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FINAL REPORT OF THE AP&L ICC MONITORING SYSTEM CONFIRMATORY PROGRAM

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SECTION 1
INTRODUCTION

Arkansas Power and Light (AP&L) Company has contracted Technology for Energy Corporation (TEC) to supply an inadequate core cooling (ICC) system for Arkansas Nuclear One. AP&L and TEC, therefore, designed and conducted an extensive experimental program on the Radcal Inventory Meter (RIM) to verify ICC capability and to provide licensing support and design data for the system hardware. The test program was conducted at facilities leased from the Oak Ridge National Laboratory (ORNL) utilizing two atmospheric air/water test facilities and the pressurized water Forced Convection Test Facility (FCTF). The air/water facilities were used to provide manometer tube design data and basic sensor response parameters. The FCTF is a typical reactor simulation facility that has been used in several Nuclear Regulatory Commission Programs. It has both blowdown and reflood capability with sufficient control and instrumentation systems to perform the tests required to simulate a reactor under small break, loss-of-coolant conditions.

The overall objectives of the test program were:

- To verify that the proposed manometer tube design permits unambiguous coolant inventory determinations (above-core),
- To confirm that the RIM probes will detect ICC conditions (above-core and in-core), and
- To identify the boundary conditions for unambiguous ICC indications (above-core and in-core).

Section 2

AIR/WATER TEST SERIES

2.1 OVERALL OBJECTIVES OF THE AIR/WATER TEST SERIES

The overall objectives of the air/water test series were:

- To provide basic design data on the manometer tube stilling column and RIM assembly's performance,
- To demonstrate that the final prototype manometer tubes and probes can make level measurements in a variety of air/water mixtures and flows,
- To obtain basic performance data, response time, and fill and drain rates of the manometer tube-probe assemblies, and
- To determine the boundary conditions of flow and void fraction under which the probe assembly can provide unambiguous data to a reactor operator.

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Section 3

UPPER HEAD TEST SERIES

3.1 OVERALL OBJECTIVES OF THE UPPER HEAD TEST SERIES

The overall objectives of the Upper Head Test Series were:

- To demonstrate that the prototype inventory meters can supply measurements to provide effective ICC monitoring of the upper head and upper plenum of the reactor,
- To provide data to determine the boundary conditions on unambiguous inventory meter ICC monitoring performance--depressurization rates (break size), flow rates (pumps off sensitivity), and refill repressurization,
- To confirm that the absolute temperature measurement provides a good indication of coolant temperature above the core in an ICC event, and
- To provide data to select the optimum sensor types and arrangements in the inventory meter probes for ANO-1 and ANO-2.

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Section 4

IN-CORE TEST SERIES

4.1 OVERALL OBJECTIVES OF THE IN-CORE TEST SERIES

The overall objectives of the in-core test series were:

- To demonstrate that the prototype RIM sensors can supply measurements to provide effective ICC monitoring of the reactor core under low-power conditions;
- To provide data to determine the boundary conditions on unambiguous RIM ICC monitoring performance - depressurization rates (break size), flow rates (pumps off sensitivity), and refill repressurization;
- To confirm that the absolute temperature measurement provides a good indication of coolant temperature above the core in an ICC event, and obtain data on how closely the RIM reflects fuel thermal performance;
- To provide data to select the optimum sensor types and arrangements in the RIM probe for ANO-1 and ANO-2.

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Section 5

OVERALL CONCLUSIONS

The breadth of the parameter space in the three test series was significant. Variations in blowdown rate, reflood rate, initial temperature, and initial flow were included. Further, three sensor types and three gas-gap length variations within two of the sensor types were tested. The overall conclusions are:

1. All RIM rods maintained their mechanical integrity, operability, and performance throughout the tests.
2. All RIM sensor types respond well to blowdown and reflood transients and could be utilized as ICC warning devices with relatively simple type-specific data processing.
3. Inventory loss or gain rate can be determined in addition to inventory.
4. There is no practical difference in response of RIM rods containing different numbers of sensor locations (12- and 16-cable pack designs).
5. The response of the sensors is predictable, including variations in absolute temperature and flow.
6. Absolute thermocouples in the RIM rods can be used to trend fuel cladding temperature.
7. RIM sensors in the instrument guide tube can be used to indicate fuel surface conditions.

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