Florida
Power
CORPORATION
Crystal River Unit 3
Docket No. 50-302

April 4, 1996
3F0496-02

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

Subject: Makeup Tank Pressure/Level Curve Calculation RAI

References: NRC to FPC letter, 3N0196-06 dated January 11, 1996
NRC/FPC Meeting Notes dated February 15, 1996

Dear Sir:

In the reference letter, Florida Power Corporation (FPC) received a Request for Additional Information (RAI) from the NRC regarding its calculation which forms the basis for the makeup tank pressure/level limit curve contained in Operating Procedure OP-103B. FPC met with NRC staff on February 8, 1996 to discuss our proposed response to these questions. In an effort to assist the NRC technical staff in reaching closure of the issue, FPC is providing our answers to those questions in written form in Attachment 1 to this letter. In addition, responses to additional questions and requests for documents received at the February 8, 1996 meeting are also provided. As requested in our February 8, 1996 meeting, FPC has re-confirmed that all design inputs which have been taken from procedural directives are correct and current.

Sincerely,

Gary Boldt

G. L. Boldt
Vice President
Nuclear Production

GLB/BG

050117

Attachments
Enclosures
xc: Regional Administrator, Region II
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NRR Project Manager

A001
1/1

Limited Dist.

Encls To: File Center 01
PM (G. Wunder)
NRC PDR

Attachments

1. Questions and Responses Regarding the MUT Pressure vs. Level Curve.

2. Schematic Diagram of CR-3 ECCS and Containment Spray Systems.

3. Current Version of Curve 8 from OP-103B, Revision 16.

Enclosures

1. MPR Letter to FPC dated 1/11/96, Crystal River Unit 3 - Review of Calculations of Maximum Allowable Makeup Tank Pressure. (Original Work)

2. MPR Letter to FPC dated 1/24/96, Crystal River Unit 3 - Review of Calculations of Maximum Allowable Makeup Tank Pressure. (Additional Work)

3. MPR Letter to FPC dated 2/13/96, Crystal River Unit 3 - Review of Calculations of Maximum Allowable Makeup Tank Pressure. (Temperature Effects)

4. FPC Calculation M94-0053, Revision 3, Allowable MUT-1 Indicated Overpressure Vs. Indicated Level.

5. CR-3 Operating Procedure OP-402, Revision 84, dated 4/3/96, Makeup and Purification System.

6. Parsons, Inc. Calculation M96-0004, Revision 0, MUT Dissolved Gas Evolution Analysis.

7. Parsons, Inc. Calculation M96-0005, Revision 0, MUT Vortexing Evaluation.

8. Parsons, Inc. Calculation M96-0006, Revision 0, MUT Vapor Pressure Evaluation.

9. Parsons, Inc. Calculation M96-0007, Revision 0, MUT/BWST HYTRAN Analysis.

Question 1

Give a brief history of the design basis of MUV-64. Please begin with an explanation of why the valve was originally designed to shut on an ESFAS signal and walk through the changes to the valve's configuration (removing the ESFAS signal and subsequently removing power). Please be prepared to explain the rationale for any configuration changes.

Response 1

March, 1977: At the time of initial commercial operation, MUV-64 was designed to automatically close upon receipt of an Engineered Safeguards (ES) signal. The reason for this auto-close design was to prevent entrainment of hydrogen from the makeup tank (MUT) into the aligned makeup pump (MUP) after an ES actuation. The chronology of valve configuration changes and associated licensing actions is as follows:

October, 1983: FPC requested NRC approval to remove the ES closure signal from MUV-64 as part of a larger request regarding on-line ES actuation logic testing. The primary reason for this request was to enhance makeup pump reliability. FPC cited previous damage to a makeup pump due to the loss of suction caused by inadvertent closure of MUV-64. FPC stated that remote manual closure of MUV-64 after ES actuation would remain available from the main control room. (Ref. FPC letter to NRC 3F1083-25 , dated October 31, 1983).

February, 1984: NRC requested additional information on the October, 1983 request. The questions pertained to reactor coolant boron dilution prior to manual isolation of MUV-64 and justification of the time frames FPC estimated for having to manually close MUV-64 during an ES actuation prior to the MUT reaching low level (five minutes to several hours). (Ref. NRC letter to FPC 3N0284-18, dated February 21, 1984).

May, 1984: FPC responded to the February, 1984 RAI. The response addressed the boron dilution question and explained the operator response times for manual operation of MUV-64. The time differences depended upon how many makeup pumps were running and the availability of suction sources from which they drew their water. The five minute time frame was based upon the Borated Water Storage Tank (BWST) suction valve for the makeup pump aligned to the makeup tank failing to open upon receipt of an ES signal. This caused that MUP to draw suction exclusively from the MUT, drawing it down to low level in five minutes. The response further explains that the opposite train makeup pump aligned exclusively to draw suction from the BWST would be available to provide the necessary core cooling. (Ref. FPC letter to NRC 3F0584-01, dated May 1, 1984).

August, 1994: The NRC approved removal of the ES closure signal from MUV-64. The NRC accepted FPC's explanation of the potential boron dilution. The NRC also accepted the five minute operator response time on the basis that the redundant MUP would remain available for core cooling should the MUP aligned to the MUT be damaged due to loss of suction. (Ref. NRC letter to FPC 3N0884-32).

September, 1984: FPC implemented the modification removing the ES closure signal from MUV-64. Remote manual closure from the main control room was maintained. (Ref. TMAR 84-06-05-01)

May, 1985: Gilbert/Commonwealth recommended to FPC Nuclear Engineering that MUV-64 be locked (secured) open to comply with 10CFR50, Appendix R. The safety analysis supporting this recommendation confirmed no hydrogen would be drawn into the MUPs after ES actuation assuming 10 psig overpressure in the MUT and the MUT at low level upon ES actuation. (Ref. Gilbert/Commonwealth letter FCS-6322 to FPC, dated March 15, 1985).

July, 1985: FPC Nuclear Engineering recommended to Nuclear Plant Operations that MUV-64 be locked (secured) open for Appendix R compliance. (Ref. IOC NEA85-0898, Widell to McKee, dated July 26, 1985). At some time shortly after this memorandum was issued, the valve was secured open in the field. Subsequent to this time, pneumatic power and control board indication for MUV-64 were removed.

August, 1985: FPC informed the NRC that MUV-64 had been locked (secured) open. Spurious closure of MUV-64 due to an Appendix R fire was noted as the reason for this decision. (Ref. FPC letter to NRC 3F0885-02, dated August 6, 1985).

Present Day: MUV-64 remained secured open from August, 1985 through the start of Refuel 10 on February 16, 1996. A modification has been performed in Refuel 10 to install a manual operator and chainwheel on MUV-64 to allow closure of the valve. Valve position indication has been re-installed on the main control board.

Question 2

During the recirculation phase of post LOCA recovery the suction for the HPI pumps would be switched to the LPI pumps discharge (piggy back) for continued high pressure injection for some LOCA events. The LPI pumps provide a discharge pressure to the HPI suction of about 200 psia. Reverse flow of radioactive sump water to the depressurized makeup tank was formerly prevented by closing MUV-64 and a check valve. These valves would isolate the safety and non-safety portions of the makeup system. Is the current configuration with MUV-64 blocked open consistent with the licensing basis including operator dose and reactor building inventory calculations? Discuss how single failure of ECCS systems was considered. Discuss how blocking open MUV-64 affects your response to TMI action item III.D.1.1.

Response 2

The fact that MUV-64 was locked open did remove one of two barriers preventing backflow to the MUT during piggyback operation. However, neither MUV-64 nor MUV-65 (the upstream check valve) forms a safety-class break in the makeup system (see Attachment 2). The entire makeup and letdown flow path, including the makeup tank and suction piping between the MUT and the makeup pumps is safety-related. The ISI code class does change at MUV-64. This code class change at a locked open valve has been identified on a precursor card and is currently being evaluated. In any event, the piping in question will remain safety-related. Note that the CR-3 design and licensing basis does not require postulating the failure of check valves. To ensure MUV-65 performs its intended function, a flow test is periodically run (SP-435, Revision 44) to verify that the valve seats with DHV-11 or -12 open to prevent backflow of ECCS fluid to the MUT. In addition, MUV-65 is included in the CR-3 Check Valve Reliability Program which further ensures it will perform its design function if called upon.

The licensing basis for the operator dose analyses performed in response to NUREG-0737, item II.D.3.4 assumed a source term consistent with Regulatory Guide 1.4 and used SRP 15.6.5 as a guidance document in performing the analyses. Appendix B of SRP 15.6.5 provides guidance to address the dose consequences due to leakage from Engineered Safety Feature (ESF) systems which recirculate sump fluid outside containment. Source terms of the magnitude described in Regulatory Guide 1.4 were associated only with large break LOCA accidents by the analysts. All system alignments considered in the dose analyses were consistent with licensing basis large (i.e., cold leg) break LOCA mitigation. For CR-3, the Decay Heat Removal (DH) System (LPI mode) and Reactor Building Spray (BS) System are the only accident mitigation systems which recirculate sump fluid outside containment in a large break LOCA. FSAR Section 6.4 and Table 6-11 describe the leakage from the portions of these systems which are located in the auxiliary building and contain radioactive sump fluid post-LOCA.

The HPI-piggyback mode of operation is not assumed or required for mitigation of the licensing basis large break LOCA. Therefore, piggyback system alignments are not considered in the dose analyses. The boundary of piping containing radioactive sump fluid is established at closed valves DHV-11 and DHV-12 (Attachment 2). With these valves closed, the sump fluid does not reach MUV-64 or MUV-65 during the recirculation phase of large break LOCA mitigation. The amount of leakage from these systems outside containment is estimated to be 2,580 gallons over thirty days. Compared to an estimated total inventory of 275,000 gallons in the reactor building for recirculation cooling, this loss is insignificant with regard to source term concentration and reactor building level for BS/DH pump NPSH and is not specifically considered in these analyses. In summary, locking open MUV-64 does not affect the licensing basis for operator dose analyses nor does it significantly affect reactor building inventory calculations.

With regard to NUREG-0737, item III.D.1.1, FPC's leakage reduction program includes the above-mentioned portions of the DH and BS systems as well as the makeup (HPI) system, the Post-Accident Sampling System (PASS), and the Containment Monitoring System. This program, implemented under Compliance Procedure CP-149, measures external leakage from these systems. Leakage from the DH and BS systems is limited to the values assumed in the operator dose analyses and is verified by Surveillance Procedure SP-312. Leakage from the other systems is limited to as low as practical for the PASS and Containment Monitoring systems. Leakage from the HPI system is limited to as low as practical with the following specific limits when combined with Reactor Coolant System leakage:

a. 1 gpm unidentified leakage

b. 1 gpm total primary to secondary leakage

   (NOTE: This limit may change to a lower value of 150 gpd per the pending technical specification change for OTSG tube inspections)

c. 10 gpm identified leakage

d. 12 gpm controlled leakage

Since the pressure boundary of MUV-64 was not affected by the decision to lock it open, the response to TMI item II.D.1.1 is unaffected.

Question 3

Please describe compliance with Appendix R for MUV-64 and the reasons for choosing to lock the valve open as the best means for complying with the regulation, considering that this configuration and method for compliance is somewhat unique.

Response 3

There were three options considered to address spurious closure of MUV-64 during an Appendix R fire. These options were consistent with industry-accepted practice for complying with the rule. The first option was to re-route circuits so that no redundant circuits traverse the same fire area. The second option was to provide fire protection for one of the two redundant circuits traversing the same fire area (e.g., Thermo-lag). The third option was to disable the component to prevent the fire from causing the component to move to a non-safe position. FPC chose to implement option three based on it being an industry-accepted method of compliance and prior experience with makeup pump damage due to spurious suction valve closure.

Question 4

Please be prepared to discuss the specifics of the calculational methods and the confidence in the calculational inputs used to determine an acceptable level versus pressure curve. Be prepared to answer the following questions:

Question 4a

During a LOCA the HPI pumps are protected against failure from ingestion of makeup tank cover gas by operational limits on makeup tank pressure as a function of level. The upper limit of makeup tank pressure (design limit) was calculated by evaluating pressure losses through the ECCS system piping from the BWST to the HPI pumps. These calculations involved use of handbook values for the flow losses through the piping runs and fittings. These were derived from standard generic values. Justify that flow losses used are appropriate for the actual piping and fittings installed in the plant. Evaluate the uncertainty in the values used. Consider uncertainties derived from interpolating in handbook tables and nomographs. Consider any data on the actual components supplied by the manufacturer or any tests on installed equipment.

Response 4a

FPC chose to have a consultant, MPR Associates, perform an independent evaluation of the internal FPC calculation which created the MUT pressure/level curve. The discussion which follows refers to this independent evaluation. Details of the MPR evaluation can be found in Enclosures 1, 2, and 3.

The calculation of the upper limit of pressure in the MUT involves many factors in addition to the head loss in the piping from the BWST to the tie-in to the MUT. Most of the other parameters and calculational methods that determine the margin for gas ingestion are bounding values (i.e., the BWST level and pressure; the flow rates in the piping; and the processes, temperature, pressure, and level in the MUT are all taken at extreme values and are assumed to occur simultaneously). Consequently, the probability of hydrogen gas ingestion, even if total head loss were at the extreme of its uncertainty band, is considered to be low. In fact, best estimate calculations show large margins to the ingestion of any gas on the order of about twelve feet of water. When considered in conjunction with the overall margins, the uncertainties in the pressure loss calculation do not have a significant contribution to the overall risk of gas ingestion.

The calculated pressure loss from the BWST to the tie-in to the MUT is made up of the losses from friction in the piping and the losses in several different types of components. The losses in each of these is treated by separate correlations in the calculation. The total head loss of about twelve feet is divided among the various components as follows:

Piping: 4.8 ft. (40%)

Elbows: 2.7 ft. (23%)

Tees: 2.7 ft. (23%)

Valves: 0.9 ft. (7%)

BWST exit: 0.8 ft. (7%)

The friction losses in the straight piping are calculated directly from the Colebrook Equation (circa 1939) or the equivalent Moody Diagram (circa 1944) that have been widely used throughout the industry for many years. Their accuracy is generally taken to be about five percent. There is some additional uncertainty in the relative roughness of the piping. However, the piping is all commercial stainless steel and the uncertainty in the roughness does not add a large additional uncertainty to the friction factor. A ten percent uncertainty in the piping part of the total pressure drop is considered reasonable.

The pressure losses in the components other than piping were obtained from standard sources, especially Crane Technical Paper 410, *Flow of Fluids Through Valves Fittings, and Pipe*. This source provides pressure loss correlations for piping system components that have been in wide use throughout the industry for as long as fifty years. Although it is not as sophisticated in its approach as some more recent methods for estimating component loss coefficients, Crane 410 has the advantage of a very large background of experience. There is no indication that there are large systematic errors in using the relations it recommends. In addition to Crane 410, other references were consulted or used where the Crane 410 values were obviously inapplicable, e.g., in complicated tees where the work of D. S. Miller, *Internal Flow Systems Design and Performance*, 2nd Ed.

(1980) was used or for the check valve where actual test data for similar valves was used.

The losses in the other components are less certain than for the friction in the piping. However, comparisons of various possible sources indicate that each of the components is unlikely to be higher than the nominal value by more than 20 percent. Furthermore, it is unreasonable to assume that all these components are at their extremes at the same time. If these various components of the head loss are combined as is normal practice for independent errors by the sum-of-the-squares, the total uncertainty in the head loss is found to be about one foot. It was also found that if all the uncertainties (including piping friction) were increased to 30 percent, the uncertainty in the total head loss would only increase to about 1.9 feet, still less than the explicit margin of 2 feet used in the MUT pressure/level calculation.

Any uncertainties in interpolating handbook tables and nomographs are well within the uncertainties that have been assumed. The data and correlations for head losses are not sufficiently precise that this is a practical concern. Testing on the system has not been conducted with sufficient instrumentation to verify flow losses in piping segments or components.

Question 4b

The calculation of pressure losses in the ECCS lines during a LOCA is dependent on the flow rates assumed for the HPI, LPI, and building spray pumps. Justify that the values used in your calculations are conservative for this purpose. Discuss how the flow rates assumed relate to various break size(s) and location(s) of possible LOCA events. FPC document M94-0053 referenced 16 combinations of HPI, LPI, and building spray flow rates. Identify the scenarios that were considered in terms of break size and location and equipment failure. Evaluate the margin to makeup tank draining for each case.

Response 4b

The makeup tank pressure/level curve represents the maximum allowed MUT pressure for a given level to prevent hydrogen entrainment into the makeup pump aligned to the MUT and BWST during an ES actuation. The HPI pump in the other train is isolated from the MUT and is not considered in the analysis. The pressures which were used to create the curve were calculated to assure there remained water in the MUT suction line when flow through that line ceased and HPI flow was exclusively from the BWST. This was accomplished by calculating the available static head pressure in the BWST at the completion of swapover to the reactor building sump and subtracting the hydraulic losses due to flow from the BWST to the common MUT/BWST tie-in point. Higher hydraulic losses in the BWST suction line result in lower pressure at the tie-in point and a more conservative (i.e., lower and to the right) MUT pressure/level curve.

The flow rates from the HPI, LPI, and BS systems were those associated with the large break LOCA accident. These are the maximum flow rates anticipated for the entire range of loss of coolant break sizes. Smaller break sizes would result in less depressurization of the primary system and more back pressure in the HPI and LPI systems. Higher RCS backpressure would increase overall system resistance and run the HPI and LPI pumps back on their curves, thus reducing system flow. Lower flows would reduce hydraulic losses and serve to "move" the calculated MUT pressure/level curve up and to the left which would be less conservative than the curve calculated for the large break LOCA. With regard to the BS system, smaller size LOCAs may or may not initiate either manual or automatic BS system operation. It is conservative for the full spectrum of break sizes to assume BS flow to maximize hydraulic losses and force the curve down and to the right.

The reason there were a large number of cases analyzed in the calculation was that there were a number iterations in the calculation to evaluate different pump/system flow combinations. Although specific LOCA break sizes and locations cannot be definitively assigned to the various cases, in general, larger flow rates equate to larger size LOCAs as described above. It should be noted that there are several cases which include two HPI pumps in operation drawing suction from a common BWST suction header. This reflects a condition which was possible at the time the original MUT curve calculation was performed in the 1990 time frame. These cases were carried forward to the 1994 calculation. Please refer to the response to question 4c below for additional information regarding the current procedural prohibitions preventing this alignment.

In Revision 3 of calculation M94-0053 (Enclosure 4 to this letter), FPC has chosen to take advantage of some of the conservatism in flow rate assumptions. This was done to compensate for the missing velocity head loss term and the use of a more conservative K-factor for one pipe fitting (tee). FPC emergency operating procedures require throttling of LPI and BS flow prior to opening the reactor building sump suction valves to swap pump suction from the BWST to the reactor building sump. This is done to reduce the NPSH required for those pumps during the recirculation phase of core and containment cooling. Those throttled flow values reduce the hydraulic losses in the BWST suction line and compensate for the increased hydraulic losses due to the velocity head term and more conservative K-factor.

In summary, the MUT pressure/level curve used in the control room today was calculated for the large break LOCA accident. In this application, system response for the large break LOCA bounds all smaller size breaks and constitutes the design basis for the entire spectrum of breaks. The calculation assumes emergency procedures are followed as-written and all applicable instrument errors are conservatively applied. The margin to draining the makeup tank is difficult to quantify based on the numerous inputs to the analysis and the combined conservatism in those inputs. As mentioned in the response to question 4a above, the true margin to gas ingestion is estimated to be approximately twelve feet of water.

Question 4c

The design limit curve for makeup tank pressure versus level appears to be based on one train operation of an HPI, LPI, and building spray pump. FPC document M94-0053 states that "a second HPI pump per train can be used for emergencies as long as it is secured before reaching a BWST level of 25.5 ft". Provide and justify the margin to makeup tank draining during 2 HPI pump operation. Justify that assumed pump flow rates and ECCS piping pressure losses used are conservative for that purpose.

Response 4c

Calculation M94-0053 was generated using a 1990 vintage calculation as a foundation. At the time the 1990 calculation was developed it was possible, given certain conditions, for all three makeup pumps to be in operation after an ES actuation. Two of those pumps would have drawn suction from one BWST suction line. Specifically, if MUP-1B was the normal running makeup pump and MUP-1A and -1C were "A" and "B" train ES-selected, respectively, all three pumps would continue to run after an ES actuation provided offsite power remained available. The margins included in calculating this BWST level limit are essentially the same as those for the MUT pressure/level curve since the same methodology was used.

Operating Procedure OP-402, Revision 84 (Enclosure 5) sets up the makeup system for normal operation and ES-standby operation. This procedure requires the normal running makeup pump to also be ES-selected. A second pump in the opposite train is selected for ES-standby operation. The third pump is not ES-selected. This ensures only two HPI pumps will be running after an ES actuation. The BWST level limit for two pumps/one suction line remains in the Limits and Precautions section of OP-402 because it is still possible, only for short durations while transferring pumps, to have three pumps running after as ES actuation. See the response to Question 5 for additional information on this issue.

Question 4d

We understand that alarms are provided in the control room to alert operators if the design limit makeup tank pressure curve is being approached. The alarms provide additional margin to prevent complete draining of the makeup tank during a LOCA and ingestion of the cover gas into the HPI pumps. Provide the basis of the alarm settings. Discuss the margin provided by the alarms in terms of pressure below the design limit as the makeup tank drains during a LOCA and reaches its minimum level during a LOCA. What are (the) uncertainties associated with the alarm limits?

Response 4d

The MUT pressure/level curve is proceduralized as Curve 8 of Operating Procedure OP-103B (see Attachment 3). The design limit curve is the one farthest to the left and is clearly labeled "Design Limit". Operation above this curve is clearly labeled "Unacceptable Region" and is prohibited. The middle curve is the annunciator alarm curve. It is located a minimum of 3 psig below the design limit curve at 55 inches MUT level up to a maximum of 6 psi below the design limit curve at 100 inches. These offsets are based on operator judgement as to the precision of control while at steady state conditions and during hydrogen additions. Operation on or to the left of this curve is labeled the "restricted region" and will cause an annunciator to alarm on the main control board. Annunciator Response Procedure AR-403, Revision 25 (Event Point 1062) requires immediate action to be taken to restore MUT pressure below the annunciator curve. The lowest curve is the computer alarm curve. It is located a minimum of 1 psi below the annunciator curve and 4 psi below the design limit curve at 55 inches MUT level up to a maximum of 2 psi and 8 psi below the annunciator and design limit curves, respectively, at 100 inches MUT level. These offsets are also based on operator judgement and the alarm curve is provided as a tool to the operators. Operation on or to the left of the computer alarm curve will cause a computer alarm to appear on the CRT above the main control board alerting the operators that MUT pressure is approaching the restricted operating region.

Curve 8 of OP-103B represents the allowed initial pressure for the operating level range of the makeup tank. Provided operation remains on or below the curve at the onset of the postulated event, hydrogen will not be ingested into the makeup pumps. The pressure/level response of the tank is not expected to exactly trace Curve 8 since the curve was developed using worst case instrument accuracies and temperature effects all assumed to occur simultaneously. It is highly improbable that this combination of effects would occur simultaneously, exactly as assumed in the calculation, in an actual plant situation. However, it is expected that the pressure/level response would track within a reasonable band on either side of Curve 8 with any deviation being attributable to the actual conditions being different from those assumed in the analysis.

Question 5

Please be prepared to discuss the adequacy of procedural guidance with regard to preventing two high head safety injection pump operation on one header below 25.5′ in the BWST. It appears that the procedures do not preclude two pump operation on one suction header, yet the procedures do not require the operators (to) remove one pump from service before reaching 25.5' in the BWST.

Response 5

Operating Procedure OP-402, Revision 84, Step 3.2.17 states:

> **"When BWST level is < 35 FT, do not operate more than 1 MUP from a single BWST suction". The basis is "To prevent hydrogen entrainment into the MUPs that are aligned to both the MUT and the BWST simultaneously during ES actuation".**

This step is included as a limit and precaution since it is still possible to have three MUPs operating simultaneously during an ES actuation if the actuation occurs during a makeup pump swapping evolution. For example, if MUP-1B is the normal running and ES-selected makeup pump and it is desired to swap the normal makeup function to MUP-1A, there is a short period of time where both pumps could be running simultaneously. The swap function involves switching the ES-selected pump to MUP-1A and starting MUP-1A while leaving MUP-1B running to ensure normal makeup flow is maintained during the transfer. Should an ES actuation occur during this time with no loss of offsite power, MUP-1A and -1C would auto start and MUP-1B would continue to run. Both MUP-1A and -1B would draw suction from the "A"-side BWST suction line. It is in this situation that limit and precaution 3.2.17 would apply. It should be emphasized that this is a transient situation and once MUP-1A is running and stable, MUP-1B would be secured. This evolution typically takes about five minutes to execute. After the swap and securing of MUP-1B, that pump would not auto-start on an ES-actuation since the ES signal has been transferred to MUP-1A.

A note included with step 4.2.12 states:

> **"The running MUP should be selected or remain selected as an ES Makeup/HPI pump; i.e., its "SWGR TRANSF PERMIT" white light should be lit".**

Aside from the pump transfer scenario described above, this note ensures no more than two MUPs would be running after an ES actuation.

Question 6

Is the design limit curve adequate considering that there is virtually no margin supplied by the curve? We understand that as makeup tank pressure is increased alarms are provided first by a computer and then by control room annunciators. Discuss operational restrictions on operating at pressures above the computer or the annunciator alarm. Are there any conditions for which operation above the alarm setpoints would be acceptable?

Response 6

As discussed above, there is significantly more hydraulic head margin available than a two-foot water column. These margins are contained in the flow rates assumed, flow loss coefficients, instrument string error calculations, and the conservative application of the those errors. All design inputs were conservatively chosen and applied to ensure a reasonable amount of margin exists in the design limit curve. In addition, the annunciator and computer alarm curves provide additional margin over and above that inherent in the design limit curve. The computer alarm curve is located 4 to 8 psi below the design limit curve. No specific action is required of the operators upon receiving the computer alarm. This alarm alerts the operators that MUT pressure is approaching the restricted region. The annunciator curve is located 3 to 6 psi below the design limit curve and allows sufficient time for action to prevent operation in the unacceptable region. Annunciator Response Procedure AR-403, Revision 25 (Event Point 1062) states:

> **"IMMEDIATELY REDUCE PRESSURE WITHIN THE LIMITS OF MAKEUP TANK PRESSURE/LEVEL CURVE 8 OF OP-103B"**

Although operation in the restricted region is allowed, sufficient operating margin and clear procedural guidance have been provided to ensure operator action to be taken to prevent crossing into the unacceptable region.

Question 7

As the pressure is reduced in the makeup tank during normal operation the ability to devolve hydrogen gas within the makeup tank is reduced. Dissolved hydrogen is important in reactor coolant system chemistry. Justify that the reactor system will be adequately protected from corrosion during operation with the current limits on makeup tank pressure.

Response 7

CR-3 maintains its chemistry program consistent with industry standards. The basis of the program is referenced in three specific documents:

- B&W Water Chemistry Manual

- INPO Guidelines for Chemistry at Nuclear Power Stations

- EPRI PWR Primary Water Chemistry Guidelines

To optimize RCS chemistry and minimize the potential for corrosion due to primary water stress corrosion cracking, dissolved hydrogen should be maintained in a range of 25 - 50 cc/kg at Standard Temperature and Pressure (STP) conditions. The B&W Water Chemistry Manual endorses the EPRI recommendations for primary water hydrogen concentration. The EPRI guidelines specifically recommend maximizing the operating time at 25 - 35 cc/kg for those plants that have steam generator tubes constructed of mill-annealed Alloy 600. CR-3's OTSG tubes fall into this category. This hydrogen concentration band protects against oxidizing conditions to facilitate good operational control and is based upon:

- 15 to 20 cc/kg scavenges free oxidizing species (hydroperoxy radicals).

- 15 cc/kg suppresses oxygen produced by the radiolytic decomposition of water in the reactor core.

CR-3 operating data from the fall of 1995 show that during normal full power operation, MUT pressure ranged from approximately 12 to 25 psig with level ranging from approximately 80 to 98 inches. Dissolved hydrogen concentration ranged from approximately 22 cc/kg to 33 cc/kg. Other factors such as the purity of hydrogen in the MUT gas space cause the fluctuation in dissolved hydrogen concentration not to directly correlate with MUT pressure and level. MUT level is required by OP-402 to be maintained between 55 and 100 inches and pressure below Curve 8 of OP-103B. Given the typical full power MUT pressure and level values and the resultant dissolved hydrogen concentrations, CR-3 is clearly able to maintain RCS dissolved hydrogen within the recommended specifications while not challenging the MUT pressure level limit curves over the full operating range of the tank.

ADDITIONAL QUESTIONS RECEIVED AT THE 2/8/96 NRC MEETING

Question 8

Please provide copies of the following documents:

The MPR evaluations

The latest revision of calculation M94-0053

OP-402

The Parsons, Inc calculations

Response 8

These documents are included as Enclosures 1-9 of this letter. Please note that the MPR and Parsons calculations have not yet been reviewed and accepted by FPC.

Question 9

We understand that BWST vacuum breaker valve DHV-70 was found to have its sensing line clogged during a recent inspection. The LFR documenting this outside design basis condition further states that neither DHV-69 nor -70 is a 100% capacity valve. Please provide the results of the as-found inspection of DHV-69 and describe the effect of degradation of these vacuum breaker valves on the assumptions made in calculation M94-0053.

Response 9

DHV-69 passed its as-found test and opened at its vacuum setpoint. The effect of having DHV-70 inoperable and neither valve sized for 100% relief capacity has been analyzed. The estimated vacuum with only DHV-69 operable and no other vacuum breaking vents available is just over 13 inches of water. Calculation M94-0053 assumes 12 inches of water vacuum in the BWST at the point of swapover. However, the BWST includes an eight inch diameter vent to the Auxiliary Building Ventilation System to capture radioactive off-gasses from the tank. This vent path has no isolation valves and is not seismically qualified. When accounting for the natural vent provided by this vent path, the 12 inch water vacuum assumption in Calculation M94-0053 is conservative. DHV-69 and -70 have been replaced in Refuel 10 with 100% capacity valves which do not operate using a sensing line or solenoid valve. The material has also been upgraded to stainless steel to prevent corrosion. These valves are periodically tested to ensure the open at the proper set pressure.

Question 10

Calculation M94-0053 assumes a maximum temperature for the water in the tank and the gas above the surface of the fluid. Although assuming a higher temperature maximizes the pressure in the gas space, lower fluid temperature increases the solubility of hydrogen in the water. Additional hydrogen in the water evolving into the gas space during drawdown would tend to increase pressure. How were competing temperature effects considered in the calculation.

Response 10

The temperature phenomena described in the question are correct. MPR Associates has provided a response to this question in Enclosure 3 to this letter. The MPR analysis shows that, for this application, it is more conservative overall to assume the maximum temperature when the combined temperature effects are considered.

Question 11

Provide the results of running SP-630 in Refuel 10 and discuss those results compared to the previous running of SP-630 in 1994. In addition, describe whether the test provided confirmatory results of the design adequacy of the MUT pressure vs. level curve.

Response 11

SP-630 was run at CR-3 at the end of March, 1996. The results were positive in that no pump cavitation was observed similar to that observed in 1994. This appears to confirm the proposed root cause of the pump cavitation in 1994 being air trapped in the suction lines due to inadequate post-maintenance venting of the system. A corrective action to Problem Report 94-0149 prompted the installation of vent and drain valves in Refuel 10 to allow adequate venting after maintenance activities. This action appears to have corrected this problem.

Because SP-630 does not simulate a worst case, full flow drawdown of the BWST and MUT, Performance Test PT-630 was created and also run at the end of March, 1996. PT-630 operates all three pumps (HPI, LPI, and BS) in a single train which draw common suction from the BWST. This includes a makeup pump concurrently aligned to the makeup tank to simulate actual ES conditions upon which OP-103B, Curve 8 is based. This test was also successful in that no pump cavitation was observed. The detailed test data have not been analyzed to confirm the design adequacy of the MUT pressure vs. level curve. As described above and at our meeting on February 8, 1996, FPC believes the current Curve 8 in OP-103B (Attachment 3) to be correct and conservative to protect the makeup pumps from damage during a design basis LOCA. FPC will provide an evaluation of the results of SP/PT-630 to the NRC in separate correspondence as soon as the data have been analyzed. This information is expected to be submitted to the NRC by May 3, 1996.

3F0496-02
Enclosure 1

MPR
ASSOCIATES INC.
ENGINEERS

January 11, 1996

Mr. Paul Tanguay
Director, Nuclear Engineering and Projects
Florida Power Corporation
Crystal River Energy Complex
15760 West Power Line St.
Crystal River, Florida 34428-6708

Subject: Crystal River Unit 3 - Review of Calculations of Maximum Allowable Makeup Tank Pressure

Dear Mr. Tanguay:

At your request we have reviewed Florida Power Corporation calculation M94-0053, Revision 2, "Allowable MUT-1 Indicated Overpressure vs. Indicated Level," as well as some material that is being prepared for the next revision (Revision 3) of that calculation. Our review has focused on the fundamental assumptions and methods of the calculation and on those portions of it which establish the curve of allowable maximum pressure in the makeup tank as a function of level. Rather than simply go through the calculation we have chosen to use independent methods, where practical, since we consider it provides more assurance of the validity of your results.

The pressure in the makeup tank is limited to assure that under accident conditions when the borated water storage tank (BWST) is being emptied, gas from the makeup tank will not be drawn into the makeup pumps. The pressure depends upon:

- The head losses from the BWST to the point at which the pipe from the makeup tank is tied into the pump suction.
- The change in pressure in the gas in the makeup tank as its level drops.

This letter includes as enclosures three calculations:

- MPR Calculation 102075DHH01, "Maximum Allowable Makeup Tank Pressure." This is the overall calculation that establishes an allowable makeup tank pressure as a function of level.
- MPR Calculation 102075DHH02, "Head Loss in BWST to Makeup Pump Flow." This is the detailed calculation of the head loss from the BWST to the point at which the makeup tank piping is tied into the makeup pump suction.
- MPR Calculation 102075DHH03, "Makeup Tank Pressure." This is the detailed calculation of the change in pressure in the makeup tank as the level drops.

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The final curve of allowable pressure is presented in calculation 102075DHH01, page 7. We have compared that curve to a preliminary curve for Revision 3 that was provided to us by Mr. R. Clauson (FPC). The curve showing the comparison is provided on page 11 of calculation 102075DHH01. It can be seen from this comparison that the shapes of the curves are virtually identical. Our curve is slightly higher, a fraction of a psi. We believe this small difference is largely because FPC calculation M94-0053 uses a higher loss coefficient for the 14x14x6 reducing tee where the flow to the makeup pumps splits from the main BWST flow. The basis for the value we used for this loss coefficient is discussed in detail in the calculation.

If you have questions on these calculations, please do not hesitate to contact us.

Sincerely,

Dwight H. Harrison

Dwight H. Harrison

Enclosures: MPR Calculations
102075DHH01, 02, and 03.

cc: Mr. R. Clauson, Florida Power, w/encls
Mr. K. Ledzian, Florida Power, w/encls