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WESTINGHOUSE CLASS 3

WCAP-12633
Rev. 1

RTD BYPASS ELIMINATION LICENSING REPORT
FOR
TURKEY POINT UNITS 3 AND 4

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1.0 INTRODUCTION

Westinghouse Electric Corporation has been contracted by Florida Power and Light to remove the existing Resistance Temperature Detector (RTD) Bypass System and replace this hot leg and cold leg temperature measurement method with fast response thermowell mounted RTDs installed in the reactor coolant loop piping. This report is submitted for the purpose of supporting operation of Turkey Point Units 3 and 4 utilizing the new thermowell mounted RTDs as processed with the Eagle 21 process protection system.

1.1 HISTORICAL BACKGROUND

Prior to 1968, PWR designs had been based on the assumption that the hot leg temperature was uniform across the pipe. Therefore, placement of the temperature instruments was not considered to be a factor affecting the accuracy of the measurement. The hot leg temperature was measured with direct immersion RTDs extending a short distance into the pipe at one location. By the late 1960s, as a result of accumulated operating experience at several plants, the following problems associated with direct immersion RTDs were identified:

- o Temperature streaming conditions; the incomplete mixing of the coolant leaving regions of the reactor core at different temperatures produces significant temperature gradients within the pipe.

- o The reactor coolant loops required cooling and draining before the RTDs could be replaced.

The RTD bypass system was designed to resolve these problems; however, operating plant experience has now shown that operation with the RTD bypass loops has created it's own obstacles such as:

- o Plant shutdowns caused by excessive primary leakage through valves, flanges, etc., or by interruptions of bypass flow due to valve stem failure.

- Increased radiation exposure due to maintenance on the bypass line and to crud traps which increase radiation exposure throughout the loop compartments.

The proposed temperature measurement modification has been developed in response to both sets of problems encountered in the past. Specifically:

- Removal of the bypass lines eliminates the components which have been a major source of plant outages as well as Occupational Radiation Exposure (ORE).

- Three thermowell mounted hot leg RTDs provide an average measurement (equivalent to the temperature measured by the bypass system) to account for temperature streaming.

- Use of thermowells permits RTD replacement without draining the reactor coolant loops.

Following is a detailed description of the effort required to perform this modification.

1.2 MECHANICAL MODIFICATIONS

The individual loop temperature signals required for input to the Reactor Control and Protection System will be obtained using RTDs installed in each reactor coolant loop.

1.2.1 Hot Leg

a) The hot leg temperature measurement on each loop will be accomplished with three fast response, narrow range, dual element RTDs mounted in thermowells. To accomplish the sampling function of the RTD bypass manifold system and minimize the need for additional hot leg piping penetrations, the thermowells will be located within the existing

RTD bypass manifold [illegible]s wherever possible. A hole will be made through the end of each scoop [illegible] that water will flow in through the existing holes in the leadi[illegible]ge of the scoop, past the RTD, and out through the new hole (Figure 1.2-1). If plant interferences preclude the placement of a thermowell in a scoop, then the scoop will be capped and a new penetration made to accommodate the thermowell (Figure 1.2-2). These three RTDs will measure the hot leg temperature which is used to calculate the reactor coolant loop differential temperature (Delta T) and average temperature (T_{avg}).

b) This modification will not affect the dual element wide range RTD currently installed near the entrance of each steam generator. This RTD will continue to provide the hot leg temperature used to monitor reactor coolant temperature during startup, shutdown, and post accident conditions.

1.2.2 <u>Cold Leg</u>

a) One fast response, narrow range, dual-element RTD will be located in each cold leg at the discharge of the reactor coolant pump (as replacements for the cold leg RTDs located in the bypass manifold). This RTD will measure the cold leg temperature which is used to calculate reactor coolant loop Delta T and T_{avg}. The existing cold leg RTD bypass penetration nozzle will be modified (Figure 1.2-3) to accept the RTD thermowell wherever possible.

If structural interferences preclude placement in the existing nozzle then the nozzle will be capped and a new penetration made to accommodate the thermowell (Figure 1.2-2).

b) This modification will not affect the dual element wide range RTD in each cold leg currently installed at the discharge of the reactor coolant pump. This RTD will continue to provide the cold leg temperature used to monitor reactor coolant temperature during startup, shutdown, and post accident conditions.

1.2.3 Crossover Leg

The RTD bypass manifold return line will be capped at the nozzle on the crossover leg.

1.3 ELECTRICAL MODIFICATIONS

1.3.1 Control & Protection System

The present RCS loop temperature measurement system uses dedicated direct immersion RTDs in the bypass loop for the control and protection systems. This was done largely to satisfy Section 4.7 of the IEEE Standard 279-1968 which applies to control and protection system interaction. The new thermowell mounted RTDs will be used for both control and protection. In order to satisfy the requirements of Section 4.7 of IEEE 279-1971, the T_{avg} and Delta T signals used in the control-grade logic will be input into a median signal selector, which will select the signal which is between the highest and lowest values of the three loop inputs. This will avoid any adverse plant response that could be caused by a single random failure.

With the elimination of the RTD bypass manifold, three (3) hot leg RTD's are installed in thermowells mounted on the RCS pipe circumference approximately in the same vertical plane. The temperatures read at these locations are somewhat different because of streaming effects. Thus, the three temperatures are processed to produce an average temperature (T_{have}) for each hot leg. The cold leg temperature measurement on each loop is accomplished with a narrow range dual element RTD installed in a thermowell. The thermowell is mounted either in the existing cold leg bypass nozzle or boss mounted in a new penetration. The cold leg sensors are inherently redundant in that either sensor can adequately represent the cold leg temperature measurement. Temperature streaming in the cold leg is not a concern due to the mixing action of the reactor coolant pump.

The process system used to calculate T_{have} and T_{cold} is designated the Temperature Averaging System (TAS). The Temperature Averaging System (TAS) becomes part of the Thermal Overpower and Overtemperature Protection System because the TAS outputs (T_{have} and T_{cold}) replace the T_{hot} and T_{cold} signals previously derived from the bypass manifold RTD.

The Eagle 21 TAS system accepts RTD input signals representing two (2) cold leg and three (3) hot leg temperature measurements per loop. The two cold leg temperatures are processed to produce an average cold leg temperature T_{cold}. The three hot leg temperatures are processed to produce the average hot leg temperature T_{have}. T_{have} is then combined with T_{cold} to produce the loop average temperature (T_{avg}) and the loop difference temperature (Delta T). The resultant signals replace the same signals previously derived in the analog Thermal Overpower and Overtemperature protection channels.

The two cold leg temperature input signals are subjected to range and consistency checks and then averaged to provide a group value for T_{cold}. If these signals agree within an acceptable interval (DELTAC), the group quality is set to GOOD. If the signals do not agree within the acceptable tolerance DELTAC, the group quality is set to BAD and the individual input signal qualities are set to POOR. The average of the two T_{cold} input signals is used to represent the group in either case. One cold leg temperature input signal per loop may be deleted manually by use of the portable Man Machine Interface (MMI). The remaining T_{cold} input signal will provide the loop T_{cold} temperature. DELTAC is an input parameter based on operating experience and is entered via the portable MMI. One DELTAC is required for each temperature loop.

The Eagle 21 TAS employs an algorithm that automatically detects a defective hot leg RTD input signal and eliminates that input from the T_{have} calculation. This is accomplished by incorporating a Redundant Sensor Algorithm (RSA) into the hot leg temperature signal processing. The RSA determines the validity of each input signal and automatically rejects a defective input.

Each of the three hot leg temperature input signals is subjected to a range check and utilized to calculate an estimated average hot leg temperature which is then consistency checked against the other two estimates for average hot leg temperature. An estimated average hot leg temperature is derived from each T_{hot} input signal by adding or subtracting as necessary, a temperature streaming correction factor. Then, the average of the three estimated average hot leg temperatures is computed and the individual estimates are checked to determine if they agree within ± DELTAH of the average value. If all of the signals do agree within ± DELTAH of the average value, the group quality is set to GOOD. The group value T_{have} is set to the average of the three estimated average hot leg temperatures.

If the signal values do not all agree within ± DELTAH of the average, the algorithm will delete the signal value which is furthest from the average. The quality of the deleted signal is set to POOR and a consistency check is performed on the remaining GOOD signals. If these signals pass the consistency check, the group value will be taken as average of these remaining GOOD signals and the group quality will be set to POOR. However, if these signals again fail the consistency check (within ± DELTAH), the group value will be set to the average of these two signals; but the group quality will be set to BAD. All of the individual signals will have their quality set to POOR. DELTAH is an input parameter based upon temperature distribution tests within the hot leg and is entered via the portable Man-Machine-Interface (MMI). One DELTAH is required for each temperature loop.

1.3.2 Qualification

The EQ for Eagle 21 instrumentation is addressed in WCAP-12374. RTD qualification will be verified to support FPL's compliance to 10CFR50.49.

The Westinghouse qualification program contained a review of the WEED Instrument Company's qualification documentation for testing performed on these RTDs. It was concluded that the equipment's qualification was in compliance with IEEE Standards 344-1975 and 323-1974 with one exception.

Specifically, requirements relative to flow induced vibration were not addressed. To demonstrate that flow induced vibration would not result in significant aging mechanisms that could cause common mode concerns during a seismic event, Westinghouse performed flow induced vibration tests followed by pipe vibration aging and a simulated seismic event. These tests confirmed that the WEED RTDs do comply with the above IEEE standards.

1.3.3 RTD Operability Indication

Control board Delta T and T_{avg} indicators along with a RTD failure alarm and annunciator will provide the means of identifying RTD failures.

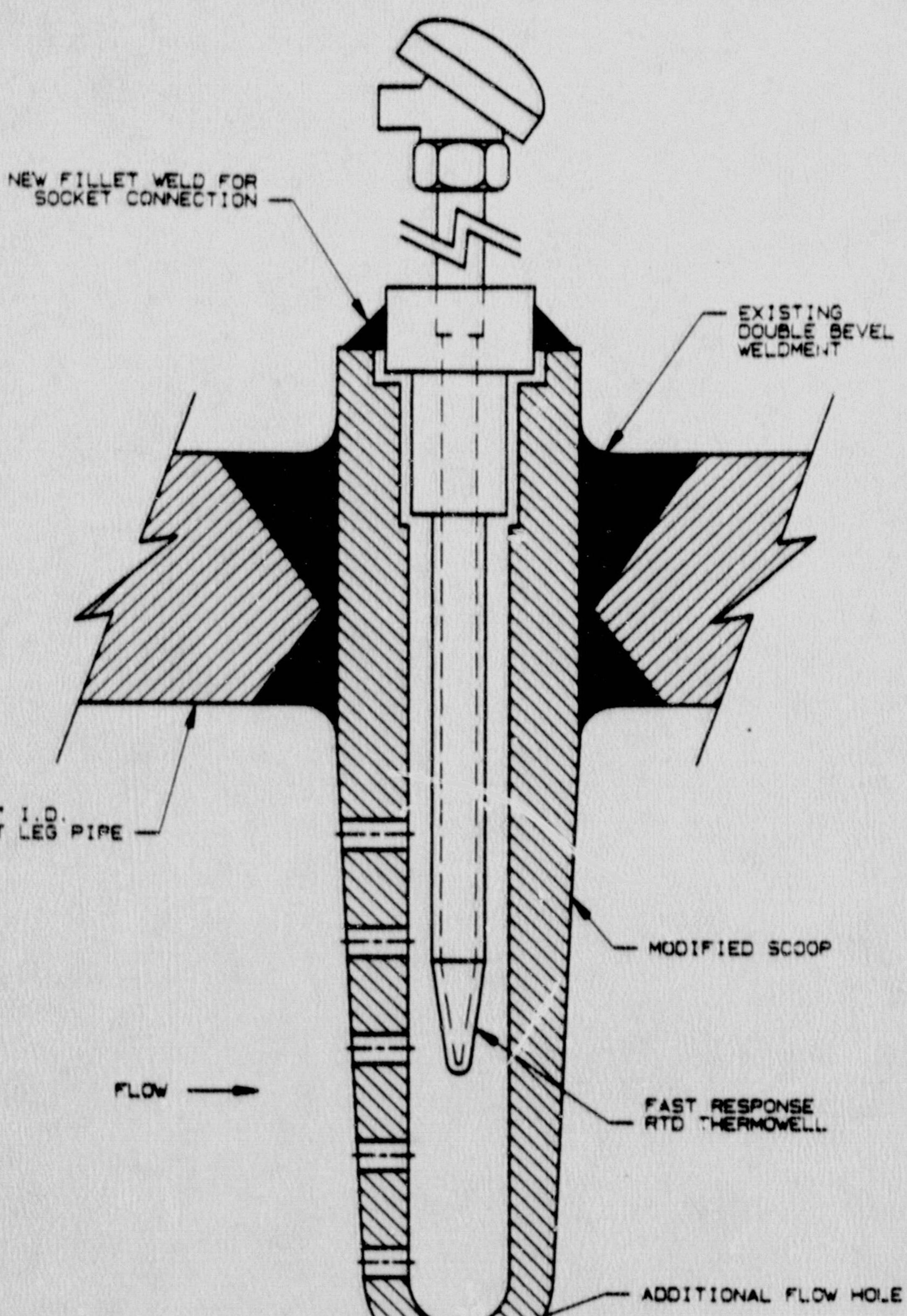

Figure 1.2-1 Hot Leg RTD Scoop Modification
for Fast Response RTD Installation

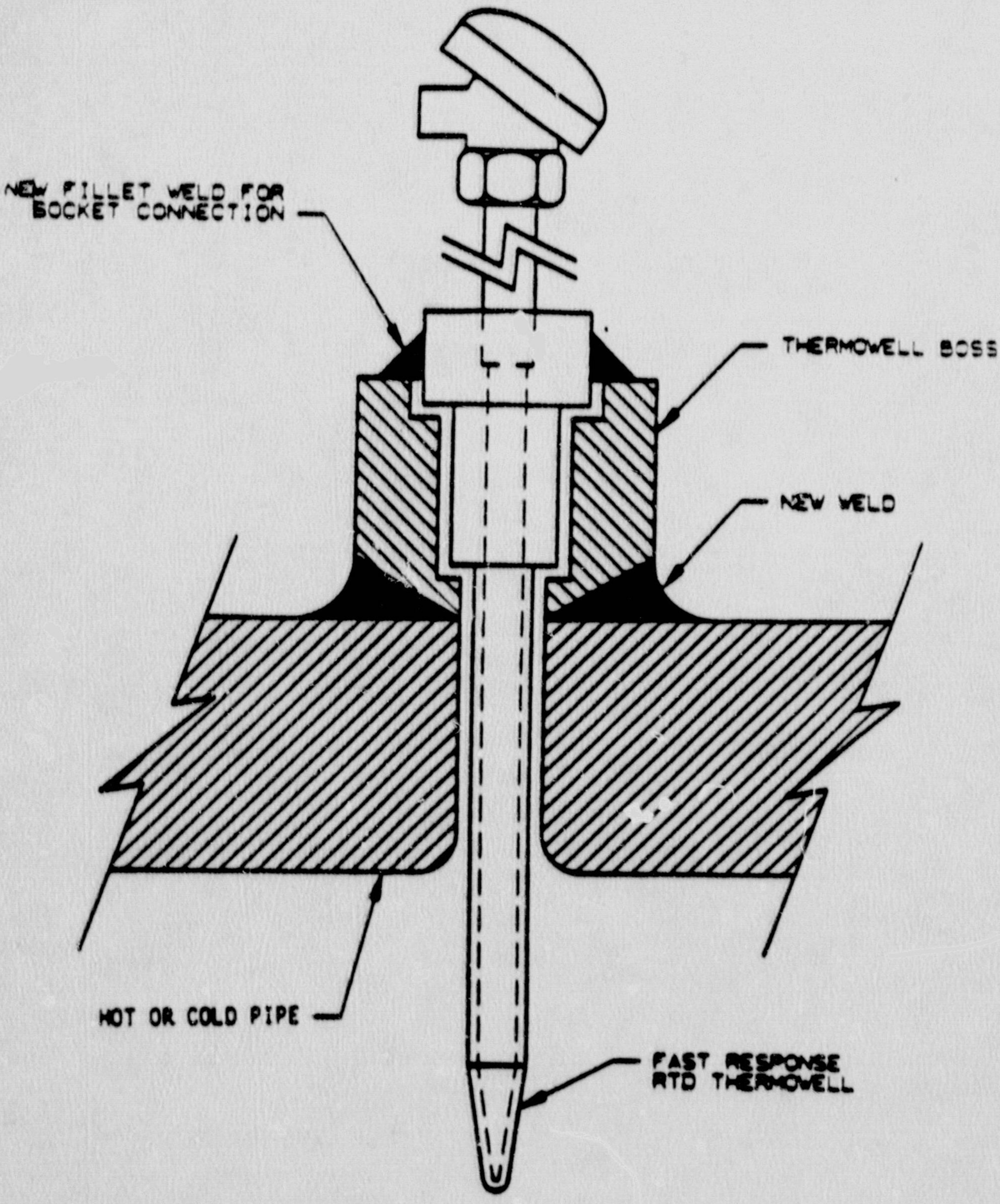

Figure 1.2-2 Hot and Cold Leg RTD Boss Installation for Fast Response RTD Installation

a,c

Figure 1.2-3 Cold Leg Pipe Nozzle Modification for Fast Response RTD Installation

2.0 TESTING

There are two specific types of tests which are performed to support the installation of the thermowell mounted fast-response RTDs in the reactor coolant piping: RTD response time tests and a hot leg temperature streaming test. The response time for the Turkey Point Units 3 and 4 application will be verified by testing at the RTD manufacturer and by in-situ testing. Data from thermowell/RTD performance at operating plants provide additional support for the system.

2.1 RESPONSE TIME TEST

The RTD manufacturer, WEED Instruments Inc., will perform response time testing of each RTD and thermowell prior to installation at Turkey Point Units 3 and 4. These RTD/thermowells must exhibit a response time bounded by the values shown in Table 2.1-1. The revised response time has been factored into the transient analyses discussed in Section 4.0.

In addition, response time testing of the WEED RTDs will be performed in-situ at Turkey Point Units 3 and 4. This testing will demonstrate that the WEED RTDs can s^tisfy the response time requirement when inst^'led in the plant.

2.2 STREAMING TEST

Past testing at Westinghouse PWRs has established that temperature stratification exists in the hot leg pipe with a temperature gradient from maximum to minimum of [ ]^{b,c,e}. A test program was implemented at an operating plant to confirm the temperature streaming magnitude and stability with measurements of the RTD bypass branch line temperatures on two adjacent hot leg pipes. Specifically, it was intended to determine the magnitude of the differences between branch line temperatures, confirm the short-term and long-term stability of the temperature streaming patterns and evaluate the impact on the indicated temperature if only 2 of the 3 branch line temperatures are used to determine an average temperatu' . This plant specific data is used in conjunction with data taken from o'.er Westinghouse designed plants to determine an appropriate temperature error for use in the safety analysis and calorimetric flow calculations. Section 3 will discuss the specifics of these uncertainty considerations.

The test data was reduced and characterized to answer the three objectives of the test program. First, it is conservative to state that the streaming pattern [ ]^{b,c,e}. Steady state data taken at 100% power for a period of four months indicated that the streaming pattern [ ]^{b,c,e}. In other words, the temperature gradient [ ]^{b,c,e}. This is inferred by [ ]^{b,c,e} observed between branch lines. Since the [ ]^{b,c,e} into the RTD averaging circuit if a hot leg RTD fails and only 2 RTDs are used to obtain an average hot leg temperature.

Both the test data and the operating data support previous calculations of streaming errors determined from tests at other Westinghouse plants. The temperature gradients defined by the recent plant operating data are well within the upper bound temperature gradients that characterize the previous data. Differences observed in the operating data compared with the previous data indicate that the temperature gradients are smaller, so the measurement uncertainties are conservative. The measurements at the operating plants, obtained from thermowell RTDs installed inside the bypass scoops, were expected to be, and were found to be, consistent with the measurements obtained previously from the bypass loop RTDs.

1

IMAGE EVALUATION TEST TARGET (MT-3)

1.0 1.1 1.25 1.4 1.6 1.8 2.0 2.2 2.5 2.8 3.2 3.6 4.0

150mm

6"

TABLE 2.1-1

RESPONSE TIME PARAMETERS FOR RCS TEMPERATURE MEASUREMENT

	RTD Bypass System	Fast Response Thermowell RTD System
	[a,c]	[a,c]
RTD Bypass Piping and Thermal Lag (sec)		
RTD Response Time (sec)		
Electronics Delay (sec)		
Total Response Time (sec)	6.0 sec	6.0 sec

3.0 UNCERTAINTY CONSIDERATIONS

This method of hot leg temperature measurement has been analyzed to determine the magnitude of the two uncertainties included in the Safety Analysis: Calorimetric Flow Measurement Uncertainty and Hot Leg Temperature Streaming Uncertainty.

3.1 CALORIMETRIC FLOW MEASUREMENT UNCERTAINTY

Reactor coolant flow is verified with a calorimetric measurement performed after the return to power operation following a refueling shutdown. The two most important instrument parameters for the calorimetric measurement of RCS flow are the narrow range hot leg and cold leg coolant temperatures. The accuracy of the RTDs has, therefore, a major impact on the accuracy of the flow measurement.

With the use of three T_{hot} RTDs (resulting from the elimination of the RTD Bypass lines) and the requirements of the latest Westinghouse RTD cross-calibration procedure (resulting in low RTD calibration uncertainties at the beginning of a fuel cycle), the Turkey Point Units 3 and 4 RCS Flow Calormetric uncertainty is determined to be [ ]^{a,c} including use of cold leg Elbow Taps (see Tables 3.1-2, 3, 4 and 5). This calculation is based on the standard Westinghouse methodology previously approved on earlier submittals of other plants associated with RTD Bypass Elimination or the use of the Westinghouse Improved Thermal Design Procedure. Tables 3.1-1 through 3.1-13 were generated specifically for Turkey Point Units 3 and 4 and reflect plant specific measurement uncertainties and operating conditions.

3.2 HOT LEG TEMPERATURE STREAMING UNCERTAINTY

The safety analyses incorporate an uncertainty to account for the difference between the actual hot leg temperature and the measured hot leg temperature caused by the incomplete mixing of coolant leaving regions of the reactor core at different temperatures. This temperature streaming uncertainty is based on an analysis of test data from other Westinghouse plants, and on calculations to evaluate the impact on temperature meas ement accuracy of numerous possible temperature distributions within the hot leg pipe. The test data has shown that the circumferential temperature variation is no more than [ ]^{b,c,e}, and that the inferred temperature gradient within the pipe is limited to about [ ]^{b,c,e}. The calculations for numerous temperature distributions have shown that, even with margins applied to the observed temperature gradients, the three-point temperature measurement (scoops or thermowell RTDs) is very effective in determining the average hot leg temperature. Turkey Point plant specific calculations for the thermowell RTD system have established an overall streaming uncertainty of [ ]^{b,c,e} for a hot leg measurement. Of this total, [ ]^{b,c,e}.

The new method of measuring hot leg temperatures, with the three hot leg thermowell RTDs, is at least as effective as the existing RTD bypass system. [ ]^{a,c}. Although the new method measures temperature at one point at the RTD/thermowell tip, compared to the five sample points in a 5-inch span of the scoop measurement, the thermowell measurement point is opposite the center hole of the scoop and therefore measures the equivalent of the average scoop sample if a linear radial temperature gradient exists in the pipe. The thermowell measurement may have a small error relative to the scoop measurement if the temperature gradient over the 5-inch scoop span is nonlinear. Assuming that the maximum inferred temperature gradient of [ ]^{b,c,e} exists from the center to the end of the scoop, the difference between the thermowell and scoop measurement is limited to [ ]^{b,c,e}. Since three RTD measurements are averaged, and the nonlinearities at each scoop are random, the effect of this error on the hot leg temperature measurement is limited to [ ]^{b,c,e}. On the other hand, imbalanced scoop flows can introduce temperature measurement uncertainties of up to [ ]^{a,c}.

In all cases, the flow imbalance uncertainty will equal or exceed the [ ]^{b,c,e} sampling uncertainty for the thermowell RTDs, so the new measurement system tends to be a more accurate measurement with respect to streaming uncertainties.

Temperature streaming measurements have been obtained from tests at 2, 3 and 4-loop plants and from thermowell RTD installations at 3 and 4-loop plants. Although there have been some differences observed in the orientation of the individual loop temperature distributions from plant to plant, the magnitude of the differences have been [

]^{b,c,e}."

Over the testing and operating periods, there were only minor variations of less than [ ]^{b,c,e} in the temperature differentials between scoops, and smaller variations in the average value of the temperature differentials. [

]^{b,c,e}.

Provisions were made in the RTD electronics for operation with only two hot leg RTDs in service. The two-RTD measurement will be biased to correct for the difference compared with the three-RTD average.

3.3 CONTROL AND PROTECTION FUNCTION UNCERTAINTIES

Calculations were performed to determine or verify the instrument uncertainties for the control and protection functions affected by the RTD Bypass Elimination. Table 3.1-1, Rod Control System Accuracy, note that an acceptable value for control is calculated. Table 3.1-6 provides the uncertainty breakdown for Overtemperature ΔT. A comparison of the Channel Statistical Allowance with the Total Allowance noted on Table 3.1-7 results in the conclusion that sufficient margin exists for the uncertainties. Table 3.1-8 documents the breakdown for Overpower ΔT. Comparing the Channel Statistical Allowance for this function with the Total Allowance noted on Table 3.1-9 will conclude that this function is acceptable. Table 3.1-10 provides the Loss of Flow breakdown.

Table 3.1-11 provides the uncertainty breakdown for Pressurizer Water Level-High. This channel is included by the substitution of the existing Hagan racks with the W digital Eagle 21 hardware. A comparison of the Channel Statistical Allowance with the Total Allowance noted on Table 3.1-11 results in the conclusion that sufficient margin exists for the uncertainties. Table 3.1-12 provides the uncertainty breakdown for T_{avg} - Low - Low. A comparison of the Channel Statistical Allowance with the Total Allowance noted on Table 3.1-12 results in the conclusion that sufficient margin exists for the uncertainties. Table 3.1-13 lists the affected protection function Technical Specification values, some modifications are necessary, as noted. However, based on the calculations performed, the changes in uncertainties are acceptable with minimal modifications to the plant Technical Specifications, primarily Allowable Values.

TABLE 3.1-1

ROD CONTROL SYSTEM ACCURACY

Tavg ERI EAO ANALOG TURBINE MSS

SENSOR/TRANSMITTER

+a,c

PMA =
SCA =
SMTE =
STE =
SD =
BIAS =

PROCESS RACKS

+a,c

RCA =
RMTE =
RTE =
RD =
CA =

\# RTDs USED - TH = 2 TC = 1

+a,c

ELECTRONICS CSA =
ELECTRONICS SIGMA =
CONTROLLER SIGMA =
CONTROLLER BIAS =
CONTROLLER CSA =

TABLE 3.1-2

FLOW CALORIMETRIC INSTRUMENTATION UNCERTAINTIES

(% SPAN)	FW TEMP	FW PRES	FW DP	STM PRESS	TH	TC	PRZ PRESS
							+a,c
SCA =							
SMTE =							
SPE =							
STE =							
SD =							
RCA =							
RMTE =							
RTE =							
RD =							
RDOT =							
BIAS =							
CSA =							
# OF INST USED				1	3	1	3
	DEG F	PSIA	%DP	PSIA	DEG F	DEG F	PSIA
INST SPAN =	194.0	1500.0	100.0	1200.0	100.0	100.0	800.0
							+a,c
INST UNC. (RANDOM) =							
INST UNC. (BIAS) =							
NOMINAL =							

TABLE 3.1-3

FLOW CALORIMETRIC SENSITIVITIES

FEEDWATER FLOW

FA

- TEMPERATURE =
- MATERIAL =

DENSITY

- TEMPERATURE =
- PRESSURE =

DELTA P =

FEEDWATER ENTHALPY

- TEMPERATURE =
- PRESSURE =

+a,c

hS	=	1199.8 BTU/LBM
hF	=	415.5 BTU/LBM
Dh(SG)	=	784.3 BTU/LBM

STEAM ENTHALPY

- PRESSURE =
- MOISTURE =

HOT LEG ENTHALPY

- TEMPERATURE =
- PRESSURE =

+a,c

hH	=	616.5 BTU/LBM
hC	=	542.5 BTU/LBM
Dh(VESS)	=	74.1 BTU/LBM
Cp(TH)	=	0.1438E+01 BTU/LBM-°F

COLD LEG ENTHALPY

- TEMPERATURE =
- PRESSURE =

+a,c

Cp(TC) = 0.1234E+01 BTU/LBM-°F

COLD LEG SPECIFIC VOLUME

- TEMPERATURE =
- PRESSURE =

+a,c

TABLE 3.1-4

CALORIMETRIC RCS FLOW MEASUREMENT UNCERTAINTIES

+a,c

COMPONENT	INSTRUMENT ERROR	FLOW UNCERTAINTY
FEEDWATER FLOW		
VENTURI		
THERMAL EXPANSION COEFFICIENT		
TEMPERATURE		
MATERIAL		
DENSITY		
TEMPERATURE		
PRESSURE		
DELTA P		
FEEDWATER ENTHALPY		
TEMPERATURE		
PRESSURE		
STEAM ENTHALPY		
PRESSURE		
MOISTURE		
NET PUMP HEAT ADDITION		
HOT LEG ENTHALPY		
TEMPERATURE		
STREAMING, RANDOM		
STREAMING, SYSTEMATIC		
PRESSURE		
COLD LEG ENTHALPY		
TEMPERATURE		
PRESSURE		
COLD LEG SPECIFIC VOLUME		
TEMPERATURE		
PRESSURE		

TABLE 3.1-4 (continued)

CALORIMETRIC RCS FLOW MEASUREMENT UNCERTAINTIES

		+a,c
BIAS VALUES		
FEEDWATER PRESSURE	DENSITY	
	ENTHALPY	
STEAM PRESSURE	ENTHALPY	
PRESSURIZER PRESSURE	ENTHALPY - HOT LEG	
	ENTHALPY - COLD LEG	
	SPECIFIC VOLUME - COLD LEG	
FLOW BIAS TOTAL VALUE		

*,**,+,++ INDICATE SETS OF DEPENDENT PARAMETERS

1 LOOP UNC	
N LOOP UNC	

TABLE 3.1-5

COLD LEG ELBOW TAP FLOW UNCERTAINTY

INSTRUMENT UNCERTAINTIES

ACCURACY OF INDICATED RCS FLOW FROM PROCESS COMPUTER

+a, c

ALL VALUES IN % FLOW

PMA	=	
PEA	=	
SCA	=	
SMTE	=	
SPE	=	
STE	=	
SD	=	
BIAS	=	
RCA	=	
RMTE	=	
RTE	=	
RD	=	
A/D	=	
ROUT	=	

+a,c

1 LOOP ELBOW TAP	=	
N LOOP ELBOW TAP	=	
N LOOP RCS FLOW TAP	=	

TABLE 3.1-6

OVERTEMPERATURE ΔT

<u>PARAMETER</u> <u>ALLOWANCE</u>

Process Measurement Accuracy

ΔT - [ ] +a,c [ ] +a,c

ΔI -

ΔI -

Primary Element Accuracy

Sensor Calibration

ΔT - [($\pm$

Pressure - $\pm$ ( ] +a,c

Measurement & Test Equipment Accuracy

Pressure - [ ]** +a,c

Sensor Temperature Effects

Pressure - [ ]

Sensor Drift

ΔT - [ ] +a,c

Pressure -

Bias

Environmental Allowance

Rack Calibration ΔT span +a,c

ΔT - [ ]

ΔI -

Pressure -

TABLE 3.1-6 (continued)

OVERTEMPERATURE ΔT

PARAMETER		ALLOWANCE
Measurement & Test Equipment Accuracy		[ ]+a,c
ΔT		
ΔI		
Tavg		
Pressure		
Rack Tem rature Effects		
ΔT	- [ ] +a,c	
ΔI		
Pressure		
Rack drift		
ΔT		
ΔI		
Pressure		

----

* In % span (Tavg - 100°F, pressure - 800 psi, power - 120% RTP, ΔT - 75°F, ΔI - ±60% ΔI)

** See Table 3.1-7 for gain and conversion calculations

*** [+a,c

TABLE 3.1-6 (continued)

OVERTEMPERATURE ΔT

Channel Statistical Allowance - 5.6% ΔT SPAN

Total Allowance = $\left[\quad\right]^{+a,c}$
Margin

TABLE 3.1-7

OVERTEMPERATURE ΔT GAIN CALCULATIONS

The equation for Overtemperature ΔT is:

$$\Delta T\ [(1 + \tau_1 S)/(1 + \tau_2 S)]\ [(1)/(1 + \tau_3 S)] \leq$$

$$\Delta T_o[K_1 - K_2[(1 + \tau_4 S)/(1 + \tau_5 S)][T[(1)/(1 + \tau_6 S)] - T'] + K_3(P-P') - f_1(\Delta I)]$$

K_1 (nominal)	=	1.0950 Technical Specification value
K_1 (max)	=	[ ]+a,c
K_2	=	0.0107/°F
K_3	=	0.000453/psi
ΔT_o:vessel ΔT	=	56.1°F
ΔI gain	=	1.5 FP ΔI/%ΔI

+a,c

Pressure Gain =
Pressure SCA =
Pressure SMTE =
Pressure STE =
Pressure SD =

+a,c

ΔI conversion =
ΔI PMA_1 =
ΔI PMA_2 =

Total Allowance (TA) =
[ ] +a,c

TABLE 3.1-8

OVERPOWER ΔT

Parameter	Allowance*
Process Measurement Accuracy ΔT - [ ]+a,c	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration ΔT - [ ]+a,c	
Sensor Pressure Effects	
Sensor Drift ΔT - [ ]+a,c	
Environmental Allowance	
Rack Calibration	
ΔT - [ ] +a,c	
Tavg	
Measurement & Test Equipment Accuracy	
ΔT	
Tavg	
Rack Accuracy	
[ ]+a,c	
Tavg	
Rack Temperature Effects Δ T - [ ] +a,c	
Rack Drift ΔT - [ ]+a,c	

TABLE 3.1-8 (continued)

OVERPOWER ΔT

---

* In % span (Tavg - 100°F, ΔT - 75°F, POWER - 120% RTP)
** [ ]+a,c

Channel Statistical Allowance = [ ] +a,c

MARGIN = [ ]+a,c

TOTAL ALLOWANCE = [ ]+a,c

TABLE 3.1-9

OVERPOWER ΔT GAIN CALCULATIONS

The equation for Overpower ΔT is:

$$\Delta T\ [(1 + \tau_1 S)/(1 + \tau_2 S)]\ [(1)/(1 + \tau_3 S)] \leq$$

$$\Delta T_o[K_4 - K_5[[(\tau_7 S)/(1 + \tau_7 S)][(1)/(1 + \tau_6 S)]]T - K_6[T[(1)/(1 + \tau_6 S)] - T''] - f_2\ (\Delta I)]$$

K_4 (nominal) = 1.09 Technical Specification value
K_4 (max) = [ ]$^{+a,c}$
K_5 = 0.02/F
K_6 = 0.00068/F
ΔT_o = vessel ΔT = 56.1°F

Total Allowance =
[ ]$^{+a,c}$

TABLE 3.1-10

LOSS OF FLOW

RCS LOW FLOW TRIP ACCURACY

+a,c

ALL VALUES IN % FLOW SPAN

PMA =
PEA =
SCA =
SMTE =
SPE =
STE =
SD =
BIAS =
RCA =
RMTE =
RCSA =
RTE =
RD =

FLOW SPAN =
SAL =
ALLV =
NOM =

MAR = [ ] +a,c
TA =

S = [ ] +a,c
CSA =

Z = [ ] +a,c
T =

TABLE 3.1-11

PRESSURIZER WATER LEVEL - HIGH

Parameter	Allowance*
Process Measurement Accuracy [ ]+a,c	[ ]+a,c
Primary Element Accuracy	
Sensor Calibration M&TE	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
Environmental Allowance	
Rack Calibration	
Rack Accuracy M&TE	
Rack Temperature Effects	
Rack Drift	

* In percent span (100 percent span)

Channel Statistical Allowance = 7.9% span +a,c

Z = [ ]+a,c
TA = [ ]

S = [ ]+a,c
CSA = [ ]

T = [ ]+a,c
MAR = [ ]

TABLE 3.1-12

Tavg - Low-Low Trip Accuracy

PMA =	[ ] $^{+a,c}$		
SCA =			
SD =			
RCA =			
RMTE =			
RTE =			
RD =			
BIAS =			
SAL =		NOM =	543.00
ALLV =			
Tavg SPAN =			

MAR =	[ ] $^{+a,c}$	S =	[ ] $^{+a,c}$	Z =	[ ] $^{+a,c}$
TA =		CSA =		T =	

TABLE 3.1-13

TECHNICAL SPECIFICATION MODIFICATIONS

Functional Unit/Page no.	Modification	Justification
Pressurizer Water Level High, page 2-4	Addition of Allowable Value, 92.2%.	Application of W setpoint methodology.
Overtemperature ΔT, page 2-7	RTD Response time constants changed.	Elimination of RTD bypass lines.
Overtemperature ΔT, page 2-8	Reduced DeltaI Gain to 1.5, added allowable value of 1.5%.	W Safety Evaluation SECL No. 89-1164, and W setpoint methodology.
Overpower ΔT, page 2-10	Removed DeltaI Gain and added allowable value of 1.4%.	W Safety Evaluation SECL No. 89-1164, and W setpoint methodology.
Overpower ΔT, page B 2-5	Removed DeltaI Gain from bases.	Safety Evaluation W SECL No. 89-1164.
T_{avg} - Low, pages 3/4 3-23, 25, & 27	Revised trip setpoint to 543°F and added an allowable value of 542.5°F.	Application of W setpoint methodology.

TABLE 3.1-13
(Continued)

TECHNICAL SPECIFICATION MODIFICATIONS

Functional Unit/Page no.	Modification	Justification
Overtemperature ΔT Table 4.3-1, Pages 3/4 3-8 and 3/4 3-12	Remove Note 12	Elimination of RTD Bypass Lines
Reactor Coolant Flow Low Page 2-4	Added an allowable value of 88.7%.	Application of W Setpoint Methodology
Setpoint Tables 2.2-1 and 3.3-3 and Bases 2-2.1, 3/4-3.1 3/4-3.2 Pages 2-3, 2-4, B2-3 3/4 3-13, 3/4 3-23, 3/4 3-25 3/4 3-27, B3/4 3-1 and B 3/4 3-2, 2-7, 2-8, 2-9 and 2-10	Added bases for using the 5 column setpoint format and provided values for functions implemented in the digital process system.	Application of W Setpoint Methodology
Tables 4.3-1 and 4.3-2 pages 3/4 3-8, 3/4 3-29, 3/4 3-32, 3/4 3-34.	Change analog channel operational test surveillance test interval to quarterly	WCAP 10271 and subsequent W evaluation for digital process control equipment
Tables 3.3-1 and 3.3-2, pages 3/4 3-2, 3/4 3-7, 3/4 3-15, 3/4 3-18, 3/4 3-22.	Channel surveillance testing	WCAP 10271 and subsequent W evaluation for digital process control equipment

4.0 SAFETY EVALUATION

The primary impacts of the RTD Bypass Elimination on the FSAR Chapter 14 (Reference 1) safety analyses are the differences in response time characteristics and instrumentation uncertainties associated with the fast response thermowell RTD system. The effects of these differences are discussed in the following sections.

4.1 RESPONSE TIME

The current response time parameters of the Turkey Point Units 3 and 4 RTD bypass system assumed in the safety analyses are shown in Table 2.1-1. For the fast response thermowell RTD system, the overall response time will consist of [ ]^{a,c} (as presented in Section 2.1 and as given in Table 2.1-1).

The new thermowell mounted RTDs have a response time equal to or better than the maximum allowed (assumed) time for the combined old bypass piping transport, thermal lag and direct immersion RTD. This allows the total RCS temperature measurement response time to remain unchanged at 6.0 seconds (Reference Table 2.1-1). This channel response time is factored into the Overtemperature ΔT (OTΔT) and Overpower ΔT (OPΔT) trip performance. Those transients that rely on the above mentioned trips must be addressed for the modified response characteristics. Section 4.3 includes a discussion of this evaluation.

4.2 RTD UNCERTAINTY

The proposed fast response thermowell RTD system will make use of RTDs, manufactured by Weed Instruments Inc., with a total uncertainty of [ ]^{a,c} assumed for the analyses.

The FSAR analyses make explicit allowances for instrumentation errors for some of the reactor protection system setpoints. In addition, uncertainty allowances are made for the average reactor coolant system (RCS) temperature, pressure and power. These allowances are explicitly applied in the initial conditions for the transients.

The following protection and control system parameters were evaluated and determined to be unaffected (with respect to current accident analysis and evaluation assumptions in References 1 and 2) by the change from one hot leg RTD to three hot leg RTDs are: the Overtemperature ΔT (OTΔT), Overpower ΔT (OPΔT), and Low RCS Flow reactor trip functions, RCS loop T_{avg} measurements used for input to the rod control system, and the calculated value of the RCS flow uncertainty. The results of system uncertainty calculations, noted in Section 3.3, indicate that sufficient margin exists to account for known instrument uncertainties.

4.3 NON-LOCA EVALUATION

The RTD response time discussed in Section 2.1 and the instrument uncertainties discussed in Section 3.3 have been considered for the Turkey Point Units 3 and 4 non-LOCA safety analysis design basis. These effects are discussed separately in the following paragraphs.

Only those transients which assume OTΔT/OPΔT protection are potentially affected by changes in RTD response time. As noted in Section 4.1, the new thermowell mounted RTDs have a response time equal to or better than the old bypass transport, thermal lag and direct immersion RTD. On the basis of the information documented in Table 2.1-1, it is concluded that the safety analysis assumption for the total OTΔT/OPΔT channel response time of 6.0 seconds remains valid. Additionally, evaluation of the effects of the RTD bypass elimination on the uncertainties associated with these setpoints supports the continued validity of the current non-LOCA safety analyses.

RTD instrumentation uncertainties can affect the non-LOCA transient initial condition assumptions and those transients which assume protection from the low primary coolant flow reactor trip. As determined in Section 3.0 the RTD bypass elimination does not increase any uncertainty that will affect any initial condition assumed in any non-LOCA transient or the low primary coolant flow reactor trip.

In conclusion, the non-LOCA safety analyses applicable to Turkey Point Units 3 and 4 have been evaluated with respect to the replacement of the existing RTD Bypass System with the fast response thermowell installed in the reactor coolant loop piping. It was determined that all safety analysis assumptions currently assumed in the non-LOCA analyses remain valid. The Reference 1 and 2 results and conclusions are unchanged and all applicable non-LOCA safety analysis acceptance criteria continue to be met.

4.4 LOCA EVALUATION

The elimination of the RTD bypass system impacts the uncertainties associated with RCS temperature measurement. The magnitude of the uncertainties are such that PCS inlet and outlet temperatures, thermal design flow rate and the steam generator performance data used in the LOCA analyses will not be affected. Past sensitivity studies have shown that the variation of the core inlet temperature (T_{in}) used in the LOCA analyses affects the predicted core flow during the blowdown period of the transient. The amount of flow into the core is influenced by the two-phase vessel-side break flow, and the core cooling is affected by the quality of the fluid. These sensitivity studies concluded that the inlet temperature effect on peak clad temperature is dependent on break size. As a result of these studies, the LOCA analyses are performed at a nominal value of T_{in} without consideration of small uncertainties. The RCS flow rate and steam generator secondary side temperature and pressure are also determined using the loop average temperature (T_{avg}) output. These nominal values used as inputs to the analyses are not affected due to the RTD bypass elimination. It is concluded that the elimination of the RTD bypass piping will not affect the LOCA analyses input and hence, the results of the analyses for Turkey Point Units 3 and 4 remain unaffected. Therefore, the plant design changes due to the RTD bypass elimination are acceptable from a LOCA analysis standpoint without requiring any reanalysis.

4.5 INSTRUMENTATION AND CONTROL SAFETY EVALUATION

The RTD BYPASS ELIMINATION functional upgrade modification affects the measurement of the RCS hot leg temperature. Prior to the modification, the RCS hot leg coolant was sampled by scoops in the main piping and an average hot leg temperature was obtained from a single RTD mounted in the hot leg bypass manifold. The RCS cold leg measurement was obtained from a single RTD mounted in the cold leg bypass manifold. With the elimination of the RTD bypass manifold, three (3) hot leg RTD's are installed in thermowells mounted in what was previously the bypass manifold scoops wherever possible. The temperatures read at these locations are somewhat different because of streaming effects. Thus, the three temperatures are to be processed to produce an average temperature (T_{have}) for each hot leg. The cold leg temperature measurement on each loop is accomplished with a dual element narrow range RTD installed in a thermowell. The thermowell is mounted either in the existing cold leg bypass connection or boss mounted in a new penetration. The cold leg sensors are inherently redundant in that either sensor can adequately represent the cold leg temperature measurement. Temperature streaming in the cold leg is not a concern due to the mixing action of the reactor coolant pump.

The process system used to calculate T_{have} and T_{cold} is designated as the Eagle 21 Temperature Averaging System (TAS). The TAS becomes part of the Thermal Overpower and Overtemperature Protection System because the TAS outputs (T_{have} and T_{cold}) replace the Thot and Tcold signals previously derived from the bypass manifold RTDs. A generic topical report providing details on Eagle 21 design philosophy, system architecture, hardware, software, qualification, verification, validation, and compliance with criteria has been documented as WCAP-12374.

4.5.2 DESIGN AND IMPLEMENTATION

The Eagle 21 TAS system accepts RTD input signals representing two (2) cold leg and three (3) hot leg temperature measurements per loop (Figure 4.5.2-1). The two cold leg temperatures are processed to produce an average cold leg temperature T_{COLD}. The three hot leg temperatures are processed to produce the average hot leg temperature T_{have}. T_{have} is then combined with T_{COLD} to produce the loop average temperature (Tavg) and the loop difference temperature (Delta T). The resultant signals replace the same signals previously derived in the analog Thermal Overpower and Overtemperature protection channels.

The two cold leg temperature input signals are subjected to range and consistency checks and then averaged to provide a group value for T_{COLD} (Figure 4.5.2-2). If these signals agree within an acceptable interval (DELTAC), the group quality is set to GOOD. If the signals do not agree within the acceptable tolerance DELTAC, the group quality is set to BAD and the individual input signal qualities are set to POOR. The average of the two TCOLD input signals is used to represent the group in either case. One cold leg temperature input signal per loop maybe deleted manually by use of the portable MMI. The remaining T_{cold} input signal will provide the loop T_{cold} temperature. DELTAC is an input parameter based on operating experience and is entered via the portable Man Machine Interface (MMI). One DELTAC is required for each temperature loop.

The Eagle 21 TAS employs an algorithm that automatically detects a defective hot leg RTD input signal and eliminates that input from the T_{have} calculation. This is accomplished by incorporating a Redundant Sensor Algorithm (RSA) into the hot leg temperature signal processing. The RSA determines the validity of each input signal and automatically rejects a defective input (Figure 4.5.2-3).

Each of the three hot leg temperature input signals is subjected to a range check. These signals are utilized to calculate an estimated average hot leg temperature which is then consistently checked against the other two estimates for average hot leg temperature. An estimated average hot leg temperature is derived from each T_{hot} input signal by adding or subtracting as necessary, a temperature streaming correction factor (Sj). Then, the average of the three estimated average hot leg temperatures is computed and the individual estimates are checked to determine if they agree within ± DELTAH of the average value. If all of the signals do agree within ± DELTAH of the average value, the group quality is set to GOOD. The group value T_{have} is set to the average of the three estimated average hot leg temperatures.

If the signal values do not all agree within ± DELTAH of the estimate of the hot leg average temperature, the RSA will delete the signal value which is furthest from the average. The quality of the deleted signal is then set to POOR and a consistency check is performed on the remaining GOOD signals. If the two remaining signals pass the consistency check, the group value will be taken as average of these remaining GOOD signals and the group quality will be set to POOR. However, if these signals again fail the consistency check (within ± DELTAH), the group value will be set to the average of the two signals; but the group quality will be set to BAD. All of the individuals signals will have their quality set to POOR. DELTAH is an input parameter based upon temperature distribution tests within the hot leg and is entered via the portable MMI. One DELTAH is required for each temperature loop.

The Eagle 21 system has been designed with the capability to perform automatic surveillance tests on the TAS algorithms associated with the RTD Bypass Elimination functional upgrade.

4.5.3 ALARMS, ANNUNCIATORS AND STATUS LIGHTS

Additional control room alarms, annunciators and status lights are provided as part of the RTD Bypass Elimination functional upgrade. These additional indications are as follows:

1. A "Trouble" alarm and annunciator window is added common to all 3 loops. This light is actuated anytime the T_{have} group value for a coolant loop is set to POOR as described in Section 4.5.2. [This alarm and annunciator informs the operator that there are only two good narrow range T_{hot} signals for one of the coolant loops.]

2. An "RTD Failure" alarm and annunciator window is added common to all 3 loops. This alarm and annunciator is actuated anytime the T_{cold} or T_{have} group value for a coolant loop is set to BAD as described in Section 4.5.2. This alarm and annunciator informs the operator that there is an invalid T_{cold} or T_{have} group value for a loop. A Technical Specification action statement will be in effect to cover this condition.

3. A bypass alarm and annunciator window is added for each affected rack. This alarm and annunciator is actuated anytime a protection rack is placed in bypass. This alarm and annunciator informs the operator that a protection channel has been bypassed. This is consistent with IEEE-279-1971. Bypassing of Protection functions for the Eagle 21 channels will be administratively controlled.

The conversion to thermowell mounted RTDs will result in elimination of the control grade RTDs and their associated control board indicators. The protection grade channels will now be used to provide inputs to the control system through isolators to prohibit faults in the control system from propagating into the protection racks.

In order to satisfy the control and protection interaction requirements of IEEE 279-1971, a Median Signal Selector (MSS) will be used in the control

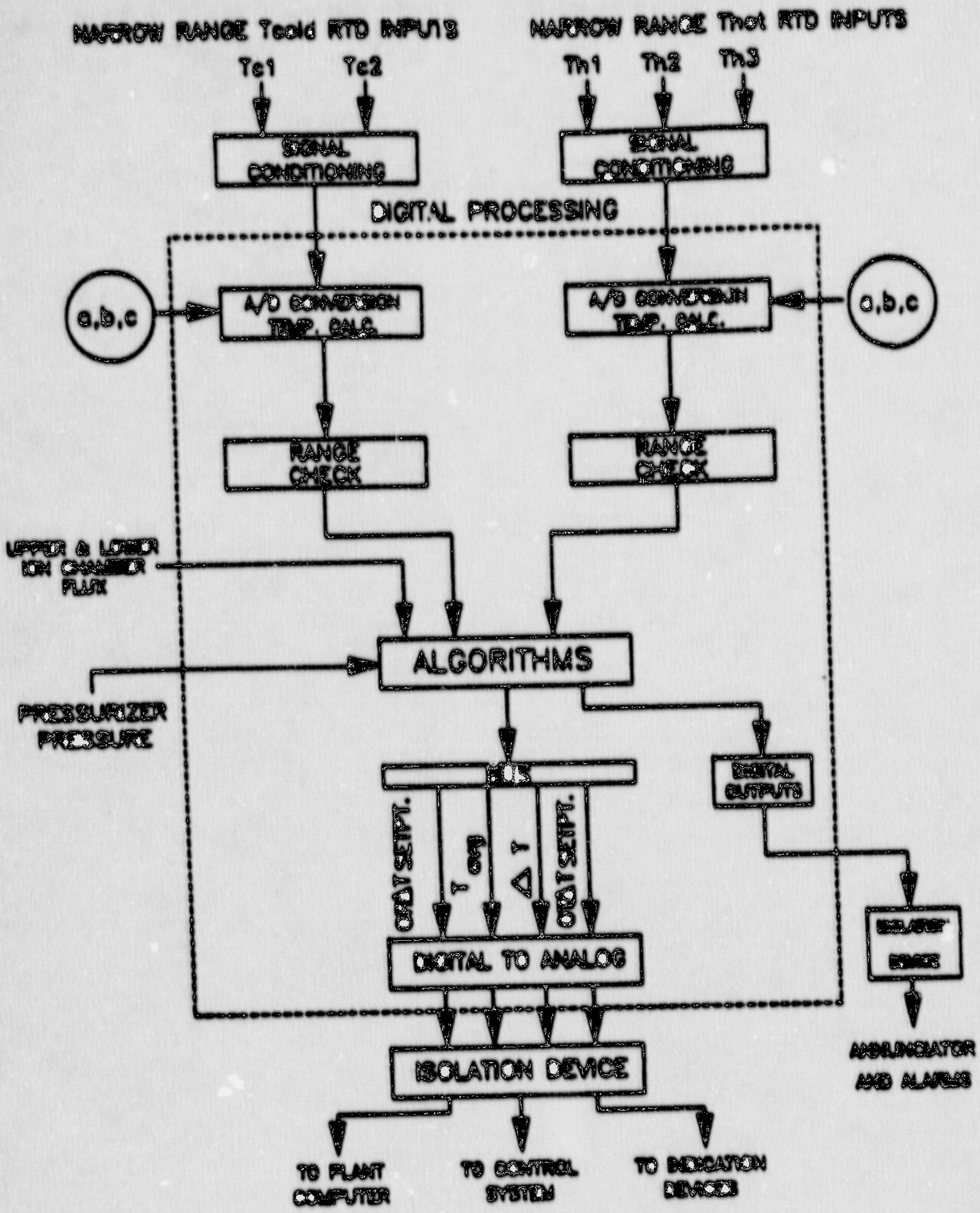

Figure 4.5.2-1 Thermal Overtemperature and Overpower Digital Flow Diagram

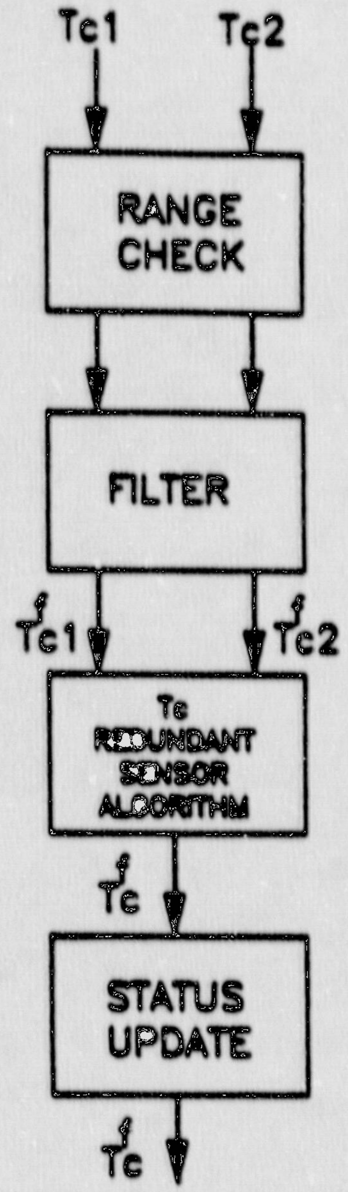

Figure 4.5.2-2 Functional Logic Diagram (T_{cold})

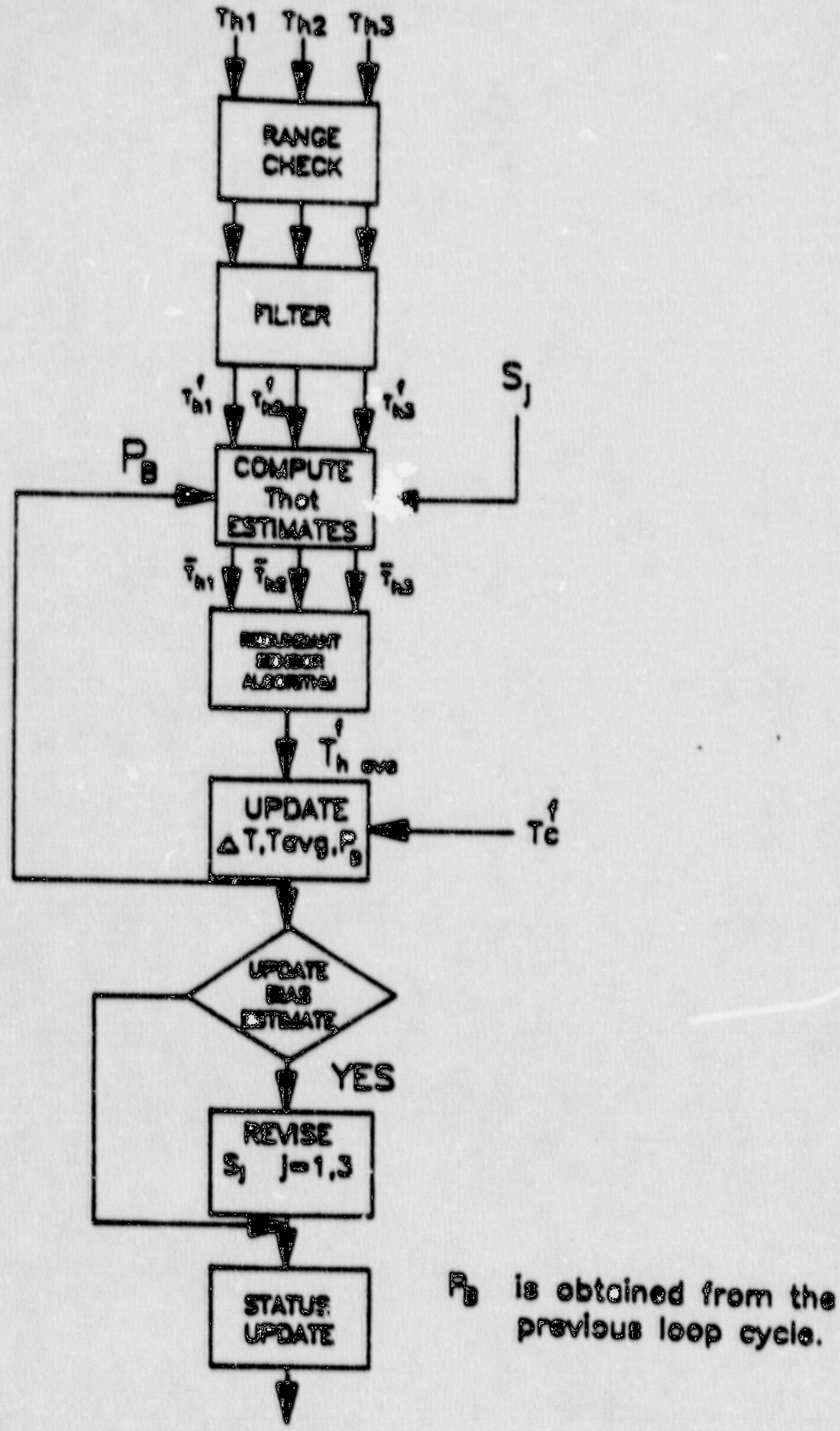

Figure 4.5.2-3 Functional Logic Diagram (T_{hot})

channels presently utilizing a high auctioneered T_{avg} or Delta T signal (there will be a separate MSS for each function). The Median Signal Selector will use as inputs the protection grade T_{avg} or Delta T signals from all three loops, and will supply as an output the channel signal which is the median of the three signals. The effect will be that the various control grade systems will still use a valid RCS temperature in the case of a single signal failure. Utilization of the Median T_{avg} and ΔT signals will have no adverse effects on Control System operability.

To ensure proper action by the Median Signal Selector, the present manual switches that allow for defeating of a T_{avg} or Delta T signal from a single loop will be eliminated. The MSS will automatically select a valid signal in the case of a signal failure. Warnings that a failure has occurred will be provided by loop to median T_{avg} and Delta T deviation alarms.

The overtemperature, overpower, T_{avg} Low-Low, Loss of Flow, and pressurizer level existing Model 7100 process electronics will be replaced with the Eagle 21 Process Protection System for each affected protection set. All existing 7100 modules for these channels will be removed for use as spares in other protection channels. The two of three voting relay logic now derived from the Eagle 21 protection channels will remain the same.

For unaffected channels, the inputs to the bistables remain the same. The Reactor Protection System for the unaffected channels will remain the same, as that previously utilized. For example, two out of three voting logic channels continues to be utilized with the model 7100 process control bistables continuing to operate on a "de-energize to actuate" principle.

The above principles of the modification have been reviewed to evaluate conformance to the requirements of IEEE-279-1971, and associated 10CFR50 General Design Criteria (GDC), Regulatory Guides, and other applicable industry standards, for the affected channels. IEEE 279-1971 requires documentation of a design basis. Following is a discussion of design basis requirements in conformance to pertinent I&C criteria:

a. The single failure criterion continues to be satisfied by this change because the independence of redundant protection sets is maintained.

b. The quality of the components and modules being added is consistent with use in a Nuclear Generating Station Protection System. For the Westinghouse Quality Assurance program, refer to 8370/7800 Rev. 11/7 A.

c. The changes will continue to maintain the capability of the protection system to initiate a reactor trip to the same extent as the existing system.

d. Channel independence and electrical separation is maintained because the Protection Set circuit assignments continue to be loop 1 circuits input to Protection Set I; Loop 2 to Protection Set II; and Loop 3 to Protection Set III.

e. Due to the elimination of the dedicated control system RTD elements, temperature signals for use in the plant control systems must now be derived from the protection system RTDs. To eliminate any degrading control and protection system interaction mechanisms introduced as a consequence of the RTD Bypass Elimination modification, a Median Signal Selector has been introduced into the control system. The Median Signal Selector preserves the functional isolation of interfacing control and protection systems that share common instrument channels. The signal selector implementation is described in Section 1.3.1.

On the basis of the foregoing evaluation, it is concluded that all I&C equipment being upgraded for Turkey Point Units 3 and 4 is in compliance with IEEE 279-1971, applicable GDCs, and industry standards and regulatory guides.

4.5.4 TEST ENHANCEMENTS

For those racks being upgraded with Eagle 21 process protection equipment, test enhancements discussed and approved generically in WCAP-10271-P-A "Evaluation of Surveillance Frequencies and out of service times for the reactor protection instrumentation system" are being implemented (Reference 2). The specific enhancements being implemented are as follows:

1. Extending surveillance intervals for Reactor Trip (RT) channels from one month to quarterly.
2. Increasing the two hour time limit to four hours for a RT channel to be bypassed to allow for testing of another channel in the same function.

In the Sequoyah Safety Evaluation Report (Docket No. 50-327) dated May 16, 1990, the NRC staff concluded that these same test enhancements were consistent with the approved Topical Report WCAP-10271-P-A and therefore, are acceptable.

4.6 MECHANICAL SAFETY EVALUATION

The presently installed RTD bypass system is to be replaced with fast acting narrow range RTD thermowells. This change requires modifications to the hot leg scoops, the hot and cold leg piping, the crossover leg bypass return nozzle, and the cold leg bypass manifold connection. All welding and NDE will be performed per ASME Code Section XI 1980 through Winter 1981 Addenda requirements. Each of these modifications is evaluated below.

The hot leg temperature measurement on each loop will be accomplished using three (3) fast response, narrow range dual element RTDs mounted in thermowells. To accomplish the sampling function of the RTD bypass manifold system and minimize the need for additional hot leg piping penetrations, the RTD thermowell assemblies will be located within the existing RTD Bypass Manifold Scoops wherever possible. [

]^{a,c} to provide the proper flow path. If a structural interferences or a skewed scoop preclude the placement of a thermowell in a given scoop, then the scoop will be capped and a new RCS penetration made to accommodate the relocated thermowell. The relocated RTD/thermowell will be located in an installation boss and be positioned such that the process measurement accuracy associated with temperature streaming (Section 3.3) will be maintained for the three RTD average temperature. The thermowell will be fabricated in accordance with Section III (Class 1) of the ASME Code. The installation of the thermowell into the scoop or boss will be performed using GTAW for the root pass and finished out with either Gas Tungsten Arc Weld (GTAW) or Shielded Metal Arc Weld (SMAW). The welding will be examined by penetrant test (PT) per the ASME Code Section XI. Prior to welding, the surface of the scoop or boss onto which welding will be performed will be examined as required by Section XI.

The cold leg RTD bypass line must also be removed. The nozzle must then be modified to accept the fast response RTD thermowell. If necessary, the RTD's will be relocated because of interferences. The installation of the thermowell into the nozzle will be performed using GTAW for the root pass and finished with either GTAW or SMAW. Weld inspection by PT will be performed as required by Section XI. The thermowells will extend approximately [ ]^{a,c} inches into the flow stream. This depth has been justified based on [ ]^{a,c} analysis. The root weld joining the thermowells to the modified nozzles will be deposited with GTAW and the remainder of the weld may be deposited with GTAW or SMAW. Penetrant testing will be performed in accordance with the ASME Code Section XI. The thermowells will be fabricated in accordance with the ASME Section III (Class 1). If structural interferences preclude placement in the existing nozzle then the nozzle will be capped and a new penetration made to accommodate the thermowell. The thermowell will be installed in a boss. The installation of the thermowell into the boss will be the same as for the nozzle installation.

The cross-over leg bypass return piping will be severed to leave a stub of pipe protruding from the nozzle and the stub will be capped. The cap design, including materials, will meet the pressure boundary criteria of ASME Section III (Class 1). The cap will be root welded to the pipe stub by GTAW and fill welded by either GTAW or SMAW. Non-destructive examinations (PT and radiographs) will be performed per ASME Section XI. Machining of the bypass return nozzle, as well as any machining performed during modification of the penetrations in the hot and cold legs, shall be performed such as to minimize debris escaping into the reactor coolant system.

The design and analysis of the loop piping and associated branch connection boss, weld, and pipe cap, where applicable, will meet the requirements of the ASA B31.1.0 Code 1955 Edition, No Addenda.

In accordance with Article IWA-4000 of Section XI of the ASME Code, a hydrostatic test of new pressure boundary welds is required when the connection to the pressure boundary is larger than one inch in diameter. Since the cap for the crossover leg bypass return pipe is [ ]^{a,c} inches and the cold leg RTD connections are [ ]^{a,c} inches, a system hydrostatic test is required after the bypass elimination modification is complete. Paragraph IWB-5222 of Section XI defines this test pressure to be 1.02 times the normal operating pressure at a temperature of 500°F or greater.

In summary, the integrity of the reactor coolant piping as a pressure boundary component, is maintained by adhering to the applicable ASME Code sections and Nuclear Regulatory Commission General Design Criteria. Further, the pressure retaining capability and fracture prevention characteristics of the piping is not compromised by these modifications.

4.7 TECHNICAL SPECIFICATION EVALUATION

As a result of the calculations summarized in Section 3.0, several protection functions' Technical Specifications are modified. The affected functions and their associated Trip Setpoint information, are noted on Table 3.1-13.

5.0 CONTROL SYSTEM EVALUATION

A prime input to the various NSSS control systems is the RCS average temperature, T_{avg}. This is calculated electronically as the average of the measured hot and cold leg temperatures in each loop.

The effect of the new RTD temperature measurement system is to potentially change the time response of the T_{avg} channels in the various loops. This in turn could impact the response of [

]^{a,c} However, as previously noted, the new RTD system (thermowell mounted RTD) will have a time response identical to that of the current system (RTD + bypass line). The additional delay resulting from the Median Signal Selector (MSS) is small in comparison with the RTD time response [

]^{a,c}. Therefore, there will be no significant impact on the T_{avg} channel response and no need, as a result of implementing the new system, to revise any of the control system setpoints. It should be recognized that control systems do not perform any protective function in the FSAR accident analysis. With respect to accident analyses, control systems are assumed operative only in cases in which their action aggravates the consequences of an event, and/or as required to establish initial plant conditions for an analysis. The modeling of control systems for accident analyses is based on nominal system parameters as presented in the Precautions, Limitations, and Setpoint document.

6.0 CONCLUSIONS

The method of utilizing fast-response RTDs installed in the reactor coolant loop piping as a means for RCS temperature indication has undergone extensive analyses, evaluation and testing as described in this report. The incorporation of this system into the Turkey Point Units 3 and 4 design meets all safety, licensing and control requirements necessary for safe operation of these units. The analytical evaluation has been supplemented with in-plant and laboratory testing to further verify system performance. The fast response RTDs installed in the reactor coolant loop piping adequately replace the present hot and cold leg temperature measurement system and enhances ALARA efforts as well as improve plant reliability.

7.0 REFERENCES

1. Turkey Point Units 3 and 4 Updated FSAR.

2. WCAP-10271-P-A "Evaluation of Surveillance Frequencies and Out of Service Times for the Reactor Protection Instrumentation System."