ARKANSAS POWER & LIGHT COMPANY
POST OFFICE BOX 551 LITTLE ROCK, ARKANSAS 72203 (501) 371-4000

April 2, 1982

2CANØ482Ø1

RECEIVED
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Mr. John T. Collins
Regional Administrator
U. S. Nuclear Regulatory Commission
Region IV
611 Ryan Plaza Drive, Suite 1000
Arlington, Texas 76011

Subject: Arkansas Nuclear One - Unit 2
Docket No. 50-368
License No. NPF-6
Information Update Relative to
R.O. 50-368/82-001/01T-0
(RTD Response Time Degradation)

Reference: 2CANØ182Ø9 Dated January 29, 1982

Gentlemen:

A second set of RTD time constant measurements has been performed following those performed immediately after the January 1982 outage of ANO-2 to restore the response time of six RTDs which are inputs to the Reactor Protection System (RPS) Core Protection Calculators (CPCs). The results of these measurements are attached as Table 1 along with the results of the previous two measurements which are provided for your reference.

You will note, upon inspection of the latest set of results, that two RTD time constants have shown more significant degradation than the others while the average response time of all RTDs has not changed significantly. One of the RTDs, 2TE-4735-3, has reached the 6.0 second limit and a second (2TE-4735-4) is at 5.9 seconds. Although these RTDs were within the allowable time constant limit at the time measured, it seems likely that continued degradation may occur in the future. We have evaluated this situation thoroughly and concluded that continued operation is justified based on the following:

The time constants of the two RTDs which have exhibited significant degradation since the January 1982 measurement are plotted on the attached Figure 1. Assuming a straight line extrapolation for the time constant degradation for these RTD elements, we expect both to

A001

be at approximately 6.4 seconds when measured in April 1982 and at approximately 6.8 seconds when measured in May 1982. These RTDs are hot leg temperature inputs which are paired with other sensors on the same hot leg and averaged together prior to input to each CPC. (See Figure 2)

The original CPCS design included only four RTD inputs for each channel. These consisted of one hot leg RTD and one cold leg RTD from each RCS loop. As a result of the "hot leg temperature anomaly" observed at ANO-2 in 1979, two additional hot leg RTDs were added to each CPC channel. In this modification, the CPC hot leg temperature inputs became hardware averaged signals from two RTDs placed on either side of the hot leg pipe. The purpose here was to provide the CPC with hot leg temperature inputs which are representative of the average fluid temperature in the pipe rather than the periodically fluctuating values caused by temperature flips occurring due to the hot leg temperature anomaly. Since the signal reaching the CPC is an average of the two RTD signals, the response time constant of the temperature input is an "effective average" which is approximately equal to but always less than the algebraic average of the two individual hot leg RTD response time constants. (See Attachment 1)

Consequently, it is clear that the original design of the CPCS is not compromised when the RTD time constant of one of the pair of RTDs on a given hot leg is greater than 6.0 seconds, as long as the effective (hardware) average time constant of the pair is less than 6.0 seconds. The pairs presently of concern are:

1. <u>2TE-4735-3 and 2TE-4710-3, Element 1</u>
   The current effective time constant of this pair is < 4.95 seconds.

2. <u>2TE-4735-4 and 2TE-4710-4, Element 1</u>
   The current effective time constant of this pair is < 5.0 seconds.

Referring to the trends indicated by Figure 1 for 2TE-4735-3 and 2TE-4735-4 and the lack of an increasing trend indicated by Table 1 for 2TE-4710-3 and 2TE-4710-4, we expect the "effective average time constants" to be no greater than 5.5 seconds for either pair as late as mid-May 1982.

Although there is some scatter in the results of the measurements, a linear extrapolation should be conservative. It is possible, however, that future measurements will not bear out our prediction. We believe that the response time measurements are considerably more conservative than the actual time constants of the RPS RTDs. We will further clarify this and explain our short-term and long-term strategies to avoid unnecessary plant outages and to effect a long-term solution to the RTD problem in the following paragraphs.

In January 1982, shortly after the measurements reported to you in our January 29, 1982 letter, 2CAN018209, (which were performed by AMS Corporation of Knoxville, Tennessee), we also contracted with Technology for Energy Corporation (TEC) also of Knoxville to perform an independent set of RTD time constant measurements. TEC uses a slightly different procedure which allows them to gather much more front end data. This, in combination with their solution method, is believed to allow reduction of the uncertainty in the measurement result significantly. Results from that set of measurements performed at ANO by TEC approximately one week after the first set of AMS measurements are presented in Table 2. We believe that two interesting conclusions may be drawn from these data. First, the measurements performed by TEC show good agreement with those performed by AMS when both organizations apply a 50% measurement uncertainty adjustment. Second, the "best estimate" results by TEC presented in Table 2 indicate that the actual time constants of the ANO-2 RTDs are considerably smaller than the conservative estimates we have been reporting. Although NRC has reviewed both the TEC and AMS methods and has indicated the acceptability of both, our database resides in the AMS method. Consequently, until we have acceptably addressed this issue on a long term basis we are hesitant to change testing methods as a basis for Technical Specification compliance.

Another reason that we consider past treatment of ANO-2's RTD time constant degradation to be very conservative is related to the usage of the temperature information by the Core Protection Calculators (CPCs). This was mentioned in our January 29, 1982 letter. Figure 2 indicates that the CPCs actually rely upon the average hot leg temperature, average cold leg temperature or in certain cases the maximum or minimum cold leg temperature for its calculations. The CPC does use both cold leg temperature sensors for asymmetric steam generator transient protection. However, this function is not relied upon because the low steam generator water level trip remains at its original setpoint and consequently provides protection for asymmetric events.

Since the CPCs use average or maximum/minimum temperature values for their calculations, the response time "seen" by the CPC is actually that of the "effective time constant" which is either the average time constant of all four hot leg temperature sensors, both cold leg sensors or the lower time constant of the two cold leg sensors in the cases where maximum/minimum values are used. Consequently, degradation of individual RTD time constants does not make the CPC calculations non-conservative unless several RTD time constants are degraded in specified combinations.

AP&L has initiated analysis efforts by Combustion Engineering to define penalty factors which may be applied to the Core Protection Calculators via addressable constants in the event the RTD time constants degrade unacceptably. Analysis is complete at this time for the penalty necessary for degradation to an 8-second RTD time constant. We expect completion of two additional analyses for RTD

time constants of 10 and 13 seconds within the next two weeks. Upon receipt of these calculations we will request a Technical Specification change which will resemble closely the draft Technical Specification markup in Attachment 2. Table 3 summarizes the results of C-E's 8-second analysis and forms the basis for one point (in addition to zero penalty at 6 seconds) on the proposed Technical Specification curve. We would appreciate NRC's early comments on this proposed format and any thoughts on how AP&L can support an expeditious review after we submit it formally to NRC in approximately two weeks.

In the longer term, AP&L believes that the couplant "Never-Seez" should be removed from the RTD thermo wells in the near future. We are investigating replacement RTDs which appear to have better response time characteristics than our existing detectors. We are also conducting tests upon a process for plating our existing detectors with a material of high thermal conductivity. Presently both of these alternatives look promising to gain improved response time characteristics which will allow the use of no couplant and still achieve better than 6-second time constants. In the event that neither approach proves viable, AP&L would still be able to use the existing RTDs without the thermal couplant, but some CPC penalty would probably be needed. Based on the experience of other utilities who use no couplant and upon testing which AP&L has performed on RTDs with no couplant, we would expect the time constants to be less than 8 seconds. Consequently, the penalty required for CPC calculations would not be large and ANO-2 should still be able to operate at full power.

We look forward to your comments relative to this letter either orally or in writing and will welcome the opportunity to explain the situation in more detail if and when required.

Yours truly,

John R. Marshall

John R. Marshall
Manager, Licensing

JRM:THC:cmc

Attachments

cc (w/att): W. Cavanaugh III
L. J. Dugger
J. M. Griffin
J. M. Levine
D. A. Rueter
INPO
Resident NRC Inspectors
NRR Division of NRC
ANO-DCC

TABLE 1
(2CANØ482Ø1)
MEASURED TIME CONSTANTS FOR ANO-2
PRIMARY COOLANT RTDs

RPS CHANNEL	RTD TAG NUMBER	ELEMENT NUMBER	T_H or T_C	RTD TIME CONSTANT (seconds)		
				1/20/82	2/20/82	3/19/82
A	4610-1	1	T_H	3.8	3.9	4.1
A	4635-1	1	T_H	3.9	3.9	4.2
A	4710-1	1	T_H	4.8	5.1	5.1
A	4735-1	1	T_H	5.0	4.7	4.7
A	4611-1	1	T_C	5.3+	4.5	4.5
A	4711-1	1	T_C	5.0	5.0	5.4
B	4610-2	1	T_H	4.4	4.1	4.1
B	4635-2	1	T_H	4.2	4.1	4.4
B	4710-2	1	T_H	4.8	5.0	4.8
B	4735-2	1	T_H	3.9	4.2	4.4
B	4611-2	1	T_C	4.4	4.2	4.2
B	4711-2	1	T_C	4.5	4.2	3.9
C	4610-3	1	T_H	3.6+	3.2+	2.7
*	4610-3	2	T_H	3.5+	2.7	2.7
C	4635-3	1	T_H	4.8	4.5	4.7
C	4710-3	1	T_H	4.2	4.4	3.9
*	4710-3	2	T_H	5.5+	4.2	3.8
C	4735-3	1	T_H	5.3	5.7	6.0
C	4611-3	1	T_C	4.4+	4.1	4.1
*	4611-3	2	T_C	3.9	3.9	4.1
C	4711-3	1	T_C	3.9	4.2	4.1
*	4711-3	2	T_C	3.9	4.2	4.4
D	4610-4	1	T_H	4.7	4.8	5.0
*	4610-4	2	T_H	5.5+	4.8	5.1
D	4635-4	1	T_H	4.1	3.9	3.9
D	4710-4	1	T_H	4.5	4.6+	4.1
*	4710-4	2	T_H	5.3+	4.2	4.2
D	4735-4	1	T_H	5.0	5.3	5.9
D	4611-4	1	T_C	3.8	3.8	3.8
*	4611-4	2	T_C	3.6	3.6	3.8
D	4711-4	1	T_C	5.0	5.1	5.1
*	4711-4	2	T_C	5.0	5.1	5.3
			Average	4.48	4.35	4.39

*Not an RPS input
+Includes 10% adjustment for measurement accuracy; all others have 50% adjustment

TABLE 2
(2CANØ482Ø1)
MEASURED TIME CONSTANTS FOR ANO-2
PRIMARY COOLANT RTDs

RPS CHANNEL	RTD TAG NUMBER	ELEMENT NUMBER	MEASURED RTD TIME CONSTANTS (seconds) AMS (1) 1/20/82	TEC (1) 1/27/82	TEC BEST ESTIMATE VALUE (2)
A	4610-1	1	3.8	3.7	1.94 ± 0.40
	4635-1	1	3.9	3.6	1.72 ± 0.48
	4710-1	1	4.8	4.8	2.06 ± 0.55
	4735-1	1	5.0	4.7	2.36 ± 0.54
	4611-1	1	5.3	4.5	2.19 ± 0.53
	4711-1	1	5.0	5.2	3.17 ± 0.61
B	4610-2	1	4.4	4.1	2.17 ± 0.48
	4635-2	1	4.2	3.9	2.22 ± 0.47
	4710-2	1	4.8	4.3	2.75 ± 0.46
	4735-2	1	3.9	3.8	1.60 ± 0.56
	4611-2	1	4.4	4.5	1.82 ± 0.57
	4711-2	1	4.5	4.6	2.14 ± 0.57
C	4610-3	1	3.6	2.6	1.32 ± 0.32
*	4610-3	2	3.5	3.0	1.97 ± 0.37
C	4635-3	1	4.8	4.5	2.57 ± 0.55
C	4710-3	1	4.2	3.8	1.67 ± 0.46
*	4710-3	2	5.5	3.9	1.76 ± 0.55
C	4735-3	1	5.3	5.5	2.58 ± 0.69
C	4611-3	1	4.4	4.0	1.78 ± 0.46
*	4611-3	2	3.9	3.9	1.72 ± 0.50
C	4711-3	1	3.9	3.7	1.48 ± 0.40
*	4711-3	2	3.9	3.9	1.97 ± 0.54
D	4610-4	1	4.7	4.8	2.87 ± 0.54
*	4610-4	2	5.5	4.7	1.99 ± 0.61
D	4635-4	1	4.1	4.2	2.25 ± 0.48
D	4710-4	1	4.5	4.9	3.16 ± 0.55
*	4710-4	2	5.3	4.6	2.08 ± 0.65
D	4735-4	1	5.0	5.4	3.02 ± 0.64
D	4611-4	1	3.8	3.8	2.35 ± 0.43
*	4611-4	2	3.6	3.7	2.18 ± 0.44
D	4711-4	1	5.0	4.8	2.17 ± 0.60
*	4711-4	2	5.0	4.7	2.66 ± 0.63
		Average	4.48	4.25	2.18

*Not an RPS input
(1) With 50% adjustment added, except as noted on Table 1 for AMS
(2) Best estimate values represent combined effect of measurement and modeling uncertainties

TABLE 3

(2CANØ482Ø1)

ACCIDENT ANALYSIS

EVENTS	AFFECTED BY	EFFECTS*
SINGLE CEA WITHDRAWAL	• DYNAMIC ΔT POWER	• LPD NON-CONSERVATIVE**
BANK CEA WITHDRAWAL	• TEMPERATURE SHADOWING OF NEUTRON FLUX (Φ) • ΔT POWER	• NEGLIGIBLE
CEA DROP	• ΔT POWER	• BOUNDED BY WITHDRAWAL
EXCESS LOAD	• TEMPERATURE SHADOWING (Φ)	• CYCLE 2 CONSERVATIVE
LOSS OF FEEDWATER	• T_C INPUT TO DNBR	• NEGLIGIBLE
LOSS OF LOAD	• T_C INPUT TO DNBR	• DNBR NON-CONSERVATIVE***
ASYMMETRIC S/G TRANSIENTS	• INDIVIDUAL T_Cs	• COLSS LIMITS WOULD CHANGE (BUT LOW S/G LEVEL TRIP PROTECTS)

*EFFECT OF DEGRADATION TO 8-SECOND TIME CONSTANT

**MUST INCREASE BERR4 BY 4.0%

***MUST INCREASE BERRO AND BERR2 BY 1.5%

FIGURE 1

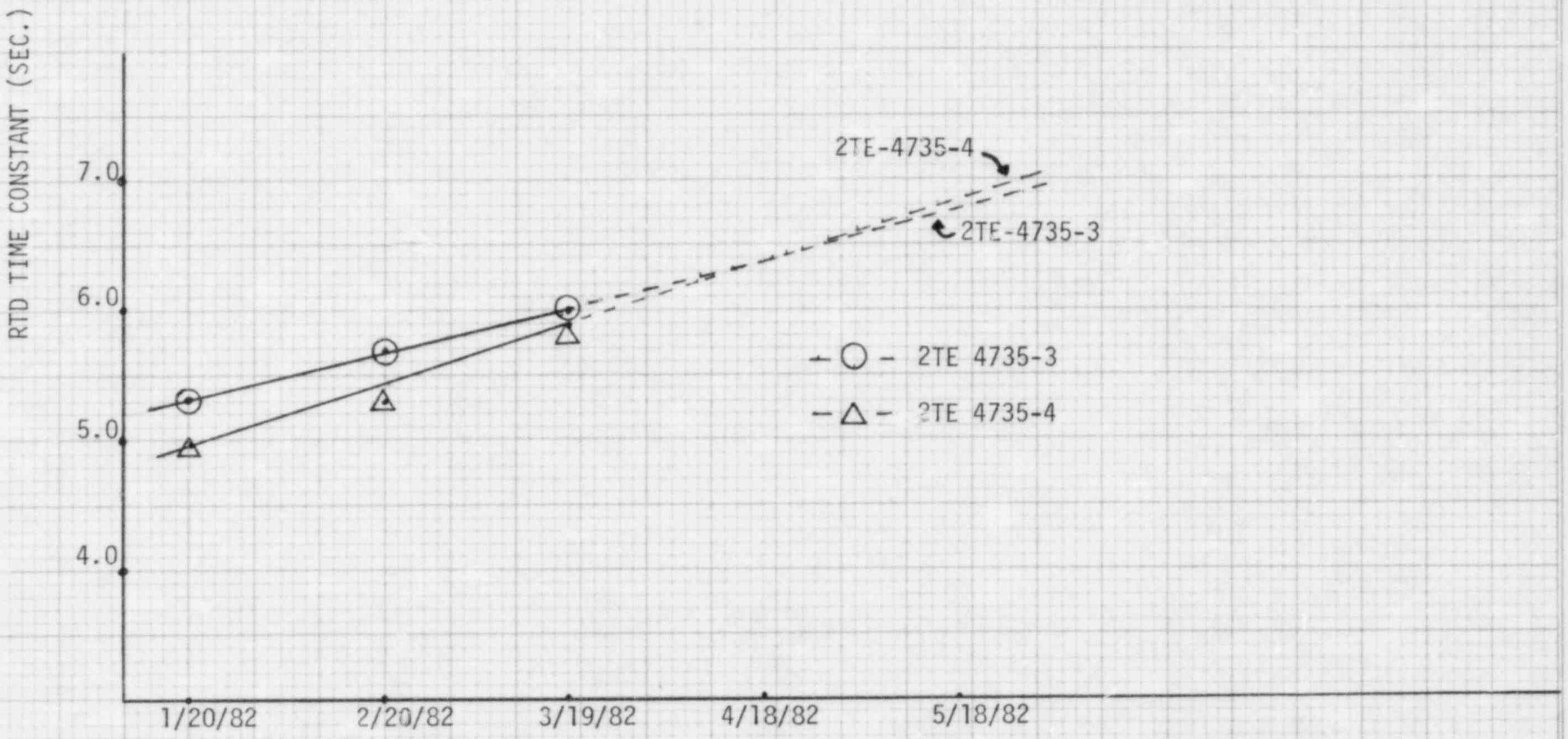
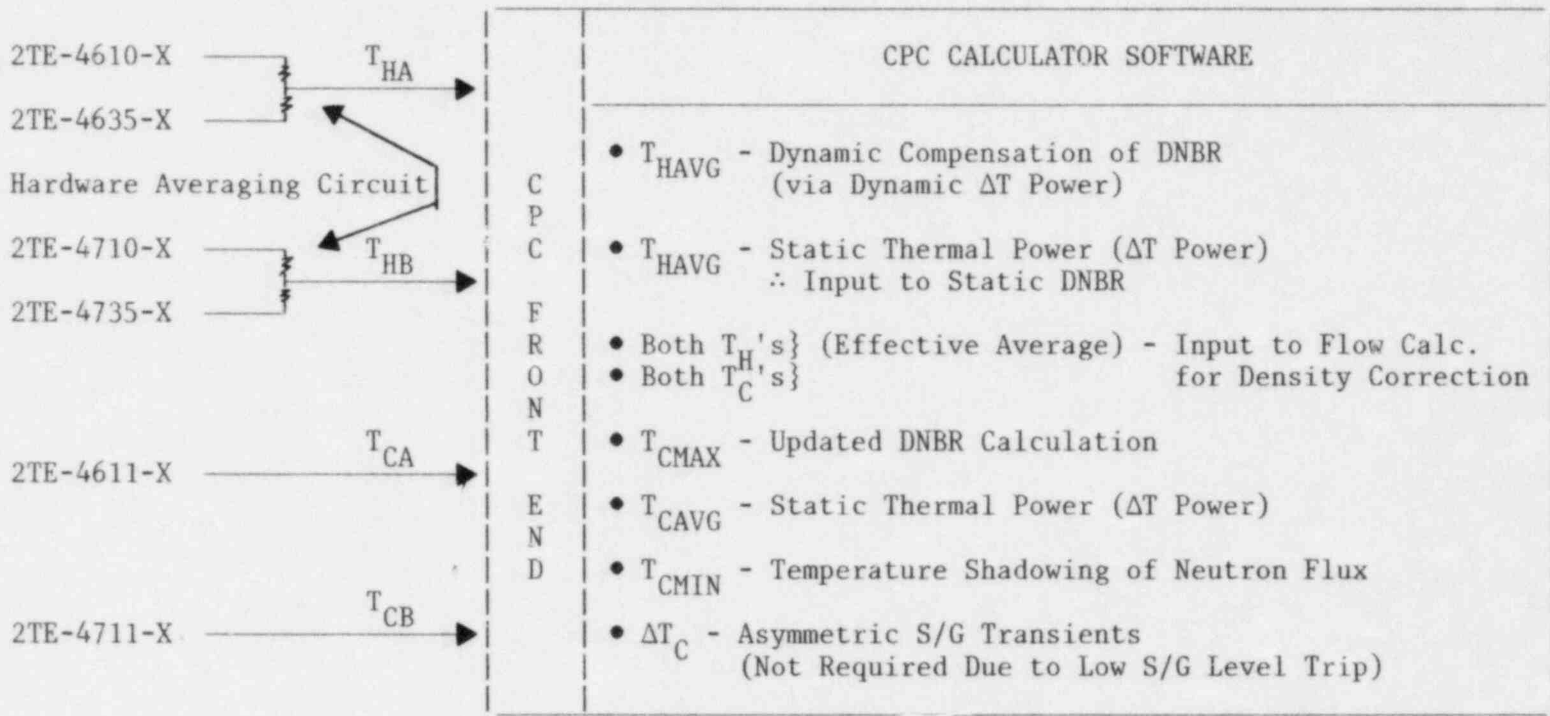

RTD TIME CONSTANT (SEC.)
7.0
6.0
5.0
4.0
1/20/82
2/20/82
3/19/82
4/18/82
5/18/82
2TE-4735-4
2TE-4735-3
2TE 4735-3
2TE 4735-4

FIGURE 2

(2CAN048201)

TYPICAL CPC CHANNEL

(TEMPERATURE INPUTS AND UTILIZATION)



X = 1, 2, 3 or 4 (Channel Number); subscripts: H = hot leg C = cold leg
A = loop A B = loop B

T_{HAVG} = Software Average of T_{HA} and T_{HB}

T_{CMAX}/T_{CMIN} = Software Selection of Max/Min of T_{CA} or T_{CB}

ATTACHMENT 1

DERIVATION OF EFFECTIVE AVERAGE RTD TIME CONSTANT

Define the response of the RTD to a step change in temperature from T_o to T_f at time t = 0 as follows:

$$(1)\quad T_i\,(t) = T_o + (T_f - T_o)\,(1 - e^{-t/\tau_i})$$

where τ_i is the characteristic response constant of the element i

Problem: Given the characteristic response constants of two elements, τ_1 and τ_2, find the characteristic response constant of the mean response of the elements.

For element 1

$$(2)\quad T_1\,(t) = T_o + (T_f - T_o)\,(1 - e^{-t/\tau_1})$$

For element 2

$$(3)\quad T_2\,(t) = T_o + (T_f - T_o)\,(1 - e^{-t/\tau_2})$$

The mean response of the two elements is

$$(4)\quad T_m\,(t) = \tfrac{1}{2}\,[T_1\,(t) + T_2\,(t)]$$

$$(5)\quad T_m\,(t) = T_o + \tfrac{1}{2}\,(T_f - T_o)\,(2 - e^{-t/\tau_1} - e^{-t/\tau_2})$$

Let the response time of $T_m(t)$ be defined as the time required for $T_m(t)$ to reach 63.2% of $(T_f - T_o) + T_o$

$$(6)\quad T_m\,(t) = 0.632\,(T_f - T_o) + T_o$$

Combining eq. (5) with eq. (6)

$$(7)\quad T_o + 0.632\,(T_f - T_o) = T_o + \tfrac{1}{2}\,(T_f - T_o)\,(2 - e^{-t/\tau_1} - e^{-t/\tau_2})$$

$$(8)\quad 1.264 = 2 - e^{-t/\tau_1} - e^{-t/\tau_2}$$

$$(9)\quad e^{-t/\tau_1} + e^{-t/\tau_2} = 0.736$$

Example: Assume τ^1 = 5 sec.; τ^2 = 6.5 sec., then

$$(10)\quad e^{-t/5} + e^{-t/6.5} = 0.736$$

Solving eq. (10) for t using the method of successive approximation, we find the response time of the average response of the elements to be 5.699 sec.

TABLE 3.3-2 (Continued)

REACTOR PROTECTIVE INSTRUMENTATION RESPONSE TIMES

FUNCTIONAL UNIT	RESPONSE TIME
10. DNBR - Low	
a. Neutron Flux Power from Excore Neutron Detectors	≤ 0.39 seconds*
b. CEA Positions	≤ 1.09 seconds**
c. Cold Leg Temperature	≤ 3.79 seconds##
d. Hot Leg Temperature	≤ 1.54 seconds##
e. Primary Coolant Pump Shaft Speed	≤ 0.80 seconds#
f. Reactor Coolant Pressure from Pressurizer	≤ 3.19 seconds
11. Steam Generator Level - High	Not Applicable

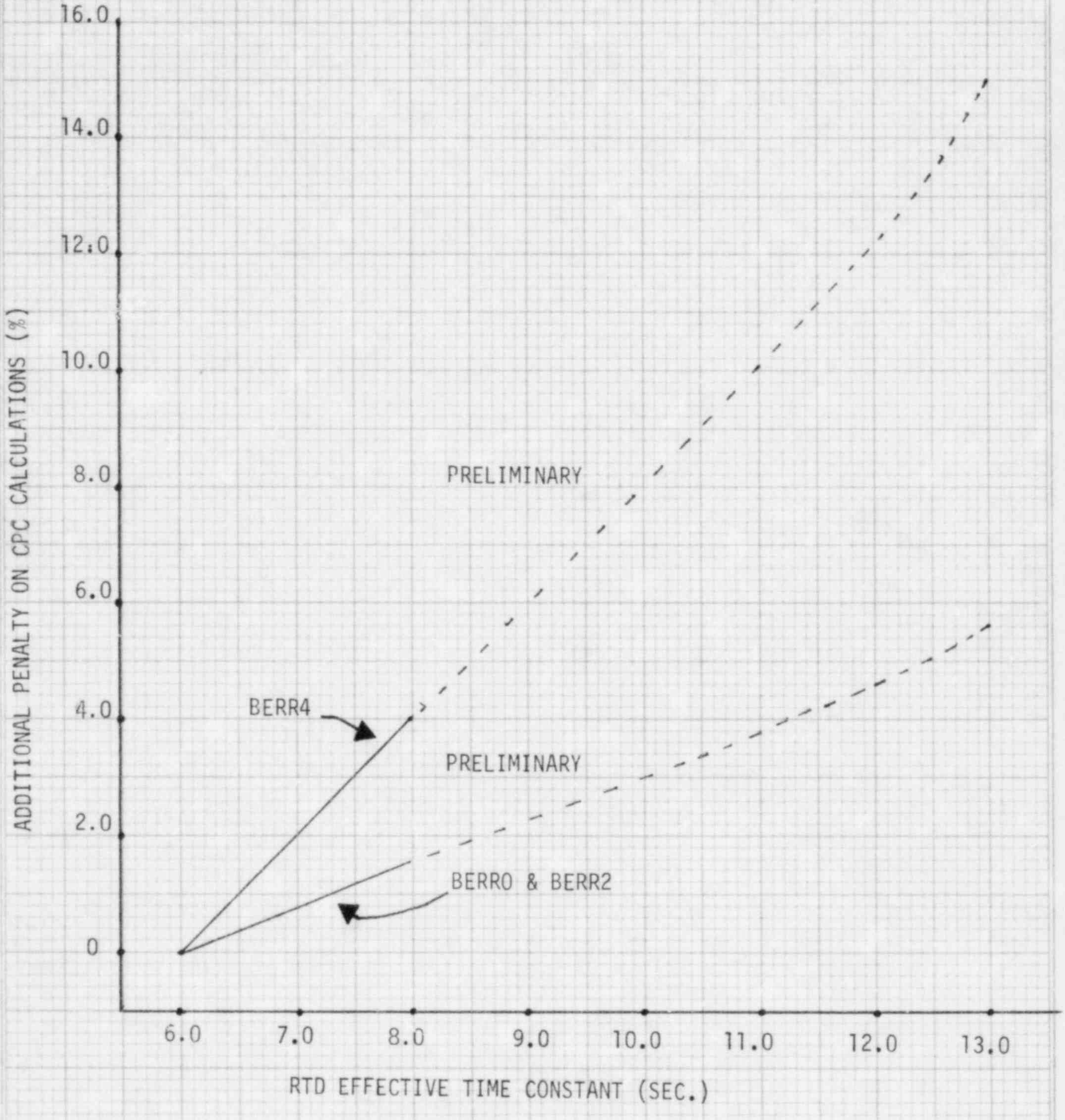
*Neutron detectors are exempt from response time testing. Response time of the neutron flux signal portion of the channel shall be measured from detector output or input of first electronic component in channel.

**Response time shall be measured from the onset of a single CEA drop.

#Response time shall be measured from the onset of a 2 out of 4 Reactor Coolant Pump coastdown.

##Based on a resistance temperature detector (RTD) response time of ≤ 6.0 seconds where the RTD response time is equivalent to the time interval required for the RTD output to achieve 63.2% of its total change when subjected to a step change in RTD temperature. If the CPC "effective time constant" values increase beyond 6 seconds, the CPC addressable constants BERR0, BERR2 & BERR4 shall be increased in accordance with Figure 3.3-1.

FIGURE 3.3-1


16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0
ADDITIONAL PENALTY ON CPC CALCULATIONS (%)
PRELIMINARY
BERR4
PRELIMINARY
BERR0 & BERR2
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
RTD EFFECTIVE TIME CONSTANT (SEC.)