Westinghouse Electric Corporation

Water Reactor Divisions

Nuclear Technology Division

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Mr. James M. Taylor, Director
Office of Inspection and Enforcement
U.S. Nuclear Regulatory Commission
Phillips Building
7920 Norfolk Avenue
Bethesda, Maryland 20014

Dear Mr. Taylor:

Subject: Notification of NRC of Shutdown LOCA Information Provided to Utilities

The purpose of this letter is to inform you that Westinghouse has recently provided information regarding a potential safety issue to all utilities with Westinghouse supplied PWRs.

As a result of NRC questions regarding the effects of the operational status of plant equipment during plant shutdown operation in Modes 3 and 4 on Emergency Core Cooling System, ECCS, performance, a review of Loss of Coolant Accident, LOCA, evaluations has been conducted. It has been determined from that review that:

1. Shutdown operating conditions are so far below the conditions for which the reactor coolant system has been designed that a large LOCA is not credible and for all practical purposes can be assumed not to occur; and

2. If a credible LOCA were to occur, operator actions can be taken to avoid exceeding the ECCS performance acceptance criteria. Certain combinations of operator actions and equipment availability are assumed in reaching the conclusion that ECCS performance would be acceptable in the event of a credible LOCA.

The Westinghouse Power Systems Safety Review Committee, SRC, was convened to review these determinations for any potential adverse effects on safety and for any obligation to report to the NRC any such effects. The SRC concluded that there were no potential adverse effects on safety with regard to large LOCA's. This conclusion is discussed in more detail below.

With respect to a credible LOCA, the SRC concluded that the evaluation of the potential effects of this matter on safety and reportability could not be completed without detailed knowledge which Westinghouse did not have regarding the operational status of plant equipment, operating procedures, and operator training for each of the plants potentially affected. Due to the fact that this information is the responsibility of the individual licensees, and would be necessary to complete the necessary evaluations, the SRC concluded that results of the evaluations that Westinghouse had performed should be sent to potentially affected utilities so that they can complete the necessary evaluations for their plants with respect to safety and reportability. Westinghouse has also consulted with representatives of the Westinghouse Owners Group on this issue.

The following information has been provided to utilities with Westinghouse PWRs to enable the individual licensees to make the determination as to whether or not their ECCS configuration or operating procedures during shutdown operation have any adverse impact on safety or constitute a reportable item.

I. BACKGROUND AND DESCRIPTION

SYSTEM CONFIGURATION

During shutdown operation the normal alignment of ECCS equipment is changed from that which is available during power operation. The cold leg accumulators are locked out at 1000 psig to avoid injection as the pressure is reduced. Some of the high head safety injection, HHSI, pumps are typically locked out at 350°F to reduce the possibility of overpressurizing the RCS at low temperature conditions. Typically only one high head safety injection pump is allowed operable below 350°F per Tech Specs. The automatic safety injection signal on low pressurizer pressure is blocked at approximately 1900 psig and the automatic safety injection signal on high containment pressure is typically not required to be available per Tech Specs at less than 350°F. The residual heat removal, RHR, pumps may be in the RHR cooling mode where suction is drawn from the reactor coolant system, RCS, hot legs.

PLANT CLASSIFICATIONS

For the purposes of this discussion, the plants can be grouped into two general classes. The class I plants are characterized by the fact that their RHR pumps also serve as the low head safety injection, LHSI, pumps. The class II plants have separate RHR and LHSI pumps. The rationale for these classifications will become evident in the following discussion. The plants in each classification are presented in Attachment I.

II. LOCA PROBABILITY

Below the RCS normal operating pressure, a rupture in RCS pressure boundary piping greater than 6 inches in nominal diameter is considered highly unlikely. Normal operation at 2000-2250 psig serves as a more severe (i.e., conservative) condition which demonstrates that pipe ruptures below normal operating pressure are highly unlikely. Specifically, engineering studies and operating experience have shown that through wall cracks in the RCS Class 1 pressure boundary piping, greater than six inches in nominal pipe diameter, are highly unlikely.

Even if a through wall crack is postulated at normal operating pressure, RCS pressure boundary leakage would be detected with existing leak detection systems and the crack will remain stable (i.e., not propagate to a pipe rupture). At less severe system conditions, additional margins of safety exist.

Thus, the conditions which would lead to a pipe rupture, a large through wall crack, would be identified during operation. However, even with the presence of such a crack, the piping system would remain stable and a piping rupture is unlikely at reduced RCS pressures.

This argument is not applicable to the Class 2 portions of the RHR system piping since it is not operated at the higher system pressures. The design pressure of the RHR system is approximately 600 psig and due to the nature of the operation of the system is considered a moderate energy system. Large ruptures of moderate energy system piping have not been considered as a part of the design basis of Westinghouse supplied PWRs. Breaks of relatively small size have been considered.

Any leakage of the RHR system piping would be expected to occur when the system is initially pressurized at less than 400 psig. The RCS conditions are under manual control by the reactor operator and the operator will be monitoring the pressurizer level and the RCS loop pressure so that any significant leakage would be immediately detected. If a break is detected, the operator would isolate the RHR system from the RCS, terminating the loss of coolant, and initiate safety injection, if necessary. Based on the results from small LOCA studies provided in various plant license applications the operator will have ample time to take these actions. Further discussions on shutdown LOCA are considered to be applicable to only breaks in the RCS inside containment which are not isolable.

Probabilistic assessments of the frequency of a loss of coolant accident at full power operation are generally divided into three categories: small LOCA (break diameter less than 2 inches), medium LOCA (break diameter between 2 and 6 inches) and large LOCA (break diameter greater than 6 inches). The data base

for estimation of the frequency of these events is drawn from the nuclear operating history and the following values have been used in the Millstone Unit 3 Probabilistic Safety Study:

Large LOCA	3.88E-4
Medium LOCA	6.11E-4
Small LOCA	9.07E-3

During operation in shutdown modes the reactor coolant system pressure is significantly lower than at full power, for which the above probabilities are applicable. As previously discussed, the probability of a large loss of coolant accident in the reactor coolant system would be significantly lower during shutdown conditions, below 1000 psig, so as to not be considered credible. The probability of a small and medium LOCA in shutdown modes can be reduced since the time spent in these modes is less than time spent at higher pressure and temperature. The probability of a LOCA during shutdown conditions in Modes 3 and 4 can therefore be stated as:

Large LOCA	Negligible
Medium LOCA	1.79E-5
Small LOCA	2.65E-4

For small and medium LOCA the probability of the event is more than an order of magnitude less than the probability of a LOCA at normal operating pressures and temperatures. No credit is taken for the reduced pressures present in shutdown conditions in the calculation of medium and small LOCA probabilities, which may reduce the probabilities further.

III. LARGE LOCA

Although a large LOCA is not considered credible during shutdown operation, the following information is provided to present what would happen if one were to occur, and what steps would need to be taken to mitigate the event.

A large LOCA of greater than one square foot in area is characterized by a very rapid depressurization of the RCS to near the containment pressure. Due to the reduced temperature and pressure of the RCS, this blowdown takes something on the order of 3 minutes to 5 minutes, rather than the approximately 30-60 seconds typical of full power operation. During this time, the fuel is cooled by the flow through the core toward the break. Since the reactor has been shut down for a period of time, the fuel rod temperatures and decay heat level is reduced from the full power case and there is no fuel cladding heatup expected during blowdown. Following the RCS blowdown the fuel cladding would begin to heat up and the reactor vessel must be refilled with ECCS water.

For breaks greater than 6 inches in equivalent diameter and less than one square foot in area, a depressurization to a pressure where LHSI/RHR pump flow is available is expected to occur. No significant clad heatup is expected until core uncovery occurs.

Automatic safety injection activation may not occur since the pressurizer pressure SI signal is blocked and the high containment pressure SI signal is typically not required to be operable or may not be reached for lower initial RCS temperatures. Operator action would be relied upon to initiate sufficient SI flow to refill or maintain sufficient reactor vessel inventory for adequate core cooling. The indications available to the operator that there is a large LOCA in progress would be the following:

1. Loss of pressurizer level
2. Rapid decrease of RCS pressure
3. Loss of RCS subcooling
4. Increase in containment pressure
5. Radiation alarms inside containment
6. Sump water level increasing

Evaluations done to date have shown that adequate ECCS performance for large LOCAs is ensured if SI water is supplied from either a LHSI/RHR pump, or the cold leg accumulators with subsequent initiation of LHSI/RHR pump flow. Realignment or activation of these systems would require operator action for most break sizes for events initiated at low RCS temperatures. For a typical 3411 MWt 4 Loop Westinghouse PWR, flow from the LHSI pumps within 10 minutes of the accident initiation is estimated to mitigate the transient without exceeding the 2200°F peak fuel clad limit of 10CFR50.46. Alternatively, it is estimated that flow from two HHSI pumps within 3 minutes to 5 minutes of the accident initiation will mitigate the transient without significantly exceeding the 2200°F limit of 10CFR50.46. These evaluations are considered to bound all shutdown conditions below 1000 psig since decay heat generation was assumed to be reduced only by 4 hours of reactor shutdown time. At subsequent times after shutdown more action time should be available as decay heat levels decrease. For shutdown conditions above 1000 psig, the cold leg accumulators will be available without operator action, increasing available operator action time to start SI pump flow.

IV. SMALL AND MEDIUM LOCA

A small and medium LOCA is characterized by a slower draining of the RCS than a large LOCA. While the core is covered, there is no fuel clad heatup. Based on various shutdown LOCA scoping studies, at least 20 minutes are available to initiate SI from a HHSI pump to prevent significant core uncovery for breaks up to three inches in diameter. Initiation of SI flow within this time will not preclude core uncovery, but should limit the fuel cladding heatup to less than

the full power small break LOCA results provided in the plant FSAR. For breaks larger than three inches and up to six inches in diameter, operator action to initiate SI from a HHSI pump is estimated to be required within 10 minutes. Additional operator action may be required, depending on the break size, within 1 hour of the event initiation to start additional HHSI pumps or to depressurize the RCS using the steam generators and to start a LHSI pump.

The indications available to the operator that there is a small or medium LOCA in progress would be the following:

1. Loss of pressurizer level
2. Decrease of RCS pressure
3. Loss of RCS subcooling
4. Radiation alarms inside containment

The small flows and reduced energy of the break flow due to low RCS temperatures may not noticably increase the containment pressure for small LOCA's.

V. LONG TERM COOLING

The RHR/LHSI pumps on the class I plants will be aligned in the RHR cooling mode during part of the operation in shutdown modes. The RHR/LHSI pumps may be damaged by extended operation with highly voided flow. Any RHR/LHSI pumps operating with suction from the RCS hot legs should be stopped as soon as possible following a loss of RCS subcooling during a LOCA to minimize the potential for damage to the pumps.

If the RHR/LHSI pumps are unavailable, flow can be supplied to the RCS by the HHSI pumps as long as there is water in the RWST. Flow can also be provided by the cold leg accumulators if they are made available. Once the RWST is empty, the safety injection flow is supplied from the containment recirculation sump. In most class I plants, the RHR/LHSI pumps are used as booster pumps for the HHSI pumps when suction is from the sump. If the RHR/LHSI pumps are unavailable, it may not be possible to get the water from the sump into the reactor vessel to ensure long term core cooling. Thus, the RHR/LHSI pumps must be tripped to ensure that the pumps are available for long term core cooling. It should be noted that the Westinghouse Owners Group Emergency Response Guidelines address operator actions for a loss of emergency coolant recirculation capability following a LOCA. Also, some Class I plants have separate pumps to provide sump recirculation capability independent of the RHR/LHSI pumps.

The LHSI pumps in the class II plants can draw directly from the containment sump and are not in operation during the RHR cooling phase of plant cooldown. Therefore, there is no LOCA long term cooling concern for these plants. The RHR

pumps should still be tripped as soon as possible following loss of RCS subcooling to minimize the potential for damage to the pumps.

VI. CONCLUSIONS FOR MITIGATION OF SHUTDOWN LOCA

Based on evaluations performed to date, it is necessary for certain timely operator actions to be completed to mitigate a LOCA during shutdown operation. Specifically:

1. The RHR pumps or the RHR/LHSI pumps should be stopped as soon as possible following the loss of RCS subcooling during a LOCA for both classes of plants if the RHR System is in service.

2. The RHR/LHSI and HHSI pumps must be aligned to the RWST for safety injection and safety injection must be manually initiated following a LOCA during shutdown operation.

If you have any questions, please call either Mr. Bruce Monty (412) 374-4249 or Mr. Neil Lewis (412) 374-5069 of the Nuclear Technology Systems Division Nuclear Safety Department.

Very truly yours,

for E.P. Rahe, Jr., Manager
Nuclear Safety Department

EPR/jmb

Attachment

cc: C. Berlinger, 1L, 1A
H. Thompson, 1L, 1A
T. Novak, 1L, 1A

CLASS I PLANTS
COMMON RHR/LHSI PUMPS

DONALD C. COOK #1, #2	AMERICAN ELECTRIC POWER
JOSEPH M. FARLEY #1, #2	ALABAMA POWER COMPANY
BYRON #1, #2*	COMMONWEALTH EDISON COMPANY
BRAIDWOOD #1*, #2*	COMMONWEALTH EDISON COMPANY
VIRGIL C. SUMMER	SOUTH CAROLINA ELECTRIC/GAS
H.B. ROBINSON #2	CAROLINA POWER AND LIGHT
SHEARON HARRIS #1*	CAROLINA POWER AND LIGHT
ZION #1, #2	COMMONWEALTH EDISON
CONN YANKEE/HADDEM NECK	NORTHEAST UTILITIES
WILLIAM B. McGUIRE #1, #2	DUKE POWER COMPANY
CATAWBA #1, #2*	DUKE POWER COMPANY
TURKEY POINT #3, #4	FLORIDA POWER AND LIGHT
ALVIN W. VOGTLE #1*, #2*	GEORGIA POWER
INDIAN POINT #2, #3	NEW YORK POWER AUTHORITY
SEABROOK #1*, #2*	PUBLIC SERVICE OF NEW HAMPSHIRE
MILLSTONE #3	NORTHEAST UTILITIES
PRAIRIE ISLAND #1, #2	NORTHERN STATES POWER
DIABLO CANYON #1, #2	PACIFIC GAS AND ELECTRIC
TROJAN	PORTLAND GENERAL COMPANY
SALEM #1, #2	PUBLIC SERVICE ELECTRIC & GAS CO.
ROBERT E. GINNA	ROCHESTER GAS & ELECTRIC CO.
WOLF CREEK	KANSAS GAS AND ELECTRIC
CALLAWAY #1	UNION ELECTRIC COMPANY
COMMANCHE PEAK #1*, #2*	TEXAS UTILITIES GENERATING COMPANY
SEQUOYAH #1, #2	TENNESSEE VALLEY AUTHORITY
WATTS BAR #1*, #2*	TENNESSEE VALLEY AUTHORITY
POINT BEACH #1, #2	WISCONSIN ELECTRIC POWER
KEWAUNEE	WISCONSIN PUBLIC SERVICE

* PLANTS WITHOUT OPERATING LICENSE

CLASS II PLANTS

INDEPENDENT RHR/LHSI PUMPS

SURRY #1, #2	VIRGINIA ELECTRIC AND POWER
NORTH ANNA #1, #2	VIRGINIA ELECTRIC AND POWER
BEAVER VALLEY #1, #2*	DUQUESNE LIGHT COMPANY
SAN ONOFRE #1	SOUTHERN CALIFORNIA EDISON COMPANY
SOUTH TEXAS PROJECT #1*, #2*	HOUSTON LIGHTING AND POWER
YANKEE-ROWE	YANKEE ATOMIC ELECTRIC

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* PLANTS WITHOUT OPERATING LICENSE