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SUBJECT: Forwards addl info re evaluation performed to determine min acuracy requirements necessary to fully benefit from reactor vessel level indication sys, per NUREG-0737, Item II. F. 2 & justification for sys accuracy of 10%.

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September 18, 1987

U.S. Nuclear Regulatory Commission
Document Control Desk
Attn: Mr. Carl Stahle
PWR Project Directorate No. 1
Washington, D.C. 20555

Subject: Inadequate Core Cooling Instrumentation
NUREG-0737 Item II.F.2
System Accuracy and Revised System Description
R. E. Ginna Nuclear Power Plant
Docket No. 50-244

Dear Mr. Stahle:

RG&E has implemented inadequate core cooling instrumentation including subcooling margin monitors, core exit thermocouples and a reactor vessel level indication system (RVLIS). This instrumentation has been included in the Emergency Operating Procedures used for response to plant events. At the request of the NRC Staff, additional information is provided with this letter which describes an evaluation that has been performed to determine the minimum accuracy requirements necessary to fully benefit from the RVLIS.

An evaluation of the Westinghouse Owners Group Emergency Response Guidelines was performed to establish a minimum accuracy design objective. This evaluation is presented in Attachment A. For worst case conditions an uncertainty of approximately 10% was determined to be an acceptable design objective.

An evaluation of the RVLIS, previously described in Reference 1, indicated that improved system uncertainty could be attained by making changes to the RVLIS algorithms and by decreasing the instrument span. The revised system is described in Attachment B. The worst case uncertainty for the revised system is 10% which meets the design objective.

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Reference 2, a generic evaluation of water level systems performed for the NRC by a consulting laboratory, suggests that system accuracy guidelines of 6% are acceptable, and a system accuracy of 15% and greater is probably not acceptable. Attachment A provides justification for the R.E. Ginna system accuracy of 10%.

Very truly yours,

Roger W. Kober

Roger W. Kober

Attachments

REFERENCES

1. RG&E to NRC letter from R.W. Kober to G.E. Lear "Implementation Report - Reactor Vessel Level Indication System" dated December 22, 1986

2. Paper presented at the ANS-ENS Topical Meeting on Thermal Reactor Safety, February 2 to 6, 1986 "Instrument Accuracy in Reactor Vessel Inventory Tracking Systems" by J.L. Anderson, R.L. Anderson, T.C. Morelock, T.L. Hauang, and L.E. Phillips

ATTACHMENT A

MINIMUM ACCURACY REQUIREMENTS

Emergency operating procedures prioritize recovery actions based upon the severity of the challenge to the plant. Each procedure establishes an optimal operating region within ultimate safety limits designed to address the potential consequences and concerns of the particular event in progress. Anticipatory safety limits define the optimal operating region and alert the operator to reduced safety margin so that preventative actions can be initiated. Safety limits detect existing challenges to plant safety so that appropriate function restoration procedures can be implemented on a priority basis. To successfully execute this prioritized response, plant process instrumentation must be sufficiently accurate to distinguish between the anticipatory safety limits and ultimate safety limits.

This evaluation examines the reactor vessel level optimal operating regions and safety limits identified in the Revision 1, Westinghouse Owners Groups Emergency Response Guidelines (ERGs) to establish the minimum accuracy requirement for RVLIS. It is intended to be used in the design of an accurate system which provides the maximum useful information to plant operators during plant emergencies. The accuracy requirement ultimately depends upon the implementation of RVLIS in the Ginna plant-specific procedures and may be greater than the generic design objective established in this evaluation provided appropriate adjustments are made in the plant specific setpoints.

[illegible]

[illegible]

System accuracy requirments have been determined for response to plant transients with the reactor coolant pumps (RCPs) on and the RCPs off. Only the pumps-off case is presented here in detail since this is the limiting condition for the Ginna RVLIS design.

OPERATING REGION AND SAFETY LIMITS

The ERG vessel level criteria for degraded core cooling presents a lower safety limit on coolant inventory for each of the procedures. This is a collapsed liquid level 3.5 ft above the bottom of the core and was selected to coincide with a mixture level below the top of the core. At lower vessel water levels, significant core heatup may occur.

An anticipatory safety limit for low vessel level is defined by the safety injection initiation criteria. Although core cooling remains adequate at this level, preventative actions to restore core cooling safety margin are performed.

The optimal upper limit on vessel level depends upon whether the procedure represents a subcooled or saturated recovery. For a subcooled recovery, the desired water level extends to full span. However, for those procedures requiring a saturated recovery, excessive inventory will unnecessarily increase leakage of reactor coolant. For these procedures, the maximum desired water level corresponds to saturation in the hot legs and is between the top of the hot legs and the top of the upper plenum.

[illegible]

The actual level corresponding to saturation in the hot legs depends upon the extent of mixing in the vessel upper plenum. With good mixing, the upper plenum fluid temperature and the hot leg temperatures will be approximately the same so that a collapsed liquid level less than the top of the upper plenum indicates saturation in the hot legs. For poor mixing conditions, the vessel level may reach the top of the hot legs. At higher levels the water may flash due to the hotter upper plenum causing a pressure increase which increases subcooling. Since the extent of mixing is uncertain, the reactor coolant system is assumed to be saturated in this analysis when the collapsed liquid level is midway between the upper support plate and the top of the hot legs. The uncertainty in this level is statistically combined with the allowance for process measurement uncertainty to determine the minimum accuracy requirement.

Excessive inventory in the reactor coolant system is prevented by safety limits on reactor coolant subcooling. No upper safety limits on vessel level exist. However, vessel level is ultimately limited by the span of the process instrumentation.

The anticipatory limits and safety limits on vessel water level for each of the emergency response guidelines correspond to one of four vessel elevations including 1) 3.5 ft above the bottom of the core, 2) the top of the core, 3) the collapsed liquid level corresponding to saturation in the hot legs, and 4) full span.

These anticipatory limits and safety limits are tabulated for each procedure in Table 3.1. Setpoints are derived from these limits so that the setpoint will assure the safety limit is not violated when instrumentation accuracy is considered.

The vessel level limits associated with Emergency Operating Procedures (EOPs) have been selected to fully achieve the objectives for which they were intended. In the case of a hot leg break, which is discussed in Reference 2, the upper limit, considering instrument error has been selected in ECA 1.1 and 3.2. to minimize loss of coolant inventory. The selection of limits is discussed in the next section. It should be noted that these cases are directly related to the minimum system accuracy requirement as shown in Table 3-2.

MINIMUM ACCURACY REQUIREMENT

The reactor vessel is divided into two regions to assess the minimum accuracy requirements. Region 1 is bounded by the lower safety limit and the lower anticipatory safety limit. Preventative actions, such as safety injection initiation, are performed in this region to restore core cooling safety margin. Region 2 is the operating region where the plant is controlled to maintain safety margin. It is bounded by the lower and upper anticipatory safety limits. The minimum accuracy requirement for each region is determined such that the maximum vessel level corresponding to the lower boundary setpoint is less than the upper boundary setpoint. This is equivalent to:

$$(E_{mar}^2 + E_{lb}^2 + E_{ub}^2)^{1/2} < UBS - LBS$$

where E_{mar} = minimum accuracy requirement

E_{lb} = uncertainty in lower boundary

E_{ub} = uncertainty in upper boundary

LBS = lower boundary setpoint

UBS = upper boundary setpoint

E_{lb} and E_{ub} are used to account for the uncertainty in the level (boundary) at which the reactor coolant system is assumed to saturate as previously discussed. E_{lb} and E_{ub} are zero for a physical boundary such as the top of the core.

For limits represented by explicit setpoint values, the region boundaries are related to the physical elevations in Table 3-1 by

$$LBS = LB + E_{mar}$$

and

$$UBS = UB + E_{mar}$$

where LB = lower boundary from Table 3-1

UB = upper boundary from Table 3-1

For implied limits on vessel level, the associated region boundary is equivalent to the physical vessel elevation.

For example, the minimum accuracy requirement for the operating region of procedure ECA-3.2 is calculated from:

$$[E_{mar}^2 + (0.0)^2 + (4.8)^2]^{1/2} < 72.5 - 52.5 + E_{mar}$$

$$E_{mar} = 9.5\%$$

Table 3-2 shows the minimum accuracy requirements for each emergency response guideline. These results show that under worst case conditions, an accuracy of approximately 10% of span is sufficient to allow the reactor coolant system to be depressurized to saturation in the hot legs without reaching the conditions requiring safety injection in procedures ECA-1.1 and ECA-3.2. These results also clearly identify these procedures as limiting with respect to the accuracy of the RVLIS. For other procedures, an accuracy of greater than 20% is sufficient.

A maximum uncertainty of 10% of span for worst case conditions is, therefore, considered to be the minimum design objective. No additional allowance for operating margin is included because the accuracy of the RVLIS increases as reactor coolant system pressure and temperature decrease (slope of the density curve is less at lower temperatures or pressures). Consequently, when safety injection pumps are stopped in ECA-1.1 or ECA-3.2, the accuracy of RVLIS will be better than the design objective. In addition, since the vessel level is maintained in the hot legs for these procedures, a relatively large change in reactor coolant inventory is necessary to decrease the indicated level. Therefore, a smaller operating margin is needed. It also appears that by using redundant indications of vessel inventory for safety injection initiation in ECA-3.2, such as reactor coolant subcooling and pressurizer level, larger uncertainty in indicated vessel level could be accomodated with no adverse effect on plant safety, i.e., when RVLIS is used in conjunction with other indications to perform an action, the uncertainty in RVLIS can be greater than if RVLIS is the only indication used to perform the action.

TABLE 3-1

VESSEL LEVEL SAFETY LIMITS FOR EMERGENCY RESPONSE PROCEDURES[1]

PROCEDURE	NOMINAL VESSEL LEVEL INDICATION (%)		
	LOWER SAFETY LIMIT	ANTICIPATORY LIMIT	
		LOWER	UPPER
ES-0.3	31.4 (e)	72.5 ± 4.8 (i)	100 (i)
E-3	31.4 (e)	72.5 ± 4.8 (i)	100 (i)
ECA-1.1	31.4 (e)	52.5 (e)	72.5 ± 4.8 (i)
ECA-3.2	31.4 (e)	52.5*(e)	72.5 ± 4.8 (i)
ECA-3.3	31.4 (e)	52.5 (e)	100 (i)
FR-C.1	31.4 (e)	52.5 (e)	100 (i)
FR-C.2	31.4 (e)	52.5 (e)	100 (i)
FR-P.1	31.4 (e)	72.5 (e)	100 (i)
FR-I.3	31.4 (e)	72.5 ± 4.8 (i)	100 (i)

[1]Ginna setpoint values correspond to WOG ERG values for 3.5 ft above the bottom of the core, top of the core, collapsed level corresponding to saturation in the hot legs and full span as appropriate for each procedure.

*This value deviates from the existing generic setpoint description. However, it is more consistent with the intent of the procedure and with safety injection initiation on vessel level in other procedures.

(e) explicit setpoint value
(i) implied limit

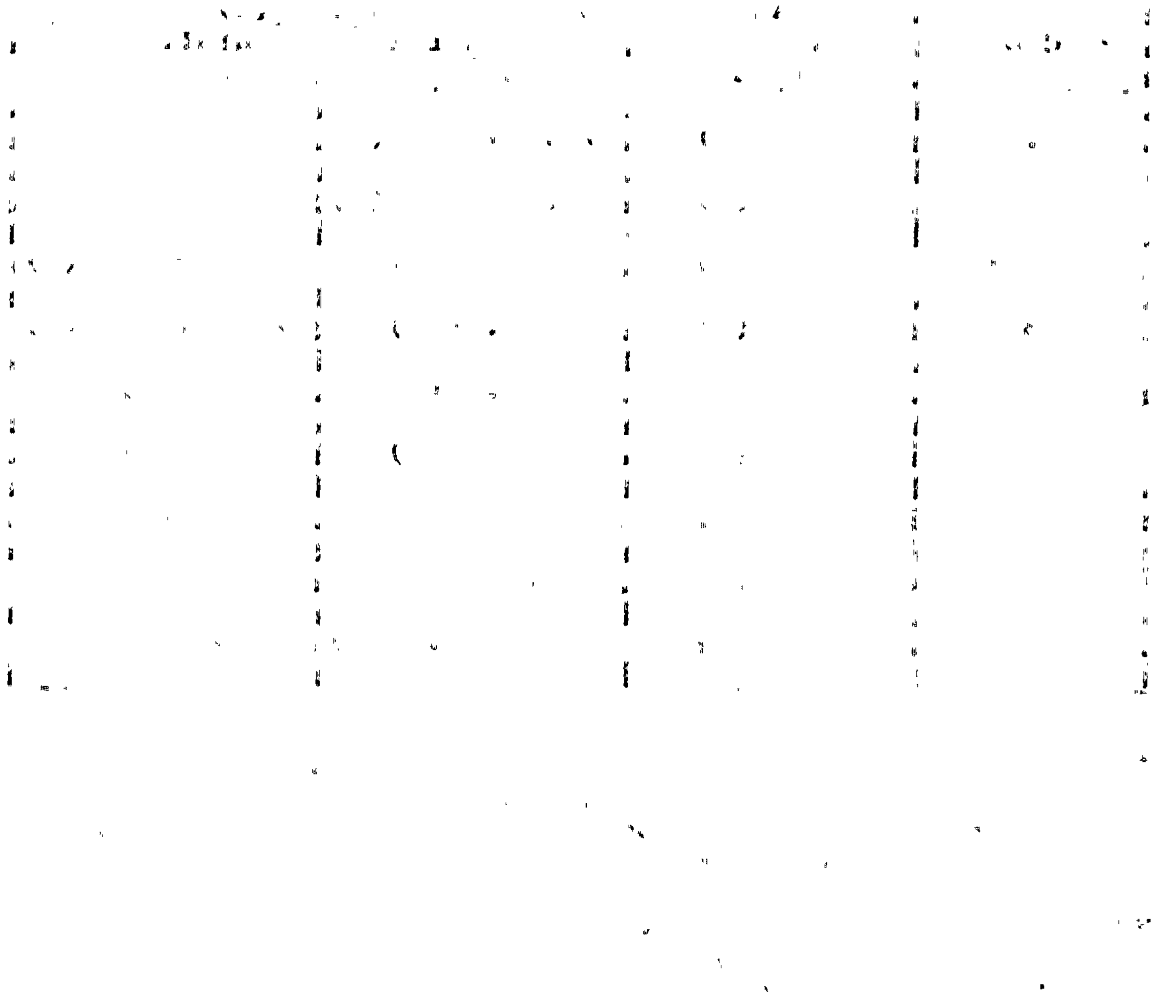

TABLE 3-2

MINIMUM ACCURACY REQUIREMENT

PROCEDURE	MINIMUM REQUIRED ACCURACY (%)	
	REGION 1	REGION 2
ES-0.3	20	27
E-3	20	27
ECA-1.1	21	9.5
ECA-3.2	21	9.5
ECA-3.3	21	24
FR-C.1	21	24
FR-P.1	21	24
FR-I.3	20	27

-2- [illegible]

[illegible]

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[illegible]	[illegible]	
		[illegible]
	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
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