requirement and hazard analysis methods. For example, Module 3/4 (TACS) put after the experiment information related to ensuring the first and second steps of the experiment would remain subcritical. That should have been an exercise performed by the students up front. In addition, the answers to the questions were highlighted in the slides, which missed several teaching opportunities. In another example, Module 5 (Planet), the experiment design had many engineered features to ensure safety of personnel. A good exercise would have been for the students to identify the types of engineered features they would put into the process (e.g., as if they were doing a new design and not an evaluation of an existing process), then compare those results to the actual design. *Add exercises in the area of process hazards analysis to the experiments about to be performed to reinforce the process analysis requirement.*

It was noted that the lead instructor on the TACS module, sat through the other modules. This is a positive Observation in that it showed some cross transfer of information. It is unknown if the other instructors have been through the TACS module. *Have all instructors be knowledgeable of what is being taught in all modules to ensure consistency of teaching.*

Infrastructure:

Access to the DAF and the experiment areas was well organized and efficient. Escorts were always on time, appropriate personal protective clothing was staged and ready to go, and the experiments were set up early to avoid delays.

The expectation of student participation was not clearly/consistently stated. At the beginning of the class, references were made to passing the closed book test with an 80% or better grade. On the day of the test the criteria for passing were communicated as 70% based on the written test and 30% on participation. Again, an 80% grade or better on the test was required to "pass" the test. This is confusing since mathematically, one could score 72% or better on the test and assuming they received all 30 points for participation still have a combined score of 80% for the course. *Resolve the inconsistencies with NCSP expectations.*

There seemed to be a high overhead in support staff to conduct the portion of the course at NCERC. Although all students have DOE clearances multiple escorts were required, in addition a fire watch is necessary for the NCERC portion, RCTs and multiple instructors/fissile material handlers/MC&A custodians were required to support portions of the class.

Operations in the DAF require safety glasses and safety toes or safety-toed shoes. Including this information in the reminders to students gives them the opportunity to bring their own if desired. *Include that in the NCSP website "Student Booklet" if appropriate.*

Observed a tendency for instructors/laboratory staff to answer questions limiting student engagement. *Consciously avoid teaching by asking questions and then answering the question.*

Clearly opportunities for additional integration of TACS and NCERC activities are available such as the development or review of the NCSE for the TACS shells. Attempts to contrast work performed under ANS-8.1 and ANS-1 by contrasting storage of HEU foils (ANS-8.1) versus hand-stacking the foils (ANS-1) is not as illustrative as TACS activities being performed to ANS-8.1 and NCERC under ANS-1.

Content by Module:

The format of the handouts differ between modules and the cross-references are often incorrect. *Update the slides for consistency and accuracy of references.*

The stated goals and objectives of the hands-on training are not focused on all the requirements of ANSI/ANS-8.1 or 8.26. — *Realign the objectives to the requirements in the standard and adjust some of the training accordingly.*

The demonstrations of varying parameters was clearly demonstrated as it pertained to the experiment; however, the extension of the concept to examining changes in process conditions to plant operations was a missed opportunity. There were random times when this was done, but better structure was needed to make the points be retained. *Provide means to transfer the demonstrated effects of parameter changes in the experiments to real-world processes that are encountered by the students.*

Reactivity changes due to changes in experiment properties were covered, but allowing the students to relate the impact of these changes to their processes was a missed opportunity. *Tie what is being observed in the experiment to work process examples that would be encountered by the students.*

There was a missed opportunity in tying the different experiments together regarding a good progression of what is being emphasized in each experiment and how it would apply to the engineer. For example, Module 3/4 (TACS) would be good for reactivity worth of materials (reflectors/moderators), Module 5 (Planet) for approaches to critical and mass / moderation effects, Module 7 (Flattop) on minute changes to reflector conditions and temperature reactivity coefficients, and Module 8 (Godiva) on prompt critical observations. *Review the primary benefit of each experiment and ensure training is focused on the benefit progression.*

The review of criticality accidents related to experiments, selected accidents closely resembling the hands-on experiments being done as part of the training. That was a good reinforcement. Given that solutions were involved in the majority of process accidents, some tie to solution events would be good. *Consider inclusion of issues that a solution experiment may pose that would not be seen in the experiments performed at the training.*

Many of the modules have repetitive content. *Review the modules for repetition and teach the items once*.

Module 1:

- A tie to DOE-STD-1173 is discussed but not to ANS-8.26. *Suggest referencing 8.26 and/or the NCSET module for training.*

Module 2:

- The Objectives could be more closely tied with requirements for NCS engineers. Are gas proportional counters the type of neutron detector typically used in the TACS and NCERC experiments and this is why this particular NDA technique is called out?

- The terms “relative multiplication”, “observed multiplication” and “apparent multiplication” are all used in this module. This module discussed two ways to determine multiplication- observed multiplication (what TACS used) and apparent multiplication (what Planet used). It explained that observed multiplication uses the ratio between count rates of a multiplied (fissionable) assembly and an unmultiplied (surrogate) assembly to determine an M that is directly relatable to k. Apparent multiplication uses an arbitrary starting configuration and designates it as the unmultiplied count rate (for Planet we started with a C_{zero} measurement (six foils?)). As mass is added to planet, the new count rates are ratioed with C_{zero} to get an apparent M. This M cannot be directly related to k. That is why the k=(m/mc)^0.3 relationship is used, where “m” in this case is mass, not multiplication.– *Consider using this module to explicitly describe differences between the two experimental approaches that the students will observe. Students would also benefit from cross referencing between experiments as they are performed; TACS to Planet and Planet to TACS.*

- Tying the information about 1/M curves to the previous weeks discussion of time-behavior of criticality accidents in Module 2 of the NFO course and perhaps providing more detailed discussion relative to prompt and delayed critical could be presented here to provide a consistent foundation for the experiments later in the week and reduce overlap.

Module 3:

- A general list of TACS experiments, approach to critical by mass, moderator, separation distance, reflection and the effects of operator hands and neutron poisons are stated to be included in the hands on portion of the class. The effect of full and half reflection by Lucite® included in the Laboratory Notebook was not mentioned in this module. *Some clarification should be made that the approach to critical by mass covers the bounding conditions and that the effects of moderator, separation distance and reflectors will be experimentally observed but not conducted as "approach to critical" experiments.*

- The distinction here is that when conducting the approach to critical by mass was performed, a systematic approach was used to incrementally increase the reactivity of the system. For the sake of brevity, the exercises related to the effects of moderator, separation distance and reflectors were done without this systematic approach and more driven by the ease and efficiency of changing the physical configuration of TACS. The behavior that we desire to instill in the NCS practitioner is systematic and methodical. *Provide a preliminary discussion of why a true approach to critical method is not required for observing the effects of moderator to avoid the mindset of "a critical chain reaction is not possible with this system" which is a behavior/attitude we are trying to avoid. Consider modifying the slides to clearly reflect that the measurements to be performed are not an approach to critical but a demonstration to show "hands on" the effects of separation, moderation and reflection.*

- The TACS experiments are conducted under ANS-8.1 which requires a written instruction which was not discussed or presented to the class. The experiments were conducted per verbal instruction. *Explain how ANS-8.1 requirements for written instruction are met. Relate this to the measurements to be performed, the first is a true approach to critical and is the boundaries of the sandbox and that the demonstrations are clearly within the sandbox.*

Module 4:

- Overall the data sheets were organized and simple to complete.

Module 5:

- Several opportunities were missed to tie to TACS exercise, discussions of safety rules for hand stacking, and moderator/reflector impacts on multiplication/k-effective. *Suggest that a compare and contrast be done in TACS to what will be done with Planet*

- Situation arose that "discovered" a foil delaminated after students handled material. Suggest that the prep for this class state that all foils to be used are inspected prior to student handling.

- Numerous references were made to TSRs and limiting conditions (i.e., excess reactivity is limited to 80 cents), this information was relevant to the student experiment in deciding how many foils could/should be added. *Provide a sheet of the relevant TSRs and other limiting conditions as an instructional tool.*

- When the experiment went to remote operations, student participation began to drop off. There was interest in operating the machine but not so much in dressing out to go add mass to the pile. One student indicated that they "don't want to dress out" and therefore didn't volunteer. The behavior we want to encourage is for the CSE to spend as much time on the floor as possible not to avoid being on the floor. Also, the class waited for donning PPE, adding foil, and return of student to control room. All members of the class handled foils on the previous day in the hand stacking exercise. *Evaluate the value of students dressing out for remote operations and the potential to save time completing the experiment. Alternatively, point out the importance of participation and being on the floor and increase the enthusiasm of the student to engage.*

Module 6:

- The BeRP ball and Np sphere demonstrations were rather ad hoc as it was late in the day that we got to them due to time spent on the Planet remote operations.

- This was mainly a "show and tell" type of presentation that while interesting, occupied many NCERC personnel to accomplish and did not directly tie to the ANS-8.26 objectives. It was felt that this time could have been used to expand on other training related to the experiments. *Re-evaluate the purpose, value and competition with ANS-8.26 objectives and make adjustments accordingly.*

- The demonstrations consisted mostly of photo ops with the BERP ball and Np spheres. The BERP ball is certainly "famous" enough for students to know something about it and to be interested in seeing it. The demo with poly sphere reflectors, people hands and the effect on neutron detection with poly and borated poly slabs was interesting but rushed. *Make an opportunity to talk/teach about the comparison of the BERP ball and poly spheres with the uranium activity as part of TACS.*

- The Np sphere could be more interesting to the students if the reference information and data were presented/provided to see how it was used in the first experimental prediction of the minimum critical mass for N??? In other words, why is it significant other than it's the largest single mass of Np. *Describe relevance/difference in the first experimental prediction for the minimum critical mass for Np.*

Module 7:

- The lecture was a good orientation/description of the experiment to be performed.

- Good reference to radiation monitors to show the consequence of approaching critical and at delayed critical.

- This module went quickly as well. Some students were not completely engaged. There were multiple groups that formed with different instructors to work out the data analysis (reactor period, worth of control rod and effect of temperature). Simple as it seems to instructors, these are terms that the typical criticality engineer does not come across often. *Make the temperature coefficient more apparent by revising the table that was used.*

- Some of the confusion came from the FLATTOP worksheet not being completely consistent with the experiment and questions. *Revise the worksheet to reflect the way the measurements are performed.*

- Clarify the "take away" from this experiment for the practioner, this could include to promote the concept of critical thinking to encourage a questioning attitude and to challenge the concept of using the "most conservative" conditions. No specific lesson was described.

Module 8:

- Provide any relevant TSRs or limiting conditions up front.

- Contrast this experiment with Flattop

- The reactivity worth of the top hat was an interesting discussion

- Redundant presentation of the Inhour Equation material. *Evaluate the need for redundancy.*

- Discussion of delayed and prompt critical was good

- There could be more discussion in the prep materials about monitoring the neutron count during delayed critical and prompt critical. *Provide more material about neutron count monitoring in the preparatory materials.*

- Good references to radiation monitors at delayed and prompt critical to show consequence. *Reinforce this by providing data sheets from a previous experiment and reviewing the information or providing additional slide*.

Module 9:

- Verbally related how some lessons learned from early experimental accidents impacted today's practices of 2-person control and in the development of our standards. *Reinforce those lessons with "Take Away" slide at the end and encouraging students to review LA-13638 on their own to look for possible connections with their facility.*

- Good emphasis of “human factors” and overconfidence in the circumstances for the accidents.

- Later showed some “consequence” pictures that students found interesting. Consider using the pictures as a pass around so those that might be “offended” can pass.

Module 10:

- (ICSBEP) covered the content of an experiment write-up for benchmarking purposes. The presentation essentially stated that the value of the experiments was for benchmarking codes (there is obviously more to it than that) and then went into detail on the degree of rigor needed to select an experiment for benchmarking. That prompted a comment from a student that because of their regulatory oversight, the engineer were to model “bounding” models to be used to demonstrate subcriticality and the degree of detail in a benchmark description was rarely performed in a nuclear criticality safety evaluation. Although there are implications related to validation associated with that statement, the main issue is that parameter effects are not necessarily being investigated by this concept and that the student didn’t verbalize the need for understanding parameter effects after the hands on training. (As a side note, I know the student very well and that student does examine parameter effects thoroughly.) *Tie the benchmark effort to giving confidence in codes so that appropriate examination of changes in process conditions can be made*.

- This was an informative module. Although some were familiar, information about DICE appeared to be useful.

- Need to update presentation to point to validation standard and integrate presentation with the validation presentation.

- Need to emphasize the use of the input files in the database are not verified for accuracy, not intended for direct use and any use of them should be with caution.

Module 11:

- This presentation was moved up in the material presented to the class, which was appropriate and appreciated.

- This should be the primary presentation of terms and concepts that are used in the NCERC measurements in order to avoid presenting the inhour, delayed vs prompt critical, etc., more than once. Other modules can just have a quick reminder.

Detailed Module/Slide-specific comments: (most are nits)

(These notes use the format MM:SS:ss where MM is a 2-digit integer for the module number, SS is the section number and ss is the slide number from the printed books.)

01:00:03 Restate the expectation of participation, tie to the requirements of ANS-8.26

01:00:04	Emphasize that ICSBEP is a product of the NCSP and OECD NEA.
01:00:14	Provide a metric for how participation fits into getting credit for the class.
02:00:05	Need to expound on why these are “limitations” of ANS-8.1, only from the perspective of performing critical experiments. Would hate to see this slide appear out of context.
02:00:03	Clarify if ANS-8.6 applies or is used for any of the experiments to be performed (e.g., TACs).
02:00:08	Reiterate in talking points how/when the codified operational practices were driven by critical accidents.
02:00:15	Footnote refers to “this experiment”, clarification needed.
02:00:16	This is another example of needing talking points. Verbal discussions referred to these nuclides as poisons that can slow down neutrons making them more likely to cause fissions when they are reflected back. Cross-sections shown are only absorption cross-sections and not scattering. Suggest clarification of the point by providing specific talking points.
02:00:22/23	Why must “we be clever”? We are using relative measurements. The “surrogate” should have other characteristic than just non-fissile. More explanation is needed.
02:00:25	Contrast Method 1 and Method 2 and give examples where each will be used in the class.
02:00:31	Relate this slide to the “Zakharov” rule introduced in the TACs discussions.
03:00:04	Would be interesting to show the decay curve for the TACs source and show current activity.
03:00:05	The “we must be clever” words used again
03:00:08	Reword slide to indicate “approach to critical by mass” as only approach to critical. Moderator, separation distance and reflection are really experiments to show the effect on multiplication of those specific parameters.
03:00:09	slide does not exist. Suggest that add slide to explain how the experiment will be conducted and how the ANS-8.1 requirement for written instruction will be met. Use this opportunity to explain nomenclature in TACS Laboratory Notebook relative to the D38 or HEU parts, Moderation and Reflection tables. Define roles that students will perform including having a “data analysis” lead to stand at projector or provide results to instructor at projector.
05:00:06	What is the purpose of showing the fissions produced in 300 days of operation of a 1000 MW power reactor? One day operation is already more than the number of neutrons in 1 ton TNT and orders of magnitude above the yield in a Godiva burst. Consider adding the number of fissions in a typical Godiva burst to slide to relate to the dose/dose-rate to individuals/surroundings.
05:00:12	Use consistent terminology between TACS discussions and those in NCERC related to Safety Rules (e.g., refer to initial and second fuel loadings must be safe as the Zakarov Rule)

07:00:20	Highlight temperature Coefficient for Flattop U
08:00:07	Opportunity to discuss PLC versus software on PC and how PLC is more conducive to safety related controls
08:00:19	Update this slide to reflect how experiment is actually conducted, include expectation for reactor period.
09:00:16	Correct typo "scamming"
09:00:22	Provide discussion how Godiva I and Godiva IV observed early compare.
09:00:26	Define CSLA and CSO acronyms
10:00:03	Include reference to ANS-8.26
10:00:05	Update to current edition
10:00:09-12	Should a reference be given for these slides or are they NCSP generated
10:00:15	Before this slide or even slide 15 introduce slide that will explain how ICSBEP designates experiments as MET, HEUM, THERM, etc.
10:00:16	Delete reference to Module 11. The benchmark is provided in book but not as Module 11.
11:00:26	Why are so many significant digits used for reactivity and so few for beta effective?
11:00:34	Change "(1000s of megawatts)" to "(typically around a 1000 MW)"