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June 30, 1988

Docket Nos. 50-277
50-278
50-352
50-353

Mr. Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555

Reference: NRC Bulletin No. 88-04
Potential Safety-Related Pump Loss

Dear Mr. Rossi:

NRC Bulletin (NRCB) 88-04, "Potential Safety-Related Pump Loss", issued on May 5, 1988, requested licensees to investigate two potential design concerns involving safety-related centrifugal pumps. The concerns include the potential for a pump to dead-head when it is operating in the minimum flow recirculation mode in parallel with another pump, and also includes concerns over the design adequacy of pump minimum flow capacities.

The NRC requested that within 60 days of receipt of NRCB 88-04, Philadelphia Electric Company provide a written response:

a) to describe the problems and the systems affected,

b) to identify any necessary short-term or long-term modifications to plant equipment or to plant operating procedures which are being implemented to ensure safe plant operations,

c) to provide a schedule for long-term resolution of significant problems identified as a result of this bulletin, and

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d) to provide justification for continued operation of the plants with particular attention being placed on the General Design Criterion 35 of Appendix A to Title 10 of the Code of Federal Regulations (10CFR50), Emergency Core Cooling" and 10CFR50.46, "Acceptance Criteria for Emergency Core Cooling System for Light Water Nuclear Power Reactors."

Attachment "A" to this letter provides our response and affidavit to the NRC for both Limerick Generating Station, Units 1 and 2, and Peach Bottom Atomic Power Station, Units 2 and 3.

Should you have any questions or require additional information, please do not hesitate to contact us.

Very truly yours,

Attachments

cc: William T. Russell, Administrator, Region I,
T. P. Johnson, USNRC Senior Resident Inspector
T. J. Kenny, USNRC Senior Resident Inspector

PHILADELPHIA ELECTRIC COMPANY
ATTACHMENT "A"

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60-DAY RESPONSE TO NRC BULLETIN 88-04
"POTENTIAL SAFETY-RELATED PUMP LOSS"

NRC Bulletin 88-04, "Potential Safety-Related Pump Loss", requested licensees to investigate two potential design concerns involving safety-related centrifugal pumps. The two broad NRC concerns discussed in the bulletin include:

1) the potential for a pump to dead-head when it is operating in the minimum flow recirculation mode in parallel with another pump (pump-to-pump interaction), and

2) the adequacy of the minimum flow capacity.

Philadelphia Electric Company's understanding of these two concerns is summarized here in greater detail.

1) Pump-to-Pump Interaction

When the minimum flow lines from two or more pumps join at some point to form a common line, there is a potential for interaction between the pumps. If the design of the piping configuration has not considered the pump unique performance characteristics, the pump with the higher discharge pressure (stronger pump) could reduce the flow through the pump with the lesser discharge pressure (weaker pump) to the point where it is inadequate for long-term integrity.

If the pumps' minimum flow lines are orificed (back-loaded) in the individual pump discharge lines upstream of the junction and if the common line has a large enough flow area such that its resistance is a relatively small part of the overall hydraulic resistance, there should be little adverse pump-to-pump interaction. The parallel pumps can be expected to operate individually or in unison with adequate minimum flow.

However, if the minimum f discharge lines are not individually orificed, but the common line is orificed or contains no orifice, interaction between the two pumps may occur. The severity of the degradation of minimum flow through a pump depends on the shape of the pump characteristic head-flow curves and the mismatch between the pumps. If the characteristic curve is such that a small change in flow results in a relatively large change in developed head, it is probable that little operational difficulty would result from an undesirable piping configuration. However, if a relatively large change in flow resulted in only a small change in developed head, some problems could be expected in satisfying the minimum flow requirements.

2. Adequacy of Minimum Recirculation Flow

The original design basis for sizing the minimum flow recirculation lines for the safety-related pumps at Limerick Generating Station (LGS) and Peach Bottom Atomic Power Station (PBAPS) was to provide sufficient flow to avoid overheating the pumps due to low flow. However, more recently, pump vendors' guidelines for minimum flow are based on avoiding hydraulic instability in addition to avoiding pump overheating, leading to higher recommended minimum flow values than those used in original system design. Hydraulic instabilities can occur at low flow rates due to flow separation across the impeller vane, which can lead to asymmetrical shaft and bearing loads in addition to pump and piping vibration. Since the pump vendor guidelines are only applicable for "continuous" or "intermittent" operation, there are no new guidelines which specifically address low flow limits for infrequent operation, as is the case for BWR Emergency Core Cooling System Pumps.

Philadelphia Electric Company, the holder of an operating license for LGS Unit 1 and PBAPS Units 2 & 3, and holder of a Construction Permit for LGS Unit 2, has completed a preliminary investigation into the applicability of the two NRC concerns to PBAPS and LGS. From this investigation, we have identified the safety-related systems potentially affected, and have developed both short and long term resolutions for the concerns. This information, including justification for continued operation is included in this response.

I. Affected Systems

A. Limerick Generating Station

The LGS safety-related systems which contain centrifugal pumps, and are therefore potentially affected are the Residual Heat Removal (RHR) System, the Core Spray System, the High Pressure Coolant Injection (HPCI) System, the Reactor Core Isolation Cooling (RCIC) System, the Safeguard Piping Fill System, the Diesel Generator Fuel Oil Transfer System, the Emergency Service Water (ESW) System, the Residual Heat Removal Service Water (RHRSW) System, the Reactor Recirculation System, and the Control Structure Chilled Water System.

The ESW and RHRSW pumps are vertical, wet pit turbine pumps. No minimum flow recirculation lines are required for these pumps because the systems are always aligned to provide an open flowpath; i.e. the pumps are not operated dead-headed.

The Diesel Generator Fuel Oil Transfer pumps do not require minimum flow bypass lines. No minimum flow recirculation lines are required for these pumps because the systems are always aligned to provide an open flowpath; i.e., the pumps are not operated dead-headed.

The Control Structure Chilled Water pumps are vertical, centrifugal, in-line pumps. No minimum flow recirculation line is required for these pumps because the system is designed for continuous flow. Most of the cooling coils which are "loads" on the system are provided with bypass lines, so that, if cooling is not needed, enough flow is bypassed around the coils to provide adequate minimum flow.

The Reactor Recirculation pumps are variable speed pumps controlled by a motor-generator (M-G) set. The pumps are prevented from running below approximately 28% rated speed by the master speed limiter. Since there are no parallel pump paths, there is no potential for pump-to-pump interaction.

The Limerick Control Rod Drive (CRD) hydraulic system pumps are not safety-related. The minimum flow bypass lines for the "A" and "B" CRD pumps join together into a common line. However, each individual minimum flow line contains an orifice. Therefore, as described in the summary, there should be little adverse pump-to-pump interaction. In addition, normally only one CRD pump is in service.

The remaining safety-related LGS systems which may be affected are discussed here.

Core Spray System

1. <u>Pump-to-Pump Interaction</u>

   The minimum flow bypass lines for the "A" and "C", and for the "B" and "D" Core Spray pumps are joined into combined minimum flow lines with a single orifice in the combined line. Therefore, there is a concern for possibly dead-heading the "weaker" of the two parallel pumps due to pump-to-pump interaction. An assessment of the design adequacy of the minimum flow bypass lines for both Unit 1 and Unit 2 Core Spray system loops has been completed. The results of this assessment have shown the system design to be adequate. Additionally, minimum flow testing will be performed to assure required minimum flow values are obtained on all Core Spray loops. The Unit 1 "A" Core Spray Loop was tested on June 23, 1988. The results of this test are presently being reviewed.

The design calculations for the Unit 2 Core Spray pumps demonstrated that, with both pumps in a Core Spray loop operating through the minimum flow bypass line, the flowrates are expected to be approximately 358 and 340 gpm per pump. (The flows in the other loop are comparable.) This corresponds roughly to a 6% margin for the "weaker" pump compared with the minimum specified flow of 320 gpm.

2. Adequacy of Minimum Recirculation Flow

The Core Spray system has been designed to provide the specified minimum flow of 320 gpm per pump, or 10% of rated pump capacity of 3175 gpm. The flow restricting orifices in the combined line were originally sized for 400 gpm per pump, or 800 gpm through the orifice with both pumps in a loop running to provide a margin.

Residual Heat Removal System

1. Pump-to-Pump Interaction

Each of the four RHR pumps for each unit at Limerick is provided with an individual minimum-flow bypass line. Therefore, there is no concern for pump-to-pump interaction. The minimum flow lines for the "C" and "D" pumps are routed to the suppression pool directly. The minimum flow lines for the "A" and "B" pumps are routed to the suppression pool via the full flow test return lines.

2. Adequacy of Minimum Recirculation Flow

The RHR system has been designed to provide the specified minimum flow of 1000 gpm per pump, or 10% of rated flow. The flow restricting orifice in each RHR pump minimum flow line was sized for 1100 gpm flow. Thus, there is approximately a 10% margin above the specified minimum flow.

Reactor Core Isolation Cooling System

1. Pump-to-Pump Interaction

The minimum flow line for the RCIC pump is not interconnected with any other line; therefore, there is no possibility of pump-to-pump interaction.

2. Adequacy of Minimum Recirculation Flow

The minimum flow line from the RCIC pump discharge to the suppression pool is provided with two orifices and a normally-closed valve which opens after the pump starts and develops discharge pressure if flow in the main RCIC flowpath is low and automatically recloses once adequate flow is established. The system has been designed to provide the specified minimum flow of 60-120 gpm, or 9%-19% of rated pump capacity of 615 gpm.

High Pressure Coolant Injection System

1. Pump-to-Pump Interaction

The minimum flow line for the HPCI pump is not interconnected with any other line; therefore, there is no possibility of pump-to-pump interaction.

2. Adequacy of Minimum Recirculation Flow

The minimum flow line from the HPCI pump discharge to the suppression pool is provided with two orifices and a normally closed valve which opens after the pump starts and develops discharge pressure if flow in the main HPCI flowpath is low and automatically recloses once adequate flow is established. The system has been designed to provide the specified minimum flow of 300-600 gpm, or 5%-10% of rated pump capacity of 5600 gpm.

Safeguard Piping Fill System

1. Pump-to-Pump Interaction

Each of the Safeguard Piping Fill pumps at Limerick is provided with an individual, orificed minimum flow bypass line. There is no possibility of pump-to-pump interaction.

2. Adequacy of Minimum Recirculation Flow

The system has been designed to provide the specified minimum flow of 20 gpm per pump, or 20% of maximum pump capacity of 100 gpm.

B. Peach Bottom Atomic Power Station

The PBAPS safety-related systems which are potentially affected are the Residual Heat Removal (RHR) System, the Core Spray System, the High Pressure Coolant Injection (HPCI) System, the Reactor Core Isolation Cooling (RCIC) System, Diesel Generator Fuel Oil Transfer System, the Reactor Recirculation System, the Emergency Service Water System, the High Pressure Service Water System, and the Emergency Cooling Water System.

Of the safety related systems mentioned above, only RHR, CS, HPCI, and RCIC have the potential of being affected by one or both of the two concerns raised in this bulletin. The other safety related systems mentioned do not require or employ minimum flow lines on their pumps for the same reasons described in the LGS discussion.

The four safety-related PBAPS systems which may be affected are discussed here.

Core Spray System

1. Pump-to-Pump Interaction

The minimum flow bypass lines for the "A" and "C", and for the "B" and "D" core spray pumps join into combined minimum flow lines. However, each individual pump minimum flow line contains a restricting orifice. With this type of configuration, as discussed previously, little adverse pump-to-pump interaction is expected.

2. Adequacy of Minimum Recirculation Flow

The Core Spray System has been designed to provide the specified minimum flow of 312.5 gpm per pump, or 10% of rated pump capacity of 3125 gpm.

Residual Heat Removal System

1. Pump-to-Pump Interaction

The minimum flow bypass lines for the "A" and "C" and for the "B" and "D" RHR pumps join into combined minimum flow lines. Each individual pump minimum flow line contains a restricting orifice. Little adverse pump-to-pump interaction is expected. This will be confirmed through testing as stated in the short term resolution section.

2. Adequacy of Minimum Recirculation Flow

The RHR system has been designed to provide the specified minimum flow of 500 gpm per pump, or 5% of rated pump capacity of 10,000 gpm.

Reactor Core Isolation Cooling System

1. Pump-to-Pump Interaction

The minimum flow line for the RCIC pump is not interconnected with any other line; therefore, there is no possibility of pump-to-pump interaction.

2. Adequacy of Minimum Recirculation Flow

The RCIC System has been designed to provide the specified minimum flow of 60-120 gpm, or 10%-20% of rated pump capacity of 600 gpm.

High Pressure Coolant Injection System

1. Pump-to-Pump Interaction

The minimum flow line for the HPCI pumps is not interconnected with any other line; therefore, there is no possibility of pump-to-pump interaction.

2. Adequacy of Minimum Recirculation Flow

The HPCI System has been designed to provide the specified minimum flow of 600-1200 gpm, or 12%-24% of total pump capacity of 5000 gpm.

II. Short Term Resolutions

A. Limerick Generating Station

No significant degradation of the Limerick Unit 1 Core Spray, RHR, RCIC or HPCI pumps is expected to have occurred. These pumps undergo routine in-service inspections as required per ASME Boiler and Pressure Vessel Code Section XI, in addition to the Technical Specification surveillance testing requirements. Furthermore, all the affected pumps are provided with continuous, on-line vibration monitoring which processes the data obtained for alarming and trending. Thus, no design changes are necessary in the short-term. The following short-term actions are intended mainly to reinforce this position.

Pump-to-Pump Interaction (Core Spray System)

As noted above, the Core Spray system pumps are the only safety-related pumps which present a concern for potential pump-to-pump interaction. Although the system design has been demonstrated analytically to be adequate from this standpoint, the following short-term actions will be taken to provide further assurance.

1. Monitor the actual flowrate for each pump during minimum flow recirculation with both pumps in a Core Spray loop running:

   Unit 1 - "A" Core Spray loop was tested on 6/23/88.
   - "B" Core Spray loop will be tested in July, 1988.
   Unit 2 - Will be performed during pre-operational testing.

Adequacy of Minimum Recirculation Flow

The following short-term actions apply to the Core Spray, RHR, RCIC and HPCI pumps.

1. The routine in-service inspections required per ASME Boiler and Pressure Vessel Code Section XI, along with the Technical Specification surveillance testing requirements will identify any pump degradation.

2. Contact pump vendors to determine whether their recommendations for minimum recirculation flow have been revised upward since the original design and under what operating regimes such restrictions apply.

B. Peach Bottom Atomic Power Station

Pump-to-Pump Interaction

Actual flowrates for each pump during minimum flow recirculation with both pumps in the loop operating in parallel will be obtained through testing.

Adequacy of Minimum Recirculation Flow

Current minimum flow parameters for each pump will be investigated. Minimum flow and duration information from pump vendors will be compared with previously acquired data. "Recommended" and "required" minimum flows will be requested from vendors. The duration of operation at the "recommended" and "required" minimum flows will also be required.

III. Long Term Resolution

A. Limerick Generating Station

Pump-to-Pump Interaction (Core Spray System)

Because the margin available on the "weaker" Core Spray pump in a loop between the calculated minimum flow and the manufacturer's recommendation is small, the following design modifications are under consideration:

1. Providing an orifice in each pump's minimum flow path upstream of the common minimum flow bypass line.

2. In addition, modify the existing orifice in the common line to minimize the associated pressure drop, thus maximizing the effectiveness of restricting orifices in the individual minimum flow lines. This will ensure that the effect of any difference in the pumps' performance with regards to minimum flow is minimized.

The final design is contingent upon the results of actual minimum flow measurement. The following schedule applies:

1. Decision to implement one of the above alternatives will be completed by September 30, 1988.

2. Physical implementation of recommended modification:
Unit 1 - Prior to restart from the third refueling outage.
Unit 2 - Design will be complete by September 1, 1988, at which time a completion date for the physical implementation of the modification will be determined.

Adequacy of Minimum Recirculation Flow

1. In order to reduce pump duty and minimum maintenance requirements, the time that the pumps are running in the minimum flow mode should be minimized. Because all the affected Limerick systems are provided with valves in the minimum flow bypass lines which close automatically once flow in the main pump discharge path is established, no changes in procedures are required for system testing or operation of the systems in non-accident modes (e.g., RHR shutdown cooling). However, the low pressure ECCS systems (i.e., RHR-LPCI and Core Spray), as a result of an ECCS initiation signal while the reactor is at high pressure, may operate in the minimum flow mode. Therefore, plant emergency operating procedures should provide guidance to the operators to place the systems in the full flow test mode, if automatically initiated on a LOCA signal and symptoms positively confirm delayed injection, until necessary to inject.

2. Depending on the results of the short-term actions to evaluate the adequacy of the specified minimum flow, the sizes of the orifices in the minimum flow lines could be increased on a case-by-case basis.

B. Peach Bottom Atomic Power Station

Pump-to-Pump Interaction

Should the actual flowrates obtained from the testing of the Core Spray and RHR pumps prove to be unsatisfactory, modifications to the system will be performed.

Testing of both units and a decision to implement any modifications will be completed in the fall of 1988, based on the current PBAPS Restart Schedule.

Physical implementation of any system modifications (if required) will be completed prior to return to service from each units' next refuel outage.

Adequacy of Minimum Recirculation Flow

Should the pump vendors determine that minimum flow rates are not adequate, the recirculation lines will be analyzed to verify the lines are capable of handling the higher flow. If appropriate, modifications to the recirculation lines will be considered.

A decision to evaluate any modifications will be made by October 30, 1988.

Should modifications be required, physical implementation will be completed prior to return to service from each units' next refuel outages.

IV. Justification for Continued Operation

The concerns stated in NRC Bulletin 88-04 are summarized as:

1. With two pumps operating in parallel in the minimum flow mode, one of the pumps may be deadheaded resulting in pump damage or failure.

2. Installed minimum pump flows may not be adequate to preclude pump damage or failure.

These concerns are addressed by the responses below which provide the basis for concluding that continued operation of both PBAPS and LGS is justified.

Pump-to-Pump Interactions

The potential for excessive pump wear attributable to minimum flow operation and/or deadheading at either LGS or PBAPS is negligible. An assessment of Limerick Units 1 and 2 concluded that pump-to-pump interaction of the Core Spray pumps in a loop does not result in individual pump flowrates below those specified by the manufacturers. To date, testing of the LGS Unit 1 "A" Core Spray loop has been completed. Actual minimum flow rates of each pump were obtained through the use of ultrasonic flowmeters. The results of this test are being evaluated to verify that pump-to-pump interaction does not exist. Continuous monitoring of Core Spray pump vibration and routine maintenance and inspections will provide early indication of pump degradation. The Core Spray and RHR systems at Peach Bottom Units 2 & 3 contain a restricting orifice in each pumps individual minimum flow bypass line to minimize pump interaction. Additionally, as was mentioned in Section II, actual flowrates for each pump during minimum flow recirculation with both pumps operating will be confirmed through testing.

Adequacy of Minimum Recirculation Flow

BWR operating experience does not indicate any excessive wear to pumps when operating under the currently specified minimum flow conditions. That is, no such reported wear has resulted in indicated degradation in pump performance. Any wear observed (per normal pump inspection requirements) has taken place over relatively long periods of time (on the order of ten years), and has been limited to gradual detectable changes in pump performance, rather than a sudden significant degradation in performance.

The following discussion is based on work done by General Electric Co. for the BWR Owners Group and is applicable to both Limerick Generating Station and Peach Bottom Atomic Power Station:

Recent inspection of some BWR RHR pumps have indicated no pump impeller damage (due to minimum flow or any other adverse conditions) that could potentially degrade pump performance over the inspection period. It is estimated that the pumps had been operated in the minimum flow mode for up to 30 hours during this period. This further substantiates that short-term operation in the minimum flow mode has little or no impact on pump life.

There have been occasions when pumps have operated deadheaded inadvertently (i.e., deadheading was not caused by minimum flow operation but, for instance, by incorrectly closing a valve). These pumps have continued to function normally.

System operation in the minimum flow mode is limited to pump start transients during monthly surveillance testing and during a postulated system start from a LOCA signal.

The total expected time in the minimum flow mode over the plant life is approximately one percent of the 30,000 hour maximum given by the pump vendors for intermittent operation. The maximum expected continuous duration in the minimum flow mode is 30 minutes for postulated small break LOCAs. Therefore, the potential for excessive wear attributable to minimum flow operation is negligible.

All Class 1, 2, and 3 centrifugal and displacement-type pumps installed in BWR's and required to perform a specific function in shutting down the reactor or in mitigating the consequences of an accident, and provided with an emergency power source, must undergo routine in-service inspection (tests) per ASME Boiler and Pressure Vessel Code Section XI, Article IWP-1000. These quarterly tests are in addition to the Technical Specification surveillance requirements intended to demonstrate compliance with the plant safety analysis.

The Section XI tests are intended to detect changes in pump performance; Article IWP-1500 ("Detection of Change") states:

> "The hydraulic and mechanical condition of a pump, relative to a previous condition, can be determined by attempting to duplicate, by test, a set of basic reference parameters. Deviations detected are symptoms of changes and, depending upon the degree of deviation, indicate need for further tests or corrective action."

In general, the in-service tests measure speed, inlet pressure, differential pressure, flow rate and vibration amplitude. Alert ranges and required action ranges are strictly defined, and require either increased frequency of testing or declaring the pump as inoperative, respectively. Performance outside of the required action range would place the affected system in a Limiting Condition for operation.

Although these tests themselves would not detect pump dead-heading or inadequate minimum flow, any deleterious effects of operating with inadequate flow would be detected in advance of significant pump performance degradation. Therefore, any changes in pump performance would be detected and corrected per routine pump testing in advance of pump degradation due to cumulative low flow effects from pump surveillance testing and normal system starts.

Limerick Unit 1, which was licensed in October 1984, has been operating for more than 3 years; and, based on this operating experience, no appreciable pump degradation is expected to have occurred. (Limerick Unit 2 is not licensed.) This conclusion is further supported by the fact that no vibration problems attributable to inadequate minimum flow have been detected. The Limerick Vibration Monitoring System continuously acquires data on speed, vibration and shaft axial position for all the safety-related pumps of concern. A "smart monitor" provides alert and danger alarms at pre-selected vibration levels. The system offers historical trending of the data and can generate displays, logs and plots.

Pump wear attributable to minimum flow operation is not a significant contributor to total system unavailability compared to other contributors (such as loss of emergency power, loss of cooling, etc.). This is based on BWR operating history, which indicates no occurrences of system unavailability upon demand due to pump wear incurred in minimum flow operation.

For the RHR and core spray pumps, the only design basis events that would lead to pumps running in the minimum flow mode and/or deadheading are events that result in an ECCS initiation signal while the reactor is at high pressure (above the pump shutoff head). These events are normally small break LOCAs and loss of drywell cooling isolation events. Of these, only certain small break LOCAs actually require ECCS injection from LPCI or core spray. Once initiated, the maximum duration that a LPCI or core spray pump may operate in the minimum flow mode for the spectrum of hypothetical LOCAs is less than 30 minutes. This is derived from postulated small break LOCAs, wherein a reactor depressurization to below the shut-off head of these pumps is delayed. For large break LOCAs, the reactor inherently depressurizes more rapidly through the break. The present minimum flow bypass line is expected to provide adequate protection for these pumps for the short durations postulated during both the small and large break LOCAs.

For other scenarios, there is adequate time to secure the RHR and core spray pumps, and restart them as necessary, precluding extended operation in the minimum flow mode.

As discussed above, only certain small break LOCAs actually require ECCS injection for LPCI or core spray where the pumps may be operated in the minimum flow mode. However, because of the excess ECCS capacity that is available, limiting LOCA scenarios do not depend on both pumps of a pair of parallel pumps to operate in order to satisfy 10CFR50.46 requirements and General Design Criteria 35 of 10CFR50 Appendix A.

The smaller break sizes result in calculated peak clad temperatures (PCTs) well below the limiting calculated PCT. Since the limiting failures for these break sizes result in one or more LPCI systems available, the effect of a core spray flow reduction due to pump unavailability is reduced; therefore, it is concluded that based on the large PCT margins for the small break sizes and the availability of LPCI for the limiting single failures the current calculated maximum PCT would be unaffected. For the next most limiting single failure in the small break range, only two core spray systems are available for low pressure ECCS injection. The maximum duration in minimum flow for this scenario is found to be less than four minutes for break sizes down to 0.3 sq. ft. It is expected that the core spray pumps would demonstrate no performance degradation for operation at low flow for this period. However, a flow reduction due to the loss of one pump in each core spray loop would not increase the calculated PCT above the limiting PCT, based on the large PCT margin available (up to 900 deg F) and the spray cooling effect of the available core spray system capacity.

For BWR plants such as Limerick 1 & 2 which are limited by the single failure of an emergency diesel generator there are at least three LPCI pumps available for ECCS injection for all breaks and single failures; therefore the impact of reduced core spray flow is much less severe than for plants limited by the LPCI injection valve failure. Since the limiting large recirculation line breaks result in a maximum duration in minimum flow of approximately one minute (in fact, the maximum line break would show essentially no time in minimum flow mode), it is included that there is no impact on the limiting licensing LOCA analysis.

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