

TENNESSEE VALLEY AUTHORITY

CHATTANOOGA, TENNESSEE 37401

400 Chestnut Street Tower II

December 3, 1979

Director of Nuclear Reactor Regulation  
Attention: Mr. L. S. Rubenstein, Acting Chief  
Light Water Reactors Branch No. 4  
Division of Project Management  
U.S. Nuclear Regulatory Commission  
Washington, DC 20555

Dear Mr. Rubenstein:

In the Matter of the Application of	)	Docket Nos. 50-327
Tennessee Valley Authority	)	50-328

Enclosed are TVA's responses to the questions on the water level measurement systems inside containment transmitted by your letter to H. G. Parris dated October 5, 1979. The Sequoyah Nuclear Plant Final Safety Analysis Report will be revised to be consistent with the enclosed responses.

The enclosed responses are based on modifications to the steam generator reference leg design (i.e., insulation) to be completed before initial criticality.

Very truly yours,

TENNESSEE VALLEY AUTHORITY

*L. M. Mills*  
L. M. Mills, Manager  
Nuclear Regulation and Safety

Enclosure

1506 278

7912060 525

Boo/  
SE  
1/1

ENCLOSURE

RESPONSE TO L. S. RUBENSTEIN'S LETTER TO H. G. PARRIS  
DATED OCTOBER 5, 1979  
WATER LEVEL MEASUREMENT SYSTEMS INSIDE CONTAINMENT

1. Describe the liquid level measuring systems within containment that are used to initiate safety actions or are used to provide post-accident monitoring information. Provide a description of the type of reference leg used, i.e., open column or seal reference leg.

Response

Two types of level measurement systems used inside containment are described below along with the particular application:

- A. An open column reference leg is used for steam generator (SG) level measurement. The instrument is connected to the SG liquid by a condensate chamber at the upper tap. The liquid in the reference leg will be at essentially ambient temperature.

Steam Generator Narrow Range Water Level Safety Functions

- Turbine trip and feedwater isolation on high-high steam generator water level
- Reactor trip on low steam generator water level in coincidence with steam flow - feed flow mismatch
- Reactor trip on low-low steam generator water level
- Auxiliary feedwater pump initiation on low-low steam generator water level
- Post-accident monitoring function

Steam Generator Wide Range Water Level Safety Function

- Post-accident monitoring function

- B. A sealed reference leg is used for pressurizer level measurement. The instrument uses a seal liquid which is not part of the pressurizer liquid and has a physical barrier (a diaphragm) that transmits the hydraulic pressure from the liquid (steam) to the seal liquid. The diaphragm is located a sufficient distance from the condensate chamber to be at ambient temperature.

Pressurizer Water Level Safety Function

- Reactor trip on high water level
- Post-accident monitoring function

1506 279

2. Provide an evaluation of the effect of post-accident ambient temperatures on the indicated water level to determine the change in indicated level relative to actual water level. This evaluation must include other sources of error including the effects of varying fluid pressure and flashing of reference leg to steam on the water level measurements.

### Response

#### A. Reference Leg Heatup

High energy line breaks inside containment can result in heatup of level measurement reference legs. Increased reference leg water column temperature will result in a decrease of the water column density with a consequent apparent increase in the indicated steam generator water level (i.e., apparent level exceeding actual level).

The following formula can be used to calculate the magnitude of this bias:

$$E = \frac{H_L}{H} \left( \frac{\rho_{L,cal} - \rho_L}{\rho_{f,cal} - \rho_{g,cal}} \right)$$

where:

$E$  = level error due to reference leg heatup, as a fraction of level span,

$H$  = level span = vertical distance between narrow range taps on steam generator,

$H_L$  = height of reference leg,

= maximum vertical distance from lower tap to water level in condensing pot on upper tap. This must be determined for the limiting instrument connections,

$\rho_{L,cal}$  = water density at containment temperature and steam generator or pressurizer pressure for which the level indication system was calibrated. If this information is not available, an upper-bound density (lower-bound temperature) must be assumed.

$\rho_L$  = water density in reference leg at the time of interest

$(\rho_{f,cal} - \rho_{g,cal})$  = difference between saturated water density and dry saturated steam density at the steam generator or pressurizer pressure for which the level indication system was calibrated. An upper-bound pressure must be assumed.

This procedure is based on the assumption that the tubing from the upper and lower taps, below the elevation of the lower tap, have the same temperature at all times.

#### B. Reference Leg Boiling

In addition to the above reference leg density change under subcooled conditions, boiling could conceivably occur in the reference leg following depressurization of any steam generator with high containment temperature. This combination of conditions could only occur following a steamline or feedline rupture inside containment. If such boiling were to occur, it could cause a major bias in the indicated level for a short time period, in the extreme case indicating 100 percent level when the vessel is actually empty.

#### C. Coolant Density Changes

A bias in indicated water level may also be introduced by changes in pressurizer or steam generator pressure, due to changes in the density of the saturated water and steam within those vessels. While prediction of the effects of rapid depressurization requires complex calculations for each specific case, the bias which would exist at low power under quiescent conditions can be calculated directly, using the following formula:

$$E = \frac{H_L}{H} \left( \frac{\rho_{L,cal} - \rho_L - \rho_{g,cal} + \rho_g}{\rho_{f,cal} - \rho_{g,cal}} \right) + \frac{L}{H} \left( \frac{\rho_f - \rho_g}{\rho_{f,cal} - \rho_{g,cal}} - 1 \right)$$

where:

- E = level error due to density changes in both the vessel and the reference leg, as a fraction of level span,
- L = true water level in the vessel, above the lower level tap,
- $\rho_r$  = saturated water density at the pressure of interest,
- $\rho_g$  = dry saturated steam density at the pressure of interest, and other symbols have the same meanings as in Section A above.

3. Provide an analysis of the impact that the level measurement errors in control and protection systems (question 2) have on the assumptions used in the plant transient and accident analysis. This should include a review of all safety and control setpoints derived from level signals to verify that the setpoints will initiate the action required by the plant safety analyses throughout the range of ambient temperatures encountered by the instrumentation, including accident temperatures. If this analysis demonstrates that level measurement errors are greater than assumed in the safety analysis, address the corrective action to be taken. The corrective actions considered should include design changes that could be made to ensure that containment temperature effects are automatically accounted for. These measures may include setpoint changes as an acceptable corrective action for the short term. However, some form of temperature compensation or modification to eliminate or reduce temperature errors should be investigated as a long term solution.

Response

A. Steam Generator Narrow Range Water Level Trip Setpoints

The only high-energy line rupture within the containment for which the steam generator water level provides the primary trip function is a feedline rupture. For such a case the low or low-low water level trip must be actuated when the pressure difference between the narrow range level taps corresponds to a zero-level value. Thus the trip setpoints must be at or above the value that would be indicated at zero true level. Because large steam generator pressure changes are not expected before trip, only the reference leg heatup effects need be considered, and not the effects of system pressure changes.

The determination of the steam generator low-low level trip for Sequoyah is as follows:

Bottom of span (percent)	0
Normal channel accuracy (percent)	+5
Post accident transmitter error (percent)	+10
Insulated reference leg effects (post accident heatup) (percent)	+3, -0
TOTAL ERROR, percent of span	+18, -15
Trip setpoint	18 percent of span
Allowable setpoint	17 percent of span

The value of +3 percent, -0 percent used for reference leg effects was obtained from the formula in the response to question 2 part A, assuming that the reference leg temperature does not exceed 340°F before reaching the High containment pressure setpoint.

As the steam generator narrow range reference legs will be insulated and bounding temperatures are available, the formula in the response to question 2 part A has been used for each section of vertical length to which a discrete temperature can be assigned.

The above setpoint revisions will be made on those trip setpoints that provide primary protection for accidents that results in an adverse environment inside containment.

The recommended setpoints derived above result in operating restrictions. Westinghouse is therefore evaluating two alternate long term solutions which will permit the lowering of the steam generator water trip setpoints. The two systems under consideration are as follows:

- Mechanical compensation of sealed reference legs
- Temperature compensation of transmitter output

B. Pressurizer Water Level Trip Setpoint

No credit is taken for this reactor trip function following a high energy line rupture inside containment. Thus the trip setpoint need not be revised to include environmental errors.

4. Review and indicate the required revisions, as necessary, of emergency procedures to include specific information obtained from the review and evaluation of items 1, 2, and 3 to ensure that the operators are instructed on the potential for and magnitude of erroneous level signals. Provide a copy of tables, curves, or correction factors that would be applied to non-accident monitoring systems that will be used by plant operators.

Response

As listed in the response to question 1, the steam generator narrow range water level and pressurizer water level instruments are used for post-accident monitoring. Because of reference leg heatup and process variable changes, the indicated parameters may provide erroneous information to the operator following a high energy line rupture. The limits of allowable indicated water level are provided based on conservative upper bound error calculations from the response to question 2.

Indicated steam generator water level can be maintained within a range that will assure that adequate heat removal capacity exists. For Sequoyah this range of indicated water level is determined as follows:

	Maximum water level	Minimum water level
Transmitter error, total, adverse environment	+25 percent	-25 percent
Level reference leg, 90°F to 340°F	+15 percent	0
Process pressure error, 800-1100 psia @bottom of span	+1 percent	
@top of span		-4 percent
Total bottom of span	+40 percent	
Total top of span		-29 percent

Therefore, to assure the steam generator tubes are covered, the indicated water level must be greater than 40 percent. To assure the steam generator is not filled, the indicated water level must be less than 71 percent.

POOR ORIGINAL

1506 284

Indicated pressurizer water level can be maintained within a range that will ensure that a water level exists in the pressurizer. For Sequoyah this range is determined as follows (the reference leg error given below is a boundary analysis and may be reduced by further analysis):

	Minimum water level	Maximum water level
Transmitter error total	+25 per cent.	-25 percent
Level reference leg, 90°F to 340°F	22 percent	0
Process pressure error 200 - 2350 psia		
@bottom of span	+3 percent	
@top of span		-5 percent
Total bottom of span	+50 percent	
Total top of span		-30 percent

Therefore to assure a water level exists (i.e. not full or empty) the indicated water level must be greater than 50 percent and less than 70 percent.

Furthermore, a remote possibility exists that the fluid in the open reference legs may flash to steam in the depressurized steam generators following a secondary high energy line rupture. Therefore to alert the operator to the possibility of erroneous indications, the following caution will be inserted in all plant emergency instructions for indicated steam generator water level.

**CAUTION:** The operator should use several plant indicated variables to verify the existence of water level in one or more steam generators due to the possibility of erroneous level indication due to measurement system errors. The backup variables that should be used include auxiliary feedwater flow, steamline pressure and primary wide range  $T_{hot}$  and  $T_{cold}$ .

In particular, the operator should not rely upon steam generator water level indications in any depressurized steam generators following a high energy line rupture inside containment. This is due to the possibility of reference leg boiling.

1506 285