11F23 om 8115

GE Nuclear Energy

ABWR

Date 7/7/93

To

Fax No. —

David Tang (11F23)
(504-1147)

This page plus 6 page(s)

From Jack Fox

Mail Code 782
175 Curtner Avenue
San Jose, CA 95125

Phone (408) 925- 4824

FAX (408) 925–1193
or (408) 925–1687

Subject RPV water Level Instrumentation Instrumentation - Diversity

Message Please provide a copy of the attached writeup to George Thomas, et al. We would like to discuss this during the 7/9/93 Conference Call.

Jack Fox

DRAFT

ABWR REACTOR WATER LEVEL SYSTEM CAPABILITIES.

Plant operations provide GE an invaluable source of data that serves to quantify equipment reliability, the ease and/or difficulty of performing routine maintenance and surveillance operations, to name a few. Most recently, plant operational concerns of Reactor Pressure Vessel (RPV) water level instrumentation inaccuracies due to non-condensable gas evolution during depressurization events has led to suggestions that the Advanced Boiling Water Reactor (ABWR) RPV water level instrumentation should be diverse within itself. GE has assessed this perspective, studied the related phenomenon, and has proposed to the United States Nuclear Regulatory Commission (NRC) staff design modifications to the ABWR RPV water level instrumentation that fully address the observed anomaly. GE believes this simple but rugged differential pressure (Δp) manometer concept employed in its ABWR RPV water level instrumentation reliably performs its safety function. The following discussion provides the rationale for this conclusion.

The concept of diverse RPV water level monitoring instrumentation is not a new one. After the TMI-2 event, there were a number of studies done by GE, NRC and others to determine whether changes and/or diverse instrumentation should be employed (e.g., NUREG/CR-3652). The conclusion then was that the Δp devices were rugged and simple. Shortcomings identified were due to installation geometries. Alternative possibilities were identified and ruled out due to complexity, lack of capability to survive in a harsh environment (i.e., near the reactor) and the existence of other information that would allow plant operations personnel to take appropriate action even if the water level indications were inaccurate. Nine years have transpired, and the subject is once again brought up, albeit in a different context -- then, it was boiloff due to high drywell temperatures after LOCA, now it is non-condensable gas evolution. However, the conclusions are the same. The Δp manometer is simple, rugged, does not suffer age-related degradation and has a fundamentally excellent track record. The correct response to indicated problems is to fix the design, rather than attempt to adopt an as-yet unqualified technology for this application.

The fundamental accuracy of the RPV water level instrumentation has not been questioned for steady-state operation, whether at power or during shutdown. It has been questioned during transients with significant blowdown. For such cases, it has been demonstrated that the appropriate safety actions would occur <u>before</u> significant inaccuracies could occur.

The Δp RPV water level monitoring instrumentation currently specified for the ABWR design is the same as that employed on many GE Nuclear Energy operating Boiling Water Reactors (BWRs) worldwide. The ABWR design utilizes Δp sensors for monitoring the RPV water level over multiple and overlapping ranges, i.e., the narrow range, wide range, and fuel zone range. Redundant instrument lines and instrumentation have been specified. The ABWR design has four redundant divisions of instrument lines and instrumentation for the RPV water level ranges which are employed to generate the safety-related function trip signals. The water level data sent to the control room is self-checked within a division and compared periodically by the plant operator with the redundant divisional information. Errors are immediately flagged for the maintenance crew to make any necessary repairs. Redundant channels in all ranges also are provided for monitoring information.

The RPV water level measurement system for the ABWR does contain a certain amount of diversity. The diversity is provided in instrument line routing, signal transmission from the primary element (Δp transmitter) to the control room, and control room display of the RPV water level. The only area where common mode failure is a concern is the instrument lines and the Δp sensors. The ABWR has four independent sets of instrument lines, one for each division. The routing of these instrument lines, from the RPV to the Δp sensors, is expected to be different for each division. The unique arrangements of the four sets of instrument lines preclude simultaneous and identical indication errors resulting from phenomenon associated with the instrument lines and the Δp sensors.

In addition, the ABWR design for the RPV water level measurement system incorporates the lessons learned from operating BWR experiences, and consequently is expected be highly reliable. The known problems which have been experienced, or have been postulated to occur during certain transient conditions, with the Δp RPV water level instrumentation on the operating BWRs have been addressed in the ABWR design. This includes:

> Minimizing the vertical drop of the RPV reference leg water level instrument lines within the drywell to reduce the loss of accuracy due to flashing of the water column after LOCAs. When the RPV pressure is low and the drywell temperature is high (i.e., sufficient to cause the water in the RPV reference line instrument lines to flash to steam) the water in the RPV reference leg water level instrument lines may flash to steam, resulting in a loss of water level accuracy. Minimizing the vertical drop of the RPV reference leg water level instrument lines within the drywell minimizes such loss of accuracy.
>
> Back-fill of the RPV reference leg water level instrument lines with water supplied from the Control Rod Drive (CRD) System to eliminate the build-up of non-condensable gasses in the water in the RPV reference leg instrument lines. Water rich in non-condensable gasses at the surface of the condensing chambers may be drawn into the RPV reference leg water level instrument lines should this line have any leaks. When the RPV is depressurized, the non-condensable gasses may come out of solution, displacing water in the instrument lines, resulting in a loss of accuracy due to the loss of water column. Back-filling the RPV reference leg water level instrument lines prevents the water rich in non-condensable gasses at the surface of the condensing chamber from flowing into the instrument lines.

With regard to threats for uncovering the core during shutdown, the ABWR is much improved over earlier BWR designs. The RPV Shutdown Cooling (SDC) Mode suction line nozzles are located about 5 feet above the Top of the Active Fuel (TAF), which limits how far the Residual Heat Removal (RHR) System can empty the RPV to a level about 5 feet above the TAF. In earlier BWRs, the RHR System could empty the RPV to an elevation corresponding to about 2/3 the core height. In addition, the

RHR System logic contains interlocks which, when in the SDC Mode, prevents pumping or draining water from the RPV to other locations in the plant.

In the ABWR, there would be other indications to alert the operating crew to take action, independent of indicated RPV water level. These are completely independent of the Δp RPV water level instrumentation. Some examples are listed in Attachment 1. The ABWR Emergency Procedure Guidelines (EPGs) instruct the plant operator to scram the reactor and flood the RPV should it be concluded from all the available information that the RPV water level is indeterminate. Plant Operator suspicions of abnormal RPV water level could arise from a number of causes, such as the alternative indications as noted in the attachment, or due to observations of abnormal behavior of the water level indications.

Summary

ABWR water level instrumentation is rugged, simple and highly redundant for failure tolerance. All known operating plant problems have been addressed in this design, and it is incredible to postulate simultaneous common-mode failures which would yield identical errors in all the Δp instrumentation. Alternative technologies are unqualified for this application; further, there is no need to add this complexity, since the plant operating staff has ample additional indications of an impending problem without relying solely on water level. The EPGs direct the operator to use all information available to him and make conservative (safe) decisions.

ATTACHMENT 1: INDICATIONS OF INADEQUATE RPV WATER LEVEL WHICH ARE INDEPENDENT OF THE ΔP RPV WATER LEVEL INSTRUMENTATION

1. During power operation, i.e., an unscrammed reactor.

A. High Steam Moisture. Should the actual RPV water level fall below the bottom of the steam dryer skirt, which is just below the RPV low water level scram setpoint, the steam dryer is bypassed, and high moisture content steam would enter the steam lines. This would result in high vibrations in the Main Steam Turbine, which would be alarmed and cause an automatic trip of the Main Steam Turbine. As the RPV water level drops further, carryunder of steam from the steam separators would increase causing fluctuations in the reactor recirculation flow. This would be noticeable as fluctuations in reactor power core flux and Turbine/Generator electrical output, if the reactor has not scrammed as a result of the trip-off of the Main Steam Turbine.

B. Reactor Power. Should the actual RPV water level fall to the level which uncovers the feedwater (FW) spargers, the incoming feedwater would quench steam in the RPV. This would cause reactor pressure fluctuations as core inlet subcooling is decreased. This would be detected from the amount of electrical generation as well as changes in neutron flux as seen by the Average Power Range Monitors (APRMs) and Local Power Range Monitors (LPRMs). The plant operators would normally respond to such abnormal indications by manually scramming the reactor.

C. Core Neutron Flux. Should the actual RPV water level fall below the Top of the Active Fuel (TAF), the neutron flux sensed by the APRMs and LPRMs would decrease. The LPRMs are located at different elevations within the fuel region of the RPV. The "D" LPRMs are located at the highest elevation, followed by the "C" LPRMs, the "B" LPRMs and the "A" LPRMs. As the core bypass zone uncovers due to the falling water level, the "D" LPRMs would see a systematic reduction in the sensed neutron flux due to the loss of the moderator at these elevations. The LPRMs provide input to the APRMs. The plant operators would normally respond to such abnormal indications by manually scramming the reactor and starting or increasing water injection to the reactor.

D. Recirculation Flow Control System (RFCS) Responses. If the actual RPV level decreased, with no scram, the Reactor Internal Pump (RIP) Net Positive Suction Head (NPSH) would decrease with accompanying RIP core flow decrease. This abnormal condition will produce high RIP motor vibration Main Control Room (MCR) alarms. If the RFCS is operating normally in the "auto core flow control" mode, the RFCS will automatically increase RIP speed until the 1,500 rpm limiters stop the speed increase. In that condition and low flow due to unavailable NPSH, the core flow will decrease causing a low flow scram. This scram is completely independent of the RPV low water level scram. The low core flow will also cause a reduction in power output (steam flow) and LPRM and APRM signals. The plant operators would normally respond to such abnormal plant indications by manually scramming the reactor.

The above discussion assumes normal plant power operation. During accident conditions, e.g., LOCA, there is ample information other than RPV water level on which to base automatic or manual actions. These include drywell pressure, suppression pool temperature, high steam line flow, steam tunnel temperature, reactor building compartment sump levels, low-level radiation monitors throughout the reactor building and other inputs from the Leak Detection and Isolation System (LDS).

2. When the reactor has been shutdown, i.e., the reactor is scrammed, but the RPV head is on the RPV.

A. Residual Heat Removal (RHR) System Instrumentation. The RHR System instrumentation may be used to determine the RPV water level when the RHR System is placed in the Shutdown Cooling (SDC) Mode. The RHR System instrumentation can be used to detect when the RPV water level is at the elevation of the RPV SDC Mode suction line nozzles. It should be noted that, for the ABWR, the RHR System SDC Mode suction line nozzles are located about 5 feet above the TAF. The RHR System has flow monitoring instrumentation. When in the SDC Mode, should the RPV water level fall below the level of the RPV SDC Mode suction line nozzles, the RHR System will generate a low flow alarm due to the loss of suction.

Also, when operating the RHR System in the SDC Mode, should the RPV water level fall below the RPV SDC Mode suction line nozzles, RPV pressure would increase to the pressure regulator setting (if the Main Steam Isolation Valves (MSIVs) are not closed) as a result of decay heat generating steam. In this condition, RHR System is incapable of removing heat from the RPV. Because of the low RPV pressure setting for isolating the RHR System SDC Mode suction lines (about 135 psig), there is also the potential for automatically isolating the SDC Mode suction lines on high RPV pressure. This isolation initiates a control room alarm.

B. Reactor Water Cleanup (CUW) System Instrumentation. The CUW System is a system which is normally in operation. Barring receipt of one of its isolation signals such as low RPV water level, this system is expected to run continuously whenever the RPV head is installed.

The ABWR CUW System draws suction from one of the RHR System SDC Mode suction line nozzles and the RPV bottom head drain line. These two suction lines join inside the primary containment. The suction line flow instrumentation is located downstream of where these two lines join. In addition, flow instrumentation downstream of each CUW System pump, provides input to a low pump discharge flow alarm.

The setpoint for the low pump discharge flow alarm is likely to be set above the flow which can pass through only the RPV bottom head drain line. Therefore, this CUW System low pump discharge flow alarm may indicate that the RPV water level has fallen below the level of the RHR System SDC Mode suction line nozzle.

C. Area Radiation Monitoring (ARM) System. When the drywell concrete shield blocks are removed in preparation to remove the RPV head, should the RPV water level have dropped substantially below its expected level, but still above TAF, the ARM System radiation sensors located on the Refueling Floor or Refueling Platform will indicate high radiation due to the loss of shielding provided by the water.

3. When the reactor has been shutdown, i.e., the reactor is scrammed, and the RPV head is removed from the RPV.

During this mode of operation, with respect to the concerns about loss of water from the Δp water legs are reduced due to the high flood level, about 23 feet above the RPV shell flange. Interlocks on the RHR System and plant operator awareness make the potential for level reduction very remote. In this condition it would take many hours for the reactor water to reach the boiling point, and many more to decrease significantly. During this time temperature conditions for the operating crew would become increasingly uncomfortable. In addition to those instruments identified under condition 2 above there are:

A. Visual observation. Visual observation of the water level in the RPV or Reactor Well assures that the core is covered.

B. Potential discharge location for RPV water. The RHR System and the CUW System have the potential for drawing water from the RPV. Due to the location of the RPV SDC Mode suction line nozzle which is about 5 feet above the TAF, the RHR System is limited to how much water it can remove from the RPV. The CUW System has the potential for completely emptying the RPV if the bottom head drain line is left open. However, the flow rate by this pathway is low – it will take more than an hour to lower the water level from the RPV flange to TAF.

The potential discharge locations for the CUW System and the RHR System, such as the Radiation Waste Tank and the suppression pool, have level monitoring instrumentation to alert the plant operator that RPV water is potentially being pumped, or draining, to other locations.

Should a break occur, the compartments containing the CUW System and RHR System piping and equipment have sump flow monitoring instrumentation, and will initiate control room alarms should sump flows be high. In addition, the Process Radiation Monitoring System (PRRM) System has radiation monitoring instrumentation which will detect high radiation in the compartments, should radioactive water from the RPV leak into these rooms.

< .TRANSACTION REPORT >

07-07-1993(WED) 19:46

[RECEIVE]

NO.	DATE	TIME	DESTINATION STATION	PG.	DURATION	MODE	RESULT
14450	7-07	19:42	408 925 1193	7	0°04'16"	NORM.E	OK
				7	0°04'16"		