CURRENT STATUS OF THE DOE/NNSA NUCLEAR CRITICALITY SAFETY PROGRAM HANDS-ON CRITICALITY SAFETY TRAINING COURSES

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Abstract

In 2011, the US Department of Energy/National Nuclear Security Administration (DOE/NNSA) Nuclear Criticality Safety Program (NCSP) developed and piloted a 2-week nuclear criticality safety (NCS) practitioner course to support training and qualification of new NCS staff. The course was developed in accordance with the American National Standard Institute/American Nuclear Society (ANSI/ANS) standard for NCS training and qualifications (ANSI/ANS-8.26-2007). In 2013, an NCS manager's course was developed for process supervisors, managers, regulators, and other professionals with NCS-related responsibilities. These courses consist of classroom education, facility training, and hands-on subcritical and critical experiments training. Each course is currently offered twice per year. The 2-week practitioner course offers a week of classroom training, with practical workshops and exercises focused on teaching students how to perform an NCS evaluation. The second week of training involves hands-on critical and subcritical experiments and measurements. The first week is offered in Las Vegas, Nevada, at the DOE Nevada Field Office or the National Atomic Testing Museum. Depending on the student's clearance level, the second week is offered at Sandia National Laboratory (SNL) (uncleared and L-cleared students) or at

the National Criticality Experiments Research Center (NCERC) (Q-cleared students). The 1-week manager's course is offered at SNL or NCERC, depending on clearance or interest, and includes classroom and hands-on critical and subcritical experiments and measurements. Thispaper provides an overview and status report for the DOE/NNSA NCSP training courses in NCS and provides information about future course offerings.

Keywords: subcritical experiments, critical experiments, training, nuclear criticality safety, education.

1. Introduction

In 2011, the US Department of Energy/National Nuclear Security Administration (DOE/NNSA) Nuclear Criticality Safety Program (NCSP) developed and piloted a 2-week nuclear criticality safety (NCS) practitioner course to support the training and qualification of new nuclear criticality safety (NCS) staff. The course was developed in accordance with the American National Standard Institute/American Nuclear Society (ANSI/ANS) standard for NCS training and qualifications (ANSI/ANS-8.26-2007). In 2013, an NCS manager's course was developed for process supervisors, managers, regulators, and other professionals with NCS-related responsibilities. This paper provides a brief, recent history of DOE NCS training and the current deployment and status of the DOE/NNSA NCSP training and education courses. Future activities are discussed to illustrate how the courses are evolving with new offerings and how the training is continuously improved and enhanced. In their current form, the courses consist of classroom education, facility training, and hands-on subcritical and critical experiments training. Each course is currently offered twice per year, and special 1-week courses are offered occasionally.

2. Brief Background of DOE/NNSA NCSP Training Courses

DOE conducted NCS training courses at Los Alamos National Laboratory (LANL) for many years until the Pajarito Site at Technical Area 18 was shut down in 2004. A four-day NCS training course was re-established temporarily at Lawrence Livermore National Laboratory (LLNL) in August of 2006. The LLNL training course was continued until 2010, providing training to more than 350 students in 35 training courses [1]. In 2009, The NCSP Criticality Safety Support Group (CSSG) began to establish an integrated DOE NCSP Training and Infrastructure Program to be consistent with the mission and vision of DOE NCSP [2].

The new course was piloted at LANL, Sandia National Laboratory (SNL) and the National Criticality Experiments Research Center (NCERC) in May 2011 and again in August 2011. The course started 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). A proposal was submitted by Oak Ridge National Laboratory (ORNL) in 2017 to offer a new course for criticality safety officers (CSOs) starting in 2019. The content of this course is pending and will be based on an NCSP CSSG tasking report due sometime in 2018.

3. Current Deployment of the Courses

DOE NCSP currently offers two 2-week hands-on courses for NCS practitioners and a 1-week course for managers and process supervisors. Typically, two courses are conducted each year for each course. Special courses typically one week in duration are offered occasionally. This has been done in the past for the United Kingdom's Atomic Weapons Establishment (AWE). Figure1 illustrates the NCSP annual course offerings.

3.1 2-week Hands-On Course

The 2-week hands-on course for NCS practitioners consists of a total of three weeks of training at the Nevada Field Office (NFO), SNL, and NCERC (students choose SNL or NCERC for the second week). All students attend the lecture portion of the course at the NFO, and then they attend the hands-on portion either at SNL or NCERC, depending on student desire or clearance level. Currently, L-cleared, uncleared, and foreign students can attend only the SNL portion of the course, while Q-cleared students can attend the NCERC portion of the course. The following subsections describe the general content of each portion of the course.

3.1.1 First Week – Lecture Portion at the Nevada Field Office

The lecture portion of the course is conducted twice per year at the NFO in Las Vegas, Nevada. Occasionally, the National Atomic Testing Museum (NATM) is used as a venue for the course because

there are no badging requirements for students to attend. Thus, the NATM venue for the course provides significant labor and cost savings for the NCSP when the course is conducted there.

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 topics such as the following

- DOE requirements, national standards, and NCSP,
- Process criticality accident lessons-learned,
- NCS fundamentals,
- ANSI/ANS-8 consensus standards,
- 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, and
- Validation of computational methods.

The core modules in this portion of the course involve lectures to introduce students to the NCS evaluation process and its dependencies. Then a comprehensive 5-part workshop is conducted over a 3-day period (about nine hours total) to provide students with the experience of performing an NCS evaluation in small teams for two mock fissile processes: (1) a glovebox plutonium oxide containerization process, and (2) the training assembly for criticality safety subcritical experiment, which is conducted in the second week at NCERC during the hands-on training portion of the course. The five workshops are aligned with the NCS Evaluation process from the ANSI/ANS standards and DOE-STD-3007 [3]:

1. Defining the normal conditions for the process and ensuring they are subcritical,
2. Defining the credible abnormal conditions for the process and ensuring they are subcritical,
3. Control selection and setting limits on the controls,
4. Student presentations of NCS evaluation control sets to the class, and
5. Class discussion of the mock process NCS evaluations and how the student control setscompare to those of the actual evaluations.

The student workshops were developed, based on a condensed version of an NCS evaluation exercise after the lecture portion of the 2-week hands-on course was moved from LANL to NFO in late 2015. The LANL lecture course included a tour of the plutonium facility (PF-4), which involved a day of the course to plan and execute. When the course was moved to the NFO, which does not include a facility tour, the NCS evaluation workshops were expanded to allow the students to spend this additional time with the workshop exercises learning process analysis, hazards analysis, and control selection by interacting with other students in a controlled environment. The NFO course points of contact and instructors include staff members from Lawrence Livermore National Laboratory (LLNL), ORNL, SNL, DOE, NNSA, NSTec, and Consolidated Nuclear Security, LLC, (Y-12 National Security Complex).

3.1.2 Second Week – Hands-On Portion at National Criticality Experiments Research Center

The second week of the 2-week hands-on course at the NCERC consists of some 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. Other lectures are provided to introduce the subcritical experiments being conducted with the training assembly for criticality safety (TACS), the plutonium BeRP ball and neptunium- 237 demonstrations, and to introduce critical (delayed and prompt critical) experiments on the Planet, Flattop, and Godiva critical assemblies. The subcritical experiments for the NCERC hands-on course are illustrated in Figure 2. The critical experiments for the NCERC hand on course are illustrated in Figure 3. Hands-on operations are performed with the subcritical experiments and with the Planet hand stack experiment. This involves significant student interaction with respect to the handling of fissile material. Operations with Flattop and Godiva IV are performed remotely with significant student interaction during the delayed critical and supercritical operations, respectively. The NCERC course points of contact and instructors include staff members from LANL, LLNL, ORNL, DOE, NNSA, and NSTec.

3.1.3 Second Week – Hands-on Portion at Sandia National Laboratory

The second week of the 2-week hands-on course at the SNL is consistent and equivalent to the NCERC portion of the hands-on course, although the course uses a single critical assembly at the Sandia Critical Experiment Facility [4]. The Seven Percent Critical Experiment (7uPCX) experiments at SNL use arrays of 6.9 wt.% enriched 235U 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. Although equivalent to the NCERC portion of the hands-on course, there are some unique differences between NCERC and SNL course content due to the design of the critical assemblies. 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. Be cause there is significant water shielding between the students and the ACRR core, the students can safely observe the burst while receiving negligible dose. Figure 4 shows the 7uPCX experiment at SNL. Figure 5 shows the ACRR core during a student demonstration. The SNL course points of contact and instructors include staff members from LLNL, SNL, DOE, and NNSA.

3.2 1 -Week Manger Course

The NCSP manager courses are conducted over a 1-week period at SNL and the NCERC. The 1-week course content is graded for managers, process supervisors, and those with NCS program responsibilities. Instead of 5 days of lecture, the manager course includes a single day of lectures on reactor physics, neutron detection, NCS fundamentals, ANS standards, 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. Only one special course has been offered to date, an adaptation of the NCERC manager course for AWE in 2015. Additional SNL manager courses have been offered as needed to train personnel as required, such as SNL manager courses for LANL process supervisors in 2013–2014. The SNL course points of contact and

instructors include staff members from LLNL, SNL, DOE, NNSA, and the University of New Mexico. The NCERC course points of contact and instructors include staff members from LLNL, ORNL, SNL, DOE, and NNSA.

3.3 Course Exam and Student Evolutions

The students for the 2-week hands-on course are required to take two exams at the end of the week— one for the NFO lecture course and another for either the SNL or NCERC hands-on portion of the course. There is a single exam on the last day of the 1-week manager course. For each exam, the student must receive a grade of 80% or greater to pass the course and receive a certificate. Students who fail the course exam with a score less than 80% are allowed to retake the entire course again with the NCSP manager's approval. The students also have the opportunity to fill out course evaluation forms to provide feedback to the course instructors and the NCSP to improve the courses and course content over time.

3.4 Future Modifications to Course

The NCSP manager has approved the development of a new 1-week course for CSOs. Traditionally, CSOs are liaisons between the NCS group at a site and the process supervisors in a process facility. CSOs typically communicate NCS information to and from the NCS group during the NCS evaluation process and during NCS evaluation implementation. The CSOs can also develop, provide, and participate in the NCS training session alongside the NCS engineers and operations staff. Course development will likely be based on the results of an NCSP CSSG tasking to provide baseline content for the course. Course development will begin in 2019.

4. Conclusions

The NCSP training and education program has been conducted since 2011 and has trained201 students in the 2-week hands-on course for practitioners and 136 students in the 1-week manager courses (337 students overall). The course is continuously improved using lessons-learned from the prior year, and new course content is added as necessary. Currently, two NCS practitioner 2-week, courses and two manager 1-week

courses are offered each year. Special courses are developed and offered periodically at the discretion of the NCSP manager. A new course is being considered for CSOs in the 2020 timeframe. Students interested in taking the courses should visit the DOE NCSP website [6] for additional information about all course offerings and for information about course registration.

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The NCSP training and education courses involve the collaboration of a large number of individuals at various sites throughout the US DOE complex:

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- Sandia National Laboratory,
- US DOE/NNSA,
- The University of New Mexico, and
- Oak Ridge National Laboratory.

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