Docket Nos. 50-413
and 50-414

April 6, 1994

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LICENSEE: Duke Power Company

FACILITY: Catawba Nuclear Station, Units 1 and 2

SUBJECT: SUMMARY OF MARCH 16, 1994, MEETING WITH DUKE POWER COMPANY ON RCS FLOW MEASUREMENT METHODOLOGY

On March 16, 1994, members of the NRC staff met with representatives of the Duke Power Company (DPC) in Rockville, Maryland. The purpose of the meeting was to discuss the licensee's application dated January 10, 1994, that proposed to change the method for determining reactor coolant system (RCS) flow rate. A list of attendees is provided as Enclosure 1.

The past method to determine RCS flow rate has been based on use of a calorimetric heat balance (CHB) on the plant secondary side, divided by the primary side differential enthalpy. On entry of the Catawba Unit 1 plant into Cycle 8 operation in early January 1994, the CHB method provided an indicated RCS flow rate that allowed operation only up to 97% power. In response, the licensee proposed a change in the method for measuring RCS flow rate to one based on a one-time normalization of the RCS cold leg elbow tap signals to constants derived from averaged valid calorimetrics from previous cycles.

The licensee had described the methodology in a meeting with the NRC staff on February 10, 1994. This meeting was held to provide further information. The concerns in Enclosures 2 and 3 were identified to the licensee to provide an agenda for discussion during the March 16, 1994, meeting. The licensee also submitted points of discussion for the meeting as set forth in Enclosure 4. Enclosure 5 are slides provided by the licensee.

The staff agreed to consider a short-term resolution to address the operation of Unit 1 for the remainder of the current fuel cycle. The staff stated that the remaining issues related to the method to be used by Catawba, Unit 2, and McGuire, Units 1 and 2, would be pursued on a longer term schedule that would include further requests for additional information and a possible a visit to the plant. The licensee responded to the short-term concerns identified by the staff during the meeting in a submittal from M. S. Tuckman, DPC, to the NRC dated March 21, 1994.

Original signed by:

Robert E. Martin, Senior Project Manager
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Enclosures:
1. List of Attendees
2-5. Handouts

cc w/enclosures:
See next page

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ENCLOSURE 1

ATTENDEES
MARCH 16, 1994, MEETING

Name	Organization
Bob Martin	NRC/PDII-3
Gregg Swindlehurst	DPC
Scott Gewehr	DPC
Jacky Lee	DPC
Michael Carroll	DPC
Rutledge Scarborough	DPC
Mark E. Patrick	DPC-Catawba-Safety Assurance
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Tim Collins	NRC/SRXB
Mark Caruso	NRC/SRXB
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Jerry Mauck	NRR/DRCH/HICB
Cliff Doutt	NRR/DRCH/HICB
David Matthews	NRR/DRPE/PDII-3
Harry Balukjian	NRR/SRXB
Robert Jones	NRR/DSSA

ENCLOSURE 2

Duke Power Responses To NRC Questions Relating To The Use of Elbow Taps For Flow Measurement

March 7, 1994

QUESTIONS ON PROPOSED TS CHANGE FOR CATAWBA/MCGUIRE RCS FLOW-RATE MEASUREMENT

Reference: Previous questions and sample calculation.

1. **For question A1, one part asked for the amount of hot leg streaming in past reloads. You provided a list of hot and cold leg temperatures. Hot leg streaming is associated with low leakage core loading and could correlate with your RCS flow rate results. To help understand the effect of this, please provide information on the core loading which indicates the relative degree (high, medium, low) of low leakage core loading (distribution of radial peaking factor) for the information in Tables 1 to 4 and Figures 1 - 4 of attachment 3.**

Response to question 1:

Attachment 1 contains core power distributions for Catawba Unit 1 for Cycles 1 through 8. As can be seen in the table ranking the core loading patterns, cycles 4 through 8 were very low leakage cores. This information along with the core exit thermocouple data was examined to determine if a correlation between the hot leg RTDs and the core exit temperature profile could be made. Core exit thermocouple data and core power distribution maps can provide some representation of the core exit temperature profile. However, the problem with determining a reasonable representation of the streaming profile in the hot leg is in determining how this core exit temperature profile is translated to the hot leg. Examinations of the available data have shown that the changes in hot leg streaming do not occur symmetrically between the four hot legs. In addition, hot leg streaming changes in an individual loop do not show any predictability from reload to reload. The main conclusions arrived at during such investigations is that generally the hotter inner core region water is translated to the upper portion of the hot leg while the cooler outer core region water appears to be communicated to the lower portion of the hot leg pipes. We feel that due to the variables involved, any attempt to define or predict the actual temperature profile in the hot leg pipe from the core exit temperature profile beyond these general conclusions would be mere guesswork on our part.

2. **For question A2, you answered that your new method of measuring RCS flow rate does not use a particular calorimetric from a past cycle to produce elbow tap coefficients, but that valid calorimetric data from-previous measurements will be used to determine an averaged set of elbow tap coefficients to reasonably and conservatively represent the final coefficient values for each elbow. Usually, a flow meter is calibrated over a wide range of flow rates. Often, the flow coefficient can vary with Reynolds number when the flow rate is below the threshold value. How do you quantify the accuracy of the elbow tap for ranges of flow appreciably (10%) below where there has been data to base it on?**

Response to question 2:

No attempt has been made to quantify the accuracy of the flow meter for flows appreciably below where there has been data to base the accuracy on. The K values for elbow taps are constants based on the physical characteristics of the elbow and as such are not expected to change unless the elbow itself is changed. The parameter which is a function of flow rate in an elbow is the ΔP across the elbow. This is the relationship which allows us to measure the flow rate directly. The main requirement for using an elbow meter to measure flow is that the flow is high enough to create an adequate ΔP across the elbow. While it is agreed that there is a flow threshold below which the elbow meter becomes less accurate or inoperable. flows in the 300,000 to 400,000 gpm range are well above any such threshold flow rate. Since the elbow tap flow meters main use is in the Reactor Protection System (RPS) to provide a reactor trip signal on a low flow signal, it is presumed the design of the elbow meter was such that it will conservatively provide a trip signal for flows approximately 10% below the normal plant operational flow. Since the elbow meters will be used to determine flow during relatively steady state operation in the flow range for which it was designed, the elbow meters will provide accurate indications of flow for surveillance purposes. Flows appreciably less than those seen during full power plant operation are only seen during transient conditions. Flow surveillances will not be conducted under such transient plant conditions. Use of the elbow taps to measure flow for surveillance proposes will not change the accuracy of the elbow tap flow indications currently used for the RPS low flow setpoint.

3. **For question A3, you provided information indicating that the flows calculated by the calorimetric heat balance have been in the range of 407,363 gpm to 378,285 gpm, or a variation of about 28,078 gpm (6.89%). You indicated that the primary function of the elbow tap in the existing Technical Specification is to provide a flow indication for the Reactor Protection System such that a reactor trip will occur at 90% loop flow. As such, the elbow tap flow meters were designed to provided an accurate flow indication over the range from 100% to 90% flow.**

   (a) Provide the relationship used to obtain the flow rates for ranges below 100% flow and also what you expect the accuracy to be when at 90% flow, a flow rate for which you have no data to base the calibration on. Do you have an added uncertainty for flow rates below 100%?

Response to question 3a:

See the response to question 2. No additional uncertainty is added for flow rates below 100%.

(b) In Tables 17 and 18 for McGuire and Tables 20 and 21 for Catawba you show the uncertainty associated with the precision calorimetric including a bias value. Please explain how the values used are obtained and what they are based on. For these tables explain how the Sensor Calibration Accuracy (SCA) is obtained.

Response to question 3b:

The uncertainties associated with the precision calorimetric are determined in a separate calculation. They are based on the uncertainties associated with the processes and measurements utilized during the calorimetric process. As presented in the meeting handouts for the February 10, 1994 meeting between Duke and the NRC, these values are determined using the uncertainty methodology identical to that submitted during the initial licensing of each station (letter from Duke to NRC dated November 23, 1982 and Catawba FSAR question 492.7). The Sensor Calibration Accuracy for McGuire and Catawba were obtained from the manufacturer's specification sheets for the transmitters used to measure elbow tap ΔP.

4. Reference I presents the general method for assessing uncertainties. Figure 3, measurement error, taken from Reference I, shows that the measurement error is composed from the effect of the sensing path from the sensing element to the measurement output of the desired value. This error is shown to be composed of the effects of normal distribution and a bias. Figure 4 from Reference I is a schematic, of components used for direct measurement of a quantity and includes output transmission, signal conditioning and readout, A/D conversion and digital computation. The process of obtaining statistical accuracy of the measurement includes the effects of all the elements used in arriving at the end result.

For question B1, you were asked what flow measurement uncertainty (FMU) value you were using for your new method of measuring RCS flow rate and to submit the analysis for the FMU. Our question was anticipating a FMU analysis modified from that submitted previously for Catawba by WCAP- 11308 (Ref. I). You have modified the cold leg elbow tap results from the previous FMU analysis to account for the reactor trip setpoint changes. The analysis should be further modified to include the added uncertainty from your new method of averaging the results of the previous calorimetrics. The previous FMU analyses have been based on statistical analysis to obtain a 95/95 probability/confidence level-, using a statistical approach similar to that described in Reference 1.

Since you are adding a new element into the previous method of measuring RCS flow rate, an uncertainty value needs to assigned to this new element. This element is the process of averaging the previous values of the flow coefficient, K to arrive at the new value of K. For example, the new value of K could be obtained by choosing (1) only certain inputs near the first operating cycles, or (2) only certain inputs near the last operating cycles. The flow calculated by either of these two methods would give different values. You have chosen to use the average of values ranging from the early to late cycles. The method of selecting the data for calculating the flow coefficient effects the final accuracy and needs to be analyzed and quantified to determine the particular FMU for your method.

Response to question 4:

No new element is being added to the previous method of measuring flow. The value of K has always been part of the determination of flow each cycle, and as such has been included in the previous uncertainty calculations. In the past the calculated value of K was only used to normalize the control room computer indication to the flow determined by the calorimetric. Theoretically the value of K, a constant, will not change once its value has been determined by calibration unless significant changes are made to the elbow. Therefore, since the calorimetric can be used to perform the calibration, the determination of K during the first calorimetric, assuming the calorimetric is accurate, could be expected to be the true value for K. Subsequent calorimetrics reflect changes to the system which are also registered by the elbow tap indications and will cause the indicated flow to change. The new Ks determined for subsequent calorimetrics will match the previous determination of K to the extent that the flow calculated from the calorimetric matches the flow as determined by the elbow tap ΔPs. Since the value of K was determined from the flow calculated by each individual calorimetric, the uncertainty in K is identical to the flow uncertainty for each calorimetric. Therefore, the precision calorimetric uncertainty component of the uncertainty calculations in Tables 17 through 20 (Attachment 2 of the responses to the previous set of questions) could be renamed as the elbow tap coefficient uncertainty.

The uncertainties calculated for the elbow tap indications of flow are those for a single calorimetric. No credit was taken for the averaging of the individual calorimetrics which went into the determination of K. Had credit been taken for averaging of the K values, as determined by the calorimetrics, a smaller uncertainty in flow or K would have resulted. In order to ensure the elbow tap flow indication remained conservative, it was elected not to take credit in the uncertainties for this averaging. The averaged values for K contain an amount of margin reduction consistent with the amount of hot leg streaming that has affected the past calorimetrics. The amount of flow margin given up for each unit may be seen in Figures 1 through 4 of Attachment 3 of the responses to the previous set of NRC questions. The increase in the difference between the analytical flow prediction plot and the proposed elbow tap flow plot represents the amount of margin built into the new K values for each unit.

5. **For question C2a, you discussed fouling at the taps. For the flow pattern in the elbow, the flow near the tap on the outside radius flows at a oblique angle towards the tap as it turns inside the pipe which could effect the accuracy of the reading with a possible velocity pressure component. Also there are possible effects (such as a turbulence and erosion) on the accuracy of the flow reading on the inner radius tap location from eddies. It is understood that you do not plan to make further calorimetric heat balances for measuring the primary side flow rate. Please comment on the continued long range (20 plus years) operation with no further calibration to check for changes (fouling or any other effects such as frictional changes) that can affect the calibration of the elbow taps. How do you plan to check for effects that can effect the calibration with time.**

Response to question 5:

As discussed in the Technical Specification change submittal, specific phenomena which might affect the elbow meter repeatability were examined. These phenomena were found to have little if any short or long term effects on the repeatability of the elbow tap flow indications. Fouling as experienced with venturi meters is not a concern since the process which causes this fouling is not present in the cold leg elbow. Deposits in the RCS from impurities in the reactor coolant are expected to be small or non existent. Most deposits of impurities in the reactor coolant are expected to occur in the hottest portions of the RCS and in regions experiencing the lowest flow. Any deposits in the RCS piping will affect the interior of all the RCS piping and not just the region of the elbow taps. This will cause a real flow change and will be reflected in the elbow tap ΔPs. If preferential deposits were to occur in the region of the taps, the reduction in pipe diameter would be extremely small in comparison to the diameter of the cold leg elbow (31"). In addition, erosion (flow accelerated corrosion) is not a concern since the velocity of the RCS fluid is small relative to velocities known to cause erosion in stainless steel. Erosion of the RCS piping will be small or nonexistent during plant life. Any changes in elbow diameter as a result of small amounts of erosion will not be significant with regard to the 31" diameter of the cold leg pipe. The elbow taps have been positioned on the elbow in such a manner that velocity pressure components and turbulence effects are minimized while not impacting the differential pressure indications.

Every attempt will be made to check for effects which may affect the calibration of the elbow meter. However, unless these effects are large such as a plugged elbow tap, detection of small changes which will affect the calibration of the elbow taps will continue to be difficult. Comparisons to the analytical flow model prediction of flow will be used to determine the extent to which the elbow tap calculated flow reflects actual flow changes.

6. **For question C2c, you stated that the elbow taps are considered to be independently calibrated from past historic data. Please comment on the accuracy of this calibration for 100% flow rate and also its accuracy over ranges where it is not based on data.**

Response to question 6:

See response to question 2 & 4.

7. **For question D1c, you provided Figures 1 - 4 of Attachment 3.**

The plot for the calorimetric flow rate has generally close agreement with your proposed elbow tap method, except for the data point taken after December 88. However, the calorimetric flow rate deviates sharply lower from your proposed method for the data taken after September 91.

(a) **Please explain the reason for the greater deviation experienced for figure 3 for data taken after September 91. Is this from an increased radial peaking profile in your low leakage core loading? If so, do you have plans for further increases in this profile?**

Response to question 7a:

The deviation of the calorimetric flow from the proposed elbow tap flow is due to hot leg streaming. The elbow tap flow is determined from the change in the elbow tap ΔPs and is not subject to the effects of hot leg streaming. This flow correlates well with the analytical flow prediction which means the elbow tap indications of flow are trending with plant changes i.e., SG tube plugging. The hot leg streaming change which causes this abrupt downturn in the indicated calorimetric flow is most likely the result of a change in radial peaking profile. As our latest cores are all of the very low leakage design, a slightly increased or shifted peak is the likely cause for the change in hot leg streaming. Future increases in the peaking profile are a possibility as core reload designs are further optimized.

The data in your Table 11 indicates that for Catawba Unit 1, the percent of steam generator (SG) tube plugging increased from 4.03% in August 92 to 7.91% in November 93. The November 93 SG percent tubes plugs value is almost double the value of August 92.

(b) **Please provide information on the effect of this large increase in SG tube plugging on the RCS flow rate and also the effect of hot leg streaming for this cycle on RCS flow rate. Is this reduction in RCS flow rate for this current cycle mostly due to SG tube plugging rather than from hot leg streaming? If so, is this not a realistic reduction in flow rate, rather than a false indication from an inaccurate hot leg reading?**

Response to question 7b:

As discussed in the response to question 7a above, the analytical prediction and the elbow tap indication of flow correlate well. The common element between these two plots is that the flow is determined without the influence of hot leg streaming. Also, note that the relative decrease in flow for the last two calorimetrics is proportional to the amount of SG tube plugging. While SG tube plugging is part of the decrease in calorimetric flow, the excessive decrease in flow beyond that shown in the analytical prediction and elbow tap flow is the result of hot leg streaming changes. Below is a table showing the percentage changes in RCS flow for the last three data points from the three methods plotted in Figure 3 of Attachment 3 of the responses to the previous NRC questions.

	Percent decrease in calorimetric flow	Percent decrease expected from analytical flow prediction	Percent decrease in elbow tap flow
Jun 91 - Oct 92	1.2%	0.18%	0.12% increase
Oct 92 - Jan 94	2.2%	0.65%	0.65%

ENCLOSURE 3

March 15, 1994

POTENTIAL QUESTIONS AND THOUGHTS ON DUKE POWER FLOW/POWER INTERACTION

What is the expected temperature distribution in the hot leg as a function of power and how is this considered in calibration of RTDs? How is it considered in using temperature data as indicated by the RTDs during operation? What was found during initial testing?

Please summarize the RTD calibration procedure with emphasis on how the actual temperature is determined.

Our previous question regarding erosion and deposit formation appears to have been addressed with respect to large changes in such items as thickness of the main flow piping or plugging of instrument lines. This was not our intention. We were more concerned with how the instrument tube to hot leg connection geometry changes with time and the justification for a conclusion? For example, if the throughwall penetration initially terminates with a sharp edge at the leg inner wall surface, does this sharp edge change with time due to flow impingement? If it changes, what is the effect on indicated behavior? If it does not change, what is the basis for that conclusion?

Similar questions apply to the RTD scoop and the proportion of each "stream" seen by the RTD.

What is the influence of the RTD scoop design on indicated temperature? How is the indicated temperature referenced to a fluid temperature and at what location within the pipe? What is the geometric constancy of the scoop and in particular the flow inlet ports? Is internal crud formation of any significance (and how was this determined)?

The proposed elbow tap calibration appears to result in a "constant" that changes with time when the past data are applied, apparently due to the "old" calibration procedure introducing a changing flow rate bias. How do we know which, if any, of the "constants" is correct. We also have difficulty with the CNS-1 flow comparison where the analytical prediction shows decreasing flow whereas the proposed method appears to indicate increasing flow over one or two cycles. Finally, one of the licensee concerns appears to be that unrecognized fouling of the feedwater venturi could bias the results in a nonconservative manner. How was this excluded?

What is the basis for assuming an average with time will provide a constant that is representative of behavior when the trend appears to be one of change?

Please summarize the reasons for the differences in flow between the four plants and between each of the indications for each plant. How does the experience of the Duke plants compare with the rest of industry?

The proposed elbow tap coefficients are not the same from loop to loop. What physical attributes differ so as to cause this difference? Please address such items as the physical location of the taps, the angle to flow, circumferential location, shape of the connection (sharp, rounded), and the lack of sensitivity to various parameters that have been used to justify using constants.

We understand that changes in use of data from elbow taps for surveillance purposes have no impact on use of data from the same taps for the RPS low flow setpoint. Your previous response on this topic appears to have been that since the data are accurate for steady state they are OK for recognizing a significance transient. This does not appear consistent with a potential problem with the steady state accuracy. Please discuss.

The change to the CHB method at McGuire in 1982 was stated as providing substantial gain with respect to margin to TS limits. Since McGuire was having trouble meeting TSs with the old method, how does changing back to the old method correct the problem of having trouble meeting TS limits with the CHB method? Apparently, the answer is that one can use the past CHB results to calibrate the elbow tap coefficients and then not make further changes in elbow tap coefficients. How is this approach any more correct than using the originally determined elbow tap coefficients?

We understand that the calorimetric heat balance (CHB) method is based on a simple flow diagram. This diagram doesn't include steam quality/superheat at the point of measurement in the calculations. Steam generator (SG) shell thermal losses and pipe thermal losses between the SG and points of measurement are not included. Frictional flow losses (heat sources) in the SG and applicable piping between the SG and points of measurement are not included. Is this simple flow diagram consistent with plant's calculations?

The argument is made that SG tube plugging cannot affect local momentum at the taps, in part because a flow distribution change would not be transmitted across the SG exit nozzle from the relatively large flow area of the SG exit plenum. Please contrast this to the temperature distribution, which we understand is transmitted, even beyond the reactor coolant pumps (or are we incorrect). If tube plugging can affect the temperature distribution and it is transmitted into the cold leg, what is that effect upon flow indication via the taps?

Points of Discussion Regarding The Elbow Tap Flow Surveillance Method

Characteristics of elbow meter flow coefficients

1. Elbow tap flow coefficients, which account for physical characteristics of the elbow, will not change unless the pipe geometry or tap locations change.

2. Elbow meters provide excellent indications of relative flow in the range of 90-100% flow, but for absolute indications they must be calibrated to an independent measure of flow.

3. Since real flow changes are completely reflected in ΔP data, variation with time in the calculated flow coefficients is due to repeated recalibration to inaccurate flow measurements.

Effect of postulated reactor coolant pump degradation on proposed flow measurement method

4. Reactor coolant pump degradation will be reflected in decreased elbow tap ΔP indications.

5. Elbow tap ΔP data trends agree well with analytical predictions which do not model RCP degradation.

6. No evidence of RCP degradation has been observed at McGuire or Catawba.

Effects of postulated fouling on proposed flow measurement method

7. RCS pipe diameters are so large that any credible fouling will have a negligible effect on ΔP across the elbow.

8. Pipe pressures at the tap locations are accurately measured as long as the connecting lines to the transmitters are not completely blocked.

9. Complete blockage of the elbow tap would be obvious from the anomalous elbow tap ΔP.

Effects of postulated flow accelerated corrosion on proposed flow measurement method

10. The RCS piping consists of stainless steel and is not subject to flow accelerated corrosion at the velocities of interest.

Hot leg streaming

11. The three hot leg RTDs in each loop can indicate different temperatures (hot leg streaming) which are not representative of the bulk hot leg temperature. This is due to incomplete thermal mixing in the reactor vessel upper plenum.

12. Small changes in ΔT due to hot leg streaming result in large indicated flow changes when using a calorimetric flow measurement method. For example a 0.6 °F change in a 60 °F full power ΔT, a 1% change, results in a 4000 gpm change in indicated flow if real flow is 400,000 gpm.

13. Core loading patterns affect the magnitude of hot leg streaming

14. Hot leg strea[illegible]ng varies between loops (asymmetric).

15. Hot leg streaming might change with time without an obvious cause.

16. Maximum distortions in hot leg temperature indications due to streaming have not necessarily yet appeared.

Method of selecting proposed flow coefficients

17. The Tech Spec surveillance initially performed during the first cycle is an appropriate method for determining elbow tap flow coefficients (i.e. a single value is safe).

18. Averaging a set of flow coefficient values is conservative since any one value is safe.

19. For constant real flow and an indicated flow less than real flow (per the calorimetric method), a conservative value for the flow coefficient will result.

20. The proposed Tech Spec results in a more conservative flow coefficient than that calculated for MNS-1 Cycle 1. If that value was conservative for that cycle, a smaller value is still conservative.

21. Of the 9 sets of elbow tap coefficients not used in calculating the proposed average coefficients only one (Jan 1994) would have decreased the proposed coefficients. The Jan 1994 data was not used since the data was not available at the time of the Tech Spec submittal.

Uncertainty allowance

22. The uncertainty calculations in the proposed Tech Spec are sufficiently conservative.

Effects of hydraulic resistance changes on flow

23. The analytical model provides an independent confirmation of trends in real flow which correlates with the elbow tap ΔP data

24. The effects of SG tube plugging and other real hydraulic changes are accurately reflected by elbow tap ΔP data.

NRC / DUKE POWER MEETING
MARCH 16, 1994

McGUIRE AND CATAWBA NUCLEAR STATIONS

TECH SPEC REVISION TO CHANGE THE METHOD OF OF REACTOR COOLANT SYSTEM FLOW MEASUREMENT

PRESENTATION / DISCUSSION

- BRIEF REVIEW OF THE PROBLEM AND THE STATUS OF INTERACTIONS WITH THE NRC
- DISCUSSION OF SPECIFIC TECHNICAL ISSUES
- WALK THROUGH OF THE CURRENT AND PROPOSED FLOW MEASUREMENT PROCESS
- UNCERTAINTIES AND MARGIN DISCUSSION
- FLOW TRENDS
- GENERAL DISCUSSION / DECISIONS

THE FLOW MEASUREMENT PROBLEM AND PROPOSED SOLUTION

- THE CALORIMETRIC FLOW MEASUREMENT PROCESS IS BEING ADVERSELY AFFECTED BY HOT LEG STREAMING. THIS RESULTS IN AN INDICATED FLOW DECREASE

- THE COLD LEG ELBOW TAP ΔPs AND AN ANALYTICAL MODEL OF LOOP FLOW INDEPENDENTLY TREND REAL FLOW CHANGES DUE TO SG TUBE PLUGGING, ETC., AND SHOW THAT THE FURTHER DECREASE IN FLOW CALCULATED BY THE CALORIMETRIC METHOD IS NOT REAL

- THE PROPOSED METHOD USES THE ELBOW TAP ΔPs AND A CONSERVATIVELY DETERMINED SET OF ELBOW TAP FLOW COEFFICIENTS TO MEASURE FLOW. ALL REAL CHANGES IN FLOW WILL BE MEASURED.

- THE REQUIRED UNCERTAINTIES HAVE BEEN INCLUDED

- THE PROPOSED METHOD WILL RESULT IN:
  - PREDICTABILITY OF FLOW
  - A SIGNIFICANT IMPROVEMENT IN METHOD
  - NO FALSE DECREASES OR INCREASES IN FLOW
  - MAINTAINING REQUIRED MARGIN (UNCERTAINTY)
  - ADDING NEW MARGIN DUE TO THE NEW METHOD
  - UTILIZATION OF REMAINING MARGIN
  - AVOIDING REPEATED REGULATORY INTERACTIONS IN RESPONSE TO FALSE INDICATED FLOW DECREASE

STATUS OF PROBLEM / RESOLUTION

- TECH SPEC FLOW REDUCTION FROM 385,000 TO 382,000 SUBMITTED WITH CATAWBA 1 RELOAD (10/93)
- CATAWBA 1 STARTUP CALORIMETRIC METHOD RESULTS IN A FLOW REDUCTION OF 2.25%, WHEN THE ACTUAL FLOW REDUCTION WAS 0.65%.
- CATAWBA UNIT 1 LIMITED TO 98% POWER SINCE 1/10/94
- PROPOSED TECH SPEC REVISION SUBMITTED 1/10/94 (NOTE: DUKE WORKING ON THIS SINCE 1992)
- FIRST MEETING WAS 2/10/94
- RECEIVED INFORMAL WRITTEN QUESTION SETS (2/3, 3/3, 3/15) AND REQUESTS BY PHONE, AND PROVIDED RESPONSES
- SHORT TERM CONCERN IS CATAWBA UNIT 1
- LONG-TERM RESOLUTION NEEDED BY 6/1/94 DUE TO MORE SG TUBE PLUGGING AND POSSIBLE DERATING AT McGUIRE UNITS 1 AND 2 AND CATAWBA UNIT 1

DISCUSSION OF SPECIFIC TECHNICAL ISSUES

- CAUSES AND CHARACTERISTICS OF HOT LEG STREAMING
  - AFFECTS MANY WESTINGHOUSE PLANTS
  - POOR THERMAL MIXING IN REACTOR VESSEL
  - CORE POWER DISTRIBUTION CHANGES
  - THREE-POINT SAMPLING OF HOT LEG TEMPERATURE
  - ASYMMETRIC BETWEEN LOOPS
  - DIFFERENT IN THE FOUR DUKE UNITS
  - UNEXPECTED CHANGES

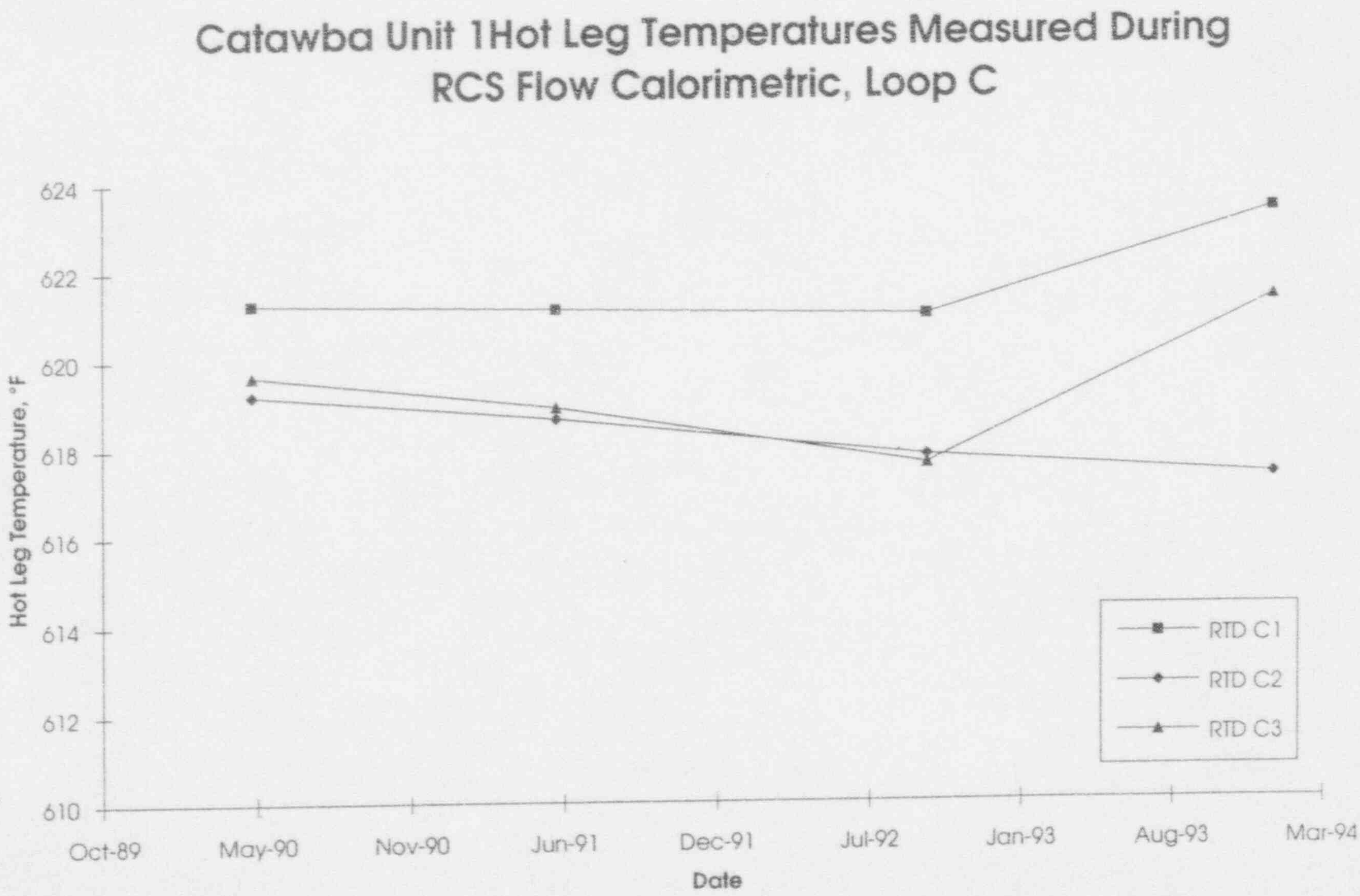
- REAL FLOW CHANGES
  - WILL BE INDICATED BY THE ELBOW TAP METHOD
  - MAY BE INDICATED BY THE CALORIMETRIC METHOD

- ELBOW TAP FLOWMETERS PROVIDE AN EXCELLENT INDICATION OF RELATIVE FLOW BETWEEN 90-100% FLOW

- REACTOR COOLANT PUMP DEGRADATION HAS NOT BEEN EXPERIENCED AT McGUIRE OR CATAWBA. IF IT OCCURS IT WILL BE INDICATED BY THE ELBOW TAPS

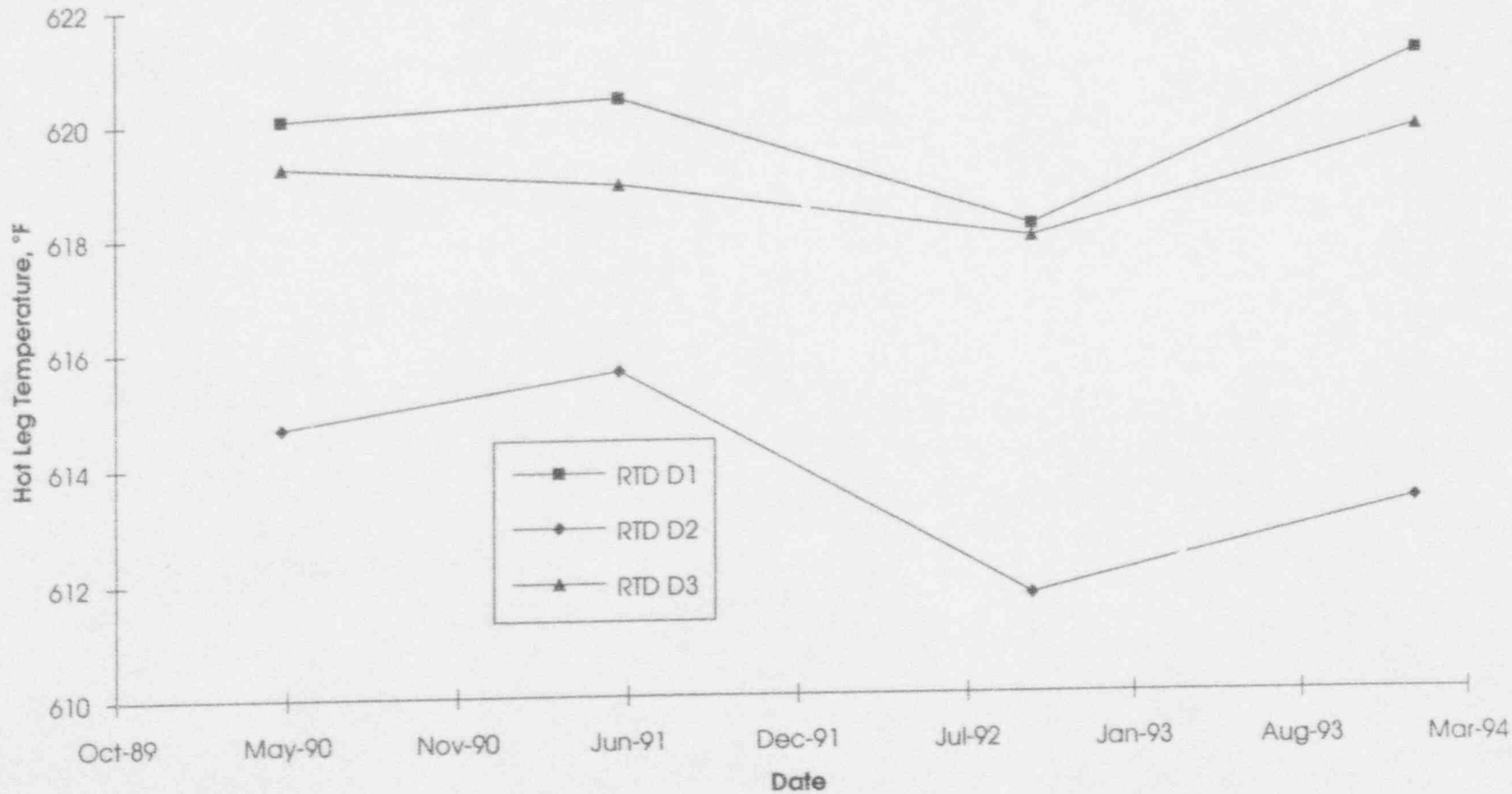
- ELBOW TAP FLOW METERS ARE NOT SUBJECT TO UNDETECTABLE FOULING PROCESSES

- ALL OF THE DATA EXCLUDED BY DUKE (DUE TO IT BEING MISLEADING) WOULD HAVE RESULTED IN A LESS CONSERVATIVE SET OF ELBOW TAP FLOW COEFFICIENTS IF IT HAD BEEN RETAINED IN THE DATABASE



Catawba Unit 1Hot Leg Temperatures Measured During
RCS Flow Calorimetric, Loop C
624
622
620
618
616
614
612
610
Hot Leg Temperature, °F
Oct-89
May-90
Nov-90
Jun-91
Dec-91
Jul-92
Jan-93
Aug-93
Mar-94
Date
RTD C1
RTD C2
RTD C3

Catawba Unit 1Hot Leg Temperatures Measured During RCS Flow Calorimetric, Loop D



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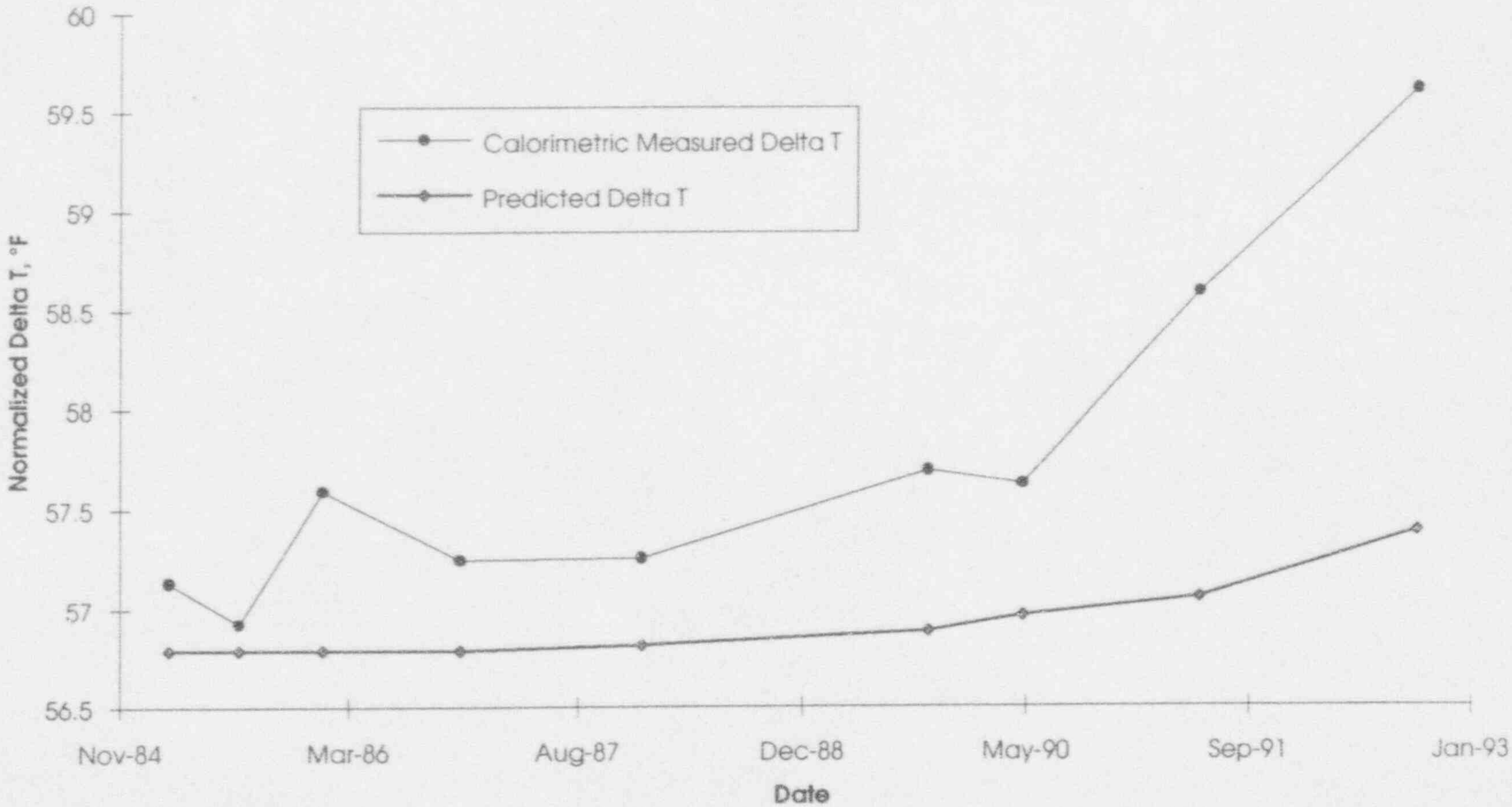
Catawba Unit 1
Predicted Delta T vs. Measured Delta T



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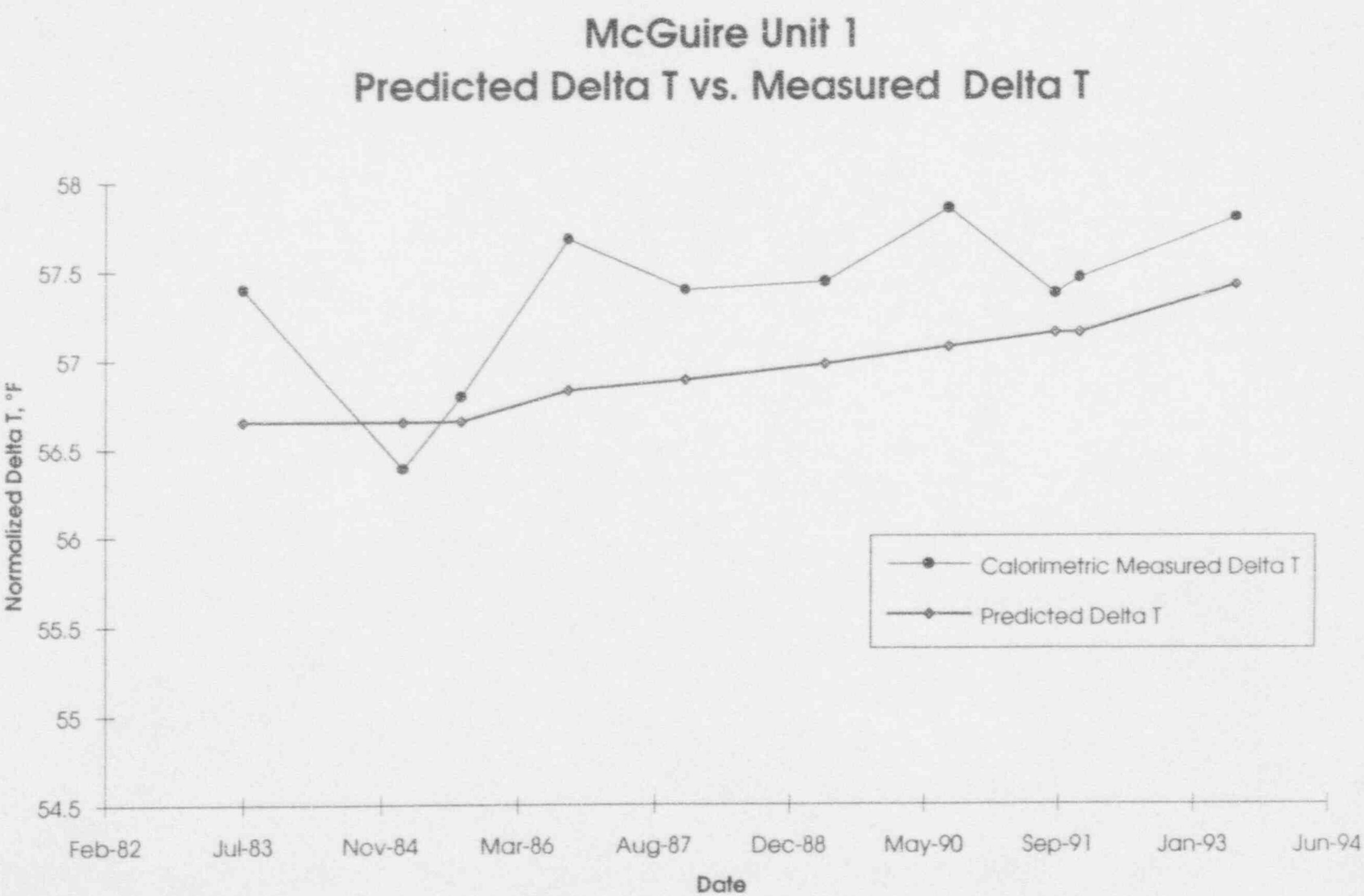
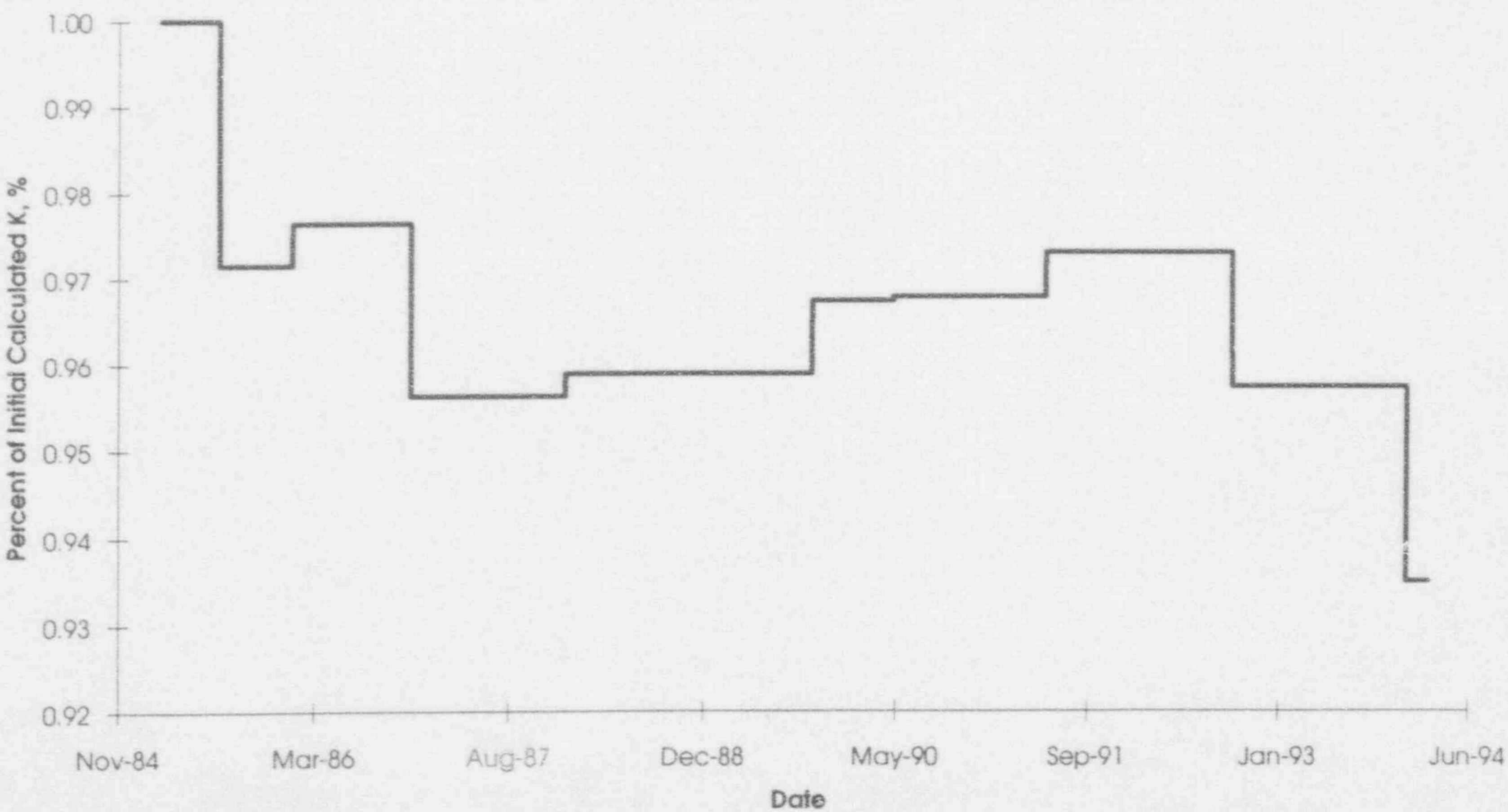
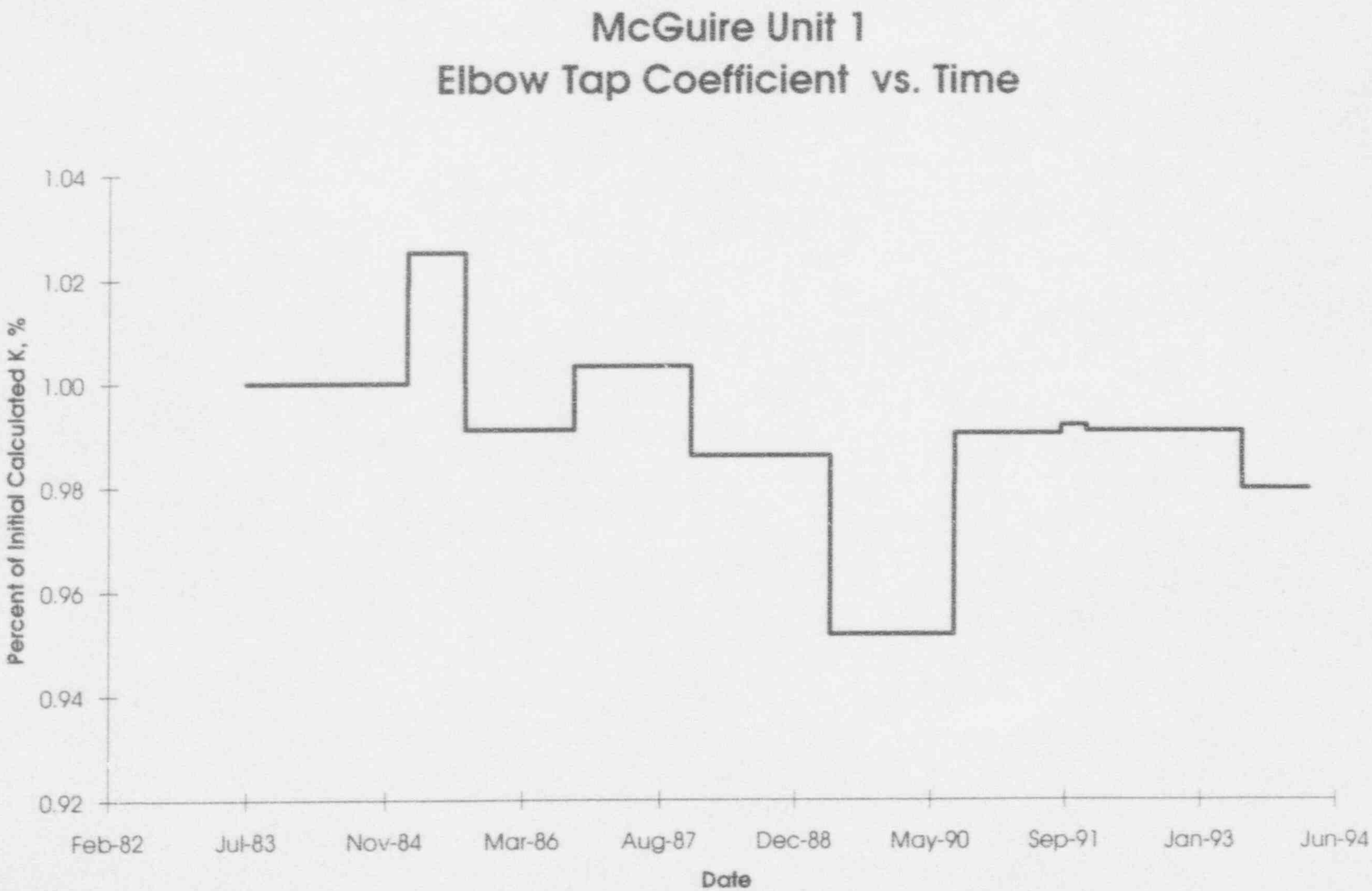


McGuire Unit 1
Predicted Delta T vs. Measured Delta T
58
57.5
57
56.5
56
55.5
55
54.5
Normalized Delta T, °F
Feb-82
Jul-83
Nov-84
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Date
Calorimetric Measured Delta T
Predicted Delta T

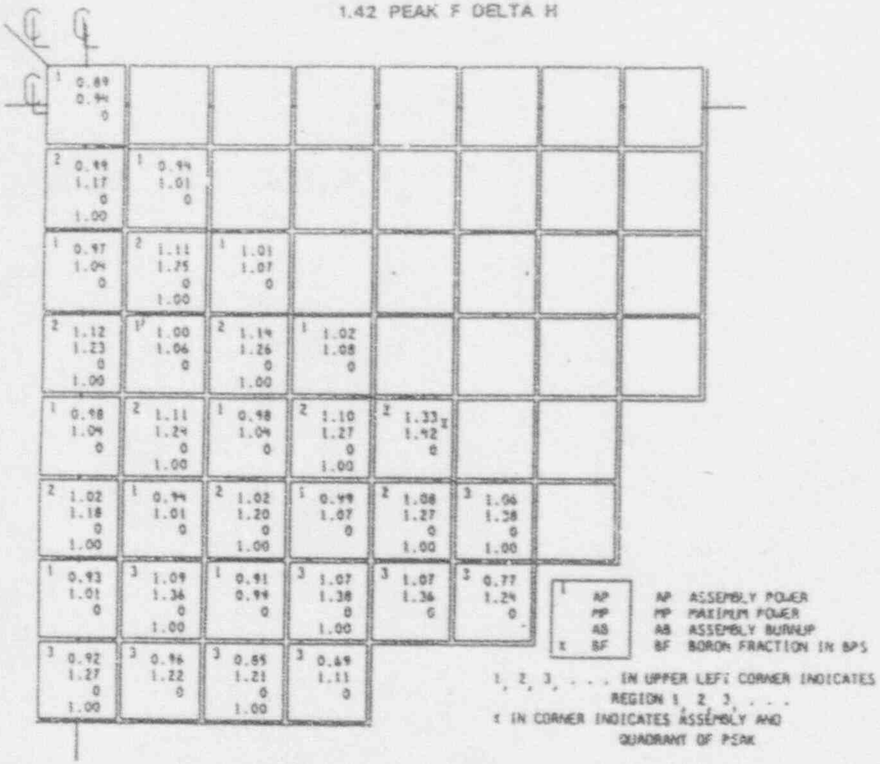
Catawba Unit 1
Elbow Tap Coefficient vs. Time





McGuire Unit 1
Elbow Tap Coefficient vs. Time
Percent of Initial Calculated K, %
1.04
1.02
1.00
0.98
0.96
0.94
0.92
Feb-82
Jul-83
Nov-84
Mar-86
Aug-87
Dec-88
May-90
Sep-91
Jan-93
Jun-94
Date

0 MWD/MTU
848 PPM
1.00 BORON FRACTION IN BP RODS
1.42 PEAK F DELTA H



REGION	POWER SHARING	BURNUP SHARING
1	0.97	0
2	1.10	0
3	0.94	0

FIGURE 3.2

C - CYCLE 1 ASSEMBLYWISE POWER AND BURNUP AT 0 MWD/MTU, HFP, ARO, NO XENON

BOC (4 EFPD), Cyc - Two-Dimensional Relative Power Distribution - HI [illegible]ibrium Xenon

	H	G	F	E	D	C	B	A
	1.0450	1.2900	1.0086	1.2399	.9469	1.1399	.9138	.5083
8	1.0718	1.3854	1.0476	1.3448	.9936	1.2158	1.0756	.7311
	1.0257	1.0739	1.0388	1.0846	1.0493	1.0666	1.1771	1.4383
	M N	B I	O M	D M	Q Q	E O	A Q	A Q
	1.2896	1.1458	1.2480	1.2018	1.2196	1.2815	1.0852	.5709
9	1.3860	1.1852	1.3611	1.3244	1.3485	1.3866	1.3241	.8820
	1.0748	1.0344	1.0906	1.1020	1.1057	1.0820	1.2201	1.5450
	I B	A A	P I	M N	Q Q	E D	A Q	A Q
	1.0084	1.2474	.9748	1.2574	1.0905	1.2427	1.0992	.7529
10	1.0433	1.3607	1.0309	1.3718	1.1675	1.3496	1.2999	1.0620
	1.0346	1.0908	1.0575	1.0910	1.0706	1.0861	1.1826	1.4104
	M O	I P	Q A	I P	E N	A A	D [illegible]	[illegible]
	1.2395	1.3019	1.2572	1.2176	1.2176	1.1759	1.1071	.4562
11	1.3639	1.3246	1.3717	1.2931	1.3391	1.3056	1.3937	.8553
	1.0843	1.1022	1.0910	1.0620	1.0997	1.1103	1.2589	1.8751
	M D	N M	P I	D L	A A	D E	C E	A A
	.9469	1.2197	1.0912	1.2177	1.0010	1.1363	.6134	
12	.9925	1.3493	1.1683	1.3396	1.0952	1.3753	1.0022	
	1.0482	1.1062	1.0707	1.1001	1.0940	1.2103	1.6339	
	Q Q	Q G	N E	A A	E C	E C	A A	
	1.1409	1.2823	1.2434	1.1761	1.1400	.5728	.2503	
13	1.2164	1.3874	1.3504	1.3055	1.3764	.9136	.5833	
	1.0662	1.0820	1.0861	1.1100	1.2074	1.5950	2.3311	
	O E	D E	A A	E D	C E	A A	A A	
	.9149	1.0861	1.0999	1.1088	.6150	.2522	P (AVG)	
14	1.0690	1.3251	1.3007	1.3950	1.0040	.5886	PEAK PIN	
	1.1684	1.2200	1.1825	1.2581	1.6326	2.3343	PEAK/ASS	
	Q A	Q A	N D	E C	A A	A A	PIN LOC	
	.5085	.5709	.7540	.4586				
15	.7335	.8823	1.0629	.8583				
	1.4424	1.5454	1.4098	1.8716				
	L B	Q A	E C	A A				

The maximum assembly power is 1.2900 at location G-8.

The maximum pin power is 1.3950 at location E-14.

The maximum pin to assembly factor is 2.3343 at location C-14.

Calorimetric Flow Uncertainty Process Description

- Power is measured on the secondary side by measuring steam pressure, and feedwater pressure, temperature, and mass flow rate
- These measurements determine the thermodynamic states of the secondary side fluid entering and leaving the SGs and enable the calculation of inlet and exit enthalpies
- Measurement uncertainties in feedwater flow, pressure, and temperature and in steam pressure are accounted for
- Power added by the reactor coolant pumps is estimated and power lost through process flow streams and to ambient is calculated
- Secondary power less pump power and plus miscellaneous losses is assumed to equal power added in the reactor vessel
- ΔT across the reactor vessel is measured by measuring hot and cold leg temperatures and RCS pressure (current method only)
- These measurements determine the thermodynamic states of the fluid entering and leaving the reactor vessel and enable the calculation of inlet and exit enthalpies (current method only)
- Measurement uncertainties in RCS pressure, hot leg temperature, and cold leg temperatures are accounted for
- Reactor vessel power is divided by reactor vessel Δh to give mass flow rate, and calculated cold leg density is used to convert to volumetric flow rate for comparison to TS requirement (current method only)
- Calculated flow in a given loop and measured ΔP across each elbow tap in that loop are used to reset the flow coefficient for that elbow tap (current method only)

Elbow Tap Flow Uncertainty Process Description

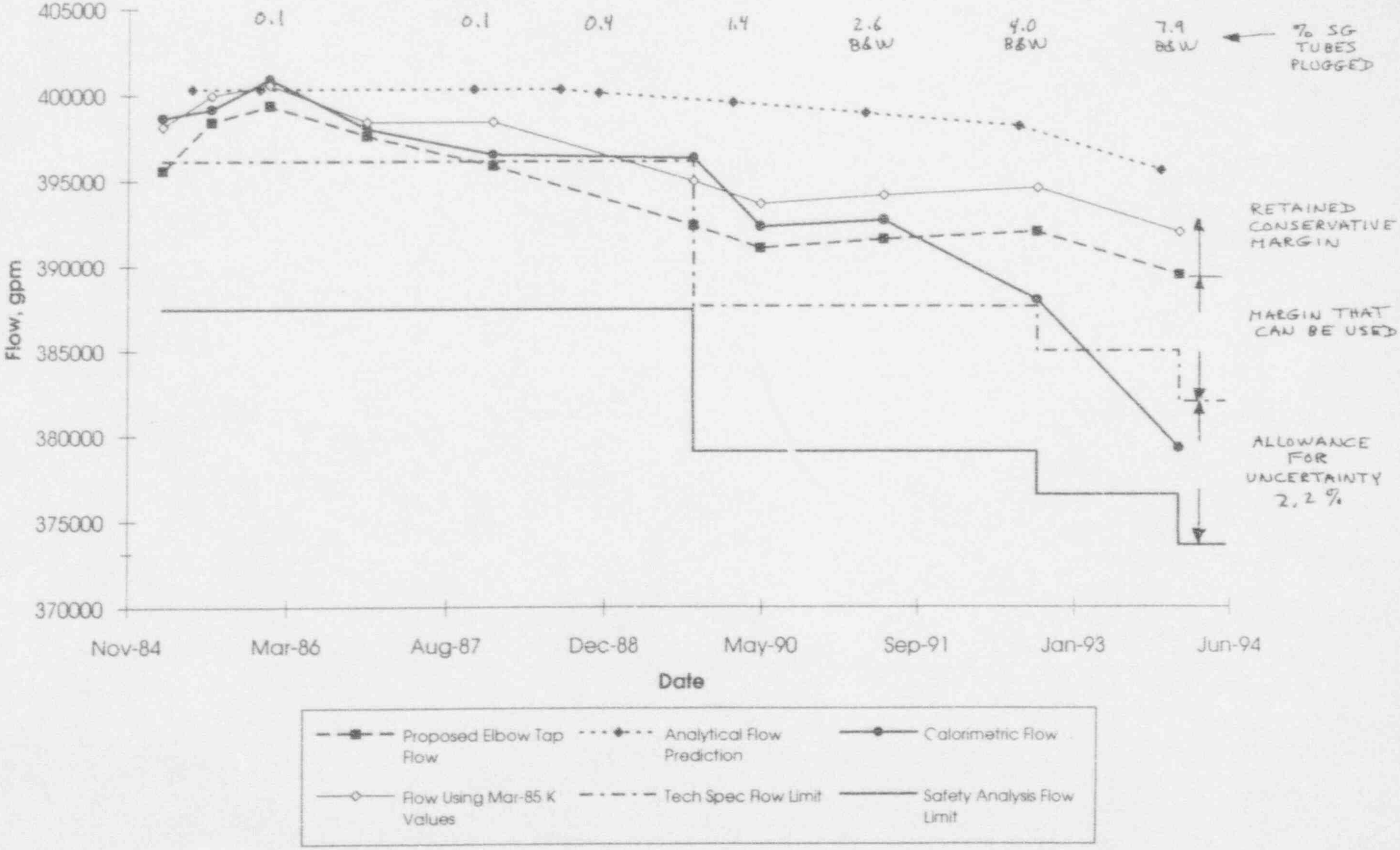
- The first five steps of the current method are still performed in the same way since calorimetric power is still required to calibrate the excore neutron flux instrumentation

- Cold leg temperature and RCS pressure are measured to determine cold leg density

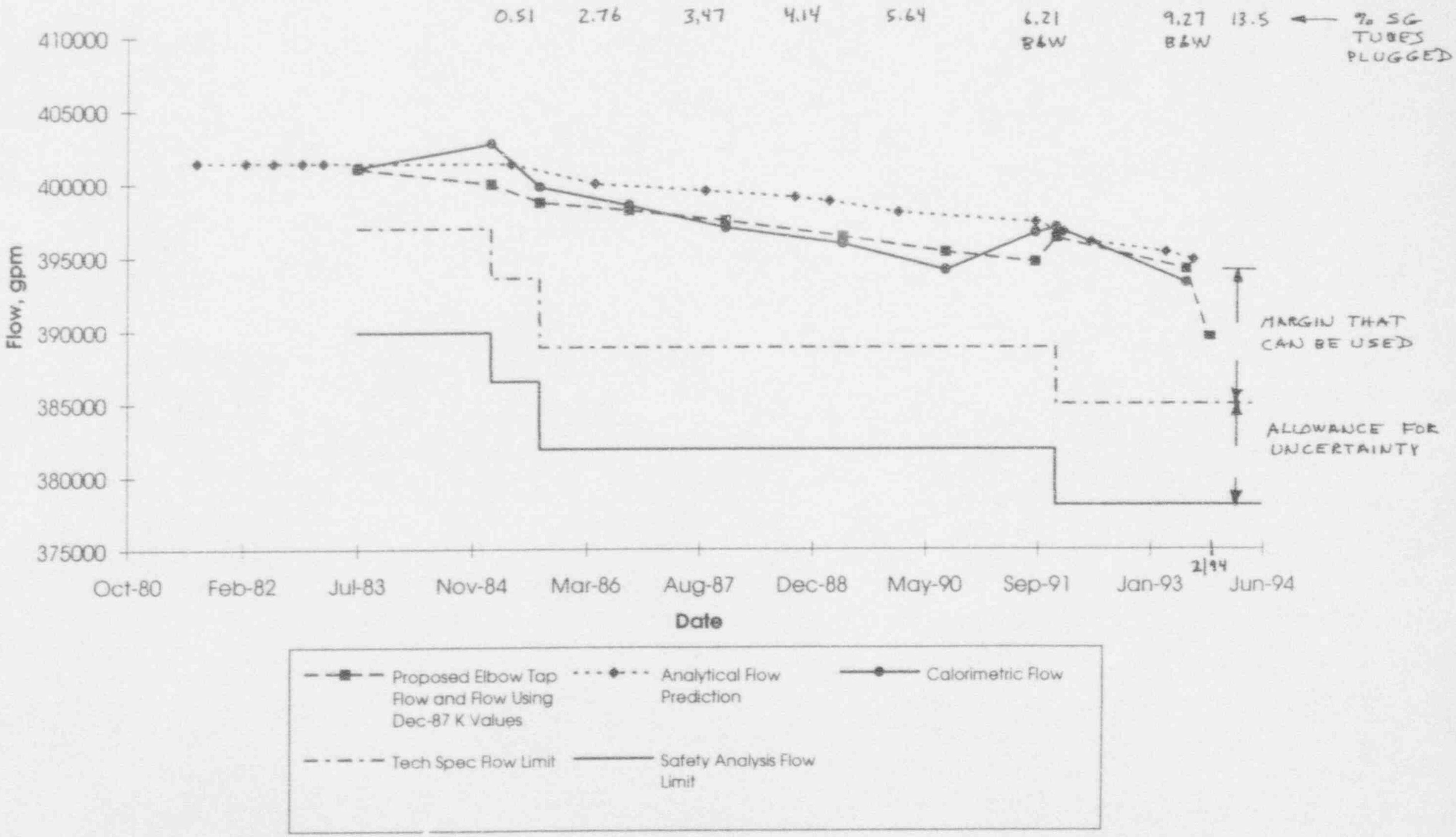
- Measured ΔP across each elbow tap in a given loop is multiplied by the calculated density, the square root is taken, and the result is multiplied by a predetermined flow coefficient to give flow in that loop as measured by that elbow tap

- The averages of the three elbow tap flows from each loop are summed to give the volumetric flow rate for comparison to the TS requirement

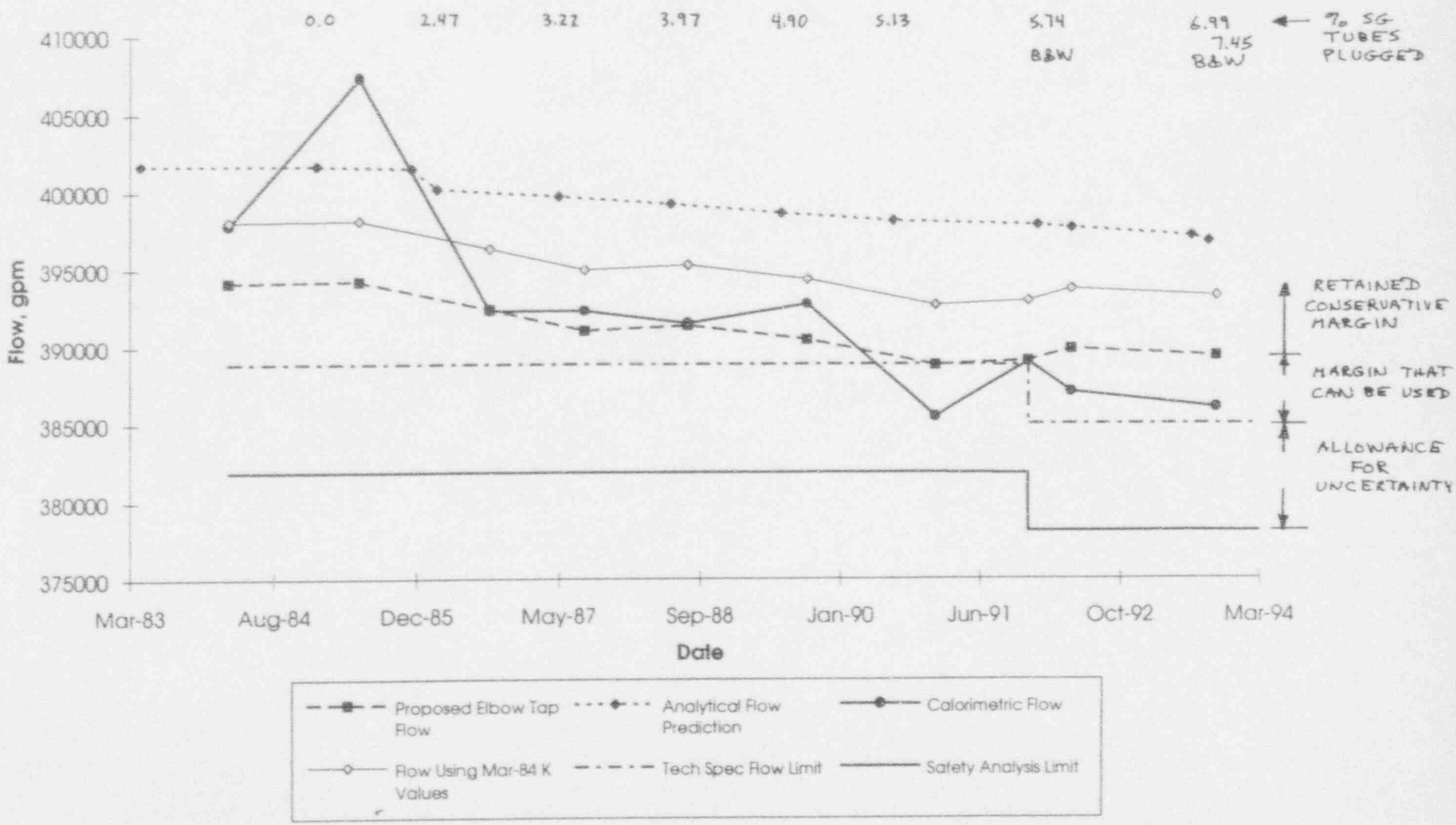
CNS-1 Flow Comparison Between Analytical Flow Prediction, Proposed Elbow Tap Method And Calorimetric Flow



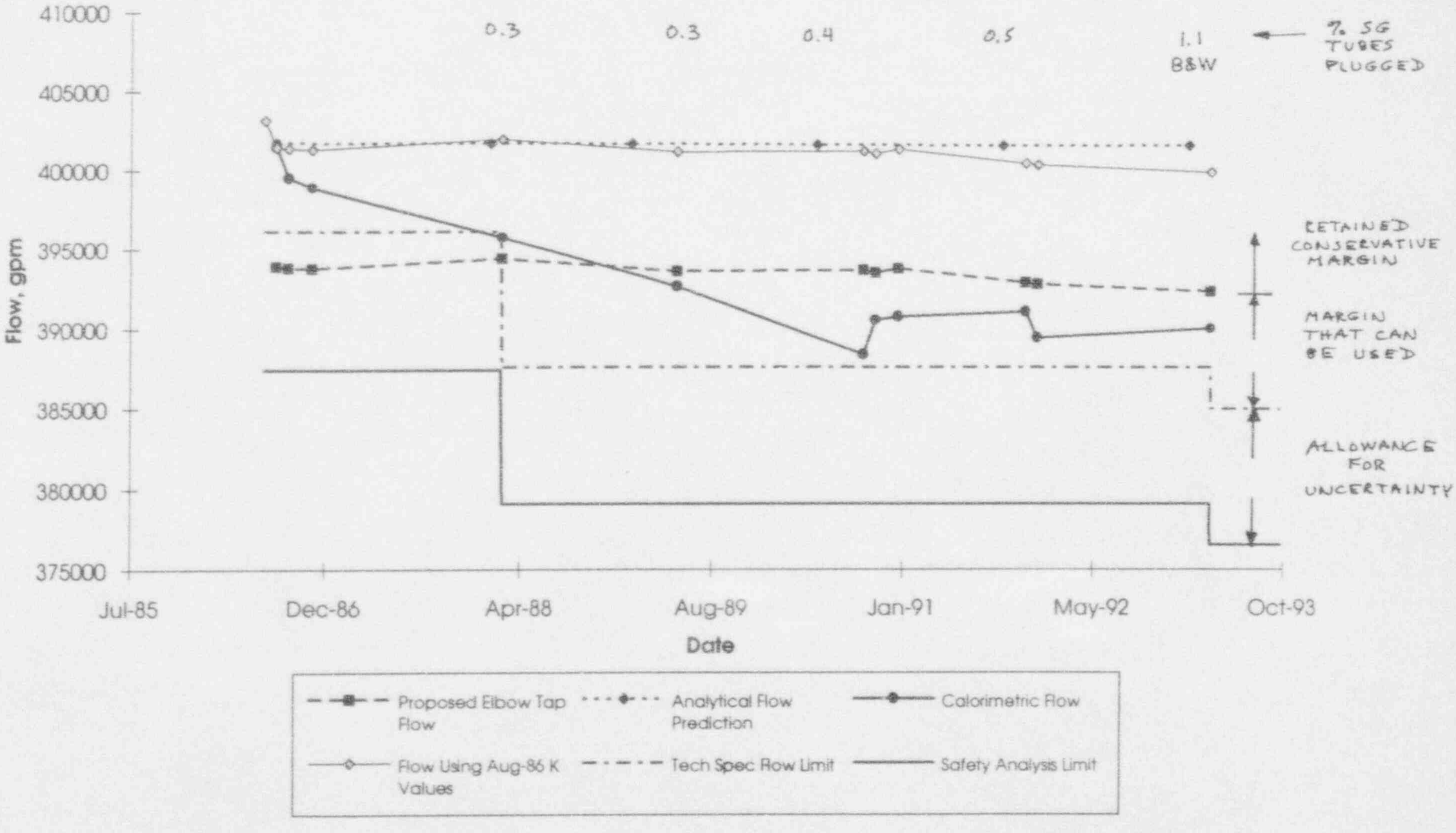
MNS-1 Flow Comparison Between Analytical Flow Prediction, Proposed Elbow Tap Method And Calorimetric Flow



MNS-2 Flow Comparison Between Analytical Flow Prediction, Proposed Elbow Tap Method And Calorimetric Flow



CNS-2 Flow Comparison Between Analytical Flow Prediction, Proposed Elbow Tap Method And Calorimetric Flow



COMMENTS ON FLOW TREND FIGURES

- THE CALORIMETRIC FLOW IS ERRATIC AND CONSERVATIVELY LOWER THAN REAL FLOW
- BOTH THE ELBOW TAP BASED FLOW AND THE ANALYTICAL MODEL FLOW ARE CONSISTENT WITH CHANGES IN REAL FLOW DUE TO SG TUBE PLUGGING AND OTHER HYDRAULIC CHANGES
- ALL FLOW METHODS ARE CONSERVATIVE AS LONG AS THE FLOW MEASURED IS GREATER THAN THE TECH SPEC FLOW
- THE REQUIRED UNCERTAINTIES ARE INCLUDED IN THE FLOW USED IN THE FSAR AND RELOAD ANALYSIS
- THE PROPOSED METHOD OF SELECTION OF THE ELBOW TAP FLOW COEFFICIENTS ADDS CONSERVATIVE MARGIN TO THE MEASURED FLOW
- ADDITIONAL MARGIN DUE TO STATISTICAL COMBINATION OF MULTIPLE CALORIMETRIC DATA HAS NOT BEEN CREDITED FOR SIMPLICITY
- THE RECOVERY OF LOST FLOW MARGIN IS MODEST DUE TO THE CONSERVATISM OF THE PROPOSED METHOD.

CURRENT McGUIRE / CATAWBA FLOW SITUATION

UNIT	TECH SPEC FLOW	CURRENT FLOW METHOD	PROPOSED FLOW METHOD
MNS-1	385,000*	388,777	389,299
MNS-2	385,000*	386,027	389,422
CNS-1	382,000	379,285	389,533
CNS-2	385,000	390,040	392,389

* - REDUCTION TO 382,000 SHORTLY