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Point Beach Nuclear Plant

Possible Common Mode Failure of Aux Feed Recirculation Lines

RCE000191

(CAP029952)

Event Date: October 29, 2002

Report Date: Draft 1

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I. Executive Summary

Purpose:

The purpose of this investigation is to determine the root and contributing causes of why a potential existed for a common mode failure where all AFW pump recirculation lines could have restricted flow rates (due to orifice plugging) resulting in eventual pump failure, and why these inadequacies where not identified previously.

Event Synopsis:

[Brief description of event]

Conclusions:

[Brief discussion of findings]

Nuclear Safety Significance:

(Explain nuclear safety significance of event)

Root Cause:

[Explain root cause & significant contributors. Use bold & bullets]

Corrective Action Synopsis:

[Briefly describe major corrective actions]

II. Event Narrative

Background
On May 5, 1988 NRC issued Bulletin 88-04, Potential Safety-Related Pump Loss. This bulletin requested licensees to investigate and correct as appropriate two mini-flow design concerns. The first concern was the potential for deadheading one or more pumps that have a common mini-flow line. The second concern is whether or not the installed mini-flow capacity is adequate to prevent damage to safety related pumps. In a response dated June 28, 1988, we acknowledged that each of the pumps in the Auxiliary Feedwater (AFW) System have their own recirculation lines with an AOV isolation valve and an orifice upstream of the common return line to the condensate storage tank (CST). We discussed the logic of the recirculation valves to open or shut dependent on AFW system forward flow. We also acknowledged that the flow orifices for the pumps needed to be replaced with higher flow orifices to ensure sufficient flow for indefinite pump cooling via the recirculation lines.

On July 7, 1988 modifications MR 88-099*A-C were initiated to increase the recirculation line flows to prevent pump degradation due to hydraulic instability. The minimum pump flow prior to this MR was 30 gpm. The MR increased this to minimum flow to 70 gpm for the MDAFPs and 100 gpm for the TDAFPs. The replacement orifices were installed during 1991.

During 1996 and 1997 several condition reports were written regarding high noise levels associated with operation of the AFW pumps while on mini-recirc. EWR 99-031 was initiated on 12/8/98 to determine if the orifices were incurring damage from cavitation and needed replacement. During 1998 and 1999 weld cracks were discovered in the recirculation piping associated with the MDATW pumps. On July 9, 1999 the Engineering Advisory Committee (EAC) reviewed three options proposed to address EWR 99-031. The options were to install a multi-stage restricting orifice (RO) of the same type as currently installed but with 10 stages instead of 2 stages used in the present design, to install a new design involving a pressure-reducing flow element in a valve body, or to install a multi-stage pressure-reducing trim in the recirculation line AOVs. The EAC did not select an option, but did recommend implementing modifications for the MDAFW pumps during 2000 and evaluate performance to determine if TDAFW pumps should be modified during 2001. Modifications MR 99-029*A-D were initiated during 1999 to replace the AFW recirculation line restricting orifices. RCE 99-081 evaluated the socket weld failures in the AFW recirculation lines and concluded that vibrations induced by the RO cavitation caused the cracking. The RO modification scope was expanded to address weld and pipe replacement and installation of oversized sockets.

The option to install a new design involving a pressure-reducing flow element in a valve body was chosen and the new orifices were installed in the recirculation lines for the MDAFW pumps during November 2000. Some difficulty was encountered in achieving the desired flow rates through the orifices and it was necessary to drill additional holes in the trim. The design was changed for the TDAFW pump orifices to include a movable

plug that could be adjusted to vary the flow. The Unit 2 TDAFW pump orifice was replaced in April 2002 and the Unit 1 TDAFW pump orifice was replaced in September 2002.

Event

On 10/23/2002 at 0400, Operations removed MDAFW pump P-38A from service for scheduled maintenance. During the day shift, Maintenance personnel conducted scheduled corrective maintenance on P-38A. Work orders 9945610, 0205651 and 9949098 were performed. These WOs consisted of changing the operating diaphragm on Aux Feed discharge control valve, AF-4012, repacking the inboard and outboard stuffing boxes (pump seals) on P-38A, and replacing service water drain valve AF-38.

While repacking the pump, Maintenance found only six packing rings on both the inboard and outboard sides of the pump instead of the expected seven rings. Maintenance put 7 rings in each seal and documented these findings on CAP029923.

The physical work with replacing AF-38 involved cutting the socket weld, manually removing the valve, inspecting the piping visually, prepping the area for reinstallation, and then installing the new valve with a socket weld.

The work on AF-4012 involved replacing the valve's operating diaphragm. Following completion of the physical work, I&C performed a drop test on the AOV diaphragm. The drop test failed and day shift turned this work over to night shift for completion.

On night shift, Maintenance changed the stem diaphragm gasket on the AOV early in the shift. Re-performance of the drop test was successful, testing on the instrumentation was completed by I&C, and the pump was turned over to Operations for post-maintenance testing.

Operations filled and vented the pump suction line, casing, and discharge line per OI 62A, Motor-Driven Auxiliary Feedwater System (P-38A & P-38B). The venting procedure requires the suction line to be vented first until a solid stream of water is observed, followed by the casing vent and finally the discharge vent.

On 10/24/2002 at 0159 hours, Operations started P-38A for post maintenance testing per IT 10, Test of Electrically Driven Auxiliary Feed Pumps and Valves (Quarterly). When the pump started, a Maintenance supervisor observed that the suction relief valve (AF-4028) momentarily lifted, reseated, but continued to drip water. The relief valve has WO 9948850 associated with it. The relief valve was also observed to not be sucking air. This was determined by the Maintenance supervisor holding his hand over the discharge tailpiece to feel for suction.

Maintenance personnel proceeded to adjust the pump packing as expected. It was observed that the recirc flow was 64.5 gpm. The shift manager was informed of the matter. The Shift Manager directed the crew to first vent the flow indicator. This resulted in no improvement in flow. He then had the crew monitor the pump casing for

overheating. The pump was reported to be cool to the touch. The shift manager then directed the crew to secure the pump. The pump was secured at 0212 hours. The crew observed a normal coast down of the pump. The Shift Manager stated he felt assured that the pump was not degraded or damaged from low recirc flow based upon the short run time (13 minutes) and the above listed parameters. IT 10 requires 70 gpm recirc flow. Minimum flow to prevent damage to the motor-driven auxiliary feedwater pumps is 50 gpm.

After the pump was secured, the Shift Manager discovered that I&C had calibrated the flow indicator the previous day. He requested that I&C perform a calibration check to verify proper operation. This was performed with different MTE than the original calibration. The calibration check was satisfactory (~0440).

The Shift Manager also requested that I&C review the instrument venting procedure with the auxiliary operator who performed the earlier vent. The auxiliary operator and I&C technician concluded that the transmitter was vented correctly. The crew also re-vented the pump suction piping, casing, and discharge piping. During each of the vents, solid streams of water were observed with no air. An auxiliary operator verified the valve lineup satisfactory.

CAP029908 was initiated by Operations at 0323 to document the inadequate flow obtained during performance of IT 10.

The AFW System Engineer was notified at 0400 on 10/24 at which time an investigation was commenced. Between 0500 and 0700 hours, the potential causes were defined in order of likelihood:

1. Restriction in the piping.
    a. Recirculation orifice AF-4008
    b. Check valve degradation: AF-112 or AF-115
    c. Manual valve problem: AF-39 or AF-27
    d. Recirc AOV stem-to-disc separation: AF-4007
    e. FE-4050A degradation
2. Instrumentation: FIT-4050A.
3. Degradation of the pump rotating assembly.
4. Valve leakage to the discharge path.
5. Pump P-38A was not adequately vented.

At about 0603, the BOP/NSSS Mechanical Systems Engineering Supervisor was established as the overall lead for Engineering for this issue.

At 0830 hours on 10/24/02, a meeting was held to discuss the issue. The BOP/NSSS Mechanical Systems Engineering Supervisor led the meeting, with representatives from Engineering, Maintenance, and Operations in attendance. It was decided to perform the following actions:

1. I&C - Re-vent the transmitter once again (Engineering to observe) and verify the position of the equalizing valve.
2. Operations - Vent all lines and the pump casing with Engineering observing.
3. Engineering - Use a UT flow transmitter to verify installed indication.
4. Engineering to take vibration data.
5. Discharge pressure will be monitored.
6. A work plan to open RO-4008 will be prepared in parallel to be worked if adequate flow cannot be achieved.

The venting was performed by Operations in accordance with OI 62A, Section 7.1. No air was noted during the vent; there was a solid stream of water from all three vents. The UT flow device was attached and the flow transmitter was vented. A pre-job brief was held by Operations with the control operator, auxiliary operator, and supervision. The brief included the direction that if recirc flow was not >70 gpm, then the pump would be secured immediately.

At approximately 1100 hours, Operations started P-38A. Equipment and components responded as expected. Indicated flow on the recirc transmitter went to about 64 gpm. The UT device flow stabilized at 60 gpm. The on-scene SRO observed these indications and directed that the pump be secured after running for less than one minute. During the run, Engineering took vibration data, which indicated, normal. P-38A was then danger tagged and drained to allow removal and inspection of the flow orifice.

Maintenance removed the orifice. The Mechanic noted several of the holes on the outside sleeve were plugged. There was no evidence of debris in the pipe (a boroscope was used to verify this). The orifice was taken to the maintenance shop where Engineering mapped the plugged holes and took photographs of the orifice. Rust blockage was noted in 24 of the 54 outer holes. Maintenance milled off the spot welds on the retaining pins to facilitate removal of the sleeves. The pins were driven out with a punch. The nested sleeves had to be tapped out using a block and hammer. The mechanic-electrician who disassembled the orifice stated that all of the sleeves except the outermost sleeve were "spotless" with no evidence of debris. Material did fall out of and off the orifice during disassembly. Four small particles were collected for further analysis.

Following cleaning and inspecting, the nested sleeves were reassembled and reinstalled using a new bonnet gasket (spiral wound) and the old seat gasket (spiral wound but already compressed because a new gasket was not available). Installation was completed by 1800 hours.

During night shift on 10/24 Operations cleared tags, and filled and vented the system per OI 62A. Maintenance, Operations and Engineering met to discuss the next test run. The Maintenance supervisor requested that the high points be re-vented prior to the run. Operations re-vented the suction (solid stream) and discharge (slight amount of air) piping. Operations then started P-38A pump per OI 62A at 2115 hours. Recirc flow was

observed to be within specification at 75 gpm. Following satisfactory observance of key parameters, the pump was secured.

Earlier in the shift, at approximately 1700 to 1800 hours, the Shift Manager directed Chemistry to sample all four AFW pump suctions and both condensate storage tanks. The purpose of these samples was to determine the water quality as it related to possible plugging of the recirc orifices. The communication received by the chemistry technician was to obtain and analyze samples from Unit 1 and Unit 2 auxiliary feedwater and from the Unit 1 and Unit 2 condensate storage tanks.

The Chemistry Supervisor stated that the Unit 1 and Unit 2 auxiliary feedwater suction samples were taken at 1C26 and 2C26, feedwater sample control panels. These were aligned to the 1&2 P29 turbine-driven auxiliary feedwater pump suctions, and that is where the samples were drawn from. The chemistry technician also took samples from both condensate storage tanks (CSTs) at their normal sample points on El. 26'. The CST sample points tap into the CST are, 6" to 1' above the elevation that auxiliary feed suction piping exits the CSTs. The samples were analyzed for total suspended solids (TSS), chlorides, fluorides, and sulfates. The Chemistry Supervisor stated that the results showed nothing abnormal.

The Shift Manager then made preparations to perform IT 10, Test of Electrically Driven Auxiliary Feed Pumps and Valves (Quarterly), for both the post-maintenance return to service test and the scheduled quarterly run on both motor-driven pumps. A Unit 2 power reduction to meet IT 10 requirements of 98% power was completed at 2200 hours. The shift manager decided to turn over IT 10 to the mid shift.

Testing of P-38A was completed satisfactorily at 0216 hours on 10/25/02; the recirc flow indicated 75.2 gpm on FIT-4050A, mini-recirc flow, at which time AFW pump P-38A was returned to service and the TSAC was exited. Testing of P-38B was completed satisfactorily at 0450 hours on 10/25/02; the recirc flow indicated 74 gpm on FIT 4050B, mini-recirc flow. A partial performance of IT 8A to test 1P29 recirc flow was performed and IT 9A was performed to verify 2P29 operation. All testing was completed and all four pumps were back in service by 1206 hours on 10/25.

ACE001023 was initiated on 10/25 at 1030 to evaluate the inadequate recirculation flow on P-38A.

On 10/25, the Operations Manager and the Assistant Operations Manager discussed the event. The Assistant Operations Manager stated that we needed a short-term follow up action plan to address the orifice plugging issue. He wanted to know if contingencies needed to put in place, such as: increase our testing frequencies; do call-ups to run the pumps more often; perform the Service Water flush more often; institute a sampling plan; etc. The Operations Manager stated that the conversation focused on the additional actions needed to done to finalize extent of condition/cause for the P-38A recirc line plugging. Late in the afternoon they paged the BOP/NSSS Mechanical Systems Engineering Supervisor who called back from home. The BOP/NSSS Mechanical

Systems Engineering Supervisor, Operations Manager, and Assistant Operations Manager had a conference call. They acknowledged that an Apparent Cause Evaluation had already been assigned to System Engineering to look into the cause of the plugging. Because ACEs have 30 day due dates, the Operations Manager and Assistant Operations Manager wanted System Engineering to develop any recommended short-term actions more quickly than 30 days. They mutually agreed to a one week due date (11/01/02) for Engineering to recommend what, if any, short-term actions should be taken. During the conversation the BOP/NSSS Mechanical Systems Engineering Supervisor asked if Operations was questioning operability, and they said they were not. The BOP/NSSS Mechanical Systems Engineering Supervisor stated that he did not have any operability concerns at this point in time. The purpose of the action plan was to find the source of the foreign material and to determine what other testing or flushing would be required to assure that future plugging does not occur. The Operations Manager stated that they also discussed the fact that we needed to look at service water to ensure we didn't have a potential to plug the orifice from service water.

The BOP/NSSS Mechanical Systems Engineering Supervisor later stated that since neither he nor the Operations Manager had any concerns with AFW operability, no immediate response was required and that over the weekend (10/26-1027) he considered the actions that might be required and formulated potential questions that needed to be answered that would be discussed at the meeting he would hold on 10/28. The Operations Manger has also stated that he didn't ask for weekend evaluation of the issue because he didn't think it was realistic that the recently designed and installed orifices would be susceptible to plugging from service water.

On 10/28/02 at 1100 hours, Engineering held a meeting to discuss the event. The meeting included the AFW System Engineer, the Engineering Programs Supervisor, the Engineering Analysis Supervisor, the PRA Supervisor, the BOP/NSSS Mechanical Systems Engineering Supervisor, a Maintenance Support Engineer, and the SW System Engineer. The outcome of this meeting identified a need to research the following items:

- What is the material?
- What is its origin?
- What are the tolerances in the pump?
- What is the size of holes in the main SW Zurn strainer?
- Can we perform an operability determination on the SW issue from a realistic approach?
- Explore the silt study.
- Get detailed information on the recirc orifice.

Early on 10/29/02, the BOP/NSSS Mechanical Systems Engineering Supervisor convened a meeting to review the issue in detail with other members of Engineering. He stated that his purpose in convening the meeting was to communicate his conclusions that he had a reasonable degree of certainty that the issue of potential orifice clogging from service water debris was valid. The meeting was convened at 0900 hours. Personnel in attendance were the Director of Engineering, the BOP/NSSS Mechanical Systems

Engineering Supervisor, the PRA Supervisor, the Auxiliary Feedwater System Engineer, the Service Water System Engineer, and the Engineering Analysis Supervisor. The Engineering Director inquired whether there was a concern regarding the ability of the system to perform its design functions. Most, if not all persons in attendance stated that they had the concern that in a situation where AFW was required to take suction from the SW system, the running pumps' recirculation orifices would likely become plugged and non-functional. The Regulatory Affairs Manager was then briefed on the issue. The BOP/NSSS Mechanical Systems Engineering Supervisor immediately informed Operations of the concern.

On 10/29/02 at 0945 hours, a meeting with Operations and Engineering personnel was held to discuss the internal tolerances of the RO with respect to potential plugging. Attendees at the meeting were the Operations Manager, a Shift Manager, the Operations Procedure Coordinator, the Acting Plant Manager, the Regulatory Affairs Manager, the CVCS and RCS System Engineer, the Service Water System Engineer, the Auxiliary Feedwater System Engineer, the BOP/NSSS Mechanical Systems Engineering Supervisor, the PRA Supervisor, the Senior PRA Engineer, and two Operating Supervisors. The presentation basically expressed a concern with the recirc orifice plugging if SW flow was initiated to the pumps. The Operations Manager stated that the discussion centered around the fact that the service water basket strainer mesh is 1/8" and the orifice is much finer (~15mil x 90 mil). He further stated that they had extensive discussion on the fact that the AFW safety related suction source is service water. They also talked about whether we could call AFW operable from the Condensate Storage Tanks (CSTs). Most people in the room were confident that the CSTs were acceptable as a suction source, however two engineers questioned that. The Operations Manager stated that he felt that the two engineer's questions were based on uncertainty. The attendees discussed whether we could do an evaluation (OPR) on the service water suction and engineering personnel concluded that we could not in the short term. The Operations Manager stated the since service water is the safety related suction source, and we had a condition where the recirc line could fail from potentially poor water quality, and there was no indication of recirc flow in the control room, we did not have reasonable confidence that AFW could perform its safety function under all accident conditions and subsequently declared AFW out of service.

At 1027 hours on 10/29/02, all four auxiliary feedwater pumps were declared out of service due to AFW recirc orifice flow issues. Upon declaring AFW out of service, the attendees discussed options for return to service. These included shutting down the plant. Per Technical Specification 3.7.5, when all AFW is out of service, we maintain stable plant conditions until we return a pump to service. We then take actions as directed by the other TSACs. The attendees also discussed compensatory measures and concluded that we needed a combination of administrative controls, briefs and training to essentially eliminate the need for the recirc line.

The Operations manager stated that the short-term actions were crew briefings and temporary information tags in the control room at the flow indicators to maintain 50/75

gpm forward flow for motor/turbine driven pumps. Once the briefings and temporary information tag placement were complete, AFW could be declared operable.

Briefing of the on-shift crew on the AFW recirc flow orifice issue was completed at 1100. Posting of temporary information tags for all 4 AFW pumps with requirements to secure AFW if minimum flow is not maintained was completed at 1210.

At 1241 a CAP was initiated by the Systems Engineering Supervisor on the concern for a potential common mode failure for the AFW pumps due to plugging of the recirculation line orifices.

All 4 AFW pumps were returned to service at 1305, based on the compensatory actions taken.

At 1410, the Engineering Director established a root cause team comprised of two Engineers from the Process Engineering Group, the AFW System Engineer, and a Design Engineer.

At 1525 the Engineering Director discussed the need for an operability determination with the Regulatory Affairs Manager and the Operations Manager because of the possible operable but nonconforming condition of the AFW pumps.

Simulator runs were made from about 1530 to 1630 to evaluate the risk impact of the compensatory measures taken.

At 1700, the Operations Manager accepted Safety Screening SCR 2002-0458 for the procedure changes needed due to the potential for AFW orifice plugging.

The 8-hour NRC notification required by 10 CFR 50.72(b)(3)(v)(D) was made using the Emergency Notification System (ENS) telephone at 1711. Event number EN 39330 was assigned to this notification.

The Operations Manager requested an OPR for CAP029952 concerning the common mode failure of the AFW pumps from Engineering at 1830.

At 2030, the Safety Monitor transitioned to Yellow for both units based on PRA Group input.

On 10/30 at 0700, the initial meeting of the Root Cause Team was held to discuss scope and responsibilities.

At 1030, the Engineering Director suspended the qualifications for design work for three individuals involved with the AFW orifice modifications.

At 1100 the site was notified that an NRC Special Inspection Team would be responding to the Event Notification.

The Engineering Director approved the charter for the Root Cause Team at 1250.

OPR000031 was completed and approved at 1850. OPR000031 concluded that the AFW pumps were operable but nonconforming because the AFW pump recirculation paths described in the FSAR were not available. Compensatory actions specified included shift briefings and placement of temporary information tags. An additional action specified was to implement operating procedure changes. The condition where compensatory actions could be terminated was stated as an engineering evaluation or modification to restore the function of the recirculation lines.

On 10/31, the Site Vice President established an event resolution team to provide management oversight to drive resolution of the issue involving the potential to have a common mode failure due to orifice plugging in the AFW recirculation lines. The organization consisted of:

- Team Lead – Nuclear Oversight Manager (temporarily relieved of job responsibilities)
- Incident Investigation – Radiation Protection Manager
- On-Line Risk Management – Production Planning Manager
- Interim Corrective Actions – Operations Manager
- Issue Resolution Team and Root Cause Evaluation – Engineering Director

III. Extent of Condition Assessment

[Written summary of the generic implications and the breadth (symptoms & causes) of the problem.]

- SG blowdown lines
- Radwaste steam?

IV. Nuclear Safety Significance

[Written summary of actual and potential nuclear safety implications. This may require input from Licensing, Engineering or Probabilistic Risk Assessment depending upon the event.]

Under development – depends on plugging probabilities. On line risk is yellow with procedural restrictions in-place.

V. Report to External Agencies

This event was determined to reportable to the NRC in accordance with 10 CFR 50.72(b)(3)(v) as a condition that could have prevented the fulfillment of the safety function of structures or systems that are needed to:...(D) Mitigate the consequences of an accident. This is an eight-hour non-emergency notification. The NRC notification was made using the Emergency Notification System (ENS) telephone at 1711 on October 29th. Event number EN 39330 was assigned to this notification.

A Licensee Event Report (LER 266/2002-003-00) will be submitted within 60 days of this event as required by 10 CFR 50.73.

CA026903 has been initiated to issue an operating experience notice to the industry if appropriate.

CAXXXXX has been initiated to report this event to KNPP.

[This section subject to revision based on conclusions regarding plugging probabilities.]

VI. Data Analysis

Information & Fact Sources

[Interview Information]
[Questionnaires/Surveys]
[Data Sources (Data, Logs, Records, Procedures, Etc.]
[Direct Evidence (Parts, Photos, Etc.]
[Relevant Industry & Station Operating Experience]

Document Review Results

EWR 99-031
The EWR was initiated on 12/8/98 to address Control Room noise resulting from operation of the AF pumps in the recirculation mode. The EWR was to determine if restricting orifices in the recirculation lines should be replaced with multi-stage restricting orifices. An action item was created on 4/15/99 and assigned to Mechanical Design Engineering. In an update to this action item made on 6/4/99, Design Engineer 1 concluded that most of the noise was due to cavitation in the restricting orifice, and that the orifice did not have an adequate number of stages. It was recommended that an EAC evaluation be performed to look at three options to resolve the issue. The options were installation of a multi-stage pressure- reducing orifice, replacement of the present orifice with a pressure-reducing flow element in a valve body, and retrofitting the AOV control valve with a multi-stage pressure-reducing trim.

On July 9, 1999 the Engineering Advisory Committee reviewed three options proposed to address EWR 99-031. The EAC did not select an option, but did recommend implementing modifications for the MDAFW pumps during 2000 and then evaluate performance to determine if TDAFW pumps should be modified during 2001. Modification requests MR 99-029*A-D were initiated to replace the AFW recirculation line restricting orifices and the EWR action item was closed on 7/29/99.

OD CR 99-1391
Rev. 0 of this OD was issued on 5/21/99 and dealt with three pinhole leaks that had developed on the MDAFW pump recirculation lines in the past year. The safety function for the recirculation line is described as designed to ensure a minimum flow through the

AF pumps to protect from adverse effects of hydraulic instability at low flow rates. The minimum flow rate for the MDAFW pumps (P-38A and P-38B) is 70 gpm, and for the TDAFW pumps (1P-29 and 2P-29) it is 100 gpm.

In the section of the OD that discusses the basis for declaring the SSC Operable But Degraded or Nonconforming, reference is made to the Westinghouse LONF/LOAC Analysis and that it requires the AFW recirc AOV to close within 60 seconds after the flow setpoint has been reached. DBD-01 describes the delay in reaching full capacity for MDAFW pumps as being 35 seconds and for the TDAFW pumps it is 39 seconds. It is then concluded that the recirculation line AOV will not be open longer than 100 seconds. The discussion then describes that various PBNP EOPs require the use of AF to maintain SG levels, and that this may require operation at low flows such that the recirculation AOV could be open. Part II of the OD specifies that implementation of MR 99-029*A-D will replace the existing orifices and that build up of the socket welds will occur during installation of those modifications.

The OD was revised on 1/7/00 to combine it with an OD from CR 99-1844, which dealt with the cause of the weld failures. The OD was revised again on 3/6/01 to reflect completion of MR 99-029*A&B for the MDAFW pumps, which restored them to a fully operable condition. The OD was closed on 10/22/02 after MR 99-029*C and D were completed.

Evaluator Observations:

- *The OD clearly recognizes the need for having AFW recirculation capability during an accident.*

MR 99-029*A/B (MDAFW Pump ROs)

The purpose of the proposed modifications was to minimize piping line noise and vibration when operating the MDAFW pumps in the recirculation mode. This would also eliminate the socket weld failures caused by cycle fatigue created by this vibration.

The scope of the modifications was to replace the existing restricting orifices with new pressure reducing orifices. In addition, a portion of piping was being replaced which included oversized weld sockets.

Installation and testing were completed during November 2000. MR 99-029*B was accepted during November 2000; MR 99-029*A was accepted in March 2001, following drilling of additional holes in the innermost stage of the orifice to achieve the desired flow rate.

The final design description contains the following relevant information:

- DBD-01, Auxiliary Feedwater System, is listed as a design input
- The replacement RO will have the same function as the existing orifice RO-4008 (RO-4014), which is to provide pressure reduction and act as a pressure boundary for the AF system piping.

- It (Bechtel Specification No. 6118-M-6 Rev. 3 dated 10/28/68) specifies that, "Each pump shall be furnished with a pressure reducing orifice to be used in conjunction with the on-off control valve in the pump recirculation piping."
- The design of the new RO is different than the presently installed orifice.
- The replacement RO is heavier than (the) existing one.
- None of the above changes is introducing new, unknown equipment to PBNP.
- The proposed modification is located in the Control Building on Elevation 8", and adheres to the requirements of the Fire Protection Evaluation Report. A fire protection analysis, for the affected area, has been performed and the Fire Protection Conformance Checklist, PBF-2060 has been completed and approved.

The design input checklist (PBF-1584 Rev. 6 3/31/99) contained the following:

- Item A.6, Incorporate new types/models of equipment not presently used at PBNP? – APPLIES TO DESIGN? – NO
- Item A.10, Consider failure effects on structures, systems, and components: - APPLIES TO DESIGN? – NO
- F.2.b, Affect fire protection requirements? – APPLIES TO DESIGN – YES
- F.2.f, Based on Tables 6.7-1 to 6.7-4 and Figures 6.6-1 to 6.6-8b and 6.9-1 to 6.9-2d, will the change add to, delete from, or revise the listed systems and components? – APPLIES TO DESIGN – YES

The modification request checklist (PBF-1606 Rev. 5 7/24/98) had the following regarding documentation updates:

- Item B.4, Component Instruction Manuals – N/A
- Item B.14, EPIX Update – N/A
- Item B.18, PSA Models and Documentation – N/A
- Item C.5, Spare parts stocking and scrapping inputs into CHAMPS – N/A
- Item D.1, Abnormal Operating, Normal Operating, and Refueling Procedures – N/A
- Item D.5, EOPs, ECAs, CSPs – N/A
- Item E.4, Preventive Maintenance – initiate/revise CHAMPS callups – N/A
- Section I, ECRs – blank

The MR 99-029*A package has an addendum with a revised IWP to drill 6 additional holes in the innermost stage of the orifice. The MR 99-029*B package utilized the existing IWP and revised it to drill 4 additional holes in the innermost stage of the orifice. There is a pen and ink change to the IWP revising the number of holes from 4 to 6.

Evaluator Observations:

- *The final design description does not discuss the potential for orifice plugging from service water*
- *The final design description does not discuss service water strainer size*
- *DBD-01 describes a safety-related function of the orifice to provide sufficient flow to prevent low-flow instabilities and excessive fluid temperature rise in the AFW pumps – this is not discussed in the final design description*

- *The basis for concluding that the RO is not new or unknown equipment does not address the new orifice size being less than the service water strainer*
- *The basis for not performing a FMEA is not provided*
- *The Fire Protection Conformance Checklist answer to question 5.8, "Will the revised shutdown component continue to perform its function required by AOP 10A, AOP 10B, AOP 10C, and AOP 10D?" is marked YES with no basis provided.*

SE 2000-0055 (MR 99-029*A/B)

The safety evaluation screening for MR 99-029*A/B concluded that there was a difference in the design of the replacement RO, so the proposed activity would constitute a change to the facility as presently described in the current CLB.

The approved safety evaluation contains the following relevant information:

- The ROs do function to support operation of the AF system pumps P-38A and P-38B and these pumps are involved in accidents (Section 2.A.1)
- The changes that will be implemented by the proposed modifications will not affect the overall performance of the AF System and operation or function of the AF pumps P-38A and P-38B to perform their intended function (Section 2.A.1)
- During accident conditions, the safety related functions of each AF pump recirculation line orifice is as follows: (in part) These ROs must provide adequate flow to prevent low-flow instabilities and excessive fluid temperature rise in the AF system pumps (Section 2.A.2)
- The components are passive in nature when the system is operational and will be designed, installed and tested in accordance with the existing procedures and controls. Therefore, they do not introduce any new failure mechanisms not already considered for the area. (Section 2.A.2)
- The modified recirculation lines will function identically to the currently installed recirculation lines (Section 2.A.4)
- The oversized socket welds and replacement ROs do not change the function, method(s) of operation, or introduce any new credible failure mechanisms to the AF pumps P-38A and P-38B and their recirculation lines (Section 2.A.5)
- The flow passage area of replacement ROs could possibly lead to reduced pump recirculation flow during operation of the pumps with SW since particles/debris in the SW could be filtered by the RO's trim. To preclude this, the RO's design directs flow through the outside of the trim. The outside cartridge of the trim contains the smallest size flow passage area. The flow passage area then becomes progressively larger. Therefore, the smallest flow passage areas are located at the zone of highest differential pressure. This design feature reduces the potential of debris accumulation on the RO's trim. (Section 2.A.5)
- The recirculation line AOV automatically closes approximately 45 seconds after the pump discharge flow is approximately 95 gpm and increasing. Failure to pass flow through the recirculation orifice during the 45 seconds would be conservative since flow to the SGs would be delivered sooner. The recirculation line AOV is also designed as a failed closed valve to ensure that recirculation

flow is not diverted from the SG in the event of a loss of instrument air. (Section 2.A.5)

- The recirculation line flow path is not require to support AF system in its response to the design basis accidents since the pumps' discharge valves will automatically open fully in response to the accident and provide a flow path for the pump. Failure to pass flow through the recirculation orifice due to potential of SW debris accumulation on the ROs trim would be conservative since flow to the SGs would be delivered sooner. (Section 2.B)

The Manager's Supervisory Staff reviewed the safety evaluation at a meeting on 4/18/00. The version of the safety evaluation presented to MSS had different wording that generated some discussion. The MSS Chairman questioned a phrase in Section 2.A.5 that stated "The AF pumps have 9 stages with 0.009" to 0.014" diametrical clearances and a minimum 0.4375" impeller vane path. Since the pumps have multiple stages and small clearances, they will reduce larger particles size contained in SW to less than 0.015"." The MSS Chairman did not feel the statement was entirely true because he felt that particles could go through the vane paths. The AFW System Engineer said the pump had 9 stages and the particles would have to clear all 9 clearances in order to pass through, and this was unlikely to occur.

The Mechanical Design Supervisor said the discussion that could be included in that section is that of plant configuration and the fact that SW is used. He also did not like the quantitative discussion and recommended discussing the recirculation line flow path.

The Design Engineer subsequently removed the phrase from the safety evaluation and included a different discussion including the phrase "The recirculation line flow path is not required to support this function since the pump discharge valves will automatically open fully in response to the accident and provide a flowpath for the pump. The recirculation line AOV automatically closes at approximately 95 gpm increasing. Failure to pass flow through the recirculation orifice during the 45 seconds would be conservative since flow to the SGs would be delivered sooner. The recirculation line AOV is also designed as a failed closed valve to ensure that recirculation flow is not diverted from the SG in the event of a loss of instrument air."

With those changes made, MSS recommended approval of the SE. The Operations Manager approved the document in the absence of the Plant Manager.

The JOSRC 50.59 Subcommittee reviewed and approved the SE without comment at its meeting held on 6/27/00.

In an earlier, undated version of the draft safety evaluation, the following information was provided:

- In summary, based on the large differential pressure across the ROs and the effect of pump discharge clearances on SW sample particle size, the replacement ROs design will not result in acute reduction in AF pumps recirculation flow, therefore, causing the pumps to fail. In addition, the body of the replacement ROs

contain a bolted blind flange that can be removed to facilitate cleaning of the trim in the event of long-term debris accumulation. This long-term accumulation can be identified in advance by noticing a changing pattern of recirculation flow values that are recorded during IT-10/10A/10B.

Evaluator Observations:

- *The safety evaluation does not discuss the Appendix R function (part of the CLB) of the recirculation line as a safe shutdown flow path.*
- *The safety evaluation only discusses the recirculation line function during AFW pump start and does not address pump shutdown or the need for operation on recirc during the other stages of accident response.*
- *The safety evaluation states that the modified recirculation lines will function identically to the existing lines even though it is assumed that the orifices may plug.*
- *The safety evaluation does not consider that loss of the recirculation line due to loss of instrument air is recoverable via actions specified in AOP-5B.*
- *The safety evaluation discussion concerning the orifice design that precludes plugging is extracted from the vendor manual, where the information is discussing why the internal throttle plug (on a different design orifice) will not stick or gall.*
- *Neither MSS nor JOSRC raised the aforementioned issues.*

MR 99-029*C/D (TDAFW Pump ROs)

The purpose of the proposed modifications was to minimize piping line noise and vibration when operating the TDAFW pumps in the recirculation mode. This would also eliminate the socket weld failures caused by cycle fatigue created by this vibration.

The scope of the modifications was to replace the existing restricting orifices with new pressure reducing orifices that had a movable plug. In addition, a portion of piping was being replaced which included oversized weld sockets.

Installation and testing of the Unit 1 TDAFW pump RO was completed during September 2002, and the modification was accepted during October 2002. Installation and testing of the Unit 2 TDAFW pump RO was completed during April/May 2002, and the modification was accepted during May 2002.

The final design description contains the following relevant information:

- DBD-01, Auxiliary Feedwater System, is listed as a design input (*D only)
- The replacement RO will have the same function as the existing orifice, which is to provide pressure reduction and act as a pressure boundary for the AF system piping.
- It (Bechtel Specification No. 6118-M-6 Rev. 3 dated 10/28/68) specifies that, "Each pump shall be furnished with a pressure reducing orifice to be used in conjunction with the on-off control valve in the pump recirculation piping."
- The design of the new RO is different than the presently installed orifice.
- The replacement RO is heavier than (the) existing one.

- None of the above changes is introducing new, unknown equipment to PBNP.
- A Fire Protection Conformance Checklist, PBF-2060 is listed as a design output (*C only).

The design input checklist (PBF-1584 Rev. 8 6/8/01 for *D and Rev. 9 11/5/01 for *C) contained the following:

- Item A.6, Incorporate new types/models of equipment not presently used at PBNP? – APPLIES TO DESIGN? – NO
- Item A.10, Consider failure effects on structures, systems, and components: - APPLIES TO DESIGN? – NO
- Item F.2.b, Affect fire protection requirements? – APPLIES TO DESIGN – NO
- Item F.2.e, Based on Section 2 and Appendix A of the SSAR, will the change add to, delete from, or affect the performance of safe shutdown systems or equipment? – APPLIES TO DESIGN – YES (for *C) and NO (for *D)

The modification request checklist (PBF-1606 Rev. 5 7/24/98 for *D and Rev. 6 10/2/01 for *C) had the following regarding documentation updates:

- PSA Models and Documentation – N/A
- Spare parts stocking and scrapping inputs into CHAMPS – N/A
- Abnormal Operating, Normal Operating, and Refueling Procedures – N/A
- EOPs, ECAs, CSPs – N/A
- Preventive Maintenance – initiate/revise CHAMPS call-ups – N/A
- ECRs – blank

Evaluator Observations:

- *The final design description does not discuss the potential for orifice plugging from service water*
- *The final design description does not discuss service water strainer size*
- *DBD-01 describes a safety-related function of the orifice to provide sufficient flow to prevent low-flow instabilities and excessive fluid temperature rise in the AFW pumps – this is not discussed in the final design description*
- *The basis for concluding that the RO is not new or unknown equipment does not address the new orifice size being less than the service water strainer*
- *The basis for not performing a FMEA is not provided*
- *Applicability of affect on Fire Protection is not addressed correctly for the *D modification.*
- *For the *C modification, the Fire Protection Conformance Checklist answer to question 5.6, "Does the modification affect operation of a system relied upon for post-fire safe shutdown (e.g. changes is system flow rate, change in normal position, etc.?" is marked NO with a statement that "Operation of the auxiliary feedwater system will not be affected. The replacement RO will be set to the same flow rate as the current RO." This is not consistent with assumptions from the previous modifications to the MDAFW pump ROs that the recirculation line may not be available due to plugging.*

SCR 2001-0981 (MR 99-029*C/D)
The safety evaluation screening for MR 99-029*C/D was performed under the new 10 CFR 50.59 rule and concluded that the activity did not adversely affect the design function of an SSC credited in safety analysis, and did not adversely affect the method of performing or controlling the design function of an SSC credited in safety analysis. Supporting information included:

- The restricting orifices design functions affected by the modifications are: (in part) They ensure adequate flow and pressure drop through the AFW pumps when they are operated in the recirculation mode, thus preventing low flow instabilities and excessive fluid temperatures. (Section I.2 and II)
- These orifices are not explicitly required in an accident to be able to pass service water, since the recirculation control valve would be closed when the pump is aligned to the steam generator. However, it is possible that when the pump is aligned to the service water system supply after the condensate storage tanks have been drained, service water could be pumped through the recirculation lines. (Section III.1)
- To preclude the chance of clogging the orifice trim, the flow is directed from the outside of the stages inward. The holes in the outer stage are the smallest and they get progressively larger in the inner stages. This causes the largest differential pressure to exist at the outer stages at locations with the smallest hole, which will reduce the potential for debris accumulation inside the orifice. (Section III.1)

The MSS and JOSRC did not review this information because it was determined to only be a screening under the new rule.

Evaluator Observations:

- *The safety screening does not discuss the Appendix R function (credited in the safety analysis) of the recirculation line as a safe shutdown flow path.*
- *The safety screening does not fully evaluate the recirculation line function while supplying service water to the SGs. The ability to start and stop the AFW pumps while on service water and to throttle back AFW flow to the SG is not addressed.*
- *The safety screening raises the issue of the potential for the recirculation orifices to accumulate debris from SW but does not provide any definitive basis for the conclusions drawn regarding its impact on AFW pump operation.*
- *The safety screening discussion concerning the orifice design that precludes plugging is extracted from the vendor manual, where the information is discussing why the internal throttle plug will not stick or gall.*
- *There is no discussion explaining the change in conclusions drawn from SE 2000-0055 regarding not needing the recirculation line.*

MR 02-029 (Upgrade safety function of AFW recirculation AOVs and line)
The purpose of this modification was to upgrade AFW minimum flow recirculation AOVs to have a safety related function to open.

The scope of the modification included removal of the internals for check valve AF-117 to prevent a common mode active failure of all AFW pumps due to isolation of the mini-recirculation line. The AF-117 valve is non-QA, non-Seismic, and non-ASME. The modification will document the upgraded design basis of the AFW recirculation line AOVs and piping to support the safety-related function to provide a flow path for the AFW pumps to prevent overheating and hydraulic instabilities.

There was not EAC review of this modification because it was scoped as a Level of Effort Minor Plant Change.

This modification was initiated on 8/20/02, and was installed, tested and accepted on 9/12/02.

The final design description contains the following relevant information:

- The minimum recirculation flow AOVs have a safety-related function to close to ensure adequate flow to the steam generators during several events.
- FSAR Section 10.2 also discusses the effects of a failure of a mini-recirc AOV to close and gives the flow that is diverted from the steam generators through the recirculation lines as limited by the flow restricting orifices.
- These min-flow recirc AOVs have never been classified as having a safety-related function to open to prevent pump damage. This has been described as a non-safety related function only, since the AFW pumps will always have forward flow to the steam generators on auto-start.
- These recirculation lines AOVs have an augmented quality function to be opened for Appendix R fires to support AFW pump operation, per SSAR 2.3.1.4.
- Letter NRC 2002-0068 dated 8/12/02 states that PBNP will classify the open function for the AFW pump minimum flow recirculation valves as safety-related. The letter also states that because not all of the recirculation flow path is safety-related, operability of the AFW pumps will not be dependent on the availability of that flow path. However, it has been conservatively decided to tie AFW pump operability to this recirculation line. Therefore, even though the recirculation line downstream of the orifices is not safety-related, it is required to be in-service to consider the AFW pumps fully operable per TS 3.7.5.
- The current safety-related boundary for the recirculation lines is at the flow restricting orifices.
- This line can be credited to support a safety-function while not being classified safety-related because failure of the piping would be conservative in terms of AFW pump protection.
- The only credible failure of the piping that would cause AFW pump damage would be if check valve AF-117 failed to open (an active failure). Therefore, the internals for this check valve will be removed.
- All other non-conservative failure modes for the recirc line are passive in nature. Several manual valves exist in the recirculation lines, and all of these valves are currently red-locked open. Mispositioning is not credible due to procedural controls in place (red locks), and a disk separation failure of a manual valve is considered passive.

- (Installation) Both units may be in any condition, but the common recirculation line must be isolated to remove the AF-117 internals. While this line is out of service, the AFW pumps will be considered fully operable. Manual operator action will be credited to prevent pump damage by stationing a level 3 dedicated operator at the AF-4035 relief valve. If the minimum flow recirculation line is needed, and the relief does not open automatically while the line is isolated, then the dedicated operator will notify the control room that the recirculation flow path is not available.
- This action for the dedicated operator will be required only when the control operator has taken action to reduce AFW flow.

The design input checklist (PBF-1584 Rev. 10 8/19/02) contained the following:

- Item A.10, Consider failure effects on structures, systems, and components. - APPLIES TO DESIGN – YES.
- Item A.10.a, The design discusses those events/accidents which the system/components are to withstand? - APPLIES TO DESIGN – YES. The AFW recirculation line is required to support AFW pump operation during events where AFW is required to provide reactor heat removal. Most of the recirculation piping is non-Seismic, as are the CSTs, but a failure would be conservative in terms of recirc flow.
- Item A.10.b, The failure effect of the system/components: - APPLIES TO DESIGN – YES. AF-117 internals are being removed to prevent a single active failure from making all AFW pumps inoperable.
- Item F.2.e, Based on Section 2 and Appendix A of the SSAR, will the change add to, delete from, or affect the performance of safe shutdown systems or equipment? – APPLIES TO DESIGN – YES. The AFW system is a safe shutdown system credited for Appendix R. The mini-recirc AOVs are credited to be opened in this scenario to provide AFW pump cooling. Upgrading the safety function of the AOVs and removing the AF-117 internals improves this capability.
- Item G.1, Installation requirements/plant conditions have been determined? – APPLIES TO DESIGN – YES. Additionally, a level 3 dedicated operator will be present to monitor the relief valve, and notify the control room if it fails to open.

The modification request checklist (PBF-1606 Rev. 6 10/2/01) had the following regarding documentation updates:

- Item B.3, Component Instruction Manuals – N/A
- Item D.5, Spare parts stocking and scrapping inputs to CHAMPS – N/A
- Item J, ECRs – blank

Evaluator Observations:

- *Design evaluation does not evaluate impact of safety function upgrade on all components in the AFW recirculation line (did not evaluate ROs or electrical circuit for AOVs)*
- *Design evaluation does not evaluate impact of safety function upgrade on past AFW modifications*

- *Design evaluation does not evaluate impact of safety function upgrade on AFW modifications in progress (MR 99-029*C)*

SCR 2002-0359 (MR 02-029)

The safety evaluation screening for MR 02-029 was performed under the new 10 CFR 50.59 rule and concluded that the activity did not adversely affect the design function of an SSC credited in safety analysis, and did not adversely affect the method of performing or controlling the design function of an SSC credited in safety analysis. Supporting information included:

- The scope of the screening involves: (in part) State in the FSAR (FSAR 10.2) and Technical Specification Basis (B.3.7.5) that (1) the open safety function for all AFW pump mini-recirc valves is safety-related, and (2) the recirculation line downstream of the flow restricting orifices have a safety function and is required for AFW operability, but the line is not safety-related since failure of the line is conservative. (Section I.1)
- The AFW system has the following functions described in the licensing basis (in part):
  - To provide sufficient feedwater to remove decay heat from both units for one hour during a station blackout (SBO) event (TDAFP only)
  - To provide sufficient flow to the steam generators to remove decay heat to achieve cold shutdown within 72 hours following a plant fire (Appendix R)
  - To provide flow to the steam generators during plant startup and shutdown, and during hot shutdown or hot standby conditions for chemical additions and when operation of the main feedwater and condensates systems is not warranted. (Section I.2)
- The AF-117 check valve has an implicit function to open to allow minimum recirculation flow from the AFW pumps to return to the condensate storage tank(s). (Section II.1)
- The safety-related flow restricting orifices in the recirc line from each AFW pump limit the flow and pressure from each pump. (Section II.1.b)
- The minimum recirculation valves for the AFW pumps have the design functions to isolate the minimum recirculation line to ensure that the AFW pumps deliver the required flow to the steam generators as needed to support the mitigation of accidents or events. (Section II.2)
- The only function identified for the AF-117 check valve was to open to allow mini-recirculation water from AFW pumps to return to the condensate storage tanks. It has no design function to close. (Section III.1)
- The change in designation of the open function of the mini-recirculation valves (AOVs) as safety-related has no adverse affect on the valve's function to open or close.

Evaluator Observations:

- *The description of design functions in Section II focuses on selected components and does not discuss the overall function of the line.*
- *The discussion of the RO function in Section II.1.b does not include its need to pass flow for pump cooling.*

- *The potential for plugging of the restricting orifices is not discussed.*
- *The discussions of specific design functions in Section II and III do not include the Appendix R function.*

SCR 2002-0377 (AFW Operability During MR 02-029)

The safety evaluation screening for AFW operability was performed under the new 10 CFR 50.59 rule and concluded that the activity did not adversely affect the design function of an SSC credited in safety analysis, and did not adversely affect the method of performing or controlling the design function of an SSC credited in safety analysis. Supporting information included:

- The Level 3 Dedicated Operator will remain in constant radio communications with the control room, and the operator's only function is to monitor actuation of AF-4035, and to notify the control room if the valve fails to open after AFW pumps start. If AF-4035 fails to relieve (open), the dedicated operator will notify the control room immediately while the pumps are still being cooled by forward flow, and the control room operators will know that when they reduce AFW flow to control steam generator level they will have to maintain the minimum forward flow in AFW pumps or secure pumps as necessary as directed by the EOPs as discussed above. (Section I.1)
- The minimum recirculation lines for the auxiliary feedwater pumps and the recirculation header for the AFW pumps have a function of providing recirculation flow paths from the AFW pumps to prevent hydraulic instabilities and to dissipate pump heat. Hydraulic instabilities are prevented by the presence of flow restricting orifices in the individual AFW pump recirculation lines, so the function of maintaining individual pump cooling and the impact of diverted CST water are the concerns. (Section II)

Evaluator Observations:

- *The responsibilities for the dedicated operator in the safety screening only address AF-4035 monitoring and notification associated with AFW pump starts, there is no discussion of monitoring when flow is reduced to less than required minimum flow values.*
- *The potential for plugging of the restricting orifices is not discussed.*

DBD-01, Auxiliary Feedwater System

The DBD section on AFW Pump Recirculation Line Orifices (Section 3.16 in the current Revision 3 of the DBD) describes the Safety-Related Functions as:

1. These orifices shall provide passive flow resistance in the recirculation line of each AFW pump; thereby establishing the required min-recirc flow and pressure drop from the AFW pump discharge pressure to CST pressure. These orifices must provide sufficient flow to prevent low-flow instabilities and excessive fluid temperature rise in the AFW pumps [REF 9.5.17].
2. These orifices shall limit the recirculation flow in the event that the recirculation control valve fails to close during the AFW operation response to an accident [REF 9.5.117].

3. These orifices shall passively maintain the AFW system pressure boundary integrity.

These functions have remained essentially the same since the original DBD was issued in 1994. However, as part of CA003702 from Root Cause Evaluation 01-069, the description of the AFW recirculation line in the FSAR, DBD-01, and the IST program was reviewed for consistency and accuracy, and required changes were initiated. One change that was identified was that the function regarding providing sufficient flow (Item 1 above) was not a Safety-Related Function because the recirculation AOVs did not have an open safety function. The original DBD-01 did identify the recirculation AOVs as having an open safety function based on the same reference provided for the ROs, REF 9.5.117, which was MR 88-099*A-C for increasing the recirculation line flow rate in response to NRC Bulletin 88-04. CR 97-3363 evaluated the open safety function of the recirculation AOVs and concluded the DBD needed to be revised to reflect that there was no open safety function. That change was made in Revision 1 of DBD-01 on 3/21/00.

As a result of CA003702, a marked-up draft of the DBD was created that showed moving the RO function for providing sufficient flow from the Safety-Related Function section to the Non-Safety-Related/Non-QA Function section. CA003702 was completed on 8/13/02.

While this change was pending, the decision was made to upgrade the open function of the recirculation AOVs to safety-related. As part of the DBD-01 changes needed to support MR 02-029, the proposed revision to the RO safety function for providing sufficient flow was abandoned.

A related issue was identified regarding the statement in the DBD regarding the RO function to limit flow. This statement was also attributed to MR 88-099*A-C. CAP029983 was initiated on 11/2/02 to resolve the actual flow limit values for the ROs.

Evaluator Observations:

- *After it was recognized that the RO did not have a safety function to provide sufficient flow, there was no additional evaluation performed to restore that function to support MR 02-029.*

NP 1.6.5, Manager's Supervisory Staff and Qualified Reviewer

Revision 3 (11/8/99) of NP 1.6.5 was reviewed to see what guidance was in effect when MSS reviewed SE 2000-0055 on 4/18/00. Section 3.2.4 lists the responsibilities of an MSS Member as:

- Review all proposed changes or modifications to plant systems or equipment where changes affect nuclear safety.
- This includes 10 CFR 50.59/72.48 evaluation reviews and a review of the modification request design scope.

Qualified Reviewer responsibilities are listed as:

- Review procedures or changes thereto, which affect nuclear safety as designated by the Plant Manager.
- Review temporary changes to procedures described in Attachment B within two weeks.

In general, the MSS Members must meet the ANSI N18.1-1971 qualifications for their discipline. There are also requirements for a Qualified Reviewer to either have 10 CFR 50.59 Safety Evaluation qualifications or be designated by the plant Manger based on plant experience.

Evaluator Observations:

- *There is no requirement for MSS Members that review modification safety evaluations to be 10 CFR 50.59 qualified.*
- *The procedure specifies MSS Members are to review the modification request design scope, but the practice it to only distribute the safety evaluation document for review.*

NP 7.2.1, Plant Modifications

NP 7.7.10, Q-List Nuclear Safety Classification for Structures, Systems, and Components

Recirculation Line Potential Failure Modes Review

On 11/6/02 a review of the AFW PRA Notebook, associated with the AFW pump recirculation lines, was performed as part of the RCE000191 charter. An experienced KNPP Design Engineer who possessed no previous PRA knowledge or experience in the development of PRA assumptions or bases performed this review. The intent of this technical review was to identify any additional potential component failures and/or postulated failure modes not already addressed in the Point Beach AFW PRA model.

The Point Beach Senior PRA Engineer provided a brief overview of the AFW PRA Notebook structure and use of the PRA Notebook drawings and section tables.

The applicable AFW Notebook drawings and section table failure modes, associated with the AFW recirculation system, were reviewed against applicable portions of the following documents:

- AFW system P&ID drawings - BECH 6118 M-217, Sheets 1, 1A, and 2.
- Fire Water P&ID drawings – BECH 6118 M-208, Sheets 1 and 2.
- Service Water P&ID drawing – BECH 6118 M-207, Sheet 1A.
- DBD-01, Auxiliary Feedwater
- DBD-12, Service Water System, Sections 3.15, 3.20, and 3.20.2.
- FSAR, Sections 10.2,10.3, and 14.
- CR 99-1391, Operability Determination, Rev. 0, dated 5/21/99.

- CHAMPS data for valves 1-AF-04002, 2-AF-04002, AF-04014, AF-04007, 1-AF-00114, 2-AF-00114, AF-00115, AF-00116 and orifice flow elements 1-FE-4049, 2-FE-4049, FE-4050A, and FE-4050B.
- Design Changes MR 99-029*A, B, C, D and MR 02-029.

The review consisted of reviewing the PRA data and assumptions against the data and assumptions located in the above listed documents. This was performed on a component-by-component basis for the components associated with the AFW pump recirculation lines. This included review of the main air/backup air supply circuits for the recirculation line AOVs and cooling water supply to the AFW pump bearings.

A summary of findings and items to be addressed were identified in Point Beach CAP030045 initiated on 11/7/02. No significant Failure Modes and Effects issues were identified under this review.

Interview Results

Civil/Structural Design Engineer
He recalled that a meeting was held to discuss making the recirculation line safety related (modification MR 02-029*). This meeting was held approximately 1.5 to 2 weeks prior to the installation of modification MR 99-029C* which, installed the last restricting orifice in the aux feedwater pump recirculation line. It was believed that Design Analysis arranged this meeting. This meeting was held after the decision was made to make the lines safety related but prior to the issuance of a letter to the NRC stating this position. It is believed that representatives from System Engineering, Mechanical Design, Design Analysis, and Design Drawings participated in this meeting. No meeting notes were taken to document the discussion.

The purpose of the meeting was to discuss the relief and check valves. The discussion focused on the common portion of the line because the rest were already safety related. A review of the recirculation lines in their entirety for the ability to provide flow was not preformed nor was the orifice discussed. The discussions included questioning if forward flow could always be credited and therefore preclude inoperability of the pumps if recirculation flow was lost. No resolution of this question was stated during the interview.

It was stated that the attendees were apprehensive about declaring a safety function for these lines since it was not designed or installed to meet this qualification. . A discussion as to whether it was necessary to remove the relief valve or any other component that may cause problems in the future also took place. No components were identified during this discussion. All participants had reservations about the check valve modification (MR 02-029) and giving the recirculation line a safety function. He stated that the participants felt that the decision to make the line safety related would eventually "bite" us.

Civil/Structural Engineering stated the Engineering felt left out of the decision process to "do the right thing" to get past the red finding. They felt that senior management dictated an action without proper input.

Design Engineer 1

The modification engineer for MR 99-029*A/B no longer works at PBNP and was contacted by telephone for this interview. The engineer was asked why this particular design of orifice was chosen. His reply was that this orifice was selected because it was the cheapest available design that would fit in the space available. The engineer stated adamantly that he knew that the orifice would plug instantly if exposed to service water. He also stated that this was not a problem because flow would always be present to the steam generators because it would not be throttled to lower values. He stated that this was the accepted function of the line at the time (no safety function/not needed). He also stated that the system engineer agreed with the conclusion that the recirculation line did not have a safety function and was not required for the pump to be operable.

When asked why the design description did not include a discussion of orifice plugging, the engineer stated that he felt placing the discussion in the safety evaluation was acceptable because the safety evaluation was a part of the design package and it didn't matter where plugging was discussed.

Design Engineer 2 (Still needs to be condensed)

1. What is your recollection of the thought process for upgrading the safety function of the AFW Recirc AOVs?

   I was not involved in the discussions related to that decision. The information just came to me. The pneumatic back-up supply for the MDAFW recirc valves was always going to be safety-related. For the TDAFW system, a whole new back-up system was needed; it began as safety-related. In the middle of the mod (Dec 01/Jan 02) the direction changed to making the mod augmented quality. Based on second hand information (Novak), Mende made the decision. The components were bought as safety-related anyway, and the MDAFW mod was already installed. During installation (Apr 02) it was decide to call the mod safety-related, just prior to the NRC Meeting (4/29/02). I think by second hand information that this came from Warner (SVP). An ECR was issued for the upgrade. Fred Cayia sent out a memo explaining the upgrade decision (NPM 2002-0228).

   In the August 2002 timeframe a decision was made to upgrade the safety function of the AFW recirc AOVs to have an open safety function. I was not involved in those discussions. Lori Armstrong was involved in making the decision. We had one short (~1 minute) discussion in the hallway regarding the topic. There was an August 12 letter (NOV response NRC 2002-0068) signed by Warner deciding to upgrade the safety function to open, but the recirc line doesn't have to be available. That didn't make sense to the engineers. I was told we needed to do the mod before the NRC inspection (9/23/02). Operations raised concerns about not declaring the AFW system inop when the line was taken OOS. Further review resulted in linking AFW

operability to the availability of the recirc line. I was not involved in any discussions until after the letter went out.

If a physical change to the plant wasn't needed, the upgrade probably wouldn't have been done via a mod. I understood that the mod involved both a physical change and a function change. I considered that the mod impacted AOV testing (IST program), and that the operability/availability decision required a change to the Tech Spec basis. In retrospect, I should have looked at more. I didn't see a problem with the RO at that time. I was under the gun to get the mod done. I also had to develop a contingency mod for the reactor head inspection. Fred Cayia told me the AFW mod was more important.

2. What direction did you get from your supervisor (Dick Hornak)? Was there any pre-job brief or coaching?

   He told me its a lot to do, and if I can't do it to let him know and he would get someone to help. That's his management style, and its OK with us (his group).

3. What is your recollection regarding the last AFW RO mod (MR 99-029*C)?

   It was released after the NRC Red Finding came to light. It was a copycat mod. I was the reviewer on the other ones. I co-signed as preparer for the safety evaluation with Alex because he wasn't qualified.

4. What do you remember about any discussions on plugging of the orifice?

   The evaluation stated that the flow path made it difficult to plug. That was taken from the vendor information. I wasn't involved with the MSSM discussion for the evaluation. The fact that I retained was that the orifice could pass SW without plugging.

5. The safety evaluation seems to have conflicting information regarding the importance of the recirc line.

   The wording in the SE and SCR does not mean that the line or RO has a safety function, but that it has a design function. The DBD was wrong. It was marked up to change the function of the RO to a non-safety function. That change was never made because the decision to upgrade the AFW recirc AOVs to have an open safety function changed what the RO needed to do.

6. Did you make any connection with the upgrade of the recirc line to the RO mod that was still being installed?

   No I didn't. The RO mod had already been done 3 times – it was a no-brainer.

7. The NRC Red Finding had implications regarding assumptions about only needing forward flow to the S/Gs – were you aware of this?

   I was aware of the finding and it's implications. I didn't relate it to the SCR for the RO mod. I did the SCR and moved on to other work.

8. Was it appropriate to do this upgrade mod as a plant minor change?

   The paper work is the same, only it doesn't go to EAC. EAC isn't being used much now. This was another mod were I had to drop everything to do it. Most of my mods in the last year have been that way – AFW mods, SI mods, reactor head mod.

9. Were you concerned with the level of independence for the RO mods, since you were the preparer on one and reviewer on others?

   Some, but we have a small group – independence is a luxury. Being the tech reviewer makes me the best person to prepare the last RO mod.

10. Is there anything else you think I should know that is relevant?

    Like I said before, everything is hurried and sporadic in nature, which is difficult to work with. If we had more time then there is a higher probability we may have caught this – I was uncomfortable with this.

11. Did you raise this concern with anyone?

I talked about it with some people (other engineers). I did not raise it officially with my supervisor.

Design Engineer 3

The mechanical design engineer interviewed stated that his involvement with the MR 99-029* modifications started with performing the technical review for the last modification being installed (MR 99-029*C). He also aided with the installation of MR 99-029*A/B when additional holes had to be added in the trim assembly to obtain the required flow in the recirculation lines for the P-38A and B auxiliary feedwater pumps.

The engineer stated that the issue of plugging was that if the orifice would plug it would be good because more water was supplied to the steam generator, if the orifice was to plug. This was the accepted site position on the issue at this time. He also stated that he believed from a legal stand point the site was better off if the AOV didn't open because the plant was designed for forward flow only and recirculation flow only lessened the flow that could be supplied to the steam generators. It was stated that the Engineering Director at the time MR 99-029*A/D was being installed absolutely refused to consider the need for the recirculation line. The engineer also stated that there was a 1985 letter to the NRC stating that even though we tested the AOV in the recirculation line in both the open and closed direction the valve had no safety function in the open direction.

The mechanical design engineer stated that he had no direct involvement in modification MR 02-029. The design review for this modification was after the root cause was performed and before the regulatory conference for the red finding associated with auxiliary feedwater. He stated that he felt that inadequate rigor was applied to the modification, that the time line was too short. He felt that the message was "Pull the check valve out and call the line safety related".

The design engineer stated that the recirculation flow was not an acceptance criterion for pump operability. This was confirmed by reviewing the procedure revisions for IT 10. The recirculation flow was for information only and was not an acceptance criterion for operability until September 9, 2002. He felt that the site upgraded parts/pieces but not the whole system when deciding to assign a safety function to the recirculation lines. As part of the upgrade process, the backup pneumatic supply to the AOVs was upgraded to safety related. The engineer stated that he originally wanted to install this modification (MR 01-144) as safety related and that somewhere above the acting Engineering Director this proposal was not approved. This occurred in January 2002. Though the engineer disagreed with this position it was consistent with our understanding of the regulatory requirements and he could not argue the point.

Design Engineer 4 (Independent Reviewer of MR 02-029)

Mechanical Design Supervisor
When asked about the safety evaluation for MR 99-029*A/B, the supervisor stated he believed that the wear ring would grind up the particles, but the MSS Chairman did not accept this argument. Therefore, the evaluation was changed to a less technical approach. This was based on not needing the recirculation line because of the AOV failure mode. He stated that the safety screening done for MR 99-029*C/D had similar thoughts but was stated somewhat differently. He did not think the orifices would plug and not requiring the recirculation line was an additional conservative position.

For the MR 02-029, he said there were a lot of other discussions on upgrading the line that he wasn't involved in. He was given the modification and had to rationalize how to do it. He recalled that the modification to install the backup pneumatics was originally going to be safety related, but he was told not to make it safety related. Later that was changed to be safety related to support the open safety function. He was given verbal directions for MR 02-029, and then had internal Engineering discussions to clarify the design specifics. He said there was nothing in the licensing basis review that pointed them to look at past decisions.

When asked if there was anything in the modification process that initiated a review of a modification that had been open for a long time pending installation, he said there wasn't. He said the 50.59 for old open modifications were reviewed with operations (on an honor system) to see if anything had changed..

AFW System Engineer 1

The engineer that had AFW system responsibilities at the time of MR 99-029*A/B was interviewed. He was asked when did the plugging issue get raised, and he recalled that it came up late in the design process. He could not recall if he was the one that brought it up. He said in the first version of the safety evaluation they had included the results of samples of service water taken from the AFW suction and compared it to the orifice size. Staff (MSS) didn't like that and the Operations Manager said it doesn't make a difference because the AFW recirc AOV goes closed. He said he believed that the build up on the orifice would be gradual, not acute, but staff wanted a yes/no answer. The position suggested seemed conservative and he had no problem with the change.

When asked how the orifice option was selected, he said RCE 99-081 concluded that the existing orifice was undersized, but an orifice with more stages wouldn't fit easily in the existing space. An isolation valve would have to be moved and that would involve a freeze seal. He wasn't sure how the choice was made between the remaining options. He thinks it may have been because the channel stream orifice was more likely to knock down the noise problem.

He stated that he did not make a connection between the outcome of the AFW Red Finding (importance of proper recirculation line operation) and the last RO modification being installed.

AFW System Engineer 2

Fire Protection Engineers

Two engineers with fire protection responsibilities were interviewed. One of the individuals participated on the modification design team for MR 99-029*A/B and the other participated on the design team for MR 99-029*C/D.

The engineer on the design team for MR 99-029*A/B stated that there was little if any discussion of orifice plugging associated with their design. He personally felt that plugging was not an issue with the proposed modification. He stated that the installation of the orifices was a non-outage work package fire protection issue and not an Appendix R operability issue.

He also stated that he never saw the safety screening or evaluation for the modification. The only information he would review was the information in the detailed design description and the fire protection checklist contained in the modification package.

The engineer stated that the orifice was an integral part of the piping system. To his knowledge, the change in orifice design did not change the fit/form/function of the component. To his knowledge the orifice remained a passive component in the system and did not require a QA code for Appendix R or fire protection. He also stated that he would like to see Appendix R and fire protection broken up into their own separate QA codes.

Discussions with the second fire protection engineer (MR 99-029*C/D) revealed the following. It was assumed that the orifice was a piece of pipe. He had no idea that it could plug and nothing in the design description told him other wise. "The orifice worked yesterday and it will work tomorrow unless someone tells me different and no body did."

The air accumulators used to open the recirculation line AOVs are installed to buy the site time to manually gag open the valves and make AOP 10A work, that is why there is a QA code 20 associated with the valves and air tanks. We do not need to manipulate the orifice therefore there is no QA 20 code associated with them.

MSSM Chairman

When interviewed, the MSS Chairman stated that the purpose of the MSS was to review safety evaluations and to either concur or disagree with the conclusions reached. It was not their responsibility to review the design package. The individual stated that he has not (at least recently) read the procedure governing the functions of the MSS. He stated that he is not qualified to perform safety evaluations and does not know if anyone on MSS is qualified to perform safety evaluations. It was stated that the MSS does not take a vote on the safety evaluation but a consensus is reached. If any member of the MSS has a strong dissenting opinion, the individual has the right to bring it to the attention of the Plant Manager. He stated that this has happened in the past.

The safety evaluation (SE 2000-0055) for modifications MR 99-029A/B stated the orifice might plug if service water was used as the suction source. The staff did not believe that the pump was capable of grinding any sand/silt into small enough particles to allow them to flow through the orifice. The staff member stated that staff recommended that service water be sampled to determine the size of the grit entrained in it. [It should be noted that this was performed prior to the safety evaluation being presented to MSS.] He believes that Engineering's opinion was that the orifice would not plug but did not present a conclusive argument to back the opinion.

Staff stated: there was no safety function for the recirculation line; they were aware that instrument air was needed for the recirc line AOV to work and instrument air is not safety related. Therefore, there was no guarantee that the AOV in the recirculation line would open. Consequently, since you could not rely on the AOV to open to provide a recirculation flow path, it did not matter if the orifice plugs and prevents recirculation flow. It was also stated that MSS has been criticized in the past for getting too involved in the details associated with safety evaluations; therefore, they didn't require this issue to be resolved operationally, nor did they assess the installation of a "filter" in the line.

Operations Representative

An interview was conducted with the Operations Department Auxiliary Feed Water System owner. He stated that he has been the owner of this system for in excess of four years.

When questioned about his involvement with modification MR 99-029*A-D, he made the following statements. He was unaware of any consideration as to the size of the service water strainer mesh when selecting the restricting orifice. He also stated that he was not aware of the size of the flow channels in the restricting orifice until November 2002. He does not remember seeing the safety evaluation or screenings associated with the implementation of this modification.

The Operations system owner was aware that an operability determination (OD 99-1391) had been written on the Auxiliary Feedwater System when weld cracking occurred on the recirculation lines. However, there were no compensatory actions required by this OD. There is no routine call up for review of operability determinations; therefore, the issue of the need for the recirculation line to be operable when throttling flow to the steam generators was lost. The system owner was also aware that there was a 10CFR50 App. R function for the air-operated valve in the recirculation line. He however, did not associate this requirement with the need for the recirculation line to be operable for the pump to be able to perform its safety function.

It was stated that per procedure, any time that the indicated recirculation flow did not meet the minimum requirements stated in IT 10 the Auxiliary Feedwater Pump was inoperable. This requirement was instituted when the flow meters were installed on the recirculation lines in the early 1990s. (As stated above in the Design Engineer 3's interview, a review of IT 10 procedure revisions shows that recirculation flow was for information only until September 2002.)

Modification MR 02-029* was initiated to remove the internals of check valve AF-117 and give the recirculation a safety related function. Operations involvement was to identify and implement any necessary procedure changes to implement this modification. It is his understanding that no one performed a comprehensive review of the Auxiliary Feedwater system or the modifications that had taken place to that system as part of design review of MR 02-029.

Thermal/Hydraulic Design Supervisor
He recalled that the issue about upgrading the AOV and recirc line came up during the NRC SSDI time frame, and he was only briefly involved. He participated in a brainstorming session on what would have to be done to upgrade the recirc AOVs to have an open safety function. He believed that upper management made the decision.

On about 8/19/02, he was assigned oversight of the upgrade modification. He said the schedule was very pressured with several aspects of the normal design development process being circumvented. The design engineer had some reservations with the modification scope and direction. This is contrary to normal practice where the design engineer evaluates various options and chooses an approach. He recalled that NMC Corporate Staff were brought in to perform an independent critique of the proposed changes out of concern for the rushed and extraordinary circumstances. During the course of the modification, at least one major scope change was made from simply

upgrading the open function of the AOV and removing a possible common mode failure (AF-117), to upgrading the line to pass flow.

Acting Engineering Director

Site Vice President

Industry and Station Operating Experience

CAP013812 (CR 01-1259) Foreign Material Exclusion (FME) for Aux Feed Work

EPIX – None

INPO OE – PBNP OE13861 on Foreign Material Exclusion (FME) for Aux Feed Work

Evaluation Methodology & Analysis Techniques

The primary analytical techniques used in this investigation were interviewing, document review, and barrier analysis. A timeline of the event is presented in Attachment A, and the barrier analysis is presented in Attachment B.

Data Analysis Summary

[Summarize Data Analysis and Facts in Order to Draw Conclusions to Support Failure Mode Identification]

Failure Mode Identification

[Failure Mode Identification Must be Supported Through Facts and Conclusions Drawn From Data Analysis.]

[IM03]	*[Reflex - Inappropriate Action (Inadequate Work Practice) Taken Based Upon the Wrong Instincts.]*

- *[Brief Discussion of Facts Supporting Failure Mode #1]*

[P01]	*[Insufficient Detail - Inadequate Guidance Contained in Procedure.]*

- *[Brief Discussion of Facts Supporting Failure Mode #2.]*

VII. Root Causes & Contributing Factors

[Brief Narrative of Conclusions]

[Identify specific Root Cause(s) and Significant Contributing Cause(s)]

Conclusions

Root Cause

Contributing Causes

VIII. Corrective Actions

[Require Corrective Actions for Each Root Cause (Corrective Actions to Prevent Recurrence) and Significant Contributing Factors. Corrective actions should identify responsible work group, action priority, and anticipated completion date. Identify any Corrective Actions Which Have Already Been Implemented.]

Corrective Actions to Restore (broke – fix)

- CA #1 Responsible Group: *[Group Name]*, Priority: *[#]*, Completion Due Date: *[Date]*

1. CA026900: Ensure that the PRA work to evaluate the risk significance of this potential common mode failure is completed expeditiously. Priority 2, Due Date 1/29/03.
2. CA026901: Review for impact on aux feed pump unavailability for NEI cornerstone indicator. Priority 3, Due Date: 12/20/02.

Interim Corrective Actions (mitigation)

- CA #1 Responsible Group: *[Group Name]*, Priority: *[#]*, Completion Due Date: *[Date]*

1. OPR000031: OPR requested to strengthen basis of Aux Feed Recieculation Lines, Priority 2, Due Date: 10/30/02: Completed, 10/31/02.
2. CA026897: Write and hang temp info tags on the pump hand switches, requiring that a minimum forward aux feed flow of greater than 50 gpm (P-38A/B) or 75 gpm (1/2 – P29) to be maintained, if not, stop affected pump; brief the Ops crews on the issue, Priority 2: Completed, temporary information tags written and place next to AFW flow indicators 10/30/02.
3. CA026898: Make changes to affected AOPs, EOPs, and other critical procedures to ensure that minimum forward flow is maintained, or the affected pump is stopped Priority 2, Due Date 11/11/02: Completed: 11/7/02.
4. CA026902: Redesign the recirc line orifices to make use of an orifice design that has aperture size >1/8", Priority: 1, Due Date: 11/22/02.

5. CA026908: Complete the interim administrative controls. Operator training and EOP and AOP changes to establish appropriate operator guidance for all accident sequences of interest. Priority 2, Due Date: 11/27/02.
6. CA026909: Independently evaluates the procedure changes being made to the EOPs and AOPs and assess their adequacy to provide adequate operator guidance. Additionally, evaluated the adequacy of the temporary information tags and objectively evaluate our decision to declare the AFW pumps operable after taking interim actions to address this issue on Tuesday, October 29, 2002. Priority 2, Due Date: 11/27/02.
7. CA026910: Independently evaluate the briefings and training conducted or planned for operating crews. We would like an objective look to ensure that the training was adequate and well documented. Priority 2, Due Date: 11/27/02.
8. CA026911: Evaluate hydraulic system response to determine if the orifices could become plugged. Priority 2, Due Date: NONE this item is being worked, to be updated by T Kendall
9. CA026912: Develop a test plan to evaluated plugging of a spare orifice. Use the vendor utilized by Kewaunee to evaluate the AFW suction orifice issue as appropriate. Priority 2, Due Date: NONE
10. CA026914: Evaluate the auxiliary feedwater system to determine the sources and quality of potential corrosion products. Priority 2, Due Date: 1/20/03
11. CA026915: Contact vendor of the orifice to obtain test data and other relevant information that could be used as input to the PRA work. Priority 2, Due Date: 11/4/02. Completed.
12. CA026917: Identify all other applications of this type of orifice in the Point Beach units and determine applicable operating history. Priority 2, Due Date: 11/15/02. Completed
13. CA026918, Ensure that modifications to the orifice design or a replacement orifice are pursued expeditiously to resolve any questions. Priority 2, Due Date 12/13/02.
14. CA026958, Ensure compliance with procedure NP 10.3.7, "On-line Safety Assessment," while at elevated risk due to the potential for common mode plugging of AFW recirc orifices. Focus should continue with daily updates to Resolution Team Leader until interim corrective actions have restored on-line risk to a "green" condition. Priority 2, Due Date: 12/4/02.
15. CA026962, Perform an incident investigation. Scope is to conduct an investigation to collect facts surrounding the maintenance conducted on the P-38A motor driven AFW pump, the post maintenance testing, the evaluation of the corrosion products discovered in the recirculation orifice and conclude with the decision to declare the AFW pumps inoperable on Tuesday, October 2002. Use applicable portions of NP 5.3.3, "Incident Investigation and Post-Trip Review," for guidance. Priority 2, Due Date 11/21/02

Corrective Actions to Prevent Recurrence (CATPRs)

- CA #1 Responsible Group: *[Group Name]*, Priority: *[#]*, Completion Due Date: *[Date]*

- CA #2 Responsible Group: *[Group Name]*, Priority: *[#]*, Completion Due Date: *[Date]*

IX. References

1. NP 7.7.10. Q-List Nuclear Safety Classification for Structures, Sustems, and Components. Revision 1.
2. NP 7.2.1, Plant Modifications, Revision 6
3. NP 7.2.1, Plant Modifications, Revision 10
4. NP 7.2.6, Engineering Change Process, Revision 2
5. NP 7.2.2 Design Control, Revision 5
6. NP 1.6.5, Manager's supervisory Staff and Qualified Reviewer, Revision 3
7. NP 7.7.12, Safety Related and QA Scope Classification Upgrade or Downgrade Process, Revision 1
8. OM 3.12, Control of Equipment and Equipment Status, Revision 8
9. OM 3.26, Use of Dedicated Operators, Revision 8
10. DG-G06, Guidelines for System, Component and Part Classification, Revision 6
11. PBF-1551, Q-List Classification Document, Revision 6
12. RCE 01-069, Increased CDF in AFW PRA Model Due to Procedural Inadequacies Related to Loss of Instrument Air, Revision 1
13. NUREG-0737, Clarification of TMI Action Plan Requirements
14. MR 97-038A/B, AFW Discharge Valves AF-4012/4019 Modification, Revision 0
15. 10CFR 50.59/72.48 Screening and Safety Evaluation, SE 97-085
16. FCR 97-033, Final Safety Analysis Report Change Request.
17. CR 96-317, FSAR Has Inaccurate AFW Flow Rate Assumptions
18. CR 97-3363, IST Program Design Basis for AFW Minimum Flow Recirculation Valves
19. CR 01-3654, Development and Revision of DBE-01 (AFW Design Basis Document) Appears to Have Been a Missed Opportunity to Identify a Design Weakness in the AFW System
20. CR 96-574, Alarm Indication Audio Levels Do Not Meet DG-G01
21. CR 97-0720, High Background Noise in Control Room
22. CR 99-2460, Control Room Noise and Pump Wear During AFW Pump Use During Plant Shutdown
23. CAP 001625 (CR 99-1391), SCAQ Action – Potential common Mode Failure Mechanism Affecting Welds in AFW Pumps
24. CAP025033 (CR 99-1844), Socket Weld Survey of Aus Feedwater Pump Recirc Piping
25. RCE 99-081, Socket-Weld Failures in Auxiliary Feedwater Pump Recirculation Piping, Revision 1
26. CAP 027667 (CR 99-1163), Water Spraying From a Cracked Weld On the Aux Feed Pump Recirc Line
27. CAP024973 (CR 99-1368), Weld Crack in Motor-Drive Aux Feed Pump Recirc Line
28. CAP 030045, Discrepancies in AFW PRA Model and Notebook.
29. FCR 98-068, Final Safety Analysis Report Change Request

30. QCR 99-0115, Code Testing Conflicts with the Aux Feedwater Mini-Flow Recirc Check Valves
31. PBNP FSAR Section 10.2 (06/01)
32. FCR 99-049, Final Safety Analysis Report Change Request
33. DBD-01, Auxiliary Feedwater System, Final Draft 12/17/92
34. Validation of Design Basis Attributes Auxiliary Feedwater System, Sargent and Lundy, April 1993
35. DBD-01, Auxiliary Feedwater System, Revision 0
36. DBD-01, Auxiliary Feedwater System, Revision 1
37. SER 91-025 Safety Evaluation for IWP 88-099*A
38. IWP 88-099*A, Revision 0
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40. NPM 93-0450, Auxiliary Feedwater Design Basis Document Review
41. NRC-92-085, In-Service Testing Pump and Valve Program Third 10-Year Program Safety Evaluation Report
42. NRC-30-130 (VPNPD-90-500), Inservice Testing Program for Pump and Valves, 12/21/90
43. NRC Letter to PBNP, Inservice Testing, Third 10-Year Program, Including Relief Requests (TAC Nos. M79386 and M79387), dated 4/17/92
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49. Inservice Testing Program Relief Request No. VRR-28, Revision 1
50. Inservice Testing Program Relief Request No. VRR-28, Revision 2
51. Inservice Testing Program Relief Request No. VRR-28, Revision 3
52. MSS Subcommittee Meeting minutes, March 28,1991
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59. NPM 2002-0594, Oversight of Plant Modifications
60. NPM 2002-0599, AFW Recirculation Line Orifice Evaluation
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63. Memo to R Flessner from B Bosacki detailing discrepancies in PRA Notebook 5.9
64. PRA 5.9 Auxiliary Feedwater System Notebook, Revision 0

65. FCR 01-050
66. FCR 02-002
67. SE 2001-0059, Operation of the Auxiliary Feedwater Pumps Without Cooling Water
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83. FAX to JP Schroeder from FLOWSERVE dated 12/09/99
84. Report From Laboratory to JP Schroeder, analytical results from Service Water Samples, dated,10/19/99
85. Letter to P Gonzales, Flowserve Corporation from JP Schroeder, Auxiliary Feedwater Pump Operation With Service Water, 12/01/99
86. NRC Inspection Report 50-266/99013
87. NUTRK item IR 99-013
88. Unofficial Station Logs 10/23/02 Mid Shift
89. Unofficial Station Logs 10/24/02 Mid Shift
90. Unofficial Station Logs 10/24/02 Day Shift
91. Unofficial Station Logs 10/24/02 Swing Shift
92. Unofficial Station Logs 10/25/02 Mid Shift
93. Unofficial Station Logs 10/25/02 Day Shift
94. Unofficial Station Logs 10/29/02 Day Shift
95. Unofficial Station Logs 10/29/02 Swing Shift
96. Work order 0212107
97. Work order 9934148
98. Work order 0205651
99. Work order 9945610
100. Work order 9949098
101. Work order 9934148
102.

X. Attachments

Attachment A: Event Timeline

Attachment B: Barrier Analysis

Attachment C: Charter

Attachment A – Event Timeline

Time	Description
10/23/02 (Wed)	
0400	P-38A OOS for scheduled maintenance. Enter TS LCO 3.7.5 for both units.
Day Shift	Maintenance repaired pump seal per WO 0205651; replaced diaphragm on valve operator AF-4012-O per WO 9945610 (diaphragm fails drop test); and replaced valve AF-38 per WO 9949098
Evening Shift	Diaphragm replaced on AF-4012 and passes drop test; performed ICP 06.086A per WO 0202494; Operations filled and vented pump suction line, casing, and discharge line per OI-62A
10/24/02 (Thur)	
0110	Commenced IT-10 (Quarterly Test of Electrically Driven Auxiliary Feed Pumps and Valves) for P-38A. P-38A is still OOS per IT-10 and TS LCO 3.7.5 is not met for both units.
0159	Started P-38A per IT-10; suction relief valve observed to lift momentarily and then continue to drip
0212	Secured P-38A due to mini-recirc flow of 64.5 gpm. Required flow is 70 gpm.
~0215-0500	I&C contacted and flow transmitter was re-vented and recalibrated; ran P-38A and flow was still 65 gpm
0323	CAP029908 initiated for P-38A, MDAFW Pump having inadequate recirc flow during IT-10
~0400	Engineering contacted; Operations informed pump is OK and investigation will begin.
0440	Completed calibration of P-38A flow transmitter; instrument found to be in calibration
~0500-0700	Engineering postulated potential failure modes
~0630	BOP/NSSS Mechanical Systems Engineering Supervisor established as overall lead for the issue
0830	Meeting with Engineering, maintenance, and Shift Manager to establish an action plan for the investigation
~1030-1100	Completed venting of the flow transmitter and AFW pump and started P-38A per OI-62A; P-38A was run on recirc only for about one minute – flow remained at ~65 gpm on installed FE and ~60 gpm on ultrasonic flow meter. Vibration data was taken and was normal.
~1100-1800	Maintenance removes RO-4008 and finds rusty looking material in openings of outer ring (24 of 54 holes had some degree of blockage), disassembles, cleans and reassembles RO. Boroscope inspection performed of piping upstream of RO-4008 up to and including FE-4050A and found no material. Very small amount of debris retained.
1700	50.59 screening completed for one time temp change to IT-10 to lower acceptance criteria for data collection purposes only

Time	Description
1710	Engineering e-mails recovery plan for comment
1830	Meeting with Engineering, Maintenance, and Shift Manager to discuss plans associated with P-38A
~1900 - 2100	Ops clearing tags; Maintenance, Engineering and Operations met. Ops reported tags cleared and system was filled and vented. Maintenance requested high points to be re-vented prior to run. Ops re-vented suction (solid stream) and discharge (slight amount of air)
2115	Started P-38A per OI-62A
2117	Secured P-38A per OI-62A. Flow was 75 gpm. P-38A is now considered available for Safety Monitor and Maintenance Rule
2336	Commenced IT-10
Evening	Samples taken of both CSTs and suction of AFW pumps looking for evidence of rust – results did not show evidence of rust.
10/25/02 (Fri)	
0008	Started P-38A per IT-10.
0050	Stopped P-38A per IT-10
0129	P-38A is available for operation per IT-10
0155	Commence IT-10C for P-38A
0216	IT-10C is complete for P-38A only. P-38A RTS. TS LCO 3.7.5 now met. Exit TSAC entered at 0400 on 10/23/02
0309-0450	Test P-38B per IT-10
0512-0608	Test 1P-29 per IT-08A
0756-1121	Test 2P-29 per IT-09A
1030	Initiated ACE001023 to evaluate inadequate recirc flow on P-38A
1132-1206	Test 1P-29 per IT-08B
1222-1255	Test P-38B per IT-10D
~1600	Operations informs Engineering that short term action plan needs to be in their hands by Friday (11/1); participants confirmed that no AFW operability concern existed at this time.
10/26-27 (Sat/Sun)	
Weekend	BOP/NSSS Mechanical Systems Engineering Supervisor considered the actions that might be required and formulated potential questions that needed answering and that would be discussed at the meeting he would hold on 10/28. The Operations Manger didn't ask for weekend evaluation of the issue because he didn't think it was realistic that the recently designed and installed orifices would be susceptible to plugging from service water.
10/28/02 (Mon)	
1100-1230	System Engineering Meeting to discuss AFW recirc orifice fouling issues. Potential for SW fouling was raised as a concern. Actual plugging event was considered a one-time occurrence.
Afternoon	Operations and Engineering management briefed on issue.

10/29/02 (Tue)	
0900	Meeting with Engineering Director held to review issue. Consensus was that the system would become dysfunctional when taking suction from SW. Licensing was contacted and Operations was briefed.
0945	Management Meeting held to identify immediate actions needed
1015	EDT group began scoping out a modification to replace existing orifices
1027	All AFW pumps declared OOS due to recirc flow orifice issue
1110	Crew briefed on AFW recirc flow orifice issue
1210	Posted temporary information tags for all 4 AFW pumps for requirements to secure AFW if minimum flow is not maintained
1241	CAP029952 was initiated for Potential Common Mode Failure of AFW Recirculation Lines
1305	All 4 AFW pumps RTS based on compensatory measures taken to brief crew and post temporary information.
1410	Engineering Director forms RCE Team
1525	Engineering Director discussed need for operability determination with Licensing and Operations – concern is being in an operable but non-conforming condition
1530- 1630	Simulator runs made on comp measures to assist in risk determination
1700	SCR 2002-0458 for procedure changes accepted by Operations Manager
1711	NRC 8 hour notification (EN#39330) made regarding AFW system
1830	OPR requested for CAP029952 concerning common mode failure for AFW pumps. OPR is due at 1500 on 10/30/02
2030	Safety Monitor transitioned to Yellow for both units based on PRA Group input
10/30/02 (Wed)	
0700	RCE Team Meeting held to define roles and responsibilities
1030	Qualifications suspended for design work for 3 individuals
1100	Notified of NRC special inspection team
1250	RCE Charter approved
1530	RCE Team Meeting
1850	OPR completed on AFW Pumps
10/31 (Thur)	
Day Shift	SVP forms event resolution team

Attachment B – Barrier Analysis

Energy/Hazard	Barrier	Assessment	Target
Modification MR 99-029*A/B	Procedure		Good AFW design – no unknown failures modes
	Design Engineer (DE1)	No information in design description on potential to plug RO; no discussion of orifice size being less than SW strainer size. **Failed to apply FMEA to design.**	
	Design Team (FPE1, OP)	Fire Protection and Operations members do not recall seeing safety evaluation that had information on plugging. **Inadequate communications among organizations.**	
	Independent Review (DE2)	Independent reviewer was a co-preparer of the safety evaluation. **Agrees that FMEA does not apply to design. Lack of independence.**	
	Supervisor Approval (MDS)	Approves design **Fails to ensure adequate FMEA performed.**	
	EAC	Specific details of RO not presented to EAC. Plugging not discussed. EAC does not select specific option to be pursued. **Inadequate communications within an organization.**	
Safety Evaluation SE 2000-0055	Procedure		No unreviewed safety question
	Preparer (DE1/DE2)		
	Reviewer (AF SE1)		

Energy/Hazard	Barrier	Assessment	Target
	MSS		
	JOSRC		
Modification MR 99-029*C/D	Procedure		Good AFW design – no unknown failures modes
	Design Engineer (*C-DE2 *D-DE1)		
	Design Team (FPE2, OP)		
	Independent Review (*C-DE3 *D-DE2)		
	Supervisor Approval (MDS)		
	EAC		
Safety Screening SCR 2001-0981	Procedure		No unreviewed safety question
	Preparer (DE2)		
	Reviewer (AF SE1)		
	MSS		
	JOSRC		

Attachment C – Charter

Root Cause Investigation Charter

CAP029952
RCE000191

Issue Manager:
Jim Freels

Problem Statement:
Discovery during the evaluation of CAP029908 (P-38A, MDAFW Pump had inadequate recirc flow during IT-10) that the recirculation line restricting flow orifices had become plugged during plant operation causing a reduced flow (but above minimum required) and that a potential existed for a common mode failure where all AFW pump recirculation lines could have restricted flow rates resulting in eventual pump failure.

Investigation Scope:
Determine the following:

- Timeline of key events
- The root and contributing causes of why the condition exists, including any potential human performance issues
- Why the problem was not identified previously

Make recommendations for:

- Correcting the problem, including any remedial actions
- Preventing recurrence of the problem
- Applicability of the root cause to other areas (extent of condition), including verification that a safety-related AFW recirculation flow path exists for the postulated failure modes

Team Members:
Team Leader – Richard Flessner, Engineering Processes
Team Member – Kevin Bennett, Engineering Processes
Team Member – Eric Schmidt, System Engineering
Team Member – William Bosacki, KNPP Design Engineering

Milestones:
Status Update – 11/4/02
Status Update – 11/11/02
Draft Report – 11/18/02
Final Report – 11/26/02

Approved: (original signed by J. Freels) Date: 10/30/02
Jim Freels, PBNP Engineering Director