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

Doug Bowen
Section Head | Nuclear Data, Criticality Safety, and Radiation Transport
Nuclear Criticality Safety Program Execution Manager
Nuclear Energy and Fuel Cycle Division
Oak Ridge National Laboratory

ICNC 2023 - 12th International conference on Nuclear Criticality Safety
October 4, 2023
Sendai, Japan

ORNL is managed by UT-Battelle, LLC for the US Department of Energy

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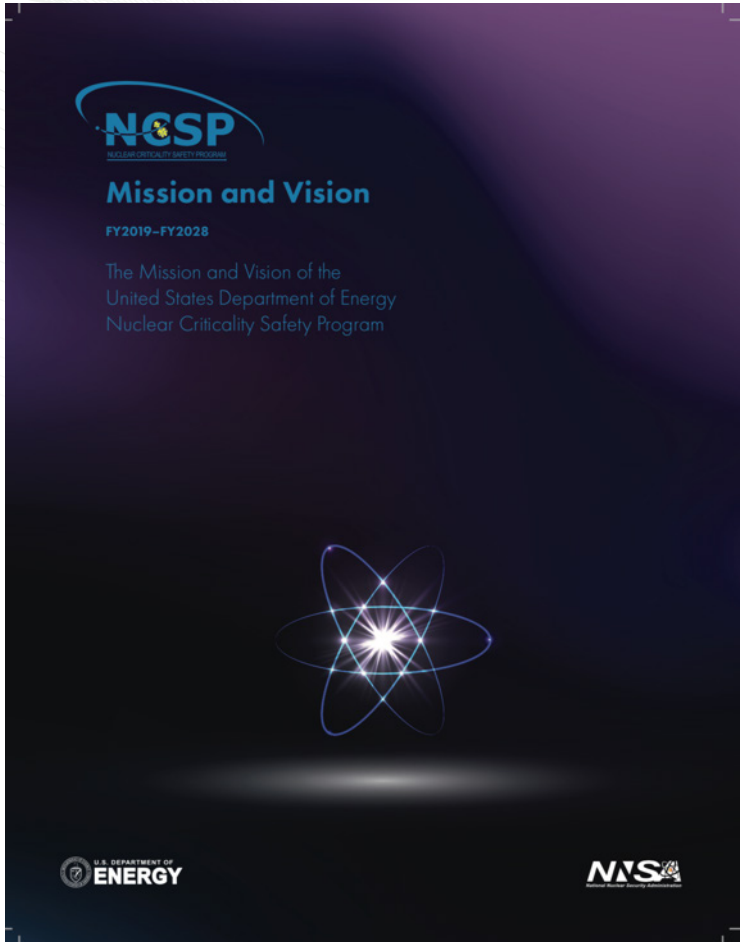
# Agenda

- Nuclear Criticality Safety Program (NCSP) training & education program
  - Training courses offered by the NCSP
  - NCSP training pipelines
  - Nuclear Criticality Safety (NCS) Education Training (NCSET) modules
  - New capabilities
  - New Course
- Concluding remarks



# US DOE Nuclear Criticality Safety Program (NCSP) Training and Education (T&E) Course Mission & Vision




## T&E Course Mission

- *The T&E program element will continue to **identify**, **develop**, and **facilitate** training needs and educational resources, including hands-on training with fissionable material systems, in areas where no suitable alternative exists*
- ***Primary purpose:** to maintain and enhance the technical abilities and knowledge of those who impact or are impacted directly by the practice of criticality safety*
  - *This includes training and education of people entering the criticality safety discipline from related scientific fields, as well as maintaining and enhancing competency levels of those already in the community*

## T&E Course Vision

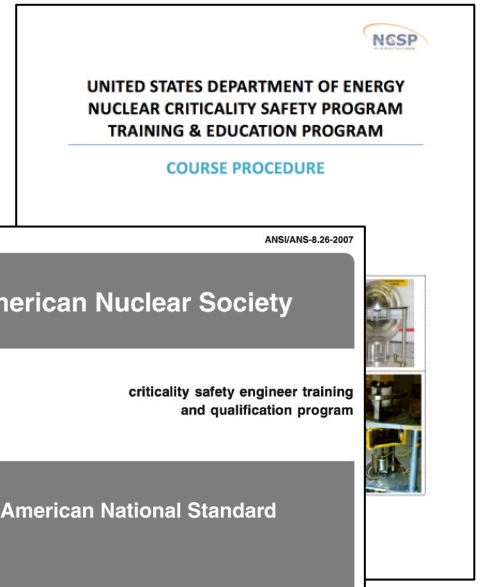
- *This NCSP element will identify, **develop**, **provide**, and **promote** practical and excellent technical training and educational resources that help ensure competency in the art, science and implementation of nuclear criticality safety and is adaptable and responsive to the needs of those responsible for developing, implementing, and maintaining criticality safety.*

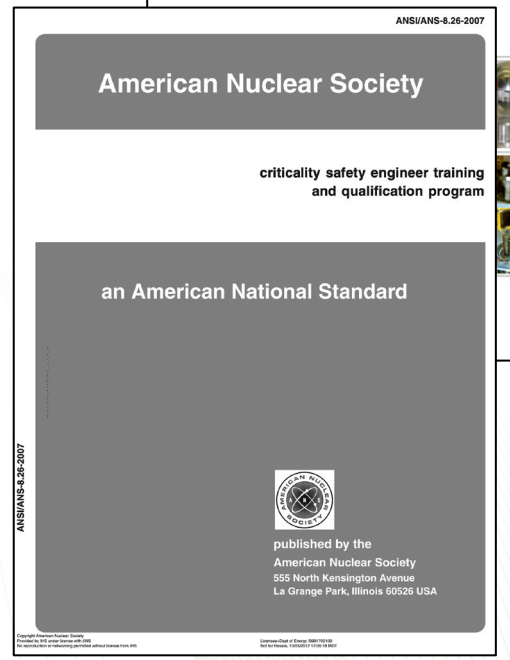
**NCSP Mission & Vision**
https://ncsp.llnl.gov/sites/ncsp/files/2021-04/ncsp_mission_vision.pdf

# NCSP Training and Education Courses

# NCSP Training and Education Courses - Objectives

Training Courses




NUCLEAR CRITICALITY SAFETY PROGRAM
U.S. DEPARTMENT OF ENERGY

NCSP Home | Program Management | Integral Experiments | Nuclear Data | Analytical Methods | Information Preservation | Training & Education

## Criticality Safety Support Group (CSSG)

Tasking and Responses

| | | | |
|---|---|---|---|
| 2009-03 | Recommendations for the Future DOE NCSP Training and Education Infrastructure Program | Jul 1, 2009 | Oct 16, 2009 |

## CSSG Recommendations for Classroom Training

The primary criterion for classroom/academic training (ANSI/ANS-8.26-2007, mainly Sections 7.5, 7.6, and 7.7) is the ability to foster consistency, throughout the DOE complex, of

- student understanding of NCS orders/guidance/standards,
- performance of NCS evaluations,
- use of formalized hazards analysis techniques,
- selection of appropriate NCS controls, and
- effective implementation and monitoring of NCS controls.

**7.5 Rules, standards, and guides**

**7.6 Nuclear criticality safety evaluations**

**7.7 Safety analyses and controls**



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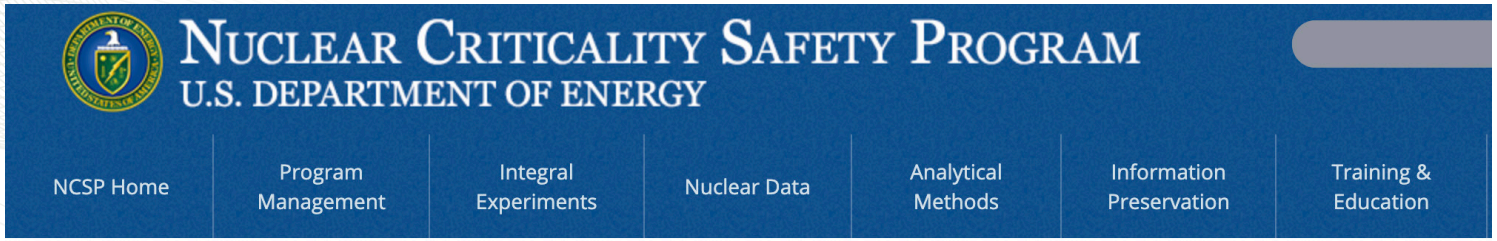
# NCSP Training and Education Courses - Objectives






## Criticality Safety Support Group (CSSG)

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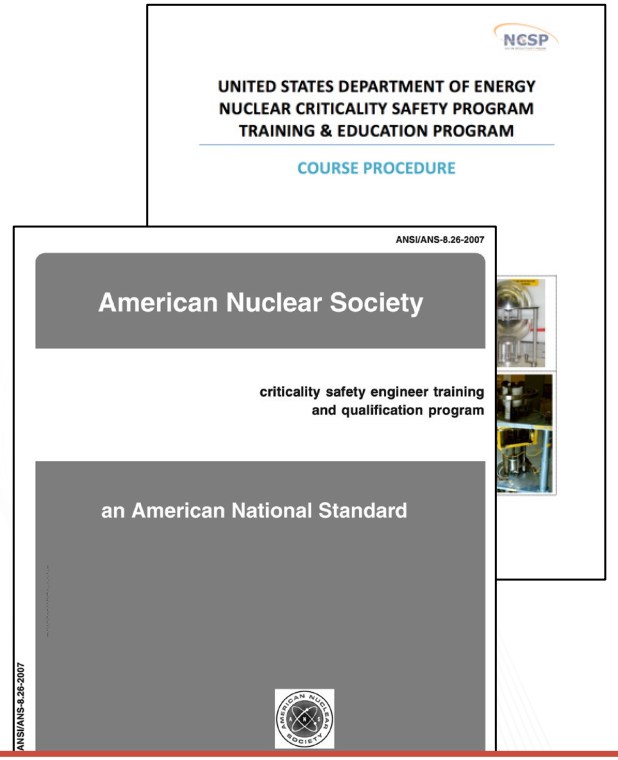


**CSSG Recommendations for "Hands-On" Training**

Criteria or considerations for hands-on training (ANSI/ANS-8.26-2007, primarily Section 7.4) include:

(1) the ease and speed that the training can be established,
(2) the cost to establish the training program, the cost to operate once established, and cost sharing opportunities with other DOE programs,
(3) the location (ease or difficulty for student/instructor travel),
(4) minimal or no restrictions related to DOE security clearance requirements,
(5) the ability to integrate with other parts of DOE NCSP training,
(6) fissile assembly/fissile material availability,
(7) DOE control of continued training availability,
(8) the effectiveness of the training,
(9) clear identification of training prerequisites,
(10) demonstration of student competency, and
(11) the use of formalized training development methods.

**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.



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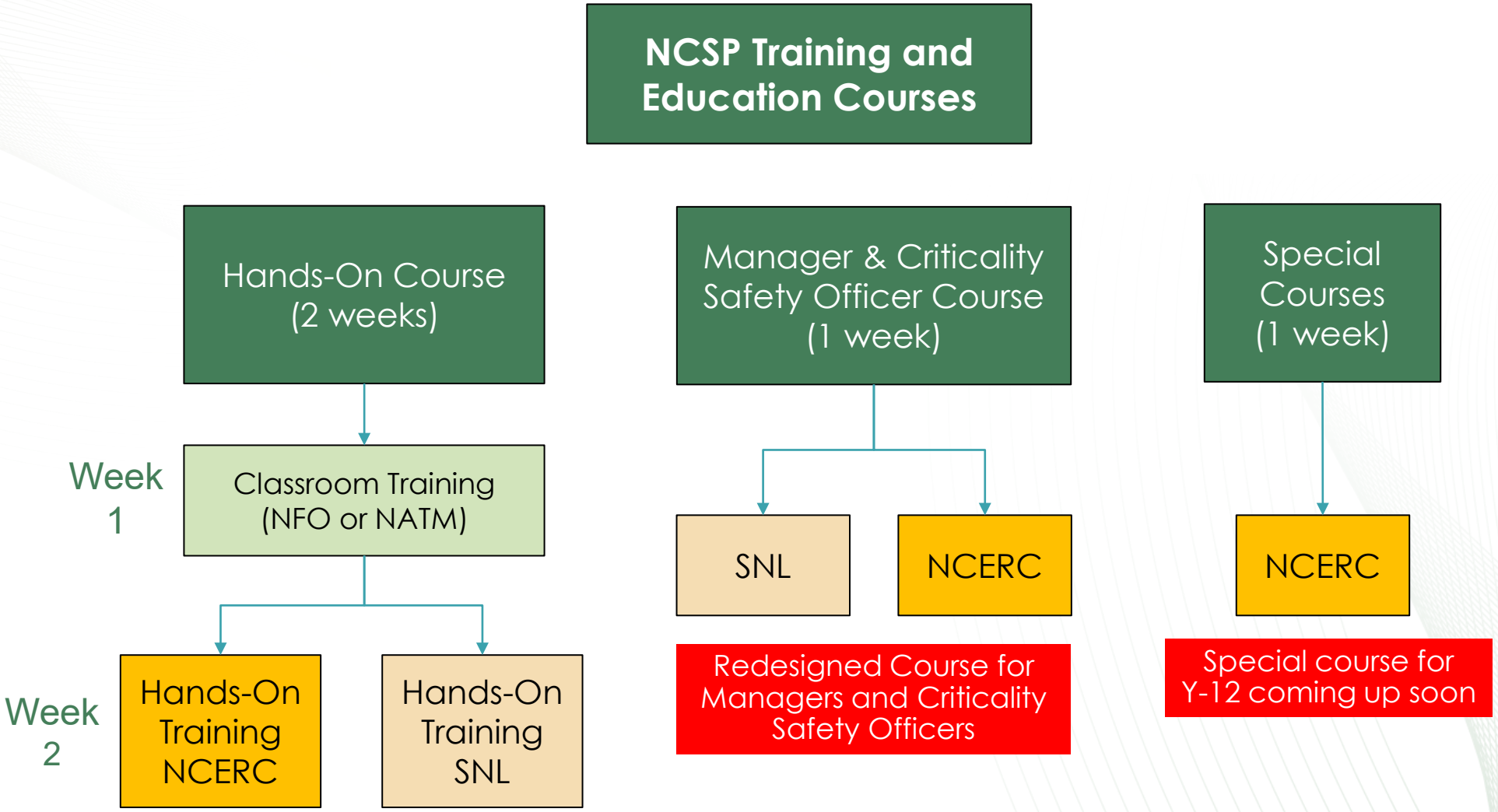
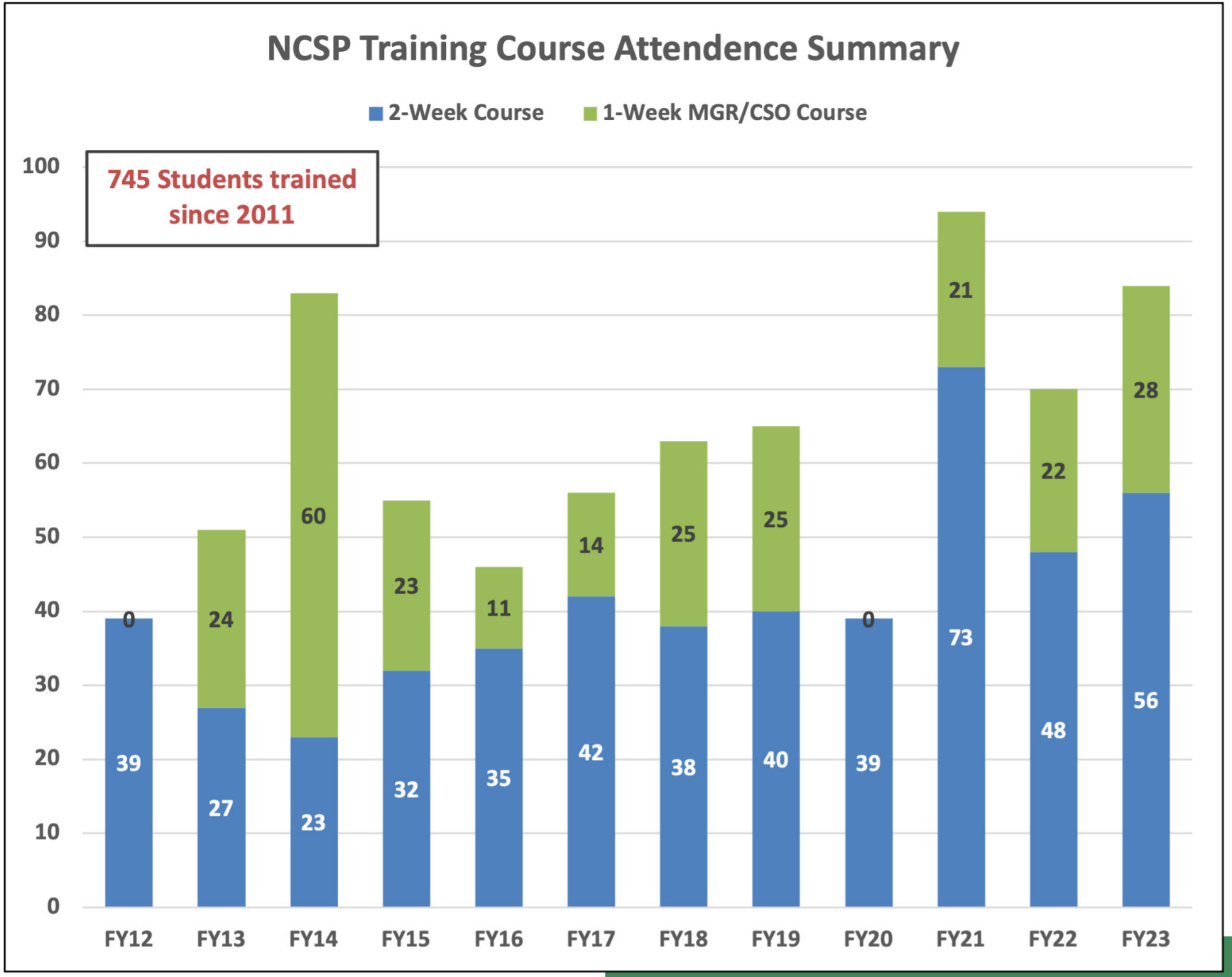
# Current Deployment of the Courses




- *National Criticality Experiments Research Center (NCERC)*
- *Nevada Field Office (NFO)*
- *National Atomic Testing Museum (NATM)*


NCSP Training Course Attendence Summary
2-Week Course
1-Week MGR/CSO Course
745 Students trained since 2011
100
90
80
70
60
50
40
30
20
10
0
FY12
FY13
FY14
FY15
FY16
FY17
FY18
FY19
FY20
FY21
FY22
FY23
0
39
24
27
60
23
23
32
11
35
14
42
25
38
25
40
0
39
21
73
22
48
28
56

# NCSP Pipeline Tasks



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# NCSP Training & Education Pipelines (1)

- UC Berkeley University Pipeline
  - This course is part of a larger pipeline project designed to stimulate student interest in the field of criticality safety
  - The class focuses on teaching the fundamentals of criticality safety and providing students hands-on experience with special nuclear material
  - Guest lectures are taught by criticality safety engineers at LLNL and LANL, giving students an opportunity to interact with members in the industry
  - The students complete a semester long project involving writing a criticality safety evaluation and participate in a hands-on experiment at LLNL
- LANL NCSP-sponsored University Pipeline for Nuclear Criticality Safety Professionals
  - New Mexico State University, Idaho State University, Texas A&M University, University of California-Berkeley, University of New Mexico
  - These collaborations included LANL Nuclear Criticality Safety (NCS) staff assisting professors in providing courses in NCS
  - LANL NCS staff acting as subject matter expert guest lecturers, supporting students with homework and projects, and mentoring students through their graduate student project

Summer 2022 NCSP Newsletter
Overview of NCSP Pipeline Tasks

NCSP
NUCLEAR CRITICALITY SAFETY PROGRAM
NEWSLETTER

SUMMER 2022

IN THIS ISSUE



Please contact Marsha Henley for information or contributions:
henleym@ornl.gov

DATES TO REMEMBER

Hands-On Training & Education Course Dates:
Two-week Practitioner Course Dates:
Aug 8-19, 2022
Jan 23-Feb 3, 2023
Aug 7-18,2023

One-week Manager's Course Dates:
Sandia – April 3-7, 2022
NCERC - Jun 5-9, 2023

T&E Page: https://ncsp.llnl.gov/training-education

LINKS TO REMEMBER

NCSP Website
NCSP Program Management
NCSP Mission and Vision
NCSP Five-Year Execution Plan
NCSP Planning Calendar
Previous NCSP Newsletters
CSSG Taskings
Nondestructive Assay Program



A Message from the NCSP Manager

Hello. For the Summer 2022 newsletter, the NCSP Management Team has chosen to highlight U.S. university nuclear engineering programs with a focus on those with NCS courses or certificates and those that have collaborations in place with DOE sites for NCS pipelines. I would like to thank everyone who participated in gathering and preparing this information, and I would also like to thank everyone who participates in these programs, particularly the students who chose to explore this career, the professors and university staff who support them, and the NCS professionals and management at the DOE sites who collaborate with these universities to foster the next generation of NCS professionals.

The NCSP has an activity-intense filled summer with conferences, meetings, the Accident Dosimetry Exercise, and many experiments, including the high multiplication neutron subcritical measurements, the low temperature TEX surrogate experiments, the fission neutron spectrum shape measurements, and the Pu-240 prompt fission neutron spectrum measurements. The high priority NCSP tasks for FY22 are on our NCSP Make It Happen List below. Wishing everyone a safe and prosperous summer. – Angela Chambers, NNSA

FY22 NCSP Make It Happen List

1. Production and delivery of hafnium to NCERC in support of TEX -Hf (IER 532) – NNL
2. Conduct nuclear accident dosimetry exercise (IER 538) – LLNL
3. Complete TEX low temperature DU surrogate testing (IER 547) – LLNL – in Nevada
4. Submit TEX HEU benchmark report to the International Criticality Safety Benchmark Experiment Program (IER 297) – LLNL – 4A approved, comments on draft report received and being incorporated
5. Complete critical experiments with $UO_2$ Rods and molybdenum foils (IER 305) – SNL
6. Complete measurements for the Flattop benchmark (IER 423) – LANL
7. Complete fabrication of lithium for critical experiment (IER 499) – Y-12 – design change
8. Complete high multiplication neutron subcritical measurements (IER 518) – LLNL
9. Measure the fission neutron spectrum shape using threshold activation detectors (IER 153 ) – LANL
10. Promote use of MCNP Version 6.3 at DOE sites – LANL
11. Complete prompt fission neutron spectrum (PFNS) measurement of Plutonium -240 at LANSCE – LANL
12. Complete Zr-91 measurements at GELINA – ORNL
13. Complete site acceptance tests for accelerator section #1 at RPI – NNL
14. Complete GELINA neutron production target – Y-12 – Received at GELINA
15. Complete Sandia CSO/Manager course pilot course – SNL
16. Complete revision to CEDT Manual – NCSP Management Team

NNSA National Nuclear Security Administration
U.S. DEPARTMENT OF ENERGY

https://ncsp.llnl.gov/sites/ncsp/files/2022-06/ncsp_newsletter_summer_2022_rev1.pdf



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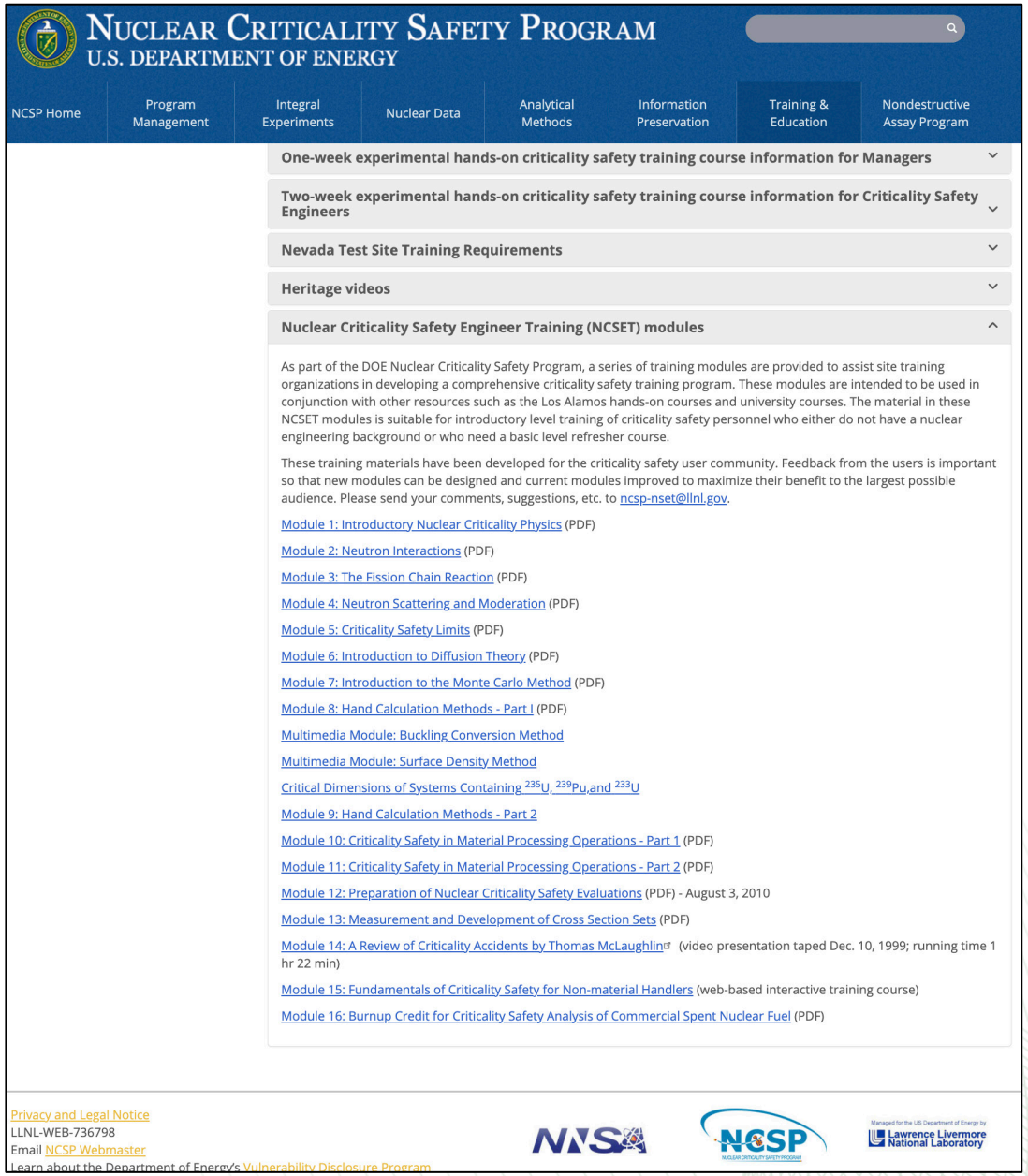
# NCSP Training & Education Pipelines (2)

- Pipeline Project with ORNL, Georgia Institute of Technology (GA Tech) and Texas A&M University (TAMU)
  - Intended to be a university-based pipeline of nuclear criticality specialists into the DOE complex
  - Should give students a hands-on training experience before they are done with college
  - This program will be developed in two stages for undergraduate and graduate students for an **NCS Certificate**:
    - **Program development**
      - Course/lecture material
      - Website
      - Hands-on laboratory exercises
    - **SE students will be recruited to partake in the "NCS Certificate" program**
  - All national laboratories across the DOE complex should benefit from this program.
    - However, the regional focus will increase benefit to SRNL, ORNL, and Y-12.

# NCSET Modules

- As part of the DOE Nuclear Criticality Safety Program, a series of training modules are provided to assist site training organizations in developing a comprehensive criticality safety training program. These modules are intended to be used in conjunction with other resources such as the 1- and 2-week hands-on training courses. The material in these NCSET modules is suitable for introductory level training of criticality safety personnel who either do not have a nuclear engineering background or who need a basic level refresher course.

- These training materials have been developed for the criticality safety user community. Feedback from the users is important so that new modules can be designed and current modules improved to maximize their benefit to the largest possible audience. Please send your comments, suggestions, etc. to the NCSP Management Team - ncsp-mgmt@llnl.gov.
  - Module 1: Introductory Nuclear Criticality Physics (PDF)
  - Module 2: Neutron Interactions (PDF)
  - Module 3: The Fission Chain Reaction (PDF)
  - Module 4: Neutron Scattering and Moderation (PDF)
  - Module 5: Criticality Safety Limits (PDF)
  - Module 6: Introduction to Diffusion Theory (PDF)
  - Module 7: Introduction to the Monte Carlo Method (PDF)
  - Module 8: Hand Calculation Methods - Part I (PDF)
  - Multimedia Module: Buckling Conversion Method
  - Multimedia Module: Surface Density Method
  - Critical Dimensions of Systems Containing $^{235}U$, $^{239}Pu$,and $^{233}U$
  - Module 9: Hand Calculation Methods - Part 2
  - Module 10: Criticality Safety in Material Processing Operations - Part 1 (PDF)
  - Module 11: Criticality Safety in Material Processing Operations - Part 2 (PDF)
  - Module 12: Preparation of Nuclear Criticality Safety Evaluations (PDF) - August 3, 2010
  - Module 13: Measurement and Development of Cross Section Sets (PDF)
  - Module 14: A Review of Criticality Accidents by Thomas McLaughlin (video presentation taped Dec. 10, 1999; running time 1 hr. 22 min.)
  - Module 15: Fundamentals of Criticality Safety for Non-material Handlers (web-based interactive training course)
  - Module 16: Burnup Credit for Criticality Safety Analysis of Commercial Spent Nuclear Fuel (PDF)




(https://ncsp.llnl.gov/training-education)

# NCSET Modules

(https://ncsp.llnl.gov/training-education)

- The NCSP maintains series of training modules are provided to assist site training organizations and alongside the 1- and 2-week hands-on courses and university courses.
- The material in these NCSET modules is suitable for introductory level training of criticality safety personnel who either do not have a nuclear engineering background or who need a basic level refresher course.
- Feedback from the users is important
- **The NCSP is planning new NCSET modules for the following topics**:
  - The use of Non-Destructive Assay 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

**CSSG Recommendations for Other Training, Other Training Resources**

The primary criterion or objective may be stated as: Use NCSET modules, the NCSP website, special topic workshops and tutorials, and distance education methods to augment or to increase the overall effectiveness of DOE-managed NCS hands-on and classroom training.

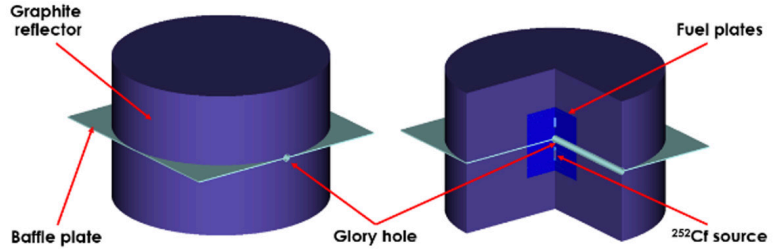
# New NCSP Capabilities Being Explored

# New capabilities

- The Oak Ridge Subcritical Assembly (ORSA) is under development
  - Funded by the NCSP and Nuclear Safety R&D programs
  - Goal – to provide subcritical, hands-on training for fissile material handlers and other operations staff in a low-security environment to enhance bandwidth for NCSP training courses
- Hands-on experiments envisioned will provide a hands-on experience equivalent to those at SNL and NCERC with a neutron multiplication of about 20-25
  - ORSA is designed to perform at least four different experiments on fissile material mass, interaction, absorption, and reflection
- Legacy AGN-201M research reactor fuel is being acquired from Y-12 for use at ORNL
- Graphite reflector and split table design is in progress, as is finding a location at ORNL to support new capability

*Washington Post Photo*

University's Nuclear Reactor blessed by Rt. Rev. Msgr. William J. McDonald, Ph.D., Rector.



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# New Course






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New Course

# DOE/NNSA Non-Destructive Assay (NDA) Program Background / History–Mission Vision–Organization

## Early history

DNFSB Recommendation 2007-1 (April 25, 2007): Safety-Related In Situ NDA of Radioactive Materials

- Large uncertainties and inaccuracies have occurred in estimating the type and quantity of radioactive material using *in situ* NDA
- These uncertainties and inaccuracies include incorrect assumptions about shielding and the spatial distribution of radioactive material, as well as poor measuring techniques
  - measurement errors, in turn, lead to potential criticality accident conditions
  - unexpected radiation exposure to workers
  - underestimation of radioactive material available for release in accident scenarios

Defense Nuclear Facilities Safety Board

## NDA Program Mission & Vision

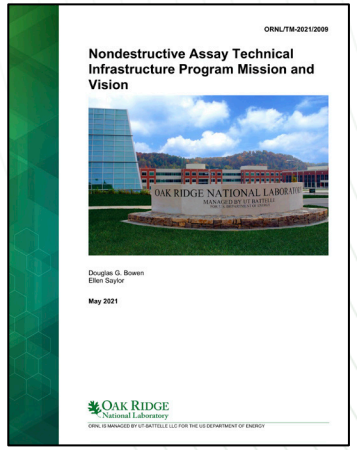
The DOE/NNSA NDA Program (NDAP) is designed to benefit nondestructive assay (NDA) needs to support DOE nuclear criticality safety programs, ensuring that NDA technology is sufficiently capable of guaranteeing the safety of those who handle, store, process, or transport fissionable materials in the complex.

Especially important for the NDAP is to maximize capabilities to identify, characterize, and manage in situ fissile material deposits in process equipment to ensure nuclear criticality safety at processing facilities.


## NDA Program Organization

The NDAP mission and vision is achieved by identifying and accomplishing a set of programmatic goals that correspond with eight broad technical program elements

- Hardware/Software Development
- Algorithm Development & Nuclear Data
- Uncertainty Quantification
- Nuclear Material
- Staffing, Personnel, and Training
- Data Management
- Requirements and Standards
- Information Preservation and Dissemination

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# New NCSP Training & Education Course to support the NDA program Mission and Vision

- ORNL provided a hands-on Nondestructive Assay Holdup Measurements Course from Sept 11-14, 2023
  - This is the second NCSP funded course; 2 planned for 2024
- The class was attended by 13 participant representing criticality safety, material control and accountability, and nondestructive assay staff from Y-12, ORNL, TRISO-X, and USNC
- The course was designed to describe the parameters with associated uncertainties needed to determine the mass of holdup deposits
- This course was funded by Non-Destructive Assay (NDA) funding from the NCSP.


**Participants of the NDA Holdup Measurements Course Sept. 11-14, 2023**

# Concluding Remarks

- The NCSP training and education program has been conducted since 2011 – 745 students trained
  - The NCSP offers
    - 2-week hands-on courses for NCS practitioners
    - 1-week hands-on course for Managers and Criticality Safety Officers
    - 1-week NDA Hold Up Measurements training course for NCS staff
- Educational pipelines to support NCS are ongoing
  - UC Berkeley University Pipeline
  - LANL NCSP-sponsored University Pipeline for Nuclear Criticality Safety Professionals
  - Pipeline Project with the Georgia Institute of Technology (GA Tech) and Texas A&M University (TAMU)
- New NCSP funded subcritical assembly (ORSA) is being constructed at ORNL to enhance bandwidth of NCSP training and education courses

**FY2024 NCSP NCS Courses**

**2-week Hands-on Courses**
- January 22-February 2, 2024
- August 5-16, 2024

**Managers/CSO Courses (NCERC)**
- December 11-15, 2023
- March 18-22, 2024
- December 9-13, 2024 (FY25)

**Managers/CSO Course (Sandia)**
- April 29-May 3, 2024
- September 9-13, 2024

**Register now at:**
https://ncsp.llnl.gov/training-education

# Questions?

| FY2024 NCSP NCS Courses |
| --- |
| **2-week Hands-on Courses**<br>• January 22-February 2, 2024<br>• August 5-16, 2024<br><br>**Managers/CSO Courses (NCERC)**<br>• December 11-15, 2023<br>• March 18-22, 2024<br>• December 9-13, 2024 (FY25)<br><br>**Managers/CSO Course (Sandia)**<br>• April 29-May 3, 2024<br>• September 9-13, 2024 |

**Register now at:**
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