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

Subject: Duke Energy Corporation
Catawba Nuclear Station, Unit 2
Docket Number 50-414
Proposed License Amendment for Unit 2 Reactor Coolant System Cold Leg Elbow Tap Flow Coefficients

References:

1) NRC Issuance of Amendment No. 186 for Catawba Nuclear Station, Unit 2. Letter dated October 2, 2001.

2) Catawba response to Request for Additional Information dated September 13, 2001

3) Catawba response to Request for Additional Information dated September 10, 2001

4) Catawba response to Request for Additional Information dated July 25, 2001

5) Catawba License Amendments Request for Revision of Unit 2 Reactor Coolant System Cold Leg Elbow Tap Flow Coefficients dated March 9, 2001

6) NRC Issuance of Amendment No. 128 and 122 for Catawba Nuclear Station, Units 1 and 2. Letter dated February 17, 1995.

Pursuant to 10 CFR 50.90, Duke Energy Corporation requests an amendment to the Catawba Nuclear Station Unit 2 Facility Operating License for continuation of the use of the Reactor Coolant System (RCS) Cold Leg Elbow Tap Flow Coefficients. The NRC approved the flow coefficients for Cycle 12 in the Issuance of Amendment No. 186 (reference 1). This amendment

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request is to allow the continuation of the same flow coefficients beginning with Cycle 13 and for future cycles.

On February 17, 1995, the NRC approved the methodology for measuring the RCS flow rate using the cold leg elbow tap signals (reference 6). This approved methodology allowed the measurement of the RCS flow rate based upon the normalization of the RCS cold leg elbow tap signals to constants derived from averaged calorimetrics from previous fuel cycles. In the Safety Evaluation for Amendments 128 and 122, the NRC notified Duke Energy that any future changes to the cold leg elbow tap flow coefficients would require prior NRC review and approval.

In March 9, 2001, Duke requested a revision to the elbow tap coefficients (reference 5). The March 2001 amendment request provided the background information associated with the need to revise the coefficients and the technical justification to support this request. While Duke considered the March 2001 amendment request to be technically justified and safe, the NRC and Duke agreed to an interim, one-cycle approval of the revised coefficients for Unit 2, Cycle 12 and Duke would submit another amendment request for the use of these coefficients beyond Cycle 12.

This amendment request is to allow the continued use of the flow coefficients approved for Cycle 12. The contents of this amendment request package are as follows:

1. Attachment 1 provides a description of the proposed change and technical justification.

2. Pursuant to 10 CFR 50.92, Attachment 2 documents the determination that the amendment contains No Significant Hazards Considerations.

3. Pursuant to 10 CFR 51.22(c)(9), Attachment 3 provides the basis for the categorical exclusion from performing an Environmental Assessment/Impact Statement.

This submittal is a formal license amendment request, however, there are no associated technical specification changes required for this submittal.

Implementation of this amendment to the Catawba Unit 2 Facility Operating License will not impact the Catawba Updated Final Safety Analysis Report (UFSAR).

Duke is requesting NRC review and approval of this amendment request prior to March 1, 2003 in order to support the next refueling outage for Catawba. Because this amendment will not change any current plant setpoints or calibrations, this amendment will be implemented immediately upon NRC approval provided that the approval is before the initial startup for Unit 2 Cycle 13.

This letter and attachments do not contain any regulatory commitments.

In accordance with Duke Energy administrative procedures and the Quality Assurance Program Topical Report, this proposed amendment has been previously reviewed and approved by the Catawba Plant Operations Review Committee and the Duke Energy Corporate Nuclear Safety Review Board.

Pursuant to 10 CFR 50.91, a copy of this proposed amendment request is being sent to the appropriate State of South Carolina official.

Inquiries on this matter should be directed to G.K. Strickland at (803) 831-3585.

Very truly yours,

Gary R. Peterson

GKS/s

Attachments

Gary R. Peterson, being duly sworn, states that he is Site Vice President of Duke Energy Corporation; that he is authorized on the part of said corporation to sign and file with the Nuclear Regulatory Commission this amendment to the Catawba Nuclear Station Facility Operating License Number NPF-52; and that all statements and matters set forth herein are true and correct to the best of his knowledge.

Gary R. Peterson, Site Vice President

Subscribed and sworn to me: 10-10-2002
Date

Notary Public

My commission expires: 7-10-2012
Date

SEAL

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ATTACHMENT 1

DESCRIPTION OF PROPOSED CHANGES AND TECHNICAL JUSTIFICATION

BACKGROUND INFORMATION

On October 2, 2001, the NRC approved and issued Amendment Number 186 for Catawba Unit 2 (Reference 1). This amendment revised the cold leg elbow tap flow coefficients used in the determination of Reactor Coolant System (RCS) flowrate. The NRC's Safety Evaluation Report (SER) approved the revised flow coefficients for the current fuel cycle, Cycle 12, only. The SER identified a number of concerns that were the basis for the staff decision to restrict the approval to Cycle 12. The purpose of this proposed license amendment is to address the staff's concerns as identified in the SER and to request staff approval for continued use of the revised flow coefficients beginning with Cycle 13 and continuing for future cycles. There are no changes to the associated technical specifications with this license amendment request.

Catawba Unit 2 continues to experience a decrease in RCS flowrate as shown in Figure 3. The technical specification minimum flow limit is 390,000 gpm. The main contributor to the recent decrease in flow is the transition from the Framatome Advanced Nuclear Products Mark-BW fuel assembly design to the Westinghouse Robust Fuel Assembly (RFA) fuel assembly design. The RFA fuel has a higher pressure drop than the Mark-BW fuel, which causes a decrease in core and loop flow. Cycle 12 has 152 RFA and 41 Mk-BW fuel assemblies. Cycle 13 will have 173 RFA and 20 Mk-BW fuel assemblies. A smaller decrease in flow is expected in Cycle 13 due to fewer Mk-BW fuel assemblies being discharged. In addition, a flow decrease occurs during the fuel cycle due to an apparent buildup of crud on the fuel assemblies. The magnitude of the decrease in flow due to the fuel assembly design transition has been larger than projected based on vendor data and the analytical model used to trend RCS flowrate. With the revised cold leg elbow tap flow coefficients that were approved for use by the NRC for Cycle 12, the Cycle 12 flowrate was 394,400 gpm at beginning-of-cycle (Figure 3). The projected flow at end-of-cycle 12 is 393,700 gpm. The projected flow at startup of Cycle 13 is 393,800, and the minimum flow during the cycle will be 393,100 gpm. The revised elbow tap flow coefficients provide approximately 1.0% flow margin, or 4,000 gpm. Consequently, using the old flow coefficients would result in not meeting the 390,000 technical specification minimum flow at present or in the future.

The revised elbow tap flow coefficients were approved by the NRC for Cycle 12 based on the existing flow and DNBR margins and an assessment of the effect of the identified concerns on the flowrate. Approval of the revised flow coefficients was restricted to Cycle 12 pending resolution of the identified concerns as noted in the SER.

Duke requests NRC approval for the revised flow coefficients for Cycle 13 and future cycles based on technical justification that the revised flow coefficients are an appropriate and sufficiently conservative method for confirming that the RCS flow assumed in the core design and safety analyses is maintained. An alternative approach would be to lower the RCS flowrate requirement in technical specifications. That approach has an economic penalty due to core peaking factor constraints, and although conservative, is not the best technical approach for Catawba Unit 2. Duke intends to take this alternative approach for McGuire Unit 2 and Catawba Unit 1 in the near term. A license amendment requesting that the RCS flowrate be lowered from 390,000 gpm to 388,000 gpm will be submitted for those units. That approach is being taken for those units since it is the best technical approach. There is no basis for revising the elbow tap flow coefficients to gain flow margin for those units.

DESCRIPTION OF PROPOSED CHANGES AND TECHNICAL JUSTIFICATION

It is proposed to continue use of the revised cold leg elbow taps flow coefficients for Catawba Unit 2 beginning with Cycle 13 and continuing for future cycles. The proposed flow coefficients that were approved by the NRC for use in Cycle 12 are as follows:

	Loop A	Loop B	Loop C	Loop D
Tap I	0.30680	0.30313	0.31712	0.29936
Tap II	0.29606	0.28601	0.29659	0.29929
Tap III	0.30382	0.30689	0.30389	0.30137

The NRC approval of the above flow coefficients was restricted to Cycle 12 based on identified concerns that were not fully resolved. These staff concerns, which were discussed in the SER, are addressed below.

Selection of Calorimetric Measurement Data

The revised elbow tap flow coefficients were developed from three calorimetric measurements as described in Reference 5, and as shown in Figures 1 and 2. These three data are from early in plant life and were selected due to less or no effect from hot leg streaming than later calorimetric measurements. The NRC's SER states the following (p. 7):

> *"We believe that the first four calorimetrics are the most accurate the licensee has obtained. Further, as discussed in Section 3.2, some of the flow rate decrease during this time may be an indication of RCP impeller wear-in, a non-conservatism. From this perspective, the calorimetric values support a post wear-in flow rate of 400,000 gpm. The licensee's choice of these three values yields an average RCS flow rate of 398,850 gpm; a flow rate conservative by ≈1150 gpm when compared to the 400,000 gpm."*

As stated in Reference 2, the dates of the first four calorimetrics were July 29, 1986, August 19, 1986, August 27, 1986, and November 26, 1986. As stated in Reference 3, the July 29, 1986 calorimetric was performed at 75% power. The other calorimetrics were performed at essentially full power (98-100%). All of these calorimetrics were taken with the RTD bypass manifold in operation. Subsequent calorimetrics, including the third data point selected for use in the calculation of revised flow coefficients, were subsequent to removal of the RTD bypass manifold. It has previously been established that hot leg streaming will affect the RCS flow measurement to a much greater extent without the RTD bypass manifold.

RCS flow increases with decreasing power level due to lower specific volume, velocity, and pressure drop in the hot side of the loop with lower enthalpy rise across the core. Plant data indicates that flow increases by approximately 4000 gpm, or 1%, from full power to zero power. Therefore, a calorimetric measurement at 75% power would be expected to have 1000 gpm (0.25%) higher flow than at full power. In addition, calorimetric measurements at lower power would be expected to be less accurate, since the uncertainty in a measurement would be a greater fraction of the measurement. It is also expected that experience gained during the first calorimetric during initial power escalation testing would improve the quality of subsequent tests. For these reasons, we prefer to use calorimetric data from near full power.

The SER states that RCP impeller wear-in (also referred to as impeller smoothing) is a likely contributor to a decrease in RCS flow during the initial period (first few months) of pump operation. This apparent effect has been observed in some Westinghouse plants. Although this apparent effect cannot be proven or disproven conclusively, the elbow tap Δp data (Figure 1) show a decrease of approximately 2000 gpm between the 75% power calorimetric on July 29, and the full power calorimetric on August 19. As stated above, 1000 gpm (25% of 4000 gpm) of this decrease is due to the change in power level. The remaining 1000 gpm is due to the cumulative effect of any other contributors, and may include a pump wear-in effect during the 500 hours between calorimetrics. The elbow tap Δp data for the three calorimetrics from August 19 to November 26 show essentially no change in flow. It should also be pointed out that the RCPs were in operation for extended periods of time (2A - 2331 hours; 2B - 2367 hours; 2C - 2632 hours; 2D - 2140 hours; Note: not including hot functional testing hours) prior to the calorimetric at 75% power. Any pump wear-in would be expected to have occurred during that initial period of operation prior to the calorimetric measurements.

It is concluded that the selection of the third and fourth calorimetric data on August 27 and November 26, 1986, and the next calorimetric in 1988 following the removal of the RTD bypass manifold is justified. These three data provide a good basis for the elbow tap flow coefficients including some conservatism. The SER statements above are in agreement that this is a conservative approach.

Reactor Coolant Pump Energy Dissipation

The SER (pp. 6, 7) discusses a conservative error in the Duke method for accounting for reactor coolant pump energy dissipation in the calculation of RCS flow from the calorimetric data. This correction involves including only the pump energy dissipation that occurs between the cold leg RTD and the hot leg RTD. The staff calculates an error of +0.36% (real flow higher than calculated by the calorimetric). Duke has repeated this calculation with data specific to Catawba Unit 2 Cycle 12, and we have determined an error of +0.268%, or approximately 1045 gpm.

RTD Bypass Manifold

The SER (p. 5) discusses the potential impact of the RTD bypass manifold removal on the RCS flow. This issue has been evaluated and the following insights were gained. The RTD bypass manifold was removed after the end of Cycle 1. Therefore, the Cycle 1 calorimetric data included the effect of the manifold being installed, and the Cycle 2 data did not. The Catawba Unit 2 startup testing established the average flow in the manifold to be 111 gpm from the hot leg, and 172 gpm from the cold leg, for a total of 283 gpm manifold return flow per loop. The 111 gpm from the hot leg bypassed the steam generator and the cold leg elbow tap. The 172 gpm from the cold leg was essentially a recirculation loop from the RCP discharge to the RCP suction. Calculations using the analytical flow model have determined that the removal of the manifold at the end of Cycle 1 caused an increase in elbow tap flow of approximately 379 gpm (total), and a reduction in reactor vessel flow of 65 gpm. The plant elbow tap data indicate an increase in elbow tap flowrate of 648 gpm (total) at this time. This is considered a small difference between the analytical model prediction and the plant data. Variations in plant data of several hundred gpm are very typical. Since the calorimetric flow data that is used to determine the elbow tap flow coefficients uses secondary power and primary loop ΔT as inputs, the presence or absence of the RTD bypass manifold in terms of the hydraulic losses in the loop have no impact on the determination of flow and flow coefficients. The effect on RCS flow of the presence or absence of the RTD bypass manifold is, however, captured in the Cycle 1 and Cycle 2 plant data, respectively. The plant data, of course, includes the effect of all other contributors to the flow data trends. The analytical model represents the current configuration with the RTD bypass manifold removed. It is concluded that the effect of the RTD bypass manifold has been evaluated and it is a small effect. No changes to the approach are necessary.

RCS Flow Analytical Model

The SER states (p. 11) that the analytical model does not predict the effect on RCS flow due to the more subtle changes, such as fuel design changes and the RTD bypass manifold removal. The SER also states that realistic inputs should be used in the model. These issues are addressed by the following discussion of how the analytical model is applied.

As discussed above (RTD Bypass Manifold topic), the analytical model did not include the RTD bypass manifold that was installed for Cycle 1 only. The above discussion characterizes the magnitude of this omission as small. All other major changes to the primary loop (steam generator tube plugging and sleeving, fuel design changes, reactor vessel internals upflow modification, steam generator replacement) are modeled when applicable to a given unit. The modeling of these major changes uses the best available pressure drop data. These data are generally supplied by the vendor for design purposes. Duke does not use conservative data inputs to the analytical model and then characterize the flow prediction as best-estimate or realistic. Conservative data inputs (such as higher than actual steam generator tube plugging levels) would be used in the model to project the impact on RCS flow in a bounding analysis. Other changes to the plant that are not included in the analytical model, such as boric acid concentration, makeup and letdown flow, crud deposition, and non-uniform steam generator tube plugging within a steam generator, are still considered in the interpretation of the plant data and the comparison to the analytical model results. The analytical model predicts the correct trend given the accuracy of the inputs. Situations in which the analytical model results do not agree with the plant data trends do occur. These situations are evaluated and explanations, including the accuracy of the input data, are sought. Possible causes for major differences between plant data and the analytical model can usually be determined, including input data being in question. Smaller differences can result from the variation typical of plant data variations and instrument calibration effects. Offsetting effects, such as loading lower pressure drop fuel assemblies concurrent with steam generator tube plugging during a refueling outage, can make precise determinations and identification of causes difficult.

When a change in the fuel vendor and/or type of fuel is proposed, pressure drop data is obtained from the vendor. This best-estimate pressure drop information is then input into the analytical flow model by adjusting the three core region pressure drops in the model to match the vendor supplied information. The new pressure drops are also adjusted using a weighted average to account for the number of new assemblies introduced during the reload. If the vendor-supplied pressure drop data are accurate, then the change in flow predicted by the model will trend the direction and magnitude of the flow change in the plant data. For example, the introduction of Mark-BW fuel between October 1991 and February 1993 was predicted by the analytical model to produce approximately a 190 gpm increase in RCS flow, while steam generator tube plugging was expected to reduce flow by 145 gpm, leaving a total increase of approximately 45 gpm. The elbow tap flow indication during this time resulted in a decrease in flow of approximately 450 gpm. The effect of plugging steam generator tubes is known with greater accuracy and confidence than a change in fuel assembly design in a mixed core configuration. It is noted that 450 gpm is only 0.11% of the total flow.

An effort is made to address all significant changes that affect the loop hydraulics in the analytical model that is used to predict RCS flow. Experience to date with this tool has been positive for the intended purpose of predicting and trending significant changes in RCS flow. RCS flow changes resulting from design changes and maintenance activities can be evaluated and the necessary decisions can be made.

Long-Term Reliability of Elbow Tap Instrumentation

The SER (pp. 10-12) discusses a concern with the long-term behavior of the elbow tap flow indications. Two methods are suggested to substantiate our position that the elbow taps provide a reliable indication of RCS flow:

1) Compare elbow flow rates to analytically predicted flow rates for each physical change in the RCS that could affect flow rate.

2) Compare long-term elbow flow rates to independent flow rates determined by other means.

The previous submittals have shown comparisons of the analytical flow model to plant RCS flow data for the four McGuire and Catawba units. As described above (RCS Flow Analytical Model topic), this model captures the significant physical design and maintenance changes in the RCS loop hydraulics. Two aspects that are not included in the analytical model, and were questioned by the NRC, have been addressed in this submittal. The RTD bypass manifold removal is addressed above (RTD Bypass Manifold topic).

The effect of this plant modification has now been calculated with the analytical model, and the results have been compared to the plant data. The modeling of RCP energy dissipation is addressed above (Reactor Coolant Pump Energy Dissipation topic). The result of accounting for this effect more accurately would be an increase in the calculated RCS flowrate. The RTD bypass manifold will not be incorporated in the analytical model since it has been removed in all four units for many years, and the effect is small. The more accurate RCP energy dissipation modeling only affects the calculation of RCS flow in the calorimetrics, and results in a modest increase in RCS flow. It does not affect the analytical flow model, except through less conservative elbow tap flow coefficients, which we are not proposing with this license amendment request.

The analytical model does not model process effects such as crud deposition and boric acid concentration. These effects are observable in the plant data, and when comparing the analytical model to the plant data these effects are fully considered. The crud deposition effect varies significantly between units and fuel cycles, and can only be projected based on recent operating experience data. There is no value in revising the analytical flow model with correction factors based on observed plant data that varies significantly. The boric acid effect is straight-forward, but only contributes 200 gpm of RCS flow change (flow decreases during the fuel cycle). This is a second-order effect that exists in the plant data and trends with the effect of crud deposition. There is no apparent value in introducing the small boric acid effect into the analytical model.

The SER questions the accuracy of the analytical flow model, and its capability to predict the more subtle changes. This issue is addressed in detail in the RCS Flow Analytical Model topic above. Our approach is to faithfully model the effect of changes in the RCS loop hydraulics based on the data available to us. The capabilities and limitations of the analytical model have been demonstrated in this and previous submittals. It is our position that the analytical model serves its intended purpose with sufficient accuracy. An appropriate level of conservatism has been introduced by way of specific modeling decisions and assumptions that have been detailed in this and previous submittals.

The second SER suggestion is to verify the long-term elbow tap flow behavior to another means of measuring flow. This is best accomplished by data from other plants that have alternate RCS flow instrumentation. Previous submittals have provided some data from Prairie Island Unit 2. This plant is equipped with leading edge flowmeters (LEFMs), and comparisons to elbow tap flow predictions can be made directly. Unfortunately, the LEFMs have only been used for special tests that have occurred only about once a decade. Inquiries with the Nuclear Management Company and Westinghouse in regard to obtaining additional data (other than what is available to the public and in the SER on p. 12) have not been productive. The data that is available to the public shows that the elbow tap flow indications and the LEFM flow indications agree very well in limited tests conducted over a number of years.

Additional data has been obtained from three other plants with N-16-based primary loop flow instrumentation. The N-16-based instrumentation is the "Transit Time Flow Meter," and is only used at the start of each cycle to normalize the main control board RCS flow indications. The normalized data shown in Figure 5 from two plants was obtained for the purpose of comparing the RCS flow measurements from the N-16 instrumentation to the cold leg elbow tap instrumentation over a long period of time. The data for Unit A show that the N-16 flow indication and the elbow tap flow indication show a consistent decrease in primary loop total flow during Cycles 4 through 8, with an offset ranging from 0.4% to 0.7%. The data for Unit B can be characterized as somewhat consistent with deviations ranging from 0.2% to 0.75%. The larger fluctuations in the N-16 indicated flow values are attributed to the uncertainty band in the N-16 measurement process. In particular, the increases in the N-16 flow indications on Unit B at Cycles 2 and 6 cannot be attributed to real flow increases, and therefore they can be attributed to measurement process variation. Further insights from the limited available data are not possible. It can be concluded that the elbow tap based flow trends for these two units do not exhibit any behavior that is unusual over a period of many years at relatively constant primary system flowrates. The normalized data shown in Figure 6 provides a similar comparison of the N-16 flow indication and the elbow tap flow trend for a third plant. Although these data span a shorter period of time during which RCS flow changes little, the data shows that there is only an insignificant difference in the flow trends from the two measurement methods. The elbow tap flow trend is more stable as is typical of Figure 5.

Duke has 75 reactor-years of elbow tap data to support a conclusion as to the long-term reliability of this type of flow instrumentation. The elbow tap indications are stable during periods with no significant hydraulic perturbation in the RCS loop. The indications are also responsive to hydraulic changes that either increase or decrease the primary loop pressure drop and effect a change in RCS flow. Previous submittals have discussed in depth the potential degradation processes and we have concluded that the elbow tap device is very reliable and not subject to any potential long-term degradation effects. Data from Prairie Island Unit 2 and three other units with alternate RCS flow measurement instrumentation supports this conclusion.

Cold Leg Streaming

The SER states the following (p. 6) in regard to the potential effect of cold leg streaming on the RCS flow measurement:

> *"Further, there is a similar streaming effect in the RCS cold legs that could influence indicated cold leg temperature due to unequal SG tube lengths and the SG outlet plenum arrangement, with some residual influence remaining from the hot leg streaming. This effect is reduced via mixing in the RCP when T-cold is measured downstream of the RCPs."*

The data presented in Table 1 was recorded during the Catawba Unit 2 Cycle 2 calorimetric in March 1988 after RTD bypass manifold removal. The data represents eight sets of time averaged data, and compares the two (normal and spare) narrow range cold leg RTD temperature indications on each of the four loops. The orientation of the RTDs are also given in Table 1. Although these data do not span the cross section of the pipe, these temperature differences are smaller or typical of what has been observed at other Westinghouse plants that indicate cold leg streaming. The data for some of those plants can be as large as a 1.9ºF difference between the normal and spare RTD indications. Cold leg streaming is a problem when the RTD used for the flow calculation is significantly higher than the true bulk temperature. That is not the case for Catawba 2. The spare RTDs were used in the Cycle 2 calorimetric. A lower temperature results in a larger ΔT, and therefore a lower RCS flow. In Loops A, B, and C the spare RTD is lower than the normal RTD. In Loop D the spare RTD is higher than the normal RTD, but only by 0.28°F. The average difference is the spare RTD 0.31°F lower than the normal RTD. Although which temperature is closer to the true bulk temperature cannot be known with certainty, it is reasonable to expect that the lower RTD temperature is close to the bulk temperature. Using the lower RTD temperature in the calorimetric is conservative. The average of the spare RTD temperatures used in the Cycle 2 calorimetric are judged to be sufficiently close to the bulk temperature. On that basis, no flow penalty is necessary to address the cold leg streaming effect.

<u>Hot Leg Streaming Early in Plant Life</u>

The SER (pp. 2, 5, 6) states that there is a potential non-conservatism with the approach to using early calorimetric data:

> *"(2) the effect of thermal streaming during the first few months of operation where there is a potential that indicated hot leg temperature is lower than actual, a situation that is the reverse of the long-term streaming behavior."*
>
> *"However, the licensee has not fully addressed the nature of thermal streaming during the first few months of operation, a period represented by 2 of the 3 calorimetric points it requested to include in its coefficients."*
>
> *"Since the lower regions of the hot leg may contain cooler water from peripheral core regions, there is a possibility that the 2 lower RTDs are cooler than the true hot leg average temperature and that an average of the 3 RTDs may also be cooler than the true temperature. Such a condition would result in predicting a calorimetric flow rate that was greater than actual, a non-conservatism."*

The hot leg streaming effect is caused by incomplete mixing in the reactor vessel upper internals and the hot leg pipe, such that the cooler water from the periphery of the core outlet flows preferentially down the lower half of the hot leg pipe, and the hotter water from the interior region of the core flows down the upper half of the hot leg pipe. To quantify the effect of the core design on the magnitude of hot leg streaming, Cycles 1, 2, 3 and 12 of Catawba Unit 2 were investigated. The core radial power distributions were divided into a peripheral (shaded core locations in Figure 4) and an interior region, with approximately half of the core in each region, and an average radial peaking factor was calculated for each region. The following results (second and third columns below) were obtained:

Cycle Number	Peripheral Region Average Radial Peaking Factor	Interior Region Average Radial Peaking Factor	Approximate Calorimetric RCS Flow (Note 1) (gpm)
1	0.92	1.08	401,000
2	0.90	1.10	396,000
3	0.88	1.12	392,500
12	0.79	1.21	380,000

Note 1: Flow values from Figure 2

From these results it is clear that the power distribution in Cycle 1 was the flattest, and Cycles 2 and 3 were increasingly more centrally peaked. Cycle 12, typical of current highly efficient core designs, is significantly more centrally peaked. Consequently, as expected, the magnitude of the hot leg streaming increases as indicated by the decrease in the calorimetric flowrate.

The selection of the three calorimetric measurements to be used for the Catawba Unit 2 revised elbow tap flow coefficients include two near the beginning of Cycle 1 with the RTD bypass manifold installed, and one from the beginning of Cycle 2 with the RTD bypass manifold removed. One test early in Cycle 1 was not used since it was conducted at 75% power. A second calorimetric in Cycle 1 was not used since it resulted in a flow value slightly above the analytical flow model prediction. The Cycle 2 calorimetric result, which includes a significant hot leg streaming penalty as shown above, was included in order to include conservatism in the revised elbow tap flow coefficients. The RTD bypass manifold removal may have contributed to the increase in hot leg streaming also. This approach results in an approximate 1500 gpm conservatism. The SER (p. 5) states the following:

> *"Consequently, the licensee's inclusion of the calorimetric obtained at the beginning of Cycle 2 introduces a conservatism in its proposed elbow coefficients that is not introduced by the other two calorimetrics."*

With the exception of the 75% power calorimetric, all of the Cycle 1 calorimetric data and the Cycle 2 calorimetric have corresponding elbow tap Δp data that indicate nearly constant flow in the cold legs (Figure 1). This is expected since there were no significant changes in the hydraulic characteristics of the unit during this period of time.

The stability of the elbow tap Δp data in Cycle 1, along with the trend of a conservative effect of hot leg streaming on RCS flow in later cycles beginning with Cycle 2, strongly supports the absence of any non-conservative hot leg streaming effect in the Catawba Unit 2 data used as a basis for the revised flow coefficients. The relatively small change in the nature of the core power distribution from Cycle 1 to Cycle 2 also supports the conclusion that the hot leg streaming effect was conservative or neutral in Cycle 1. The inclusion of the Cycle 2 calorimetric, which introduces a 1500 gpm hot leg streaming penalty (when averaged with the two data points from Cycle 1), is a sufficiently conservative approach for selection of the revised flow coefficients.

SUMMARY

The concerns raised in the SER that limited the NRC's approval of the revised cold leg elbow tap flow coefficients to Cycle 12 for Catawba Unit 2 have been addressed in this submittal. Duke is proposing to use the revised flow coefficients beginning with Cycle 13 and continuing into the future. Although the revised flow coefficients involve a reduction in the level of conservatism, sufficient conservatism remains as discussed above. The RCS flow margins and penalties are as shown in the table below. The Duke values are developed in this submittal and previous submittals. The NRC values are based on the SER and do not reflect the new information in this submittal.

	Duke Flow Margin (Penalty)	NRC Flow Margin (Penalty)
a) Selection of calorimetrics used to calculate the revised average elbow tap flow coefficient	1500 gpm	1150 gpm
b) RCP energy dissipation	1045 gpm	1450 gpm
c) RTD bypass manifold removal	379 gpm	600 gpm
d) Cold leg streaming	0 gpm	(2000 gpm)
e) Early hot leg streaming	Included in Item a	Included in Item d
f) 0.22% RCS flow uncertainty margin	880 gpm	880 gpm
Total	3804 gpm = 0.97%	2080 gpm = 0.53%

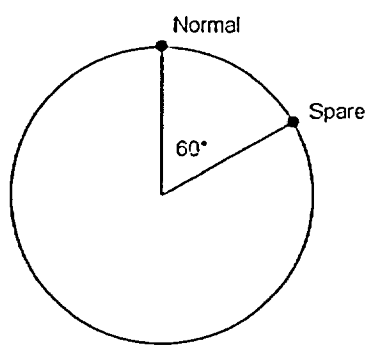
The revised cold leg elbow tap flow coefficients reduce the excessive conservatism in the original flow coefficients by 1.0%, while maintaining approximately 1.0% conservative margin based on the Duke calculations. This conservative margin is sufficient along with the technical justification to support the proposed license amendment.

Table 1

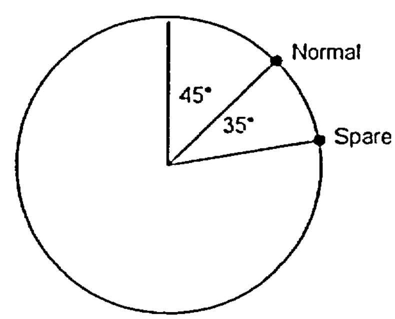
Catawba Unit 2 Cycle 2
Calorimetric T-cold RTD Streaming Data

Data	Loop A	Loop A Spare	Loop A ΔT	Loop B	Loop B Spare	Loop B ΔT	Loop C	Loop C Spare	Loop C ΔT	Loop D	Loop D Spare	Loop D ΔT
1	561.28	560 87	0.41	562 05	561.40	0 65	562.02	561.83	0.19	562 69	563.35	-0 66
2	561.22	560 73	0.49	561.95	561.21	0.74	561.94	561.51	0.43	562.58	562.78	-0.22
3	561.09	560.59	0.50	561.83	561.09	0.74	561.80	561.38	0.42	562.45	562.65	-0.20
4	561.12	560.62	0.50	561.86	561.12	0.74	561.85	561.42	0.43	562.49	562.69	-0.20
5	561.11	560 67	0.44	561.86	561.11	0.75	561.82	561.35	0 47	562.48	562.70	-0.22
6	561.80	561.26	0.54	561.99	561.69	0 30	562 40	561.93	0.47	563 08	563.30	-0 22
7	560.73	560.19	0.54	561.36	560 62	0 74	561.03	560.87	0 16	561.99	562.20	-0 21
8	561 01	560 49	0.52	561.65	560 92	0 73	561.63	561.16	0 47	562.16	562.52	-0.36
Ave.			0 49			0 67			0.38			-0 28

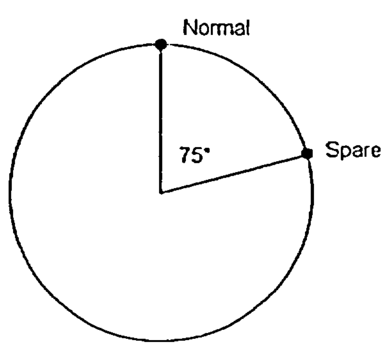
Note: The RTD orientations on each loop looking toward the reactor vessel are as follows:



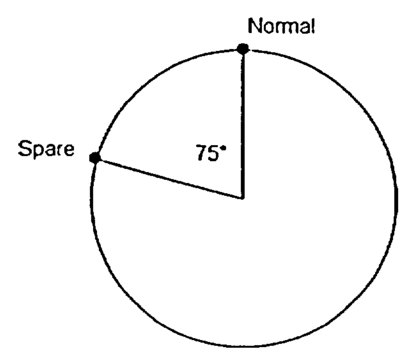
Loop 2A



Loop 2B



Loop 2C



Loop 2D

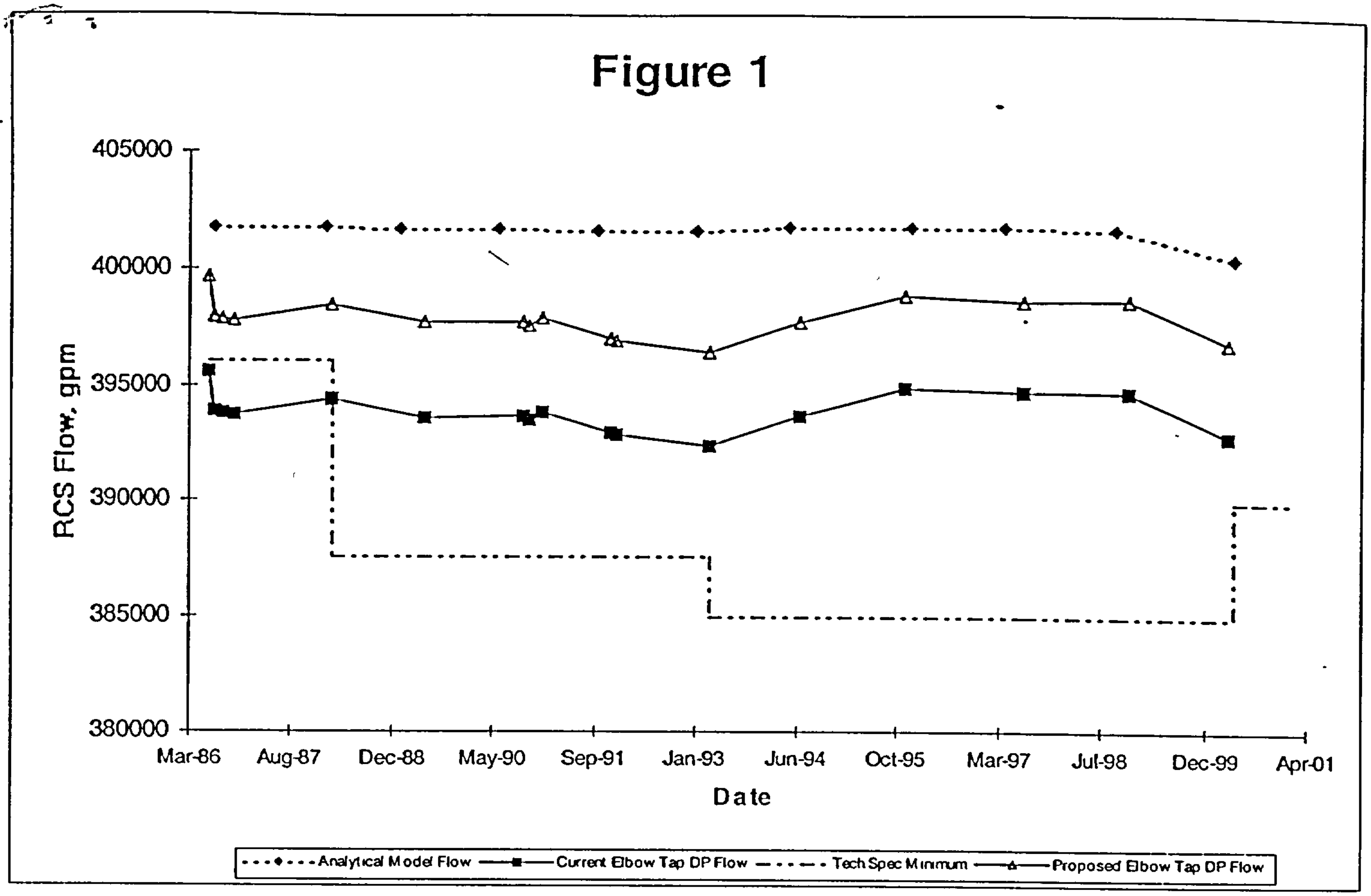


Figure 1
405000
400000
395000
390000
385000
380000
RCS Flow, gpm
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Date
Analytical Model Flow
Current Elbow Tap DP Flow
Tech Spec Minimum
Proposed Elbow Tap DP Flow

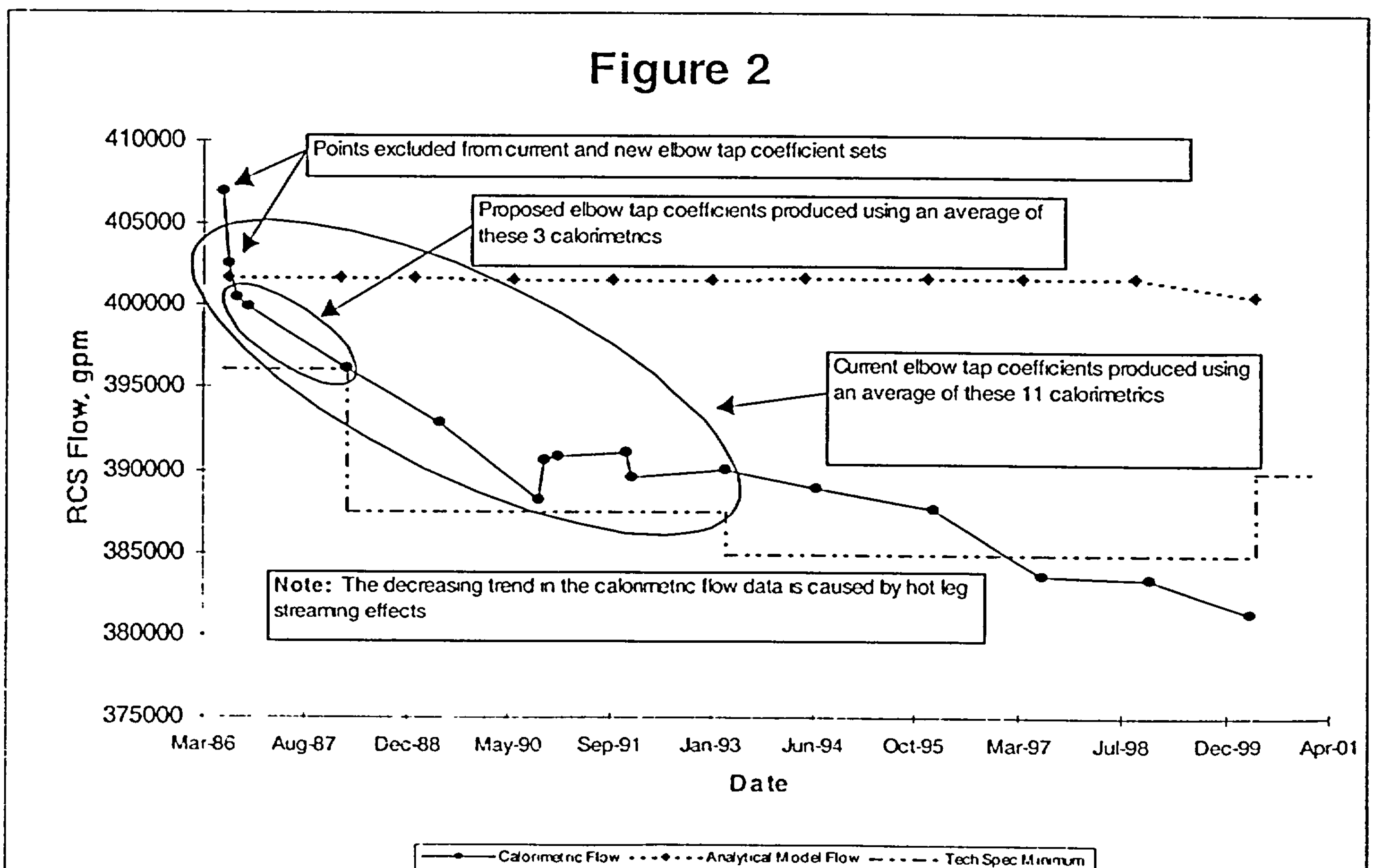
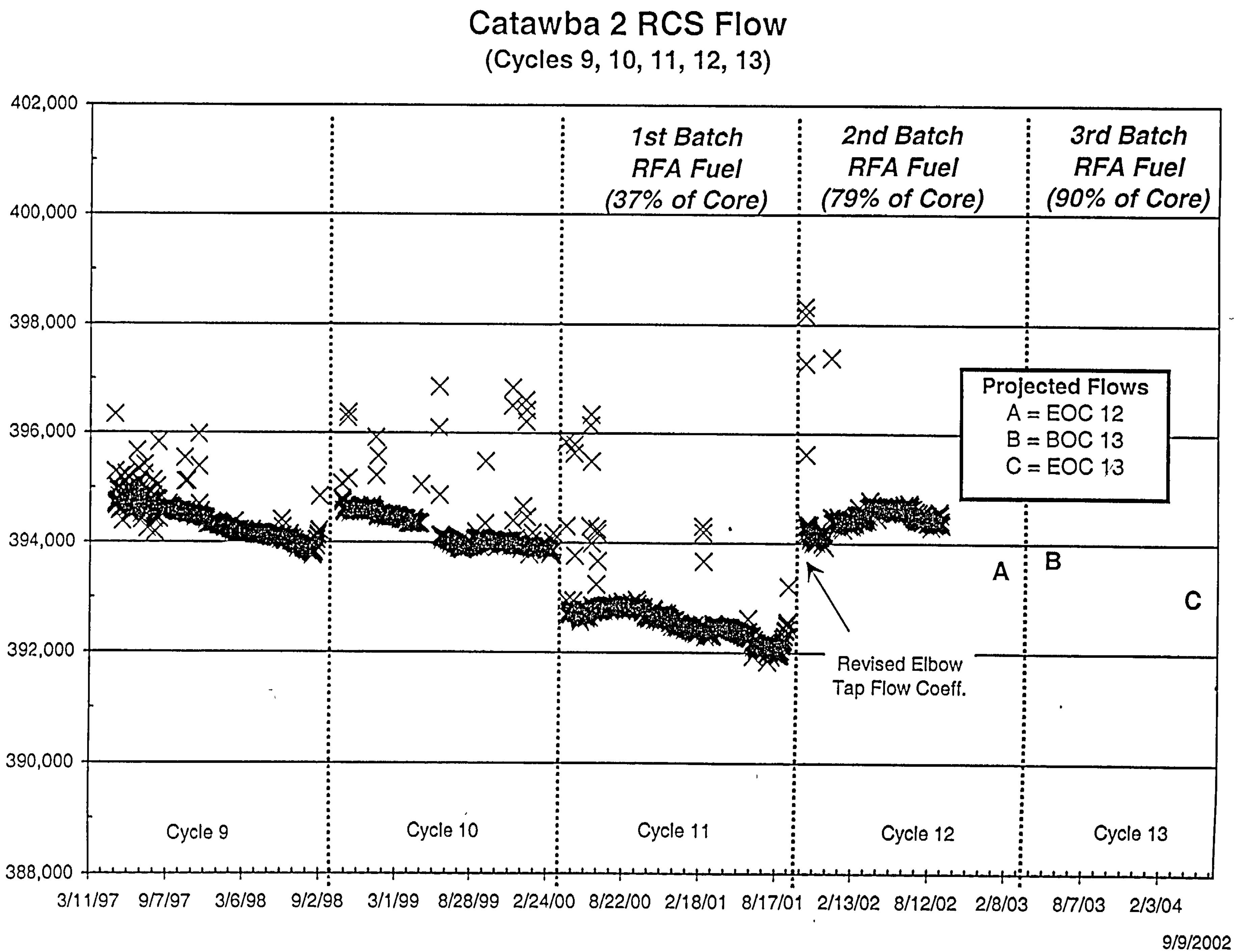


Figure 2
410000
405000
400000
395000
390000
385000
380000
375000
RCS Flow, gpm
Points excluded from current and new elbow tap coefficient sets
Proposed elbow tap coefficients produced using an average of these 3 calorimetrics
Current elbow tap coefficients produced using an average of these 11 calorimetrics
Note: The decreasing trend in the calorimetric flow data is caused by hot leg streaming effects
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Oct-95
Mar-97
Jul-98
Dec-99
Apr-01
Date
Calorimetric Flow
Analytical Model Flow
Tech Spec Minimum



Catawba 2 RCS Flow
(Cycles 9, 10, 11, 12, 13)
402,000
400,000
398,000
396,000
394,000
392,000
390,000
388,000
1st Batch RFA Fuel (37% of Core)
2nd Batch RFA Fuel (79% of Core)
3rd Batch RFA Fuel (90% of Core)
Projected Flows
A = EOC 12
B = BOC 13
C = EOC 13
A
B
C
Revised Elbow Tap Flow Coeff.
Cycle 9
Cycle 10
Cycle 11
Cycle 12
Cycle 13
3/11/97
9/7/97
3/6/98
9/2/98
3/1/99
8/28/99
2/24/00
8/22/00
2/18/01
8/17/01
2/13/02
8/12/02
2/8/03
8/7/03
2/3/04
9/9/2002

Figure 3

Figure 4

C2C12

0.9625					
1.2930	1.1630				
1.1850	1.3170	1.0940			
1.2820	1.1710	1.2410	1.1700		
1.1640	1.2720	1.2130	1.2370	1.2340	
1.2050	1.1650	1.1850	1.1290	1.1830	1.0660
0.8714	1.1180	1.0600	1.0890	0.6073	0.3184
0.3731	0.4396	0.3873	0.3710		

C2C3

0.9950					
1.3240	1.0150				
0.9780	1.1350	1.1650			
1.2730	0.9540	1.2640	0.9860		
1.0070	1.2380	0.9650	1.2460	1.1150	
1.2320	1.0120	1.2010	0.9510	1.0060	1.0910
1.2070	1.1880	0.8620	1.1110	0.6660	0.4920
0.9590	0.7530	0.7850	0.4940		

C2C2

0 8740					
1.2240	1.1890				
1.1730	1.2000	1.0370			
1.1810	1.0200	1.2360	0 9220		
0.9790	1.1740	0 9700	1.1090	0.9070	
1.1240	0 9700	1.2080	0.9500	1.0880	1.0680
1.0990	1.1010	1.0620	1.0720	0.8690	0.3850
0.9910	0.9400	0 8410	0 3970		

C2C1

0.9870					
1.0810	1.0380				
1.0640	1.1980	1.0860			
1.1970	1.0760	1.1910	1 0540		
1.0320	1.1500	1.0170	1.0970	1.2780	
1.0320	0.9650	1.0220	0.9710	1.0130	0.9690
0.9210	1.0540	0.8910	1.0100	0.9830	0.6980
0.8750	0.9060	0.8050	0.6440		

Figure 5

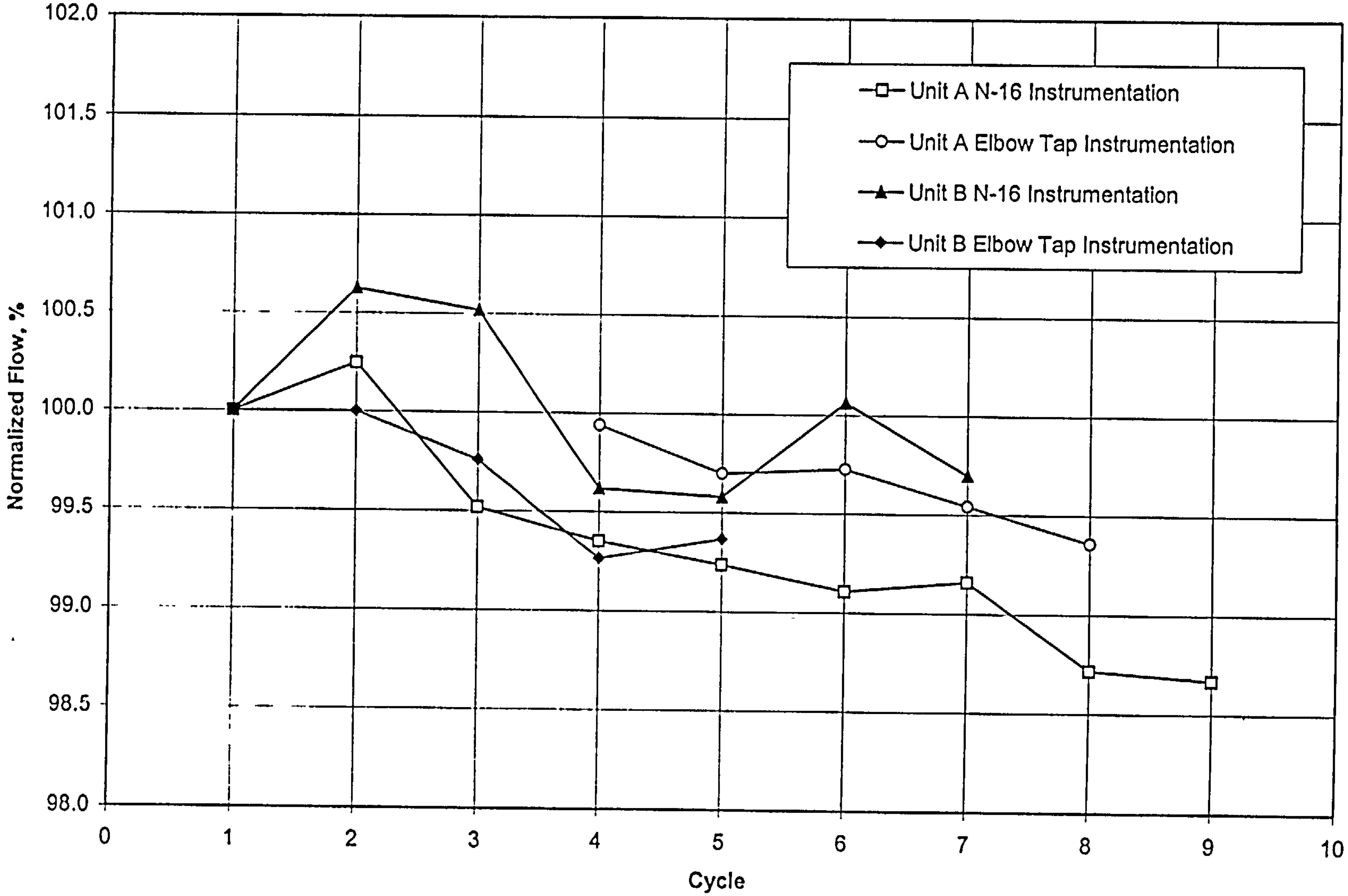


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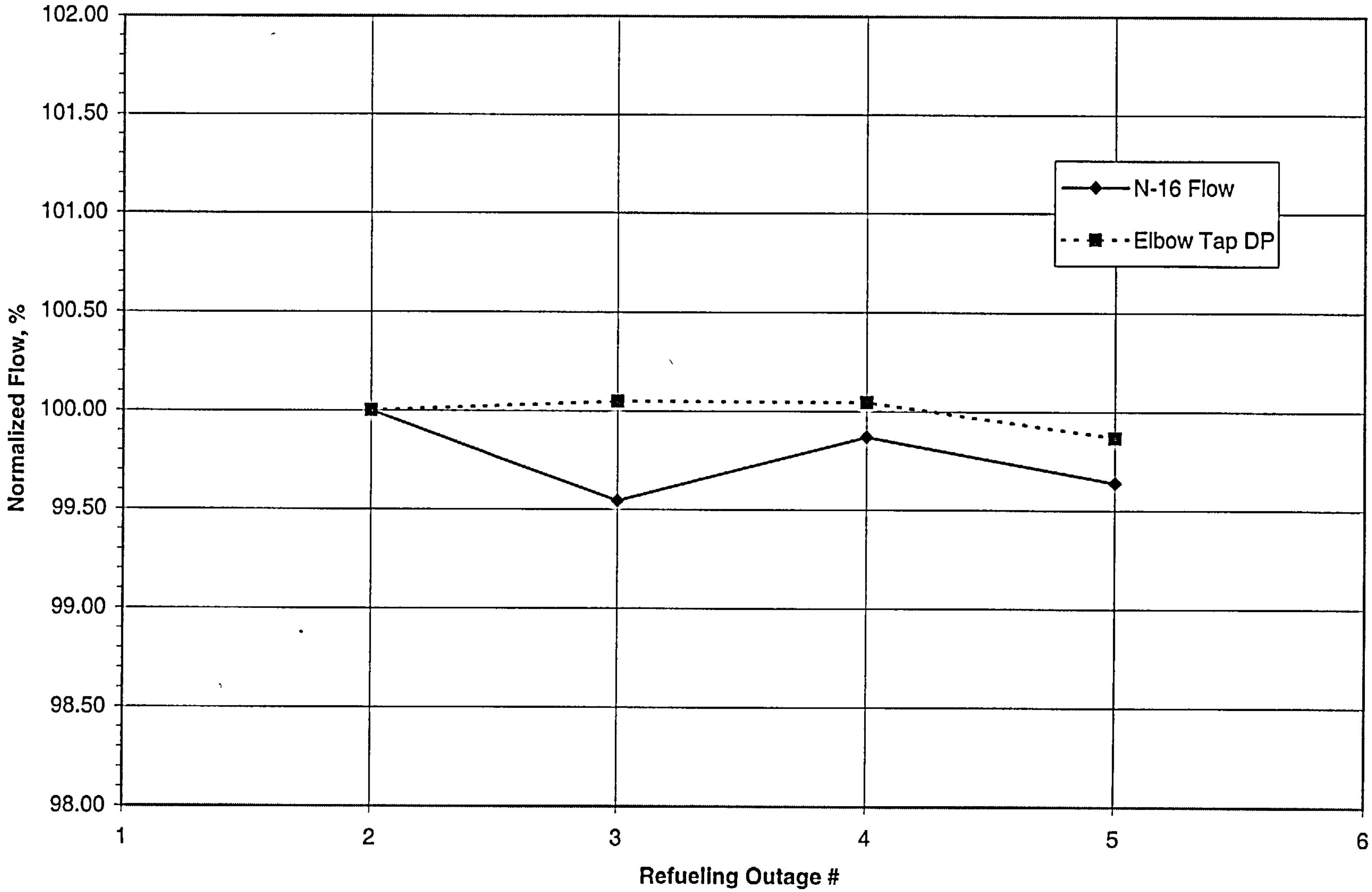
Figure 6



ATTACHMENT 2

NO SIGNIFICANT HAZARDS CONSIDERATION DETERMINATION

The following discussion is a summary of the evaluation of the changes contained in this proposed amendment against the 10 CFR 50.92(c) requirements to demonstrate that all three standards are satisfied. A no significant hazards consideration is indicated if operation of the facility in accordance with the proposed amendment would not:

1. Involve a significant increase in the probability or consequences of an accident previously evaluated, or

2. Create the possibility of a new or different kind of accident from any accident previously evaluated, or

3. Involve a significant reduction in a margin of safety.

First Standard

The proposed amendment will not involve a significant increase in the probability or consequences of an accident previously evaluated. No component modification, system realignment, or change in operating procedure will occur which could affect the probability of any accident or transient. The revised cold leg elbow tap flow coefficients will not change the probability of actuation of any Engineered Safeguards Feature or other device. The actual Unit 2 RCS flow rate will not change. Therefore, the consequences of previously analyzed accidents will not change as a result of the revised flow coefficients.

Second Standard

The proposed amendment will not create the possibility of a new or different kind of accident from any accident previously evaluated. No component modification or system realignment will occur which could create the possibility of a new event not previously considered. No change to any methods of plant operation will be required. The elbow taps are already in place, and are presently being used to monitor flow for Reactor Protection System purposes. They will not initiate any new events.

Third Standard

The proposed amendment will not involve a significant reduction in a margin of safety. The removal of some of the excess flow margin, which was introduced by the hot leg streaming flow penalties in later calorimetrics, will allow additional operating margin between the indicated flow and the Technical Specification minimum measured flow limit. The proposed changes in the cold leg elbow tap flow coefficients will continue to be conservative with respect to the analytical model flow predictions, since the proposed coefficients will continue to contain some hot leg streaming penalties from the calorimetric determined coefficients used in the average.

An increase in the RCS flow indication of approximately 1.0% will increase the margin to a reactor trip on low flow but will not adversely affect the plant response to low flow transients. Current UFSAR Chapter 15 transients that would be expected to cause a reactor trip on the RCS low flow trip setpoint are Partial Loss of Reactor Coolant Flow, Reactor Coolant Pump Shaft Seizure and Reactor Coolant Pump Shaft break transients. Three reactor trip functions provide protection for these transients, RCS low flow reactor trip, RCP undervoltage reactor trip and RCP underfrequency reactor trip. The transient analyses of these events assume the reactor is tripped on the low flow reactor trip setpoint. This is conservative and produces a more severe transient response since a reactor trip on undervoltage or underfrequency would normally be expected to trip the reactor sooner and therefore reduce the severity of these transients.

The RCS low flow reactor trip is currently set at 91% of the Technical Specification minimum measured flow of 390,000 gpm. The setpoint will not be revised as a result of this change, which means the transients relying on this function will behave in the same manner with the reactor trips occurring at essentially the same conditions as previously analyzed. Therefore, any small increase in the reactor trip margin gained by the small increase in the indicated RCS flow will not adversely affect the plant response during these low flow events.

Based upon the preceding discussion, Duke Energy has concluded that the proposed amendment does not involve a significant hazards consideration.

ATTACHMENT 3

ENVIRONMENTAL ANALYSIS

Pursuant to 10 CFR 51.22(b), an evaluation of this license amendment request has been performed to determine whether or not it meets the criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9) of the regulations.

This amendment to the Catawba Unit 2 Facility Operating License allows for the implementation of revised cold leg elbow tap flow coefficients. Implementation of this amendment will have no adverse impact upon Unit 2; neither will it contribute to any additional quantity or type of effluent being available for adverse environmental impact or personnel exposure.

It has been determined there is:

1. No significant hazards consideration,

2. No significant change in the types, or significant increase in the amounts, of any effluents that may be released offsite, and

3. No significant increase in individual or cumulative occupational radiation exposures involved.

Therefore, this amendment to the Catawba Unit 2 Facility Operating License meets the criteria of 10 CFR 51.22(c)(9) for categorical exclusion from an environmental impact statement.