OVERVIEW AND CURRENT PROGRESS OF THE DOE/NNSA NUCLEAR CRITICALITY SAFETY PROGRAM TRAINING AND EDUCATION PROGRAM

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ABSTRACT

Since 2011, the US Department of Energy/National Nuclear Security Administration (DOE/NNSA) Nuclear Criticality Safety Program (NCSP) has been providing a two-week nuclear criticality safety (NCS) practitioner course to support the training and qualification of new NCS staff. In 2013, an NCS Manager's course was developed for process supervisors, managers, regulators, and other professionals with NCS-related responsibilities, and, in 2017, an additional course was proposed for Criticality Safety Officers (CSOs). In addition to hands-on training, other NCSP-funded tasks include training on sensitivity/uncertainty methods, NCS resource pipeline tasks, development of NCS guides, maintenance and development of Nuclear Criticality Safety Education Training (NCSET) modules, and designing of a new subcritical assembly for hands-on training purposes. This paper provides an overview of the NCSP training and education program. The status of the NCSP hands-on training program will also be provided.

KEYWORDS

Subcritical experiments, critical experiments, training, Nuclear Criticality Safety, education.

1. INTRODUCTION

The United States Department of Energy/National Nuclear Security Administration (DOE/NNSA) Nuclear Criticality Safety Program (NCSP) has offered a 2-week nuclear criticality safety (NCS) practitioner course to support the training and qualification of new NCS staff since 2011. The course was developed in accordance with the recommendations from the NCSP Criticality Safety Support Group (CSSG) tasking report 2009-03, *Recommendations for the Future DOE NCSP Training and Education Infrastructure Program* [1], and designed to meet the fundamental requirements of the American National Standard Institute/American Nuclear Society (ANSI/ANS) standard for NCS training and qualifications (ANSI/ANS-8.26-2007) [2]. In 2013, an NCS manager's course was developed for process supervisors, managers, regulators, and other professionals with NCS-related responsibilities. This course was modified in 2020 to include training material applicable for Criticality Safety Officers, based on CSSG tasking 2018-01, *Educational/Training for Improving Effectiveness of NCS interface with Operations/Production* [3]. The Nuclear Criticality Safety group in Nuclear Energy and Fuel Cycle Division at Oak Ridge National Laboratory provides instructor and course coordination for DOE/NNSA for these courses. In addition to hands-on training, other tasks for the NCSP Training

and Education program include training on sensitivity/uncertainty methods, MCNP [4] / SCALE [5] training, NCS resource pipeline tasks, development of NCS guides, maintenance and development of Nuclear Criticality Safety Education Training (NCSET) modules, and designing of a new subcritical assembly for hands-on training purposes. This paper provides an overview of the NCSP Training and Education program. The status of the NCSP hands-on training program is also given.

2. OVERVIEW of the DOE/NNSA NCSP HANDS-ON TRAINING COURSE TRAINING AND EDUCATION PROGRAM

In 2009, the NCSP CSSG began to establish an integrated DOE NCSP Training and Infrastructure Program to be consistent with the mission and vision of DOE NCSP [6]. The new course was piloted at Los Alamos National Laboratory (LANL), Sandia National Laboratories (SNL), and the National Criticality Experiments Research Center (NCERC) in May 2011 and again in August 2011. The course began to be offered regularly in January 2012. In 2013, the NCSP began offering a 1-week NCS hands-on course for managers, process supervisors, and persons with NCS responsibilities. Then, in late 2015, preparations were made to transition the lecture portion of the course from LANL to the Nevada Field Office (NFO). The NCSP updated the 1-week manager course for CSOs in 2020 and piloted the revised course at NCERC in 2021 and SNL in 2022. Figure 1 provides an illustration of the NCSP T&E courses.

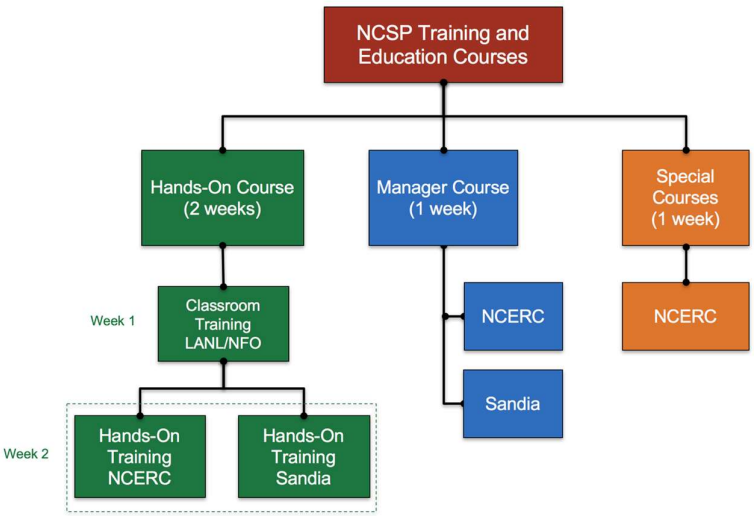

Figure 1. NCSP current course offerings

For US fiscal year (FY) 2023, the NCSP allocated $1,510,000 of its $28,050,000 budget (~5.4%) to the Training and Education (T&E) program. Most of this funding is dedicated to hands-on training to support the 1-week manager/Criticality Safety Officer (CSO) course and the 2-week hands-on NCS engineer course, and requires participation from the following sites:

- Oak Ridge National Laboratory (ORNL, which provides training and education coordination for the NCSP)
- SNL
- LANL at the NCERC at the Device Assembly Facility (DAF) at the Nevada National Security Site (NNSS)
- Mission Support and Test Services, LLC (MSTS)
- Lawrence Livermore National Laboratory (LLNL), and
- Y-12 National Security Complex (Y-12)

2.1. Two-Week Hands-On Course

The 2-week hands-on course for NCS practitioners [7] consists of training at the Nevada Field Office (NFO) or the National Atomic Testing Museum (NATM) in Las Vegas, Nevada (lecture week #1), SNL (hands-on, week #2), and NCERC (hands-on, week #2). All students attend the lecture portion of the course at the NFO, and then attend the hands-on portion either at SNL or NCERC, depending on student desire or clearance level. Currently, students with or without a security clearance and foreign national students (non-US citizens) can attend the SNL portion of the course, whereas only those students with a security clearance can attend the NCERC portion of the course. Students must pass an exam for each portion of the course to receive a course certificate.

The lecture segment of the course is conducted twice per year at the NFO or the NATM in Las Vegas, Nevada. The focus of the lecture portion of the course is NCS evaluation development, and the course is designed around this goal. Lectures are taught on the following topics:

- DOE requirements, national standards, and NCSP
- Process criticality accident lessons learned and NCS fundamentals
- ANSI/ANS-8 consensus standards and computational methods validation
- Single unit and array hand calculation methods
- Human factors and reliability principles for NCS evaluations
- Nondestructive assay (NDA) – interpretation and application of NDA methods and results to NCS evaluations
- Five workshops on the NCS evaluation process per ANS-8 standards and DOE-STD-3007 [8]

The second week of the course at NCERC and SNL consists of technical lectures for experimental methodology, neutron detectors, reactor physics, experimental criticality accidents, and an overview of the International Criticality Safety Benchmark Evaluation Project (ICSBEP) Handbook.

Experiments are performed at NCERC and SNL to support educational needs and hands-on training. At NCERC, the following experiments are performed. Items in bold are hands-on.

- **Training Assembly for Criticality Safety** (TACS – operated by LLNL)
- **Plutonium BeRP ball and ^{237}Np demonstrations**
- Delayed and prompt critical experiments with the following assemblies
    - **Planet**
    - Flattop
    - Godiva

At SNL, hands-on operations at the Sandia Critical Experiment Facility are conducted with 6.9 wt % enriched ^{235}U low-enriched water-moderated fuel rods. There are currently four different critical experiments that can be conducted with this critical assembly that are part of the hands-on course at SNL: (1) approach-to-critical experiment based on fuel loading, (2) approach-to-critical experiment based on moderator level, (3) approach-to-critical experiment based on the spacing of two fuel arrays, and (4) demonstration of the effect of removing interior fuel rods from the fuel array. There is also a super-prompt critical burst demonstration with the Annual Core Research Reactor (ACRR) that is performed to demonstrate the effects of a criticality accident.

2.2. One-Week Manager/Criticality Safety Officer Course

The NCSP Manager/CSO courses [7] are conducted over a 1 week period at SNL and the NCERC. The 1-week course content was developed for managers, process supervisors, CSOs, and those with NCS program responsibilities. Instead of 5 days of lectures, the manager/CSO course includes a single day of lectures on reactor physics, neutron detection, NCS fundamentals, ANS standards, NDA

importance for NCS, human factors and equipment reliability, NCS evaluations, the ICSBEP Handbook, and process/experimental criticality accident lessons learned. The remainder of the course involves hands-on operations with the SNL and NCERC critical assemblies. At the discretion of the NCSP manager, the 1-week manager course has been adapted for occasional special courses, as indicated in Figure 1.

Demand for the NCSP T&E courses continues to increase. The NCSP typically offers two 2-week courses and two 1-week Manager/CSO courses per year (one at SNL and one at NCERC). In 2024, two additional Manager/CSO courses will be offered. The course dates are listed below, and those interested can register on the NCSP T&E webpage [7].

- 2-week hands-on courses
  - Jan. 2–Feb. 2, 2024 at NATM/SNL/NCERC
  - Aug. 5–16, 2024 at NATM/SNL/NCERC
- 1-week manager/CSO courses at Sandia
  - Apr. 29–May 3, 2024
  - Sept. 9–13, 2024
- 1-week manager/CSO courses at NCERC
  - March 18–22, 2024
  - Dec. 9–13, 2024

3. OTHER NCSP T&E TASKS

The NCSP supports other tasks aligned with the NCSP mission and vision to achieve T&E goals. The following list provides some information about the ongoing and future T&E tasks important to the NCSP.

- Training for SCALE and MCNP for NCS engineers learning to perform calculations to support NCS evaluation development.
- Pipeline programs with DOE sites (LANL, LLNL, and ORNL) with universities to generate student interest in the field of NCS. In addition to finding interested students for future placement in NCS programs, the goal is also to reduce the amount of time necessary for the new NCS practitioners to become qualified as NCS engineers.
- NCSet module development is planned for the following.
  - The use of NDA to support NCS programs.
  - Criticality accident alarm system placement and emergency planning guidance.
  - Practical application of the NCS sliderule to support emergency planning activities.
  - NCS guidance for facility deactivation and decommissioning activities.
- One of the more impactful tasks is the development of the Oak Ridge Subcritical Assembly (ORSA) [9], which is funded by the NCSP to provide subcritical, hands-on training for fissile material handlers and other operations staff in a low-security environment. The four hands-on experiments envisioned will provide a hands-on experience similar to those at SNL and NCERC with a neutron multiplication of about 20. Fuel will be acquired from storage at Y-12 for use at ORNL. Graphite reflector and split table design is in progress, as is finding a final location at ORNL to support this task.

4. CONCLUSIONS

The NCSP training and education program has been conducted since 2011 and has trained nearly 800 students to date. The course is continuously improved using lessons learned from prior years, and new course content is added as necessary. Course demand continues to increase, and more T&E courses have been added to accommodate additional demand. The NCSP has a variety of T&E tasks aligned

with the T&E Mission and Vision to support the general NCS community. Training and education pipeline programs to more effectively staff NCS programs at DOE sites are underway, and new training capabilities (guides and a subcritical assembly) are being developed to assist NCS programs.

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