A.2

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

April 30, 1982

Docket No.: See Attached Listing
LS05-82-

Mr. Ken P. Baskin, Chairman
CE Owners Group
Southern California Edison Company
Post Office Box 800
2244 Walnut Grove Avenue
Rosemead, California 91770

Dear Mr. Baskin:

SUBJECT: CE REACTOR VESSEL LEVEL MEASUREMENT SYSTEM USING HEATED JUNCTION THERMOCOUPLE

REFERENCE: TMI Item II.F.2

We have reviewed the CE reactor vessel level measurement system using heated junction thermocouples and found that additional information is required.

Accordingly, please respond to the enclosed request which has been previously discussed with you by May 15, 1982.

This request for information is within the purview of OMB Clearance Number 3150-0065.

Sincerely,

Dennis M. Crutchfield

Dennis M. Crutchfield, Chief
Operating Reactors Branch #5
Division of Licensing

Enclosure:
Request for Additional
Information

cc w/enclosure:
See next page

XA

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REQUEST FOR ADDITIONAL INFORMATION ON CE REACTOR VESSEL LEVEL MEASUREMENT SYSTEM USING HEATED JUNCTION THERMOCOUPLES

1. Provide an analysis of the response (with the reactor coolant pumps running) of the heated junction thermocouple level measurement system (a) with the full length separator tube, and (b) with the split separator tube in the System 80 plants. Also discuss the instructions to the operator for interpretation of the indications.

2. Provide an analysis of the response of the heated junction thermocouple level measurement system with a break in the upper head (a) with the full length separator tube, and (b) with the split separator tube in the System 80 plants. Also discuss the instructions to the operator for interpretation of the indications.

3. Provide an analysis of the response of the heated junction thermocouple level measurement system after a large break LOCA. In particular how will the level inside that separator tube compare with the level outside, taking into account the drain rate of the separator tube. What instructions will be provided the operator for interpretation of the indicators?

4. Describe the effects of failure of the following components of the heated junction thermocouple level measurement system with respect to measurement system response, information presented to the operator, and effects on recovery from an abnormal transient.

A. Sensor

1) Single thermocouple failure in a single sensor. The thermocouple is assumed to fail by a break in at least one thermoelement that would result in an open circuit.

a. Would the automatic checking procedure detect the fault before the Q SPDS continued to record data?
b. What would happen to the differential output?

2) Heater failure in a single sensor. The heater is assumed to fail by a break in the heater element that would result in an open circuit.

a. Would the automatic checking procedure detect the fault before the Q SPDS continued to record data?
b. What would be the effect on the other heaters in the same string?

3) Assume a rupture in the sensor sheath so that coolant is admitted into the sensor.

a. Would the automatic checking procedure detect the fault before the Q SPDS continued to record data?
b. What would be the effect on the heater in the affected area, and other heaters in the same string?

B. Probe

1) Reactor vessel seal failure.

C. Cables

1) Assume failure of connector.

a. Complete failure of connector.
b. Partial failure (only some of the connections fail).

2) Severed cable.

3) Wet connector.

4) Incorrect wiring at connectors (or any other location inside containment).

A common error in large installations is the incorrect wiring of the thermocouple extension cables by connection of the Alumel extension lead to the Chromel thermoelement et cetera. Under stable containment conditions this could produce an offset. If the temperature of the containment were to rise, much larger temperature errors could result. This situation should be analyzed for the effect on both the thermocouple signals from the individual thermocouples and the differential signals.

D. Control Circuit

1) If the heater supply is designed for fast response, rapid fluctuations in the control signal can induce oscillations in the heater supply output. This in turn could cause heater failure by overheating or fatigue.

A.3

Phillips

APR 1 1982

Mr. Fred Cadek
Westinghouse Electric Corporation
Box 355
Pittsburgh, Pennsylvania 15230

Dear Mr. Cadek:

As you know, the NRC is presently reviewing its requirements concerning Inadequate Core Cooling (ICC) instrumentation. Design requirements are specified in Section II.F.2 of NUREG-0737, and in Appendix B of that document. In the course of our review, it has come to our attention that some aspects of our design requirements, e.g., the seismic qualification for core exit thermocouples, may impose a cost burden for some plants which is not justifiable in terms of the potential need and benefits derived from that aspect of the design.

Please provide us with cost data which show the costs associated with the various design alternatives for inadequate core cooling instrumentation described in the table below. This data will be used by the NRC for the purpose of a cost/benefit evaluation to determine if some of our existing requirements can be relaxed while still meeting the safety objectives of the ICC instrumentation system.

The table identifies five design options which we want to consider. In addition, we would appreciate industry comments and cost estimates concerning a sixth option, which would be your recommendation for an optimum design based on value/impact considerations. This may, of course, be identical to one of the identified five options. Estimates for both forward fit (new plant design) and backfit (new plant design modifications and operating reactor design upgrade) are desired and should be clearly identified.

For purposes of your cost estimate, you should assume that the NRC will require all of the instrumentation identified in the first column of Table I as a minimum ICC instrumentation system. Assume that the current designs of the Westinghouse RVLIS system and the Combustion Engineering Heated Junction Thermocouple (HJTC) system meet the inventory monitoring requirements with reactor coolant pumps off. You can also assume for these cost estimates that other differential pressure (d/p) measurement concepts are acceptable in principle for inventory monitoring with the pumps off if they include pressure sensing taps from the reactor vessel head to the lowest level of the hot leg and from the top of the hot leg candy cane for B&W designed reactors. Assume also that the Westinghouse d/p monitor and the Combustion Engineering HJTC system provide adequate inventory trending with pumps on. Other concepts which are acceptable in principle for trending the primary coolant liquid inventory content or void with pumps on are based on pump power or pump current measurements.

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For all design options, assume that NRC will require high Quality Assurance standards for design, construction and installation in conformance with Appendix B 10 CFR Part 50. Any option recommended by you should be described and cost/benefit considerations should be discussed. The benefit of a design option should be assessed in terms of its contribution to ICC monitoring system reliability, capability to avoid plant down time for maintenance, need for multiple channels to verify the information during an accident or to prevent plant shutdown due to ICC system unavailability, performance under expected environmental conditions, protection against ambiguity because of failure under harsh environmental conditions, and special problems associated with separation requirements for safety grade and non-safety grade instrumentation. If you recommend design requirements other than those associated with the traditional safety grade of equipment, please be explicit. For example if a power source need not be Class 1E, we would still expect it to be of some specified high reliability and battery backed if momentary interruption is not tolerable.

We request that you provide us with your cost estimates by April 19, 1982. Thank you for your cooperation.

Sincerely,

/S/

Roger J. Mattson, Director
Division of Systems Integration

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IDENTICAL LETTERS TO:

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*SEE PREVIOUS CONCURRENCE

OFFICE	DSI:CPB	DSI:CPB	DSI:AD:CPS	DSI:DIR				
SURNAME	*LPhillips	*CBerlinger	*LRubenstein	RMATTSON				
DATE				4/ 1 /82				

TABLE I

COST/BENEFIT STUDY

FOR ICC INSTRUMENTATION

Cost of Design Options ($/Plant)

Instumentation	1	2	3	4	5	6
Core Exit Thermocouples						
Subcooling Margin Monitor						
Inventory Trending with RCS Pumps Off						
Inventory Trending with RCS Pumps On						

DESIGN OPTIONS

1. Reference Design - meets NUREG-0737 design requirements.
2. Delete all seismic design requirements from reference design.
3. Delete environmental qualification requirements, except seismic, from reference design.*
4. Delete single failure design requirements (redundancy) from reference design.
5. Delete Class 1E power source requirement from reference design.
6. Respondents' Recommended Design (Describe differences relative to Option 1)

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* In this option, when we say "delete environmental qualification", we mean that there need be no qualification by testing under expected accident conditions, but the equipment would be expected, by design or analysis, to survive and function under design basis accident conditions.

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

A.

APR 2 1982

MEMORANDUM FOR: William J. Dircks
Executive Director for Operations

FROM: Victor Stello, Jr., Chairman
Committee to Review Generic Requirements

SUBJECT: MINUTES OF CRGR MEETING NO. 11

The Committee to Review Generic Requirements met on Wednesday, March 24, 1982, from 1-5 pm. Attendance at the meeting is shown in the Enclosure. The following matters were considered:

1. Mr. Guzy of RES presented the proposed Regulatory Guide SC78-4, "Qualification and Acceptance Tests for Snubbers Used in Systems Important to Safety." The Committee requested that further information be provided on the questions below in order that the Guide can be reconsidered at a future meeting.

   (a) In view of the potential $20-40 million cost that could result from implementing the proposed Reg. Guide,

   - what safety problems would be corrected by this Guide that warrant these costs?
   - are there less costly alternatives?
   - to what degree would snubber problems still persist because of improper installation, maintenance or operational problems?

   (b) What is the expected increase in occupational exposure associated with implementing the proposed Reg. Guide?

   (c) Are there less prescriptive alternatives than Appendix A, which appear to be a purchase specification for snubbers, to achieve the goal of improved snubber performance?

   (d) Why and to what extent is 10 CFR 50 Appendix B, Quality Assurance, required by the proposed Reg. Guide?

   (e) What is the safety basis for the proposed implementation plan?

   (f) What is the design basis for the acceptance criteria in the proposed Reg. Guide (for example, water hammer loads)?

   (g) Why is rule language, "shall" and "shall not," used in the proposed Reg. Guide?

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2. Dr. Mattson of NRR presented a status summary on TMI Action Plan Task II.F.2, "Instrumentation for Detection of Inadequate Core Cooling." The discussion centered on the instrumentation systems proposed by PWR vendors for measuring reactor coolant level. The Committee did not reach a decision on a recommendation concerning the proposed systems pending further information from NRR on total ICC system costs and certain other questions regarding how the system is to be used by the operators. Nonetheless, the Committee agreed with the general approach outlined by NRR.

The impetus for considering the need for additional instrumentation to detect inadequate core cooling came from the experience of TMI. One of the most important lessons from that accident was that the operators required more information on the status of core cooling during an accident than was available in the control room at the time. This realization led to early actions by NRC to require the installation of Subcool Monitors (SM) in PWR control rooms and to upgrade the number and quality of core-exit thermocouples (TC) in PWRs. Even with this added instrumentation, however, there remained, during a small LOCA, a period of time after the system reaches saturated conditions (indicated by SM) but before the core has boiled dry (indicated by TC) when the operators have insufficient information to track the inventory of coolant in the vessel and primary system. It was to fill this gap that NRR has required extensive further studies by the industry to determine whether additional instrumentation could be provided to monitor the status of core cooling.

Based on the discussions with NRR and review of extensive material prepared by NRR and industry, the Committee reached the following preliminary conclusions:

(a) Additional instrumentation to detect ICC would be highly desirable to complement the current package of Subcool Monitors and thermocouples.

(b) Rather than requiring an unambiguous indication of water level in the vessel (which is probably not possible), it is probably sufficient to require only a void indication or inventory tracking system to aid the operators in the period between saturation and core dryout.

(c) A differential pressure system and a heated junction thermocouple system appear to be acceptable methods for void indication or tracking inventory.

(d) Other means, such as reactor coolant pump electrical current suggested by the LOFT project, may also be beneficial for tracking coolant density (and hence inventory) under pumps on condition.

(e) The instruments comprising the ICC package should be viewed as a whole, not individually, and clear guidelines should be developed on the use and limitations of each instrument in the ICC package.

(f) If a void indication or inventory tracking system is utilized, it should not be made operational until after appropriate Emergency Operating Procedure Guidelines for the overall ICC package are reviewed and approved. The system should be factored into the task analysis portion of the Detailed Control Room Design Review by the licensee, and operators should be trained in its operation and limitations.

(g) The cost-benefit assessment should be based on consideration of the costs of the overall package, including the need for redundancy and qualification requirements.

The Committee requested that this topic be reviewed again after receipt of further information from NRR.

Victor Stello, Jr., Chairman
Committee to Review Generic Requirements

Enclosure: List of Attendees

cc: CRGR Members
Office Directors
G. Cunningham, ELD
Commission (5)
Regional Administrators

A-5 Summary of Westinghouse Owners' Group Responses to Concerns of the Failure Mode and Effects Analysis for Westinghouse DP Systems

For the Westinghouse DP system, the WOG has responded to the concerns (A.1 in Appendix A) about the effects on the measurement system response of the failure of critical components, including a break or leak in connecting lines or valves; plugging of connecting lines or ports; failure of the sensor diaphragm, the RTD on connecting lines or the overpressurization limit switches for hydraulic isolators; failure of connectors at the transmitter, failure of the signal or power cables and electronic transmitters for the DP transducer and failure of the processor (complete or partial).

The details of FMEA responses from WOG are summarized as follows:

(1) All connections to the reactor coolant system are orificed so that a break is not classified as a LOCA, and the charging pumps can make up the leakage. The increased charging flow would be one confirming indication of leakage.

Indications for the three standard system instrument ranges during (1) normal operation, (2) with a break in a single connecting line in the upper location, and (3) with a break in a single connecting line in the lower location are presented in the following table:

INSTRUMENT	UPPER RANGE	NARROW RANGE	WIDE RANGE
Normal indication, pumps on	Offscale Lo	Offscale Hi	100%
Normal indications, pumps off	100%	100%	33%
Upper connection location	Vessel Top	Vessel Top	Vessel Top
Indication with break	Offscale Hi	Offscale Hi	Offscale Hi
Lower connection location	Hot Leg	Vessel Bottom	Vessel Bottom
Indication with break	Offscale Lo	Offscale Lo	Offscale Lo

Except for a break in a hot leg connection with pumps on, at least one meter would provide a clear indication of a break in any connection. If the common vessel top or bottom connection failed, both trains of connected instruments would indicate the failure. Additional confirmation of a break would be provided by checking the volumetric displacements at the hydraulic isolator gauges in the containment penetration area.

If a leak developed in a connection, the pressure drop of the leakage flow would move the indicators in the same direction as a break. Since the instrument spans are relatively small, very little leakage flow would be required to produce an offscale indication.

In most cases, vessel level indications would not be available when a connection breaks or leaks, in which case the core exit thermocouples would provide the necessary indication for an ICC condition.

In the system provided for plants equipped with UHI, the upper connection for the narrow range and wide range instruments is on the hot leg. The indications with a break in a connection would be the same as for the standard system indications in the table above.

(2) Since the lines are cleaned, tested, filled and then sealed, and the ports are in low velocity, subcooled water areas, there is no mechanism that would cause plugging.

(3) The hydraulic isolator is provided with two diaphragms in series, with a water-filled volume between the diaphragms. A crack or pinhole leak in one diaphragm would have no affect on the system performance. If both diaphragms leaked, slow volume displacements could pass through the isolator without moving the diaphragms and the needle on the gauge, and the limit switch would not respond to a downstream leak. A large downstream leak, such as a break in the

capillary line, would most likely cause a displacement of the isolator diaphragms and closure of the internal valve, isolating the leak.

Periodic surveillance of the hydraulic isolator gauges would detect an abnormal (neutral) displacement resulting from a leak in both diaphragms.

(4) Switches operated by the hydraulic isolator displacement will provide an indication of an abnormal displacement of $\pm$ 0.4 cu. in. from neutral. Larger displacements are required to close either internal valve. If a switch failed, the operator would be advised immediately of an abnormal volume displacement. System operation would not be affected until the displacement actually closed a valve, and the dp transmitter would then respond. Periodic surveillance of the hydraulic isolator gauges would detect a displacement at or beyond the switch setpoint.

(5) Like the hydraulic isolators, the DP transducer is provided with two diaphragms in series, so there would be no effect on the system unless both diaphragms leaked. The dp transmitters are provided with overrange protection, i.e. internal valves that close when the transmitters move offscale. Therefore, no large differential pressure would be applied to the diaphragm to cause a failure.

(6) The electronic transmitter is basically a loop current regulating device consisting of a current amplifier, regulator, power supply and load. Each transmitter loop circuit is independent so that failure in the loop circuit only affects its corresponding main control board display. The display of the second train is not affected. The operator can detect a difference of the same two readings (Train A and Train B) and can institute troubleshooting procedures to determine the faulty loop circuit during plant operations. During refueling/maintenance outage, a calibration check is performed so that any malfunction can be identified and corrected.

(7) Model 752 Barton dp Transmitter uses a terminal block for hard wire connection for the incoming leads and for the connection to the amplifier card. The terminal block is designed with melamine separation between connection studs to ensure that electrical separation is maintained.

A loose terminal connection can result in no output or erratic output of the dp transmitter and can be detected by differences in the remote display readings by the operator and troubleshooting action can be initiated.

(8) Failure of the incoming cable to a dp transmitter will result in no output or erratic output of the dp transmitter resulting in differences between readings in the main control board displays which can be detected by the operator.

(9) Complete failure of the processor in the microprocessor RVLIS (Reactor Vessel Level Instrumentation System) is detected by a "deadman circuit" which, during normal operation, is reset by the processor at the completion of each update cycle.

At the end of each display update cycle, the processor program performs a sequence of tests to determine whether the program memory (PROM) has any altered bits and whether the read-write memory (RAM) has any faults. If faults are detected, an error message is displayed on both the local and remote digital displays and the caution level annunicator relay is actuated.

In cases of processor failure, both partial and complete, the operator is alerted that the system is malfunctioning by the actuation of the caution level annunicator. Level information is not displayed by a malfunctioning system so that incorrect data is not presented.

ORNL has reviewed WOG's responses to concerns of the FMEA for the Westinghouse DP System and found them to be satisfactory. ORNL has also found that the comprehensive nature of these responses show evidence of careful consideration of these factors during the design phase of the system.

A-6 Summary of Combustion Engineering Owners' Group Responses to Concerns of CE Heated Junction Thermocouple Responses to an Upper Head Break or a Large Break LOCA and a Failure Mode and Effects Analysis

For the Combustion Engineering HJTC System, the CEOG has responded to concerns (A.2 in Appendix A) about the effects of an upper head break or a large break LOCA on measurement system response and has provided an analysis of the failure mode for each critical component, including thermocouple sensor, heated junction thermocouple probe, cables, and control circuits.

The details fo the CEOG submittal are summarized as follows:

(1) For a postulated break in the upper head, the principal question is whether hold-up of two-phase mixture inside the separator tube might cool the HJTC sensors resulting in an indication of an unchanged water level while the water inventory outside the probe could decrease. Test results incidate that this is not the case. The separator tube provides a true indication of the collapsed level even under these conditions.

A top blowdown was simulated in the Phase II tests of the HJTC probe assembly. With the test vessel completely filled with water and at a pressure of about 1800 psig, a valve at the top of the vessel was opened. This initiated a blowdown from the top of the test vessel at a rate of about 10 psi/sec, which is about 10 times faster than during a small break. Three HJTC sensors were located about 54 inches apart at the top, middle and bottom of the separator tube which was placed inside the test vessel.

The differential temperature for the top and middle HJTC sensors increased in sequence after the blowdown valve was opened, indicating that the water level in the separator tube was receding from the top down in the same manner the water inventory outside the separator tube was receding. The test ended before the bottom sensor was uncovered. This test showed that a two-phase mixture that could keep the HJTC sensors cooled did not flow up the separator tube as a result of the top blowdown.

Based on present information, the response of the HJTC level measurement system to a break in the upper head is expected to be generally similar to the response for a break elsewhere in the primary system. Thus, the operator would not need any special instructions for this case.

(2) The HJTC System is intended to provide the operator with information that he can use in mitigating the consequences of a transient which produces a void in the reactor vessel. The blowdown portion of a large break LOCA occurs approximately during the first half minute of the transient and proceeds much too fast for the operator to take any action. Thus, the HJTC System is not designed to measure the collapsed water level during this time period. It will, however, measure the collapsed level during the reflood portion of a large break which proceeds at a much slower rate than the blowdown.

It is not expected that any substantial water hold-up will occur in the separator tube during a large break. There is one set of eight 9/32 inch diameter holes at both the bottom and at the top of the separator tube. This provides a flow area for drainage that is approximately equal to the inside area of the separator tube. The total volume inside a full-length separator tube is only about 0.05 ft^3. Thus, the flow holes in the separator tube pose no significant restriction to the escape of flashing steam or draining water. During a rapid depressurization like in a large LOCA blowdown, the water inside the separator tube is expected to flash and escape from the separator tube in the same time period as the water in the surrounding region flashes and is discharged from the primary system.

Phase II test results show that the water level inside the separator tube lags the level outside the separator by less than four inches for an outside drain rate of 5 in/sec. This agrees with calculations that have been performed for conservatively high drain rates outside the separator. Thus, the separator tube is capable of draining fast enough so that the level inside the tube is very close to the level outside the tube.

For a large break LOCA, it will be recommended that the operator disregard the indicated level until after the initial blowdown period is over and the reactor coolant system pressure has become stable. This blowdown period will last for only a short time during the initial part of the transient.

(3) The A/D circuitry uses a "flying capacitor" input isolation technique for the thermocouple (TC) inputs to the microprocessor. If a thermocouple circuit opens, an open TC detention circuit drives the capacitor to a full scale input voltage, which is detected in the microprocessor as a fault condition. The open thermocouple circuit has a fixed time constant which will take a few microprocessor cycles to drive the capacitor up to a full scale value and be detected. After detection that the thermocouple is failed, the microprocessor (μP) provides a fault indication at the operator display and disregards the TC input in all future calculations.

If the chromel wire from the heated junction breaks, the differential (ΔT) output will continue to increase until the microprocessor detects a full scale heated junction temperature voltage reading. Then the thermocouple input will be recognized as faulty and disregarded.

If the chromel wire from the unheated junction breaks, the differential output will continue to decrease and eventually go negative. This continues until the P detects an unheated junction voltage reaching the top of scale. The thermocouple input will be disregarded.

For a break in the alumel wire, common to the heated and unheated junctions, the differential output will remain essentially constant but will drift up as both heated and unheated inputs are driven to the top of scale value. The processor detects and alarms the open TC and will disregard its use.

(4) The heater controller used in the RVLMS is a time-modulated controller. When the control signal from the processor calls for full power, the controller delivers 100% power, 100% of the time. If the processor calls for 50% power (for example), the controller delivers 100% power for only one half of its duty cycle. The particular controllers utilized in the Heated Junction Thermocouple System have a duty cycle of 0.8 seconds. The sensor heaters and the controllers are sized such that full power is applied to all heaters during all normal operating conditions (i.e., when the sensors are covered, or at high pressure). In the event that uncovery occurs, the heater controllers may be called upon to reduce power to the heaters depending on the absolute temperature of any heated thermocouple or on the differential temperature of any sensor.

The heater control scheme uses a proportional control law in which the microprocessor heater control signal goes from 100% to 0% over a temperature input range of 200°F. This shallow slope prevents large changes in power from being applied for small changes in input temperature. Some heater power cycling has been observed to occur because of the sampling rate of the microprocessor.

During Phase III tests of the system, the fluctuations of the heated junction temperature have been observed to be relatively small, on the order of 10°F. These fluctuations are insignificant when compared to the temperature swings which result from uncovery or quenching of the sensor, and do not contribute significantly to heater fatigue.

ORNL has reviewed the CEOG response to concerns about an upper head break, a large break LOCA and the FMEA for the CE heated junction thermocouple system and has found the submittal to be satisfactory. ORNL has also concluded that the comprehensive nature of these responses is indicative of CE's careful consideration of these factors during the design phase of the system.