Characterization of Fuel Pellet Oxidation in Defected Fuel Elements Using O/M Measurements and Optical Microscopy

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ABSTRACT

Fuel-pellet oxidation may occur in defected fuels due to coolant ingress, leading to altered fuel properties and, consequently, altered irradiation performance under normal operation. Off-normal and accident scenarios may also be affected by a possible decrease in fuel melting temperature. To address these concerns, the CANDU Owners Group (COG) has initiated a project to quantify the extent of fuel oxidation in selected defected fuel elements. These investigations included measuring the oxygen-to-metal (O/M) ratios (i.e., the *stoichiometry*, or the ratio of the number of oxygen atoms to the number of uranium atoms in the fuel) and characterizing pellet microstructures using standard optical microscopy techniques.

To date, O/M ratio measurements have been performed for three defected elements using a technique termed *coulometric titration*. All of the elements were irradiated under normal operating conditions (burnup < 250 MWh/kgU, peak element linear-power < 55 kW/m); one element had much larger secondary defects than the other elements.

The element with the large defect exhibited the highest O/M ratio, compared to the other elements (2.11 versus 2.00). The extent of UO_2 oxidation in this element was the greatest near the defects. For the sections taken near the defects, the radial trend was for largest oxidation near the mid-radius, with lower values at the centre and edge. The other two elements with small defects exhibited little fuel oxidation.

Optical examinations revealed that the large defect was associated with local UO_2 loss. The observed pellet microstructures indicate that UO_2 oxidation occurs most rapidly along fuel cracks and grain boundaries.

The observed O/M ratio measurements and corresponding fuel microstructures correlate well for each of the three elements. The results to date indicate that fuel pellet oxidation is primarily dependent on defect size. Further investigations are in progress to better determine the effect of other operational parameters on pellet oxidation.