Materials Selection and Validation for Advanced Light Water Reactor Electricity Generating Power Plants

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Abstract - The materials selection for the new Westinghouse AP1000 power plant will be presented. The basis for these materials selections will be identified with respect to prior plant experience and the scientific evaluation of materials' degradation phenomena. The key materials selections will be identified and the rationale for the expected materials durability in plant environments will be summarized.

The proper selection of materials and materials processing routes for plant components is a crucial factor in the design of modern electricity generating nuclear power plants. Such plants are designed to withstand operating service for lives of sixty years and greater. The ability of the materials of construction of reactor internals, pressure boundary and piping systems and heat exchanger units to withstand the irradiation, temperature and corrosion inducing environments is key to successful plant design and sustainable operation. Modern reactor's materials selections are based on well founded materials that have demonstrated reliable performance in the first generations of power generating reactors. Additionally, materials substitutions, modifications and, upgrades have been employed in operating reactors to increase operational durability. Such materials changes have been supported by extensive testing and characterization of materials after exposure to plant environments. These studies of the materials microstructural changes and the degradation of material properties have provided the technical basis for the materials improvements and substitutions that have been implemented in existing electricity generating nuclear power plants. These materials form the basis of the materials selection for the new plants that will be built in the next years to meet the global demand for new electricity capacity.

This presentation deals materials selection from an industrial perspective. It relates the key materials behaviors that have been identified with respected to modification of materials properties due to exposure to reactor environments with the performance characteristics required for modern power plant service. The genesis of materials improvements in Light Water Reactor materials for power generating systems will be presented. The key materials properties and behaviors that govern the lives of the ferritic steels used in pressure vessels, the austenitic steels employed in internals and the nickel base alloys used in heat exchanger piping and dissimilar metals joining will be identified. The trends for the materials property changes as a result of plant irradiation, thermal and environments exposure will be reviewed and the basis for the prediction of plant aging behaviors will be presented. In particular, the key developments of modern modeling techniques in identifying key areas of materials concern with respect to plant aging will be reviewed. The results of such modeling will be correlated with the behavior observed in materials in operating power plants.