NCSP
NUCLEAR CRITICALITY SAFETY PROGRAM
NEWSLETTER
Summer 2020

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Hands-On Training & Education Course Dates:

Two-week Practitioner Course Dates:

Jan 25-Feb 5, 2021 Aug 9-20, 2021

Aug 9-20, 2021

One-week Manager's Course Dates:

Apr 5-9, 2021 Jun 7-11, 2021

Course Registration: https://ncsp.llnl.gov/trng_apply.php

LINKS TO REMEMBER

- NCSP WEBSITE
- NCSP HISTORY & PROGRAM OVERVIEW
- NCSP ORGANIZATION CHART
- NCSP MISSION AND VISION
- NCSP FIVE-YEAR EXECUTION PLAN
- NCSP PLANNING CALENDAR
- PREVIOUS NCSP NEWSLETTERS
- CSSG TASKINGS
- NONDESTRUCTIVE ASSAY PROGRAM

Dr. Angela Chambers, NCSP Manager

CSSG TASKINGS - FY2020

https://ncsp.llnl.gov/cssg_tasking.php

2020-01 - Update/Replace DOE-STD-1158 with a New Document

2020-02 - Review of FY21 NCSP Proposals by the CSSG

2020-03 - CSSG review of DOE Order 420.1C, III.3.f.

NCSP Hands-on Training and Education Courses

ANS WEBINARS

Spotlight on National Labs

Los Alamos National Laboratory (https://www.ans.org/webinars/view-lanl2020/).

Los Alamos National Laboratory, originally a top secret lab called Project Y, was established in 1943 as the center for nuclear weapon design and was the heart of the Manhattan Project. Since then, LANL has expanded its focus and now conducts research into many fields, including national security, energy, space exploration, materials science, biology, and engineering. It's been home to over a dozen Nobel Prize winners, including Neils Bohr, Sir James Chadwick, Enrico Fermi, Maria Goeppert Mayer, Richard Feynman, and Hans Bethe.

The webinar will touch upon LANL's history and some of today's exciting nuclear projects and missions. Topics include LANL's weapon design mission, nonproliferation, critical experiments, and space nuclear reactors!

Panelists:

- Thom Mason,Director of Los Alamos National Laboratory
- Alan Carr,Historian of Los Alamos National Laboratory
- Leslie Sherrill,Group Leader, XTD-IDA (Integrated Design and Assessment)
- Alexis Trahan,Engineer, NEN-1 (Safeguards Science and Technology)
- Joetta Goda,Engineer, NEN-2 (Advanced Nuclear Technology)
- Patrick McClure,Engineer, NEN-5 (System Design and Analysis)

Moderator:

- Nicholas Thompson, Engineer, NEN-2 (Advanced Nuclear Technology)

SPECIAL ISSUE OF NUCLEAR TECHNOLOGY DEDICATED TO KRUSTY TEST

(A Special Article from LANL INSIDE NEWS)

“An entire issue of Nuclear Technology journal has been dedicated to the design work and results of the Kilowatt Reactor Using Sterling TechnologY (KRUSTY) test.

KRUSTY was the culmination of the National Aeronautics and Space Administration (NASA) Kilopower Project to design, build and test a space nuclear reactor. This test was the first such test since the end of the Space Nuclear Auxiliary Power (SNAP) project at the end of the 1960s.

Patrick McClure of the Systems Design and Analysis Group (NEN-5) wrote the forward to the special issue, which has eight peer-reviewed technical articles on various aspects of the KRUSTY test, which has received many accolades.

“Kilopower was intended to serve both human exploration Needs on planetary surfaces as well as science needs for deep-space exploration,” McClure said.

Experiments for the KRUSTY Test at the National Criticality Experiments Research Center (NCERC) in Nevada.

The Laboratory — in conjunction with NASA and DOE — conducted numerous experiments to test the Kilopower system, a fission reaction power system designed at Los Alamos in conjunction with NASA. Designed to provide between 1 and 10 kilowatts of power, Kilopower can work in harsh environments, such as space, and is efficient, reliable, safe, low cost and compact.

The KRUSTY test successfully demonstrated the efficiency of Kilopower fission power for lunar and planetary exploration. It is anticipated this new nuclear power system could enable long-duration crewed missions to the Moon, Mars and destinations beyond.

From reactor design to high-temp experiment

The technical articles move through the design, development and progressive testing of KRUSTY. As a fission reactor, KRUSTY was the first nuclear-powered operation of any truly new reactor concept in the United States in more than 40 years.

Kilopower was progressively tested in space-like environments to ensure it would operate as predicted. The final test that proved KRUSTY’s abilities took place in March 2018 over 28 consecutive hours. During the final test, the thermal power ranged from 1.5 to 5.0 kW (thermal), with a fuel temperature up to 880°C. Each 80-W (electric)–rated Stirling converter produced ~90 W (electric) at a component efficiency of ~35% and an overall system efficiency of ~25%.

The testing showed that the system operated as expected, and KRUSTY is highly tolerant of possible failure conditions and transients.

Ready for liftoff

Kilopower is poised to power outposts on the Moon and Mars. Where more power is needed, multiple Kilopower units could be deployed.

The safety of the system is based on its innovative structure and physics. The heat-pipe design, with no moving parts in the core, and the self-regulating physics contribute to Kilopower’s large safety margin. Kilopower uses less than five curies of naturally occurring radioactivity. The reactor activates once it reaches its destination (in deep space, on another planet, or in high orbit).

The project was jointly funded by the Space Technology Mission Directorate at NASA and the Criticality Safety Program at the National Nuclear Security Administration (NNSA). The research supports the Laboratory’s Energy Security mission area and the Complex Natural and Engineered Systems capability pillar.”

Action Sheet 66 at the U.S. DOE-Euratom Coordination Meeting

(Presentation - June 15-16, 2020 – Brussels, Belgium)

The Nuclear Criticality Safety Program (NCSP) nuclear data experimental work is partly performed in collaboration with the Joint Research Center (JRC) from the European Union. This work is executed in action sheet 66 under the umbrella of the DOE/EURATOM agreement. On June 16th Klaus Guber from ORNL gave a presentation about progress on action sheet 66 at the online U.S. DOE-Euratom Coordination Meeting, held in Brussels, Belgium.

Nuclear Data are pertinent to all nuclear application modeling calculations and require better data as the computational capabilities expand and requirements by the sponsors. The nuclear data found in libraries such as the Evaluated Nuclear Data Files (ENDF) have sometimes significant deficiencies to describe the application under investigation adequately. For almost two decades NSCP supports nuclear data work, which is depicted in Fig 1. Experiments among others are performed at Geel Electron Linear Accelerator (GELINA) of the JRC-Geel. These data are analyzed and an evaluations is created which is submitted to the national nuclear data center for inclusion in the ENDF library. From there processing codes can download the files and process it for input to codes to perform calculations of nuclear applications.

During FY 2019 neutron transmission and capture experiments using an enriched $^{142}CeO_2$ sample have been performed at the time-of-flight facility GELINA (Fig.2). Cerium is a high yield fission product and the need for improved cross sections has been specifically identified for the Hanford Plutonium Finishing Plant. The obtained experimental data have been reduced to cross section and transmission, respectively. To calculate the theoretical cross section and transmission, the ENDF/B-VIII Ce resonance parameters were used. However, oxide samples require to include oxygen resonance parameter in the resonance parameter file to describe correctly the transmission.

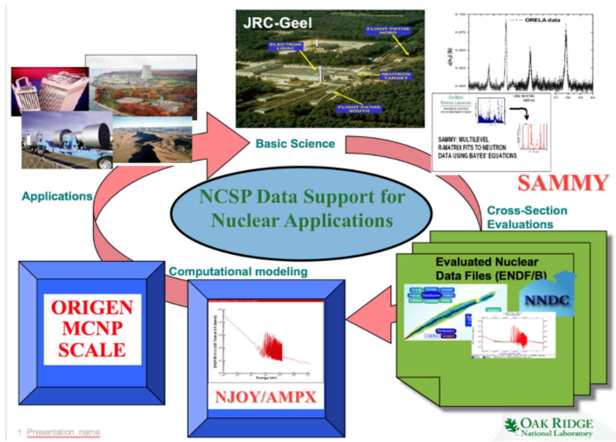


Figure 1. NCSP Support for Nuclear Data.

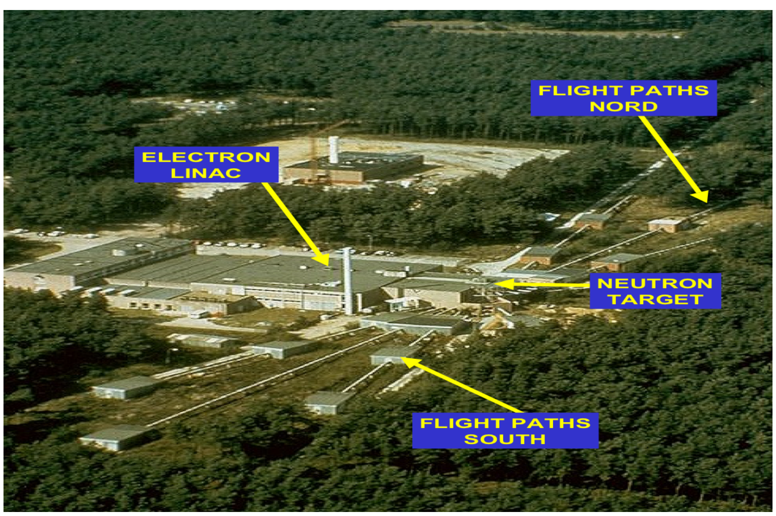


Figure 2. The Time-of-Flight Neutron Source GELINA.

Due to the lack of such file in the ENDF library, the Oak Ridge National Laboratory resonance description for oxygen was used.

The ENDF/B-VIII library shows for the (n,g) cross section and transmission data serious discrepancies compared to the measured data and literature. Resonances are misassigned or missing (compare to Fig. 3 and 4). A further investigation reveals that after the re-evaluation of WPEC SG23 for fission products, those resonances made it into ENDF/B VII.1 parameter file.

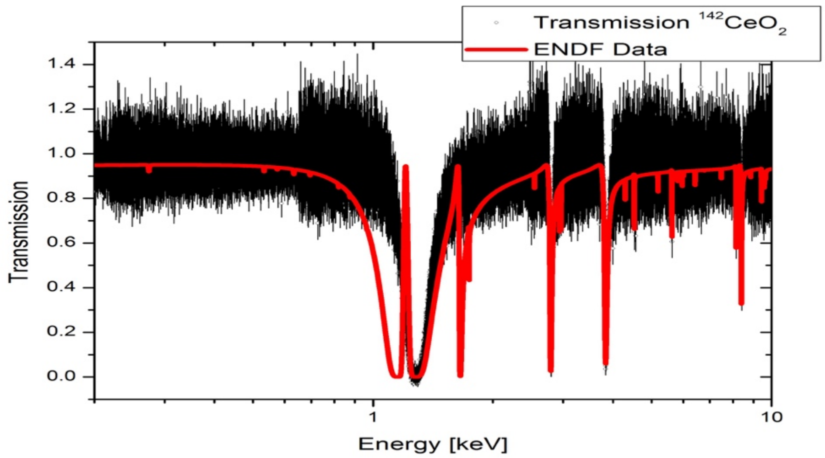


Figure 3. Neutron Transmission of $^{142}CeO_2$ Compared to Calculated Transmission using the ENDF Library. Resonances are Misassigned.

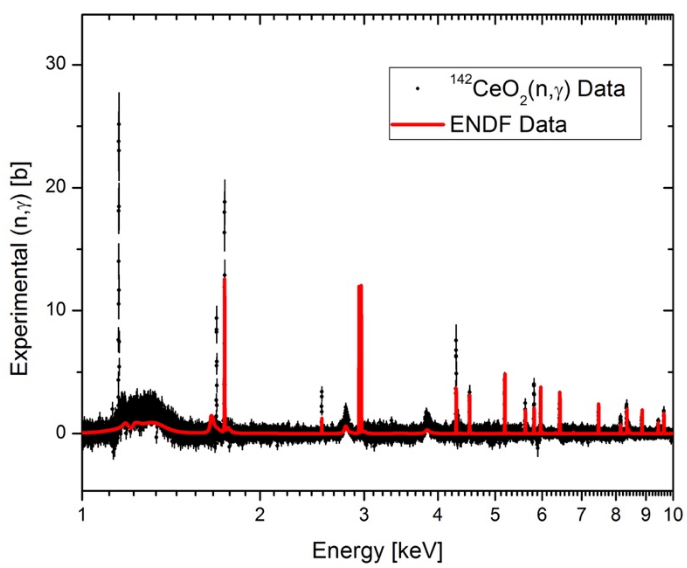


Figure 4. Neutron Capture of $^{142}CeO_2$ Compared to Calculated Capture Cross Section using the ENDF Library.

A report for ^{142}Ce experiments is in preparation and the data analysis is underway. The evaluation should be finalized by the end of 2020 and submitted to National Nuclear Data Center at BNL for inclusion into the ENDF library.

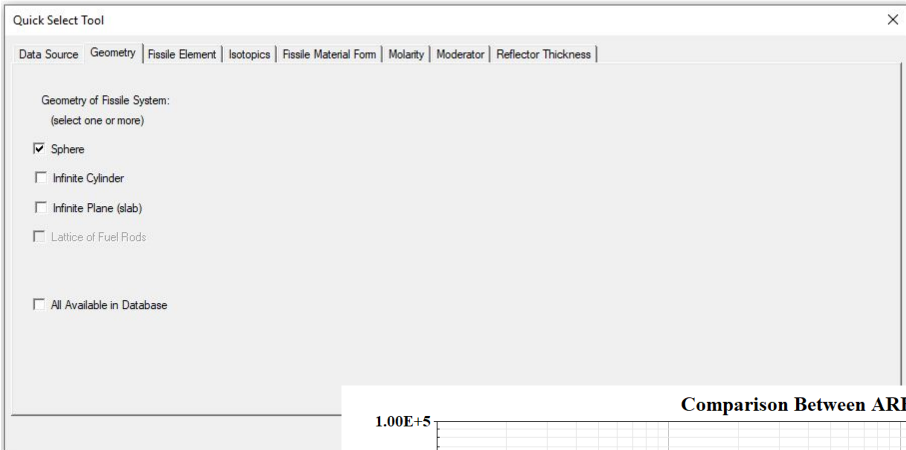
CritView Version 1.04 *(now available at https://ncsp.llnl.gov/am_critview.php)*
(Electronic Handbook for ARH-600 and More)

CritView has been updated. This update addresses many of the issues that have been identified over the years since the prior release.

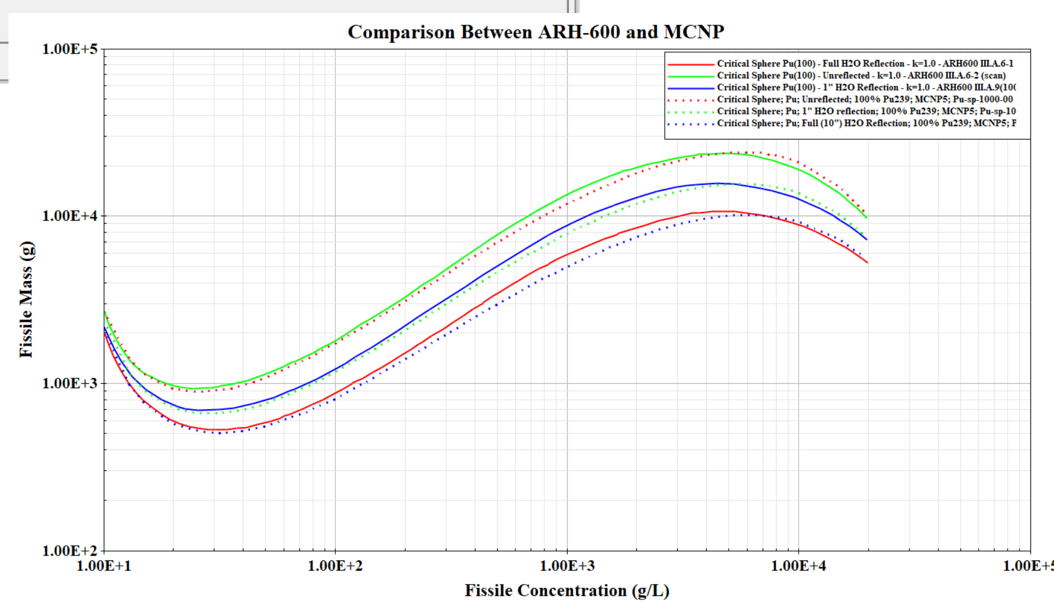
New/Updated Features:

- New User's Guide
- Improved Interface
- Updated Data Base, more Flexible, faster Data Reads
- Ability to add User Generated Data
- Available for Free on the NCSP Webpage!

Example of User Interface:



Example Plot:



The CritView code is used as an electronic equivalent of a nuclear criticality handbook (e.g., ARH-600). CritView includes an electronic library of critical data and allows the user to select and display various parameters in units of interest as well as include additional user-supplied data.

ARH-600 and other data are best estimate and do not include uncertainty or bias; therefore, CritView is intended primarily as a scoping and visualization tool. Care must be employed if the data is used directly in criticality safety analyses.

CritView Version 1.04 *(cont'd)*

ARH-600 and CritView – A Brief History

<u>Introduction</u>

During the beginning of the nuclear era, computers and material cross sections were almost unheard of. Thus, the nuclear material process developers primarily relied upon critical experiments. The results of the experiments were frequently used to directly support process operations. The use of hand calculation methods such as geometric transformations using neutronic bucking relationships were applied to allow the experimental results to be applied to disparate configurations.

As computers came into the picture the CS practitioners developed codes to assist with the process evaluations. However, these computers were slow, and computer time was expensive, cross-section libraries were limited, thus basic parametric analyses were performed and documented to facilitate comparison with, and extension of, the experimental results. The documentation of these results allowed the use of this information by other practitioners.

<u>ARH-600</u>

The ARH-600 parametric evaluation compendium was developed at the DOE Hanford site in Washington state in the early to later 1960's. At the time computers and their codes were obviously not as powerful and advanced as today. It is of note, then, that even though the calculations were performed using simple geometries (1 or 2 dimensions), few group cross sections (1 to 3 groups), the uncertainties were large (sometimes more than 10%), and the curves in ARH-600 were drawn using a French curve, with the goal to incorporate as many of the 3-6 points available, the results are reasonably close to what we find today using modern codes and cross sections. Other sites also developed their own compendiums, and these have been published in documents such as LA-10860 (LANL) and TID-7016 (ORNL).

<u>CritView</u>

The CritView code was developed at Hanford, starting in the early 2000's. Over the years this effort has been funded by the DOE NCSP. The original scope for CritView was to be a modern replacement for ARH-600 using the current available codes and cross sections. The results would include significantly more validation and peer review than was documented for ARH-600.

The ARH-600 code was developed as an electronic equivalent of a nuclear criticality handbook (e.g., ARH-600). The code takes an electronic data library and allows the user to plot data as needed. This approach has two distinct advantages over a paper handbook. First, the database can be easily expanded to include additional configurations or modeling techniques. Secondly, the code provides flexibility by allowing the user to easily change the units, parameters, and formats of the plots.

CritView provides the ability to quickly and easily change the axis dimensions and units of data plots. For example, a plot showing the relationship between critical radius and concentration can be converted to show the relationship between critical mass and concentration. Similarly, if the plot shows concentration in units of g/cc (for example) it can be changed to g/L. Other major functionality includes the ability to compare curves, to list out the data points in a curve, and to export the plot to a graphics file for use in a document.

The CritView code is intended to evaluate the behavior of various fissile configurations (e.g., minimum critical mass, minimum critical diameter, etc.). The data included in the associated database (like the data in ARH-600 itself) is typically a best estimate of critical (e.g., k_{eff} = 1.0) and does not include accommodation for uncertainty or bias. As such it can be somewhat non-conservative and should not be considered as providing subcritical limits. The code is primarily intended as a scoping tool for estimating minimum critical configurations, and for determining potential areas of interest in a criticality safety parametric study. It is not intended to supplant analysis of specific configurations. In general, it is recommended that the code not be used to directly set limits or controls for criticality safety.

CritView is distributed through the NCSP's website *at* <u>https://ncsp.llnl.gov/am_critview.php</u>. It is currently being maintained by SRNS under contract to the NCSP.

NCSP Hands-on Training and Education Courses

Two-week Practitioner Course Dates:

Jan 25-Feb 5, 2021   Aug 9-20, 2021

The NCS Practitioners Courses were held at the National Atomic Testing Museum (NATM), the National Criticality Experiments Research Center (NCERC) and Sandia National Laboratories in Las Vegas, Nevada. The courses are designed to meet the ANSI/ANS-8.26, "Criticality Safety Engineer Training and Qualification Program," requirement for hands-on experimental training.

Then NATM portion of the course involves classroom lectures and workshops for NCS Evaluation development and the NCERC and SNL portions of the course involve experiments with the critical assemblies.

MSTS, LANL, ORNL, LLNL, SNL, Y12 and NFO staff participated in the course execution.

One-week Manager's Course Dates:

Apr 5-9, 2021   Jun 7-11, 2021

The Managers courses were held at both NCERC and SNL. THE courses are designed for fissile material handlers, process supervisors, line managers and regulators with criticality safety responsibilities.

MSTS, LANL, ORNL, LLNL, SNL, Y12 and NFO staff participated in the course execution.

Class Information:
https://mcnp.lanl.gov/classes/classinformation.shtml

Fees and Registration Information:
https://laws.lanl.gov/vhosts/mcnp.lanl.gov/classes/CostsRegistrationInfo.shtml

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SCALE Course Information:
https://www.ornl.gov/scale/scale-training