Framatome
partnered with
Idaho National Laboratory

NE-19-18484, Advanced Metallic U-Zr Fuel for LWR Applications – FMEA and PIRT Development

YEAR AWARDED: 2019

TOTAL PROJECT VALUE: $596k (DOE Funds Awarded: $477k; Awardee Cost Share: $119k)

STATUS: Completed

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DESCRIPTION: Framatome is a world leader in nuclear energy, recognized for its innovative solutions and value-added technologies for designing, building, maintaining, and advancing the global nuclear fleet. The company designs, manufactures, and installs components, fuel, and instrumentation and control systems for nuclear plants and offers a full range of reactor and engineering services. Framatome is investigating a new fuel design that includes a fuel rod with annular fuel slugs that consists of a 50 wt.% Zr uranium-zirconium (U-50Zr) alloy enriched to less than 20% ^{235}U with an external zircaloy cladding while maintaining other aspects of the typical LWR fuel rod design. The rods are in a rectangular array supported and positioned by spacers within the fuel assembly bundle that maintains the position and location of the 24 guide tubes plus an instrument tube of the current U.S. pressurized-water reactor (PWR) 17 × 17 design UO_2 fuel assembly. Top and bottom nozzles maintain the interfaces with the reactor control components and core internals. Because the Nuclear Regulatory Commission's Standard Review Plan was developed for zirconium-clad UO_2 fuel, new design-specific criteria and design-basis limits needed to be established for the U-Zr design. The new alloy fuel design was anticipated to have failure/damage modes associated with fuel rod failure or damage mechanisms are unique to the design that need to be identified and the failure/damage mechanisms developed to define design-specific criteria to address.

BENEFIT: Framatome used failure modes and effects analysis (FMEA) to determine and define potential failure mechanisms for the U-50Zr alloy design. For each failure or fuel system damage mode, phenomenon associated with the failure/damage mechanisms would be identified. A phenomenon identification and ranking (PIRT analysis) was performed to identify phenomena that need more understanding through research or testing.

IMPACT: Based on the results of the initial FMEA and PIRT completed by Framatome, experts from Idaho National Laboratory (INL) wrote a review and addressed phenomena related to the mechanism and identify gaps in knowledge or understanding. Specific outcomes of this collaboration between INL and Framatome included a series of material experiments to assay fundamental material properties for the alloy system.

NEXT STEPS: Framatome and INL will finish the experimental work and issue a report by the end of 2021.