Innovative Features and Fuel Design Approach in the IRIS Reactor

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IRIS (International Reactor Innovative and Secure) is currently being developed by an international consortium of industry, laboratory, university and utility establishments, led by Westinghouse. The IRIS design addresses key requirements associated with advanced reactor designs, including improved safety, enhanced proliferation resistance, competitive electricity production cost, and improved waste management. It utilizes innovative engineering to improve the plant performance characteristics. However, IRIS design is firmly based on proven LWR technology, therefore, no new technology development is needed, and it has potential for near term deployment, i.e., in 2010's. IRIS is a modular, small/medium size (350 MWe) PWR with integral vessel configuration. An important feature in support of proliferation resistance is a straight-burn long life core, of the order of 5-8 years, or even longer. Moreover, this feature has a positive impact on plant availability factor (reduced down-time for refueling) and consequently economics, as well as on reduced high-level waste. However, it poses new challenges in core physics, related to fuel design and neutronics, and selection of core design parameters. This challenge is amplified by opposing objectives of designing a fuel with novel characteristic, yet at the same time avoiding uncertainty and/or delay in reactor deployment that could result if an extended fuel irradiation testing is necessary. An overview of the IRIS reactor will be presented in this paper, followed by a more detailed discussion on the fuel/core design activities. IRIS fuel/core design approach and distinguishing features are mentioned in this abstract.

IRIS core will utilize low-enriched oxide fuel (<20% fissile, but possibly exceeding 5%). To simplify the plant complexity, IRIS design aims to eliminate or at least reduce soluble boron utilization. This would improve core reactivity characteristics (more negative MTC coefficient), thus allowing some increase in neutron moderation, and consequently better fuel utilization through increased discharge burnup. To control excess reactivity associated with the longer cycle, advanced burnable absorber configurations are being employed. For the 8-10 years core lifetime, UO2 or MOX fuel with fissile content in the 8-10% range is needed. However, this fuel requires additional considerations and may need some testing before it can be licensed. Therefore, the initial IRIS core is designed with 5% UO2 fuel using current, licensed fabrication technology, providing a 4-5 year core lifetime. Search for a clear path forward that will make feasible and practical future implementation of 8-10 year cycle resulted in development of the variable lattice approach. Several interchangeable fuel assembly designs have been developed; they are compatible with 5% UO2 fuel, as well as with higher enrichment (~8-10% fissile) UO2 as well as MOX fuel. Fuel lattice parameters (p/d factor) are selected in each case such to provide adequate neutron moderation, while maintaining main fuel rod parameters (e.g., pellet diameter, linear heat rate) within acceptable limits in all cases. Thus, this minimum risk approach involves initial use of 5% fuel, and later replacement with higher-enrichment longer-cycle UO2 or MOX fuel (when licensed), since core parameters were selected to ensure good performance and fuel utilization in each case. Additional details on design selections and variable-lattice approach will be presented in full paper.

Finally, one aspect of current R&D efforts (pursued primarily by university members of the IRIS consortium) involves evaluating more radical innovative solutions for possible longer-term applications, such as very tight (or otherwise reduced-moderation) light water lattice with high conversion ratio, novel fuel rod geometry, use of Thorium, and so on. An overview of these activities will be also presented.