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PROTECTIVE COATINGS AS ACCIDENT TOLERANCE CONCEPTS AND THEIR IMPACT ON NEUROTIC PERFORMANCE: A REVIEW

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Due to favorable characteristics such as low neutron absorption cross section, and good mechanical performance, Zirconium (Zr)-based alloys, have been used as fuel cladding material, and it has adequately served the nuclear industry over the past 50 years. As industry expanded, fuel cladding failure and damage rates decreased significantly "from initial defect rates of about 1/100 fuel rods in the late 1960s to less than 1/100,000 in 2005"[1].This contributed to the optimization of nuclear fuel cycle, and cladding design. However, the Fukushima Diiachi power plants accident in 2011 highlighted the serious consequences for the problem of zirconium alloys accelerated oxidation in high temperatures. Following this accident, the "Accident Tolerant Fuel (ATF)" programs have been lunched worldwide. By definition, ATFs are fuels/cladding concepts that, comparing with the standard Uranium Dioxide - Zr fuel system, are able to tolerate loss of active cooling in the core for a considerably longer time periods, while maintaining/ improving normal operation nuclear fuel performance.

Protective coatings on Zr-based claddings have been proposed within the frame of ATFs. These coatings are thought of as short-term concepts expected to improve corrosion and high-temperature oxidation resistance, and reduce hydrogen absorption of Zr-based alloys, without introducing significant modifications into current light water reactors design. However, a wide spectrum of factors can affect the behavior of coated Zr-based claddings, in both normal operation and accident conditions such as: coating adhesion, thermal conductivity, thermal neutron cross-section and the accompanied flux fluctuations, radiation resistance, and mechanical properties. Currently, studies are conducted worldwide to evaluate various performance aspects for coated Zr-based alloys, by the deposition of metallic (Fe-based alloys, Cr, Cr- Al, Ni-Cr, etc.), non-metallic (oxides, nitrides, carbides) and MAX-phase [2] coatings. The impact of coatings on reactor Neutron performance is one of the important areas being currently evaluated extensively, since it has a direct relation with safety and reliability as long as nuclear power plants economics.

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