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July 11, 1988
NRC-88-0182

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, D. C. 20555

Reference: 1) Fermi 2
NRC Docket No. 50-341
NRC Operating License No. NPF-43

2) NRC Bulletin No. 88-04 "Potential Safety-Related Pump Loss", Dated May 5, 1988

Subject: Response NRC Bulletin No. 88-04 "Potential Safety-Related Pump Loss"

The NRC issued NRC Bulletin 88-04, "Potential Safety-Related Pump Loss", on May 5, 1988. The purpose of the bulletin is to request that licensees investigate and correct design concerns involving safety-related system pumps. These concerns involve minimum flow piping configurations for systems with two or more pumps and the adequacy of installed minimum flow capacities.

The NRC requested that within 60 days of receipt of Bulletin 88-04, licensees provide a written response that (a) summarizes the problems and the systems affected, (b) identifies the short-term and long-term modifications to plant operating procedures or hardware that have been or are being implemented to ensure safe plant operations, (c) identifies as appropriate, a schedule for long-term resolution of this and/or other significant problems that are identified as a result of this bulletin, and (d) provides justification for continued operation particularly with regard to General Design Criterion (GDC) 35 of Appendix A to title 10 of the Code of Federal Regulations (10 CFR50), "Emergency Core Cooling" and 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling System of Light Water Nuclear Power Reactors."

A generic response to NRC Bulletin 88-04 has been developed by the Boiling Water Reactor Owners Group (BWROG). Per this letter, Detroit Edison does endorse the positions taken by the BWROG as a response to NRC Bulletin 88-04. This response will act as a supplement to that of the BWROG. A copy of the BWROG response is provided as Attachment 1.

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The Fermi 2 Plant Specific Supplement to the BWROG position involves the response to the concern for (I) potential deadheading of the safety-related pumps, and (II) adequacy of the minimum flow capacity of those systems not addressed by the BWROG response.

I. POTENTIAL DEADHEADING OF SAFETY RELATED PUMPS:

The Bulletin 88-04 concern for the potential deadheading of a safety related pump occurs when the pump is operating in the minimum flow mode in parallel with another pump. The safety-related systems at Fermi 2 which have 2 or more pumps in parallel on a minimum flow line are Residual Heat Removal (RHR) and Core Spray.

A. Residual Heat Removal

The RHR system is not affected by NRC Bulletin 88-04, because RHR pump's minimum flow discharge lines are orificed (backloaded) in the individual pump discharge lines prior to the junction between the two pipes, and the common line is large enough in flow area such that its resistance is a relatively small part of the overall hydraulic resistance. Therefore, there will be little pump-to-pump interaction, and they can be expected to operate individually or in unison with no problems.

B. Core Spray

As discussed in the BWROG response, if the minimum flow discharge lines are not individually orificed, but the common line is orificed or provide greater flow resistance than the individual lines, interaction between the two pumps may occur. Also, the severity of the attenuation of minimum flow through any pump depends on the shape of the head flow curves showing a magnitude of the mismatch between the pumps.

An evaluation of the core spray system has been made because the potential for pump interaction does exist. This evaluation takes into consideration the actual line and component resistances for the as-built configuration of the minimum flow lines. The test data shows that the four core spray pumps (2 pumps per division) have virtually the same head profile in the minimum flow range, showing little pump interaction, i.e., one pump does not deliver a greater flow rate over the others.

The evaluation uses the "worst case" scenario. The "worst case" scenario assumes that in a given division, one pump is already operating while the other pump (with the most discharge line flow restrictions) is trying to start up. This "worst case" scenario was analyzed by modeling the performance of each pump over specific time steps in the minimum flow mode.

The evaluation of the Core Spray System shows that the core spray pumps will run without the threat of one pump deadheading the other. Furthermore, the core spray pumps have been tested and verified to ensure that they will perform their design function.

The potential for excessive wear attributable to minimum flow operation is negligible since short term operation in the minimum flow mode has little or no impact on pump life. This subject is further addressed in the BWROG report. Also, the operating experience at Fermi 2 does not indicate any excessive wear to the core spray pumps when operating in the minimum flow mode.

The current inspection requirements for the safety related pumps and the Technical Specifications should provide adequate protection against pump performance degradation due to low flow operation. This position is supported by the attached BWROG evaluation. Therefore, no short-term or long-term modifications will be required by Fermi 2.

The justification for continued operation for Fermi 2 as requested by Bulletin 88-04 has been provided in the attached BWROG response to the NRC.

II. ADEQUACY OF THE MINIMUM FLOW CAPACITY OF THOSE SYSTEMS NOT ADDRESSED IN THE BWROG RESPONSE.

NRC Bulletin requests all licensees to investigate the adequacy of the minimum flow capacity of all safety related pumps. At Fermi 2, the safety systems that have a minimum flow line and that are of potential concern to this minimum flow adequacy include High Pressure Cooling Injection (HPCI), Reactor Core Isolation Coolant (RCIC), RHR, Core Spray, RHR-Service Water (RHR-SW), Emergency Equipment Service Water (EESW) and Diesel Generators Service Water (DGSW). The attached BWROG position addresses HPCI, RCIC, RHR and Core Spray. Therefore, RHR-SW, EESW and DGSW are the systems at Fermi 2 that require a separate evaluation.

The RHR-SW, EESW and DGSW systems do have minimum flow lines but they are not needed. Per the Fermi 2 system operating procedures, the manual valves in the normal operating flowpaths for each system are locked open and control valves without position indication in the control room are blocked from being fully closed. These valves are locked or blocked open such that the flow exceeds the minimum required flow for each pump. Thus, the systems will always operate with the discharge lines open, eliminating the need for a minimum flow line.

The only use of these minimum flow lines would be for pump protection in the case of an inadvertent valve misalignment. The design of the minimum flow lines for RHR-SW, EESW and DGSW at Fermi 2, was investigated to ensure adequate flow for pump protection. Each RHR-SW, EESW and DGSW pump has its own minimum flow line and was evaluated. Per conversations with the pump manufacturer, the pumps and plant piping have been sized for adequate flow.

III Conclusion

Based on the evaluation of the RHR and Core Spray Systems, the potential for deadheading these pumps when operating in the minimum flow mode is minimal. The evaluation of RHR-SW, EESW and DGSW showed there is no concern over the adequacy of installed minimum flow capacities for these systems. The BWROG letter addresses the RHR, Core Spray, HPCI, and RCIC systems for adequacy of minimum flow and provides the requested justificationfor continued operation. Based on these evaluations, no modifications to the plant or procedures are necessary.

If you have any questions, please contact Lynne Goodman at (313) 586-4211.

Sincerely,

B Ralph Sylvia

Enclosure

cc: A. B. Davis
R. W. Cooper
R. C. Knop
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BWR OWNERS' GROUP

Donald N. Grace, Chairman
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BWROG-8836
June 29, 1988

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

SUBJECT: RESPONSE TO NRC BULLETIN 88-04, "POTENTIAL SAFETY-RELATED PUMP LOSS"

Gentlemen:

The NRC issued NRC Bulletin (NRCB) 88-04, "Potential Safety-Related Pump Loss", on May 5, 1988. The purpose of the bulletin is to request all licensees to investigate potential design concerns involving safety-related pumps. The NRC concerns involve the potential for a pump to dead-head when it is operating in the minimum flow mode in parallel with another pump, and the adequacy of the minimum flow capacity.

The NRC requested that within 60 days of receipt of NRCB 88-04, licensees are to provide a written response that (a) summarized the problems and the systems affected, (b) identifies the short-term and long-term modifications to plant operating procedures or hardware that have been or are being implemented to ensure safe plant operations, (c) identifies an appropriate schedule for long-term resolution of this and/or other significant problems that are identified as a result of this bulletin, and (d) provides justification for continued operation particularly with regard to General Design Criterion (GDC) 35 of Appendix A to Title 10 of the Code of Federal Regulations (10 CFR 50), "Emergency Core Cooling" and 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling System for Light Water Nuclear Power Reactors."

Provided in the Attachment is the information requested by the NRC. Some of the information will be supplemented by plant-specific submittals, specifically that pertaining to items (b) and (c) above. The Justification for Continued Operation (JCO) provided in the Attachment is generic. The

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JCO concludes that continued operation is justified because the potential for pump damage due to minimum flow operation or dead-heading is negligible, sufficient redundancy and ECCS capacity exists to meet the requirements of 10 CFR 50.46 and GDC 35, and routine maintenance is expected to detect any pump damage before system performance is degraded.

The comments/positions provided in this letter have been endorsed by a substantial number of the members of the BWROG; however, it should not be interpreted as a commitment of any individual member to a specific course of action. Each member must formally endorse the BWROG position in order for that position to become the member's position.

If you have any questions concerning this information, please contact the undersigned or W.A. Zarbis (GE) on (408) 925-5070.

Regards,

Donald N. Grace

D.N. Grace, Chairman
BWR Owners' Group

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Attachment

cc: S.D. Floyd, BWROG Vice Chairman
R.F. Janecek (CECO)
BWROG Primary Representatives
Executive Oversight Committee
S.J. Stark (GE)
NRC Regional Administrators
R. Evans (NUMARC)
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W.S. Green (INPO)

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ATTACHMENT

I. SUMMARY OF PROBLEM AND AFFECTED SYSTEMS

A. Summary of Problem

The original design basis for sizing the minimum flow lines for safety-related BWR systems is to provide sufficient flow to avoid overheating the pumps due to low flow. However, current pump vendor guidelines for minimum flow are based on avoiding hydraulic instability in addition to avoiding pump overheating, leading to higher suggested minimum flow values than those used in BWR 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** low flow operation, there are no guidelines for low flow limits for infrequent operation such as that experienced for only a limited postulated range of BWR loss-of-coolant accident (LOCA) events.

In addition, the pump minimum flow rate can be reduced (possibly leading to a condition where the pump is being run dead-headed) if there is a single minimum flow line for a pair of pumps operating in parallel. If the pumps have different pump shutoff heads, the pump with the higher shutoff head will deliver a greater flow rate; if there is a significant difference between the shutoff heads, the pump with the lower shutoff head may become dead-headed.

When the minimum flow discharge 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 piping configuration is not controlled, the pump with the higher discharge pressure could reduce the flow through the pump with lesser discharge pressure to the point where it is inadequate for long-term integrity.

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* Continuous operation is considered as more than two cumulative hours at minimum flow in any 24-hour period.

** Intermittent operation is less than two cumulative hours of minimum flow operation in any 24-hour period.

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If the pumps' minimum flow discharge lines are orificed (backloaded) in the individual pump discharge lines prior to the junction between the two pipes, and if the common line is large enough in 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. They can be expected to operate individually or in unison with no problems.

However, if the minimum flow discharge lines are not individually orificed, but the common line is orificed or provides greater flow resistance than the individual lines, interaction between the two pumps may occur. The severity of the attenuation of minimum flow through any pump depends on the shape of the head-flow curves of the pumps, and the magnitude of 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 occur. Further, the rate of attenuation of minimum flow through the lesser pump would be expected to accelerate with time.

B. Affected Systems

NRC Bulletin 88-04 addresses only safety-related systems; however, both safety-related and non-safety related systems are discussed below.

The BWR systems that may be affected are the Residual Heat Removal (RHR) System, including the Low Pressure Coolant Injection (LPCI), containment spray, pool cooling, and shutdown cooling functions; the core spray system (high or low pressure); the High Pressure Coolant Injection (HPCI) System; the Reactor Core Isolation Cooling (RCIC) System; and the Feedwater Coolant Injection (FWCI) System. For plants that do not have an integrated RHR system, the systems that provide the RHR system functions must be evaluated separately.

Support systems, such as service water, reactor building closed cooling water systems or keep-full systems, are diverse in design and operation. However, these systems should not be a concern since they typically do not require minimum flow lines and/or are operated at their design rating at all times.

The Control Rod Drive (CRD) hydraulic system has either an individually valved or orificed minimum flow path discharging to the condenser, and a continuous cooling water flow. During power operation, these multiple-stage, centrifugal pumps are run near their rated point. Upon plant scram, the flow rate would increase. If one of the discharge lines were to be blocked, the minimum flow path provides more than adequate minimum flow (approximately 20% of rated flow). Since only one pump is operated at a time, there is no potential for pump-to-pump interaction. However, the Emergency Procedure Guidelines (EPGs) may require running both pumps as a post-LOCA vessel water source; since this would only be after a plant scram, the pumps would not operate at low flow. Therefore, it is concluded that the current minimum flow path is adequate, and there is no potential for low flow pump-to-pump interaction.

The recirculation pumps are either variable speed pumps controlled by a motor-generator (M-G) set, or a constant speed pump controlled by a flow control valve. For M-G set plants, the pumps are prevented from running below approximately 28% rated speed by the master speed limiter. For valve control plants, the two-speed pumps are run with a minimum flow control valve position of approximately 22% at power operation above approximately 30% of rated power. Multiple interlocks prevent the recirculation pumps from running at a low flow condition. Since there are no parallel pump paths, there is no potential for pump-to-pump interaction.

C. Potential for Dead-Heading

The potential for dead-heading is addressed on a plant-specific basis.

D. Adequacy of Pump Minimum 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.

System operation in the minimum flow mode is limited to pump startup during surveillance testing, pump start for suppression pool cooling and shutdown cooling, and during system start on a LOCA signal. The total expected time in the minimum flow mode over the plant

life is at most one percent of the guideline recommended by the pump vendors for intermittent operation.* Therefore, the potential for excessive wear attributable to minimum flow operation is negligible.

Recent inspection of some BWR RHR pumps have indicated no pump impeller damage (due to minimum flow) that could potentially degrade pump performance over the inspection period. It is estimated that the pumps had been intermittently 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.

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.

II. SHORT-TERM AND LONG-TERM MODIFICATIONS

Operation in the minimum flow mode, which includes the potential for dead-head operation, is already minimized to the short periods of pump startup during routine testing and to system startup upon a LOCA signal. Based on pump vendor guidelines and operating experience, operation in the minimum flow mode (including dead-heading) is not expected to adversely affect pump operation. In addition, pumps have been inadvertently operated in the minimum flow and dead-headed conditions for significant periods of time. These pumps continue to operate satisfactorily with no indications of adverse consequences. Inspections of pumps that have been normally operated, including testing, indicate no significant wear from operating at the low flows.

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* Some pump vendors recommend minimum flow guidelines for intermittent operation, where intermittent operation is defined as less than 2 cumulative hours of minimum flow in any 24-hour period. For a plant design life of 40 years, this is equivalent to approximately 30,000 hours. Similar minimum flow limits have been suggested by other pump vendors.

In summary, then, experience to date indicates that minimum flow operation and dead-heading have not caused any problems. Therefore, the current inspection requirements for safety-related pumps and systems provided in the ASME Boiler and Pressure Vessel Code and also the Technical Specifications should provide adequate protection against pump performance degradation due to low flow operation.

III. SCHEDULE

An appropriate schedule for long-term resolution of the concerns identified in NRC Bulletin 88-04 will be provided on a plant-specific basis.

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 dead-headed 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 BWRs is justified.

A. All Class 1, 2, and 3 centrifugal and displacement-type pumps installed in BWRs which are 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 per ASME Boiler and Pressure Vessel code Section XI, Article IWP1000. These quarterly tests are in addition to the Technical Specification surveillance requirements intended to demonstrate compliance with the plant safety analyses. 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."

The in-service tests measure speed (if variable 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 (since these are intended to be full flow tests), 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.

B. The potential for pump excessive wear attributable to minimum flow operation and/or dead-heading is negligible, since system operation in the minimum flow mode is limited to surveillance testing and during system start on a LOCA signal.

C. BWR operating experience indicates that short term operation in the minimum flow mode and/or dead-heading has little or no impact on pump life. Pumps continue to function normally after such operations.

D. Pump wear attributable to minimum flow and/or dead-heading is not a significant contributor to total system unavailability. Other factors (such as loss of emergency power, loss of cooling, etc.) are more significant. BWR operating history indicates no occurrences of system unavailability due to pump excessive wear attributable to low flow operation.

E. For the LPCI/RHR and core spray pumps, the only design basis events that would lead to pumps running in the minimum flow mode and/or dead-heading 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\RHR or core spray after running at low flow.

Once initiated, the maximum duration that a LPCI/RHR 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 reactor depressurization to below the shut-off head of these pumps is delayed. For large break LOCAs, where the full complement of ECC systems is more fully utilized, the reactor inherently depressurizes 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.

F. As discussed in Item E 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 10 CFR 50.46 requirements and General Design Criteria 35 of 10 CFR 50 Appendix A. In fact, a realistic LOCA analysis would show that only one low pressure ECCS pump is typically necessary to satisfy core-cooling requirements during and following a LOCA.

The design basis LOCA evaluations for some plants assume that both core spray pumps are functioning. For these plants, the limiting calculated peak clad temperature would not be affected, even in the unlikely event that pump operability is affected by dead-heading.