USQ PROCESS
POTENTIAL INADEQUACY IN THE SAFETY ANALYSIS (PISA) FORM
(DO NOT USE FOR PROPOSED CHANGES)

Facility or Activity: Advanced Test Reactor (ATR)

USQ Process No.: TRA-USQ-2004-385

Subject: ATR Surge Tank Level Instrument Limiting Control Settings

Describe the New Information/Discovery:

The ATR Technical Safety Requirements (TSR-186) include a limiting condition for operation (LCO 3.3.4) related to primary coolant system surge tank level. The LCO specifies the instrumentation to be used to monitor surge tank level, the required accuracy of the instrumentation, and the required range for surge tank level on the instrument.

An updated calculation (Draft EDF-5090) of the surge tank level instrument uncertainty and the operating limits has identified a non-conservative error in the previous determination (TRA-ATR-1482) of the uncertainty that can be introduced by differences in the temperature between water in the surge tank and the water in the reference leg for the level measurement. The existing analysis applied the temperature difference over the 10-inch span of the measurement rather than the total height of the reference leg (approximately 230 inches).

Additionally, the updated calculation indicates the measurable uncertainty of the surge tank level instrument may be as high as 1.1% which exceeds the required accuracy of 1% in LCO 3.3.4.

The safety basis analysis derives an allowable analytical range of 40 to 60 cubic feet. This range is converted to an allowable operating range based on the instrument uncertainty analysis in TRA-ATR-1482. The instrument output is in percentage. The conversion between percentage output and air volume is given in EDF-4106 and TRA-ATR-1453. The analytical limits correspond to instrument readings from 76% (40 cubic feet of air) to 24.7% (60 cubic feet of air). The TSR LCO is based on a 3% instrument uncertainty resulting in an LCO range of 73% to 28%. Application of the maximum temperature difference defined in TRA-ATR-1482 over the full height of the reference leg results in a worst-case uncertainty of +25.3% and -24% compared to the 3% used in the TSR derivation.

The procedural operating range of the surge tank is 50 ± 5%. Applying the worst-case updated uncertainties to the 50 ± 5% operating range results in a potential range of 80.3% to 21% or 38 cubic feet to 61 cubic feet. Applying the worst-case updated uncertainties to the 73% to 28% LCO range results in a potential range of 98.3% to 4% or 32 cubic feet to 68 cubic feet. In both cases, the air volume could exceed the analytical limits from the safety basis.

Operation with a high percentage or low air volume side is not likely to occur. This occurs when the surge tank is hot and the reference leg is cold which is physically unlikely. Operation with a low percentage or high air volume side is possible particularly during the early part of a reactor operating cycle before the surge tank water temperature equilibrates. This condition occurs when the surge tank is cold and the reference leg is hot. The revised instrument uncertainties are based on a very conservative 60 F temperature difference applied in each direction.

Operation with less than 40 cubic feet or more than 60 cubic feet of air in the surge tank would be outside of the analyzed condition.

The upper limit on air volume (lower limit on surge tank level) is derived from the Condition 3 small break loss of coolant accident (LOCA) with concurrent failure of the LOCA primary coolant pump (PCP) shutoff system. The depressurization of the PCS combined with continued operation of a PCP draws most of the water from the surge tank into the primary coolant system leaving the potential for air pull through or formation of an air entraining vortex. These phenomena were evaluated in EDF-4206 and EDF-4304 which concluded the current limiting conditions for operation on surge tank level and the current emergency firewater injection system (EFIS) actuation setpoint precluded a significant amount of air from leaving the surge tank. Actuation of EFIS refills the surge tank.

The current lower limit on air volume (upper limit of surge tank level) was also derived from the LOCA analyses in TRA-ATR-1487. The sensitivity of various accident sequences to low initial surge tank air volumes has been examined in various analyses (TR-797, TRA-ATR-1453, EDF-4953, EDF 5212, and TRA-ATR-1487). Most events do not show a strong sensitivity to low air volume. TRA-ATR-1487 concluded the worst-case low initial air volume for minimum thermal-hydraulic margins during the design basis LOCA was 44 cubic feet for two PCP operation and 56 cubic feet for three PCP operation (i.e., well within the anaytical range limits). The analyses in TR-797 and TRA-ATR-1453 examined surge tank air volumes between 15 cubic feet and 65 cubic feet. EDF-4953 and EDF-5212 examined sensitivity of the loss of commercial power accident consequences to low initial air volume down to 40 cubic feet. Fuel plate thermal-hydraulic margins were slightly reduced at smaller

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air volumes, however, the sensitivity was not strong and there were large margins to limits.

Identify the applicable safety basis document(s) (i.e., DSA, SAR, BIO, TSRs, OSRs):

Upgraded Final Safety Analysis Report for the Advanced Test Reactor, SAR-153, August 10, 2004, Section 15.6, Decrease in Primary Coolant Inventory

Upgraded Final Safety Analysis Report for the Advanced Test Reactor, SAR-153, August 10, 2004, Chapter 16, Derivation of Technical Safety Requirements

Technical Safety Requirements for the Advanced Test Reactor, TSR-186, August 10, 2004

Polkinghorne, S. T., Analysis of ATR Small Break LOCA with Engineered Safety Feature to Automatically Trip Primary Coolant Pumps, TRA-ATR-1487, July 29, 1999

Vetter, D. L., Controls for EFIS Pressure Setpoint, Surge Tank Level, and Primary Coolant Pump Engineered Safety Feature for Loss of COolant Accident, TRA-ATR-1482, Revision 2, November 18, 2003
Atkinson, S. A., ATR Technical Specifications Accidents Sensitivity to Surge Tank Level, TR-797, March 12, 1976.

Pickar, M. S., ATR Surge Tank Level Uncertainty Analysis, Draft EDF-5090

Atkinson, S. A., ATR Surge Tank Narrow Range Level Indication Uncertainty and Operating Limitiations to Prevent Overpressure or Surge Tank Draining, TRA-ATR-1453, April 7, 1999

Vetter, D. L., ATR Primary Surge Tank (670-M-12) Level Accuracy Verification, EDF-4106, August 28, 2003

Erickson, P. A., Vortex Formation in the TRA-670-M-12 Surge Tank, EDF-4206, November 11, 2003

Lucas, D. S., A RELAP5/MOD3 Model for the Estimation of Air Pull-Through for a Draining Tank, EDF-4304, November 18, 2003

Polkinghorne, S. T., Evaluation of Safety Limits for ATR Low Vessel Differential Pressure, EDF-5212, September 13, 2004

Polkinghorne, S. T., Reanalysis of Loss-of-Commercial Power Accident, EDF-4953, July 15, 2004

I. PISA ASSESSMENT

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a. Is there a potential inadequacy in the analytical methodology and/or tools used in the safety basis?
☒ Yes ☐ No

b. Is there a potential discrepancy between the safety basis assumptions, provisions, or conditions, in the accident analysis and the facility operation or parameters?
☒ Yes ☐ No

c. Is the actual physical condition of the facility different than as described in the safety basis (discrepant as-found condition)?
☐ Yes ☒ No

d. Has an actual or postulated operational event or incident revealed a potential inadequacy in the safety basis?
☐ Yes ☒ No

Provide an explanation of the assessment result:

The application of the temperature difference over the limited span of the measurement rather than the entire length of the reference leg is a potential inadequacy in the methodology used to derive the operating limit. The additional uncertainty introduced by the potential temperature differences could result in plant operation outside of the analytical limits derived in the safety basis.

R. T. McCracken USQ Evaluator Print/Type Name	USQ Evaluator Signature	1-3-05 RTM 1-3-05 Date
D. W. Suthers Nuclear Facility Manager Print/Type Name	Nuclear Facility Manager Signature	1/3/05 Date

If the answer to ALL of the assessment questions above is No, file the completed form.

If the answer to any one of the assessment questions is Yes, there is a potentially inadequate safety analysis (PISA):

- Nuclear Facility Manager document actions (Section **II**), including interim operating restrictions, taken to place or maintain the facility in a safe condition.
- Nuclear Facility Manager execute reporting process per MCP-190, for PISA.
- USQ evaluator proceed to Section **III**.

II. DOCUMENT ACTIONS TAKEN TO PLACE OR MAINTAIN FACILITY IN A SAFE CONDITION

At the time of discovery the ATR was in an extended outage to complete a core internals changeout. No immediate action was necessary.

The increase in EFIS actuation setpoint from an analytical limit of 17 psia to 28 psia must be completed prior to operation in the POWER OPERATION MODE.

EDF-4935 evaluates an increase in the emergency firewater injection system (EFIS) actuation pressure setting to ensure an air entraining vortex does not form in the surge tank. The analytical limit is raised from 17 psia to 28 psia. This change is scheduled to be implemented at the end of the core internals changeout. A scoping calculation was performed with the EDF-4935 model to examine the effect of raising the initial air volume from 60 cubic feet to 68 cubic feet. As shown in the attached figure, the surge tank water level remains above the required submergence level indicating that an air entraining vortex will not form thus the increased EFIS actuation setpoint can compensate for the additional surge tank uncertainty until additional evaluation is performed.

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The potential for operation with the initial air volume less than 40 cubic feet is not likely and compliance to ATR plant protection criteria margins limits is not strongly dependent on the minimum air volume. The current operating limit would limit the minimum air volume to 38 cubic feet even with the maximum error applied. Therefore, no interim action is necessary to preclude the potential for low air volume.

III. DETERMINATION

Identify applicable section(s) of the safety basis document(s) (i.e., SAR, BIO, TSRs, OSRs).

Upgraded Final Safety Analysis Report for the Advanced Test Reactor, SAR-153, August 10, 2004, Section 15.6, Decrease in Primary Coolant Inventory

Upgraded Final Safety Analysis Report for the Advanced Test Reactor, SAR-153, August 10, 2004, Chapter 16, Derivation of Technical Safety Requirements

Technical Safety Requirements for the Advanced Test Reactor, TSR-186, LCO 3.3 4, Surge Tank LevelAugust 10, 2004

IIIa: POTENTIAL FOR AN INCREASE IN PROBABILITY OR CONSEQUENCE OF AN ACCIDENT OR MALFUNCTION EVALUATED IN THE SAFETY BASIS

1. Could the PISA increase probability of occurrence of an accident previously evaluated in the safety basis?
   Yes ☐ No ☒
   Explain:
   The issue under evaluation is an initial condition for the accident analyses. The state of this initial condition does not impact the probability of occurrence of an accident evaluated in the safety basis.

2. Could the PISA increase the consequences of an accident previously evaluated in the safety basis?
   Yes ☒ No ☐
   Explain:
   The analysis for a LOCA with a concurrent failure of the LOCA PCP shutoff system assumes the primary pump output is not degraded by air drawn from the surge tank. Since there is an increased potential for air to be drawn from the surge tank, the consequences of this event may be increased.

3. Could the PISA increase the probability of occurrence of a malfunction of equipment important to safety previously evaluated in the safety basis? Yes ☒ No ☐
   Explain:
   The additonal uncertainty introduces the potential for operating with more air in the surge tank than currently analyzed. This potentially increases the probability that air may be drawn from the surge tank. Air from the surge tank may cause a malfunction of the primary or emergency coolant pumps.

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4. Could the PISA increase the consequences of a malfunction of equipment important to safety previously evaluated in the safety basis? Yes ☐ No ☒

   Explain:
   The change in the initial condition of the surge tank does not affect the consequences of a malfunction of equipment important to safety.

IIIb: POTENTIAL FOR CREATION OF AN UNANALYZED ACCIDENT OR MALFUNCTION OF A DIFFERENT TYPE

5. Could the PISA create the possibility of an accident of a different type than previously evaluated in the safety basis? Yes ☐ No ☒

   Explain:
   The change in the initial condition of the surge tank does not create the possibility of an accident of a different type than previously evaluated.

6. Could the PISA create the possibility of a malfunction of equipment important to safety of a different type than previously evaluated in the safety basis? Yes ☐ No ☒

   Explain:
   The change in the initial condition of the surge tank does not create the possibility of a malfunction of equipment of a different type than previously evaluated.

IIIc: POTENTIAL FOR REDUCTION IN A MARGIN OF SAFETY

7. Could the PISA reduce a margin of safety as defined in the safety basis? Yes ☒ No ☐

   Explain:
   Since there is potential to operate outside of the analytical limits defined in the safety basis there is a potential reduction in the margin of safety.

IIId: USQ DETERMINATION CONCLUSION

8. Based on the responses to questions 1 – 7 above, does the PISA constitute an Unreviewed Safety Question? Yes ☒ No ☐

   Explain:
   Based on the above discussion the PISA does constitute an unreviewed safety question.

NOTE: If USQ determination result is positive, additional notification for ORPS is required per MCP-190.

IV. APPROVAL/CONCURRENCE SIGNATURES

APPROVAL:

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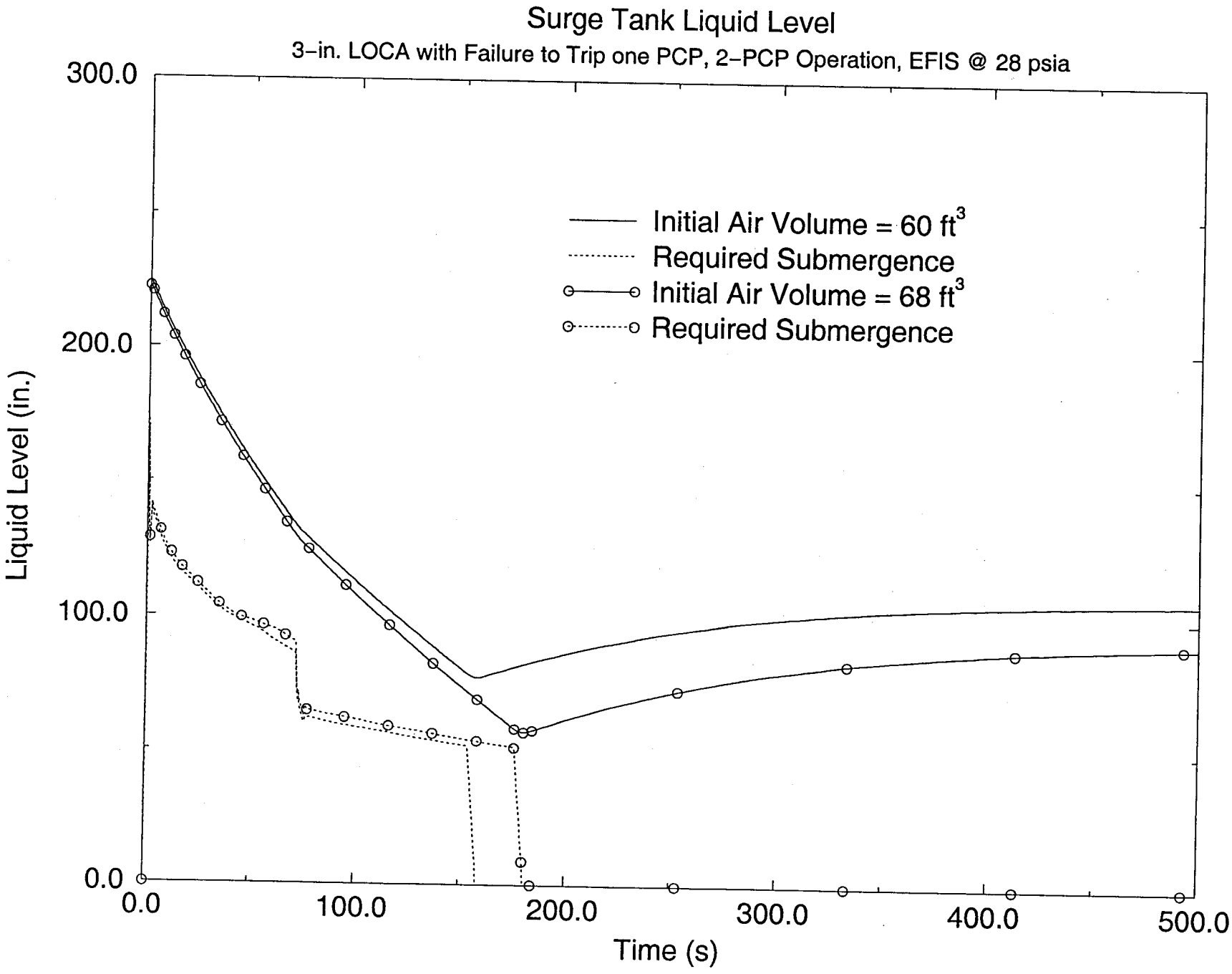
Print/Type Name	Signature	Date
R. T. McCracken USQ Evaluator	R. T. McCracken USQ Evaluator	1-3-05 / RTM 1-3-05 Date
D. W. Suthers Nuclear Facility Manager	D. W. Suthers Nuclear Facility Manager	1/3/05 Date

CONCURRENCE:

Print/Type Name	Signature	Date
A. P. Hoskins Independent Review Committee Chair	A. P. Hoskins Independent Review Committee Chair	1-3-05 Date


Surge Tank Liquid Level
3-in. LOCA with Failure to Trip one PCP, 2-PCP Operation, EFIS @ 28 psia
Initial Air Volume = 60 ft3
Required Submergence
Initial Air Volume = 68 ft3
Required Submergence
Liquid Level (in.)
300.0
200.0
100.0
0.0
0.0
100.0
200.0
300.0
400.0
500.0
Time (s)