REQUALIFICATION OF THE LOFT REACTOR FOLLOWING A LOSS OF COOLANT EXPERIMENT (LEVEL I)

by

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During a Loss of Coolant Experiment (LOCE), the LOFT reactor experiences an acceleration of 10 G's and fuel cladding temperature changes at a rate of 1100 °K/sec. These unparalleled conditions present a unique startup problem to the LOFT program: How can the integrity of the fuel be confirmed so as to minimize operation if damage has occurred?

The Level I Requalification Program is designed to accomplish this. It is a progressive series of tests, designed to detect damage at the earliest possible time, and thus preclude or minimize operation if damage exists. The program consists of two basic parts.

First, fuel specialists examine the LOCE data for possible damaging conditions and the results of primary coolant sample analysis for signs of failed fuel. This examination considers data from fuel cladding and guide tube thermocouples, accelerometers, and linear motion detectors mounted on the fuel in addition to normal process instrumentation. When the data indicates a high probability of fuel damage, requalification proceeds to a higer level, involving visual inspection of all or part of the fuel. If visual inspection reveals no significant damage Level I testing may be resumed.

Second, the requalification program proceeds to a series of mechanical and physics tests. Comparison of the results of these tests with "baseline" data from similar tests enables detection of changes in core performance. Any difference between the baseline and requalification data in excess of the uncertainty of the measurements is initially assumed to result from core damage. If any such differences are observed, a detailed study is made of measurement conditions and factors other than fuel damage which could produce changes in the results. This review also considers the results of the other tests before concluding fuel damage has occurred. The tests include:

I. Subcritical Tests

a) Flow and System Operability Tests

Severe mechanical damage would likely impede flow in the core and distort guide tubes housing the control rods and the Traversing In-Core Probe (TIP). To test for this condition, core flow and pressure drop are measured and compared to the baseline, and the control rods and TIP system are exercised to verify operability.

b) Control Rod Drop Times

Comparison of control rod drop times with baseline values provides a more sensitive test for mechanical damage to the guide tubes. The drop times are recorded for both no-flow and normal flow conditions, and compared to baseline results using a statistical program, which determines, using the mean and standard deviation obtained from a series of drops, whether a significant change in drop times has occurred.

II. Critical Tests

a) Critical rod configurations are recorded at various rod heights to detect changes in the reactor's overall physics characteristics. The results are compared to the baseline configuration by converting differences in configuration to equivalent reactivity differences, using measured rod worths and reactivity coefficients. An equivalent reactivity difference in excess of the uncertainty of the measurement and the reactivity coefficients indicates damage may have occurred.

b) Axial flux Profiles

Axial flux profiles are measured with control rods banked at various heights, and with each individual rod misaligned to the upper limit, with the compensating bank low. The various flux profiles are examined for discontinuities and irregular shapes, which are expected to result from damaged fuel, and compared to the baseline.

c) Differential Control Rod Worth

Differential control rod worth is measured with the control rod bank at high and low positions, and for each of the individual rods. The single rod worths are measured at different points from the insertion limit to the upper limit while adjusting the remaining rods to maintain criticality. The bank worths measure overall core physics response; the single rod measurements provide spatial resolution of the core's physics response.

d) Nuclear Signature

Data from nuclear detectors, thermocouples, resistance temperature detectors, accelerometers, and flow detectors are acquired during steady-state operation and processed with a Fourier analyzer. The resulting spectral "signatures" are compared with the baseline signatures for changes. A change in the frequency spectrum of the system may indicate a change in the reactor's structural characteristics.

Upon completion of the Level I Requalification Test a select requalification working group evaluates the results and recommends one of the following: 1) the reactor be allowed to continue operation; 2) a higher level of requalification testing, including visual inspection of the fuel be performed; 3) or that the fuel be replaced prior to further operation.

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