TerraPower
partnered with
Los Alamos National Laboratory

NE-22-28590: Chlorine Nuclear Data Measurement and Evaluation

YEAR AWARDED: 2022

TOTAL PROJECT VALUE: $530,000

STATUS: Completed

PRINCIPAL LAB INVESTIGATORS: Sean Kuvin (LANL), Anselmo Cisneros (TerraPower)

DESCRIPTION: TerraPower, based in Bellevue, Wash., is developing the Molten Chloride Reactor Experiment (MCRE). Design and operation of MCRE relies heavily on the quality of nuclear data, including nuclear data for the stable chlorine isotopes ^{35}Cl and ^{37}Cl for many reactions. Recent ^{35}Cl measurements were not consistent with previously evaluated nuclear data in the most important neutron energy range to the MCRE. This project involved performing new ^{35}Cl measurements, analyzing the experimental data from these measurements, generating new ^{35}Cl and ^{37}Cl cross-section evaluations in the Evaluated Nuclear Data File/B format, and assessing the impacts of the expected changes to chlorine nuclear data for the MCRE application. In support of this effort, TerraPower partnered with experimentalists and theorists from Los Alamos National Laboratory (LANL), who have the relevant knowledge and experience in both measuring and evaluating fast spectrum cross-sections for chlorine isotopes.

BENEFIT: Producing high quality measurements of the ^{35}Cl reaction cross-sections and re-evaluating the chlorine evaluated nuclear data libraries will reduce regulatory uncertainty toward chloride salt reactors.

IMPACT: The improved knowledge of the ^{35}Cl(n,p) reaction cross-section, supported by new Los Alamos Neutron Science Center (LANSCE) measurements, significantly improves the accuracy and precision of criticality calculations for the MCRE and other fast spectrum applications that employ chloride salts. This conclusion was supported by a peer review panel assembled by TerraPower and conducted over two days through video conferencing. The first session was dedicated to an overview of the measurements conducted at LANSCE, along with complementary measurements from University of California, Berkeley, Ohio University, and CERN. The scale of the cross sections measured at LANSCE were found to be consistent, within uncertainties, by the preliminary results shared by UCB and Ohio University in the energy range of interest for this project. This supports confidence in the updated evaluated nuclear data, which was primarily based on the LANSCE measurements due to the lack of other available experimental data.

SIGNIFICANT CONCLUSIONS: Results from the work are available in a conference presentation, “Reactivity Impact of Updated 35Cl Nuclear Data on the Molten Chloride Reactor Experiment” (PHYSOR 2024), and two journal publications which were submitted for peer review. The 35Cl nuclear data evaluation produced in this project has been archived in Brookhaven National Laboratory’s ENDF/B repository for consideration in a future release.

NEXT STEPS: This effort was timely, as it began addressing significant nuclear data concerns associated with MCRE. Differential experimental data is still sparse, however, along with a lack of adequate benchmarks for the relevant conditions of interest to MCRE and future commercial Molten Chloride Fast Reactor applications. Terrapower intends to continue to help the Cross Section Evaluation Working Group (CSEWG) curate and update chlorine nuclear data files into the next ENDF/B release. Continuing efforts include designing and executing fast spectrum benchmark experiments, validation of chlorine nuclear data using CLYC scintillator detectors, integral activation measurements, and more. Differential data on ^{37}Cl is still significantly lacking, which becomes an increasing concern as isotopic enrichment is considered. Reaction studies such as (n,n’) on both ^{35}Cl and ^{37}Cl, ^{37}Cl(n,p), etc., are studies that can be performed with high precision directly on isotopically enriched samples at LANSCE.