WESTINGHOUSE CLASS 3

WCAP-12479

RTD BYPASS ELIMINATION LICENSING REPORT FOR BEAVER VALLEY UNIT 2

Y. A. JEN

R. M. WATERS

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Approved by: R. J. Sterdis, Manager
Operating Plant Licensing I

Approved by: W. R. Rice, Manager
Chemical Waste and
Balance of Plant System

Westinghouse Electric Corporation
Nuclear and Advanced Technology Division
P.O. Box 2728
Pittsburgh, Pennsylvania 15230-2728

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9004240474 900416
PDR ADOCK 05000412
P PDC

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W. G. Lyman

S. S. Zawalick

G. E. Lang

C. E. Leach

J. F. Petzold

J. P. Kutz

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1.0 INTRODUCTION

Westinghouse Electric Corporation has been contracted by Duquesne 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 Beaver Valley Unit 2 utilizing the new thermowell mounted RTDs.

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 <u>Hot Leg</u>

a) The hot leg temperature measurement on each loop will be accomplished with three fast response, narrow range, single 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 three existing

RTD bypass manifold scoops wherever possible. A hole will be made through the end of each scoop so that water will flow in through the existing holes in the leading edge 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 (ΔT) and average temperature (T_{avg}).

b) This modification will not affect the single 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 Cold Leg

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). Temperature streaming in the cold leg is not a concern due to the mixing action of the RCP. For this reason, only one RTD is required. This RTD will measure the cold leg temperature which is used to calculate reactor coolant loop ΔT and T_{avg}. The existing cold leg RTD bypass penetration nozzle will be modified (Figure 1.2-3) to accept the RTD thermowell. One element of the RTD will be considered active and the other element will be held in reserve as a spare.

b) This modification will not affect the single 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

Figure 1.3-1 shows a block diagram of the modified protection system electronics. The hot leg RTD measurements (three per loop) will be electronically averaged in the process protection system. The averaged T_{hot} signal will then be used with the T_{cold} signal to calculate reactor coolant loop ΔT and T_{avg} which are used in the reactor control and protection system. This will be accomplished by additions to the existing process protection system equipment.

The present RCS loop temperature measurement system uses dedicated direct immersion RTDs for the control and protection systems. This was done largely to satisfy Section 4.7 of the IEEE Standard 279-1971 which applies to control and protection system interaction. The new thermowell mounted RTDs will be used for both control and protection. In order to continue to satisfy the requirements of Section 4.7 of IEEE 279-1971, the T_{avg} and ΔT 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.

1.3.2 Qualification

The 7300 Process Electronics modifications will be qualified to the same level as the existing 7300 electronics. RTD qualification will be verified to support Duquesne Light's compliance to 10CFR50.49.

1.3.3 RTD Operability Indication

Existing control board ΔT and T_{avg} indicators and alarms will provide the means of identifying RTD failures, although the now redundant indication for the T_{avg} and ΔT signals will be removed. The spare cold leg RTD element provides sufficient spare capacity to accommodate a single cold leg RTD failure per loop. Failure of a hot leg RTD is addressed via manual action as the plant I&C personnel would defeat the failed signal and rescale the electronics to average the remaining two hot leg signals (see Figure 1.3-1 and Section 4.5).

a,c

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

a,c

Figure 1.2-2 Hot 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

Figure 1.3-1 RTD Averaging Block Diagram.
Typical for Each of 3 Channels

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 Beaver Valley Unit 2 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 time response testing of each RTD and thermowell prior to installation at Beaver Valley Unit 2. 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 Beaver Valley Unit 2. This testing will demonstrate that the WEED RTDs can satisfy the response time requirement when installed 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 temperature. This plant specific data is used in conjunction with data taken from other 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. The operator can review temperatures recorded prior to the RTD failure and determine an [ ]^{b,c,e} into the "two RTD" average to obtain the "three RTD" expected reading. A generic procedure has been provided to Duquesne Light which specifies how these [ ]^{b,c,e} are to be determined. (Appendix A) This significantly reduces the error introduced by a failed RTD.

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.

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 latest Westinghouse RTD cross-calibration procedure (resulting in low RTD calibration uncertainties at the beginning of a fuel cycle), the Beaver Valley 2 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 3.1-11 were generated specifically for Beaver Valley Unit 2 and reflect plant specific measurement uncertanties 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 measurement 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. The most recent 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}. This overall temperature streaming uncertainty provides additional margin when applied to the 3-loop Beaver Valley Unit 2 plant, since the 3-loop temperature distributions are not similar, so more of the total streaming uncertainty would be random.

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 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. Based on test data, the bias value would be expected to range between [ ]^{b,c,e}. Data comparisons show that the magnitude of this bias varied less than [ ]^{b,c,e} over the test period. Appendix A provides a procedure for utilizing the actual plant bias data. Note that this procedure only allows the use of positive (or zero) bias values.

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, notes that the calculated uncertainty is the same as previously assumed in the Safety Analyses. Table 3.1-6 provides the uncertainty breakdown for Overtemperature Delta-T. 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 Delta-T. 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 notes that the Total Allowance (TA) for this function is larger than the Channel Statistical Allowance, thus the uncertainties are provided for. Table 3.1-11 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

+a,c

	Tavg	TURB PRES
PMA =		
SCA =		
M&TE=		
STE =		
SD =		
BIAS=		
RCA =		
M&TE=		
M&TE=		
RTE =		
RD =		
CA =		
BIAS=		

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 =							
M&TE=							
SPE =							
STE =							
SD =							
R/E =							
RDOT=							
BIAS=							
CSA =							
# OF INST USED					3	1	3
	DEG F	PSIA	% DP	PSIA	DEG F	DEG F	PSIA
INST SPAN =	500.	2000.	120.	1200.	100.	100.	800.
							+a,c
INST UNC. (RANDOM) =							
INST UNC. (BIAS) =							
NOMINAL =	437.	890.		790.	605.0	545.0	2250.

TABLE 3.1-3

FLOW CALORIMETRIC SENSITIVITIES

FEEDWATER FLOW

[ ]+a,c

FA
- TEMPERATURE =
- MATERIAL =

DENSITY
- TEMPERATURE =
- PRESSURE =

DELTA P =

FEEDWATER ENTHALPY

- TEMPERATURE =
- PRESSURE =

hS	=	1199.7 BTU/LBM
hF	=	416.6 BTU/LBM
Dh(SG)	=	783.0 BTU/LBM

STEAM ENTHALPY

[ ]+a,c

- PRESSURE =
- MOISTURE =

HOT LEG ENTHALPY

- TEMPERATURE =
- PRESSURE =

hH	=	627.6 BTU/LBM
hC	=	537.9 BTU/LBM
Dh(VESS)	=	89.7 BTU/LBM
Cp(TH)	=	1.485 BTU/LBM-DEGF

COLD LEG ENTHALPY

[ ]+a,c

- TEMPERATURE =
- PRESSURE =

Cp(TC)	=	1.226 BTU/LBM-DEGF

COLD LEG SPECIFIC VOLUME

[ ]+a,c

- TEMPERATURE =
- PRESSURE =

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

		+a,c
SINGLE LOOP UNCERTAINTY	(WITHOUT BIAS VALUES)	
N LOOP UNCERTAINTY	(WITHOUT BIAS VALUES)	
N LOOP UNCERTAINTY	(WITH BIAS VALUES)	

TABLE 3.1-5

COLD LEG ELBOW TAP FLOW UNCERTAINTY

INSTRUMENT UNCERTAINTIES

	% DP SPAN	% FLOW
		+a,c
PMA =		
PEA =		
SCA =		
SPE =		
STE =		
SD =		
RCA =		
M&TE=		
RTE =		
RD =		
ID =		
A/D =		
RDOT=		
BIAS=		

FLOW CALORIM. BIAS = 0.0

FLOW CALORIMETRIC = 1.6

INSTRUMENT SPAN = 120.

+a,c

SINGLE LOOP ELBOW TAP FLOW UNC =

N LOOP ELBOW TAP FLOW UNC =

N LOOP RCS FLOW UNCERTAINTY
(WITHOUT BIAS VALUES) =

N LOOP RCS FLOW UNCERTAINTY
(WITH BIAS VALUES) =

TABLE 3.1-6

OVERTEMPERATURE ΔT

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
[ ]+a,c	
Primary Element Accuracy	
Sensor Calibration	
[ ]+a,c	
Sensor Pressure Effects	
Sensor Temperature Effects	
[ ]+a,c	
Sensor Drift	
[ ]+a,c	
Bias	
Environmental Allowance	
7300 Process Equipment Seismic Allowance- [ ] a,c	
Rack Calibration	
[ ]+a,c	

TABLE 3.1-6 (continued)

OVERTEMPERATURE ΔT

Parameter	Allowance*
Measurement & Test Equipment Accuracy	
[ ]+a,c	[ ]+a,c
Rack Accuracy	
[ ]+a,c	
Rack Comparator Setting Accuracy	
Two inputs	
Rack Temperature Effects	
Rack Drift	
ΔT	
Tavg	

---

* In % span (Tavg - 100 °F, pressure - 800 psi, power - 120 % RTP, ΔT - 101.1 °F, ΔI - ± 60 % ΔI)

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

*** [ ]+a,c

Channel Statistical Allowance =

[ ]+a,c

TABLE 3.1-7

OVERTEMPERATURE ΔT GAIN CALCULATIONS

The equation for Overtemperature ΔT is:

$$\Delta T[(1)/(1 + \tau_4 S)] \leq$$

$$\Delta T_o[K_1 - K_2[(1 + \tau_1 S)/(1 + \tau_2 S)][T[(1)/(1 + \tau_5 S)] - T'] + K_3(P - P') - f_1(\Delta I)]$$

K_1 (nominal)	=	1.2806 Technical Specification value
K_1 (max)	=	[ ]+a,c
K_2	=	0.017/°F
K_3	=	0.000823/psi
vessel ΔT	=	67.4 °F
ΔI gain	=	1.75 FP ΔI/%ΔI

Pressure Gain =
Pressure SCA =
Pressure SMTE =
Pressure STE =
Pressure SD =
[ ]+a,c

ΔI conversion =
=
ΔI PMA_1 =
ΔI PMA_2 =
[ ]+a,c

Total Allowance (TA) =
[ ]+a,c = 7.0 % ΔT span

TABLE 3.1-8

OVERPOWER ΔT

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
[ ]+a,c	
Primary Element Accuracy	
Sensor Calibration	
[ ]+a,c	
Sensor Pressure Effects	
Sensor Temperature Effects	
Sensor Drift	
[ ]+a,c	
Environmental Allowance	
Cable Insulation Resistance Degradation	
Rack Calibration	
[ ]+a,c	
Measurement & Test Equipment Accuracy	
[ ]+a,c	
Rack Accuracy	
[ ]+a,c	
Rack Comparator Setting Accuracy	
Two inputs	
Rack Temperature Effects	
Rack Drift	
ΔT	
Tavg	

TABLE 3.1-8 (continued)

OVERPOWER ΔT

---

* In % span (Tavg - 100 °F, ΔT - 101.1 °F = 120 % RTP)

** [ ]+a,c

Channel Statistical Allowance =

[ ]+a,c

TABLE 3.1-9

OVERPOWER ΔT GAIN CALCULATIONS

The equation for Overpower ΔT is:

$\Delta T[(1)/(1 + \tau_4 S)] \leq$

$\Delta T_o[K_4 - K_5[[(\tau_3 S)/(1 + \tau_3 S)][(1)/(1 + \tau_5 S)]]T - K_6[T[(1)/(1 + \tau_5 S)] - T"] - f_2(\Delta I)]$

K_4 (nominal) = 1.0781 Technical Specification value
K_4 (max) = [ ]+a,c
K_5 = 0.02
K_6 = 0.00128
vessel ΔT = 67.4 °F

Total Allowance =
[ ]+a,c = 4.9 % span

TABLE 3.1-10

LOSS OF FLOW

Parameter	Allowance*
Process Measurement Accuracy	[ ]+a,c
[ ]+a,c	
Primary Element Accuracy	
[ ]+a,c	
Sensor Calibration	
[ ]+a,c	
Sensor Pressure Effects	
[ ]+a,c	
Sensor Temperature Effects	
[ ]+a,c	
Sensor Drift	
[ ]+a,c	
Environmental Allowance	
Rack Calibration	
Rack Accuracy [ ]+a,c	
Measurement & Test Equipment Accuracy [ ]+a,c	
Comparator	
One input [ ]+a,c	
Rack Temperature Effects	
[ ]+a,c	
Rack Drift	
1.0 % ΔP span	

* In % flow span (120 % Thermal Design Flow) % ΔP span converted to flow span via Equation 3-21.8, with F_{max} = 120 % and F_N = 100 %

Channel Statistical Allowance =

[ ]+a,c

TABLE 3.1-11

TECHNICAL SPECIFICATION MODIFICATIONS

Overtemperature ΔT

TA = 7.0 % ΔT span
Z = 5.1
S = 1.49 (Temperature) + 0.73 (Pressure)
Nominal values as noted on Overtemperature ΔT Gain Calculations
Allowable Value ≤ 1.6 % ΔT span

Overpower ΔT

TA = 4.9 % ΔT span
Z = 1.71
S = 1.49
Nominal values as noted on Overpower ΔT Gain Calculations
Allowable Value ≤ 2.5 % ΔT span

Loss of Flow

TA = 2.5 % span
Z = 1.39
S = 0.60
Nominal Trip Setpoint ≥ 90.0 % Loop Design Flow
Allowable Value ≥ 88.8 % Loop Design Flow

4.0 SAFETY EVALUATION

The primary impact of the RTD Bypass Elimination on the FSAR Chapter 15 (Reference 1) safety analyses are the differences in response time characteristics and instrumentation uncertainties associated with the fast response thermowell RTD system. The affects of these differences are discussed in the following sections.

4.1 RESPONSE TIME

The current response time parameters of the Beaver Valley Unit 2 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 old bypass piping transport, thermal lag and direct immersion RTD. This then 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 Delta-T and Overpower Delta-T trip performance. Therefore, those transients that rely on the above mentioned trips must be evaluated for the modified response characteristics. Section 4.3 includes a discussion on the evaluation for these events.

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, allowances are made for the average reactor coolant system (RCS) temperature, pressure and power. These allowances are made explicitly to the initial conditions.

Protection and control system parameters which were evaluated and determined to be unaffected (with respect to current accident analysis and evaluation assumptions References 1, 2, 3 and 4) by the change from one hot leg RTD to three hot leg RTDs; the Overtemperature ΔT (OTΔT), Overpower ΔT (OPΔT), and Low RCS Flow reactor trip functions, and the calculated value of the RCS flow uncertainty. System uncertainty calculations were performed for these parameters to determine the impact of the change in the number of hot leg RTDs. The results of these calculations, noted in 3.3, indicate sufficient margin exists to account for known instrument uncertainties.

Section 3.3 documents the increase in uncertainty associated with the RCS loop Tavg measurement. It was determined that insufficient margin exists to accommodate this increase without impacting the FSAR safety analysis assumption for initial condition RCS temperature uncertainty.

In summary, the replacement of the RTD Bypass System with fast response thermowell mounted RTDs installed in the reactor coolant loop piping in the Beaver Valley Unit 2 plant results in changes to the Reactor Protection System response times and the rod control system temperature measurement accuracy. These changes directly impact the FSAR safety analysis assumptions and are dispositioned in the following sections.

4.3 NON-LOCA EVALUATION

The changes in the RTD response time discussed in Section 2.1 and the instrumentation uncertainties discussed in Section 3.3 have been considered for the Beaver Valley Unit 2 non-LOCA safety analysis design basis. Only those transients which assume OTΔT/OPΔT protection are potentially affected by changes in the RTD response time. Instrumentation uncertainties can affect the non-LOCA transient initial condition assumptions and those transients which assume protection from low primary coolant flow reactor trip, OTΔT and OPΔT.

As noted in Section 3.0, the RTD bypass elimination can potentially affect the rod control system accuracies and flow calorimetric instrumentation uncertainties. The calculations documented in Section 3.0 support the continued validity of the non-LOCA safety analysis initial condition RCS flow assumption. Section 3.3 documents a rod control system temperature measurement accuracy of ±4.1°F. This is an increase of 0.1°F from the 4.0°F uncertainty documented in FSAR Section 15.0.3.2 for use in the safety analyses. The 4.0°F uncertainty is reflected in the at-power initial condition vessel average temperature assumptions summarized for the FSAR Chapter 15 transients in FSAR Table 15.0-2. The effects of the 0.1°F increase on the Beaver Valley Unit 2 non-LOCA safety analysis design bases (References 1, 2 and 3) have been evaluated. It is concluded that sufficient safety analysis margin to the non-DNB limit criteria is available in the non-LOCA transients to accommodate an increase of 0.1°F in the reactor coolant temperature initial condition assumption. Generic DNB margin has been allocated to offset the temperature increase for all FSAR transient calculations of minimum DNBR. No other FSAR non-LOCA safety analysis initial condition are affected. It is therefore concluded that the impact of the RTD Bypass Elimination on non-LOCA initial condition assumptions is accommodated by safety analysis margin and generic DNB margin. All non-LOCA safety analysis acceptance criteria continue to be met and the conclusions presented in References 1, 2 and 3 remain valid.

The RTD response time and instrumentation uncertainties associated with the RTD Bypass Elimination can potentially affect protection systems assumed to be available for mitigation of design basis non-LOCA transients. The protection system setpoints evaluated in Section 3.0 are OTΔT, OPΔT and Low Primary Coolant Loop Flow (Loss of Flow) reactor trip. The transients which assume protection from these functions are listed below.

Reference	Accident	Assumed Protection Function
FSAR Section 15.0.6	Core Thermal Limit Protection	OTΔT/OPΔT
FSAR Section 15.2.2	Loss of External Electrical Load/Turbine Trip	OTΔT
FSAR Section 15.4.2	Uncontrolled RCCA Bank Withdrawal at Power	OTΔT
FSAR Section 15.4.6	CVCS Malfunction that results in Decrease in the RCS Boron Concentration (Mode 1)	OTΔT
FSAR Section 15.3.1	Partial Loss of Forced Reactor Coolant Flow	Loss of Flow
FSAR Section 15.3.3	Reactor Coolant Pump Locked Rotor	Loss of Flow
WCAP-10961-P (Reference 2)	Steamline Break for EQ Outside Containment	OPΔT
WCAP-9226-P (Reference 3)	Reactor Core Response to Excessive Secondary Steam Releases (at Power)	OPΔT

As noted in Section 4.1, the new thermowell mounted RTDs have a response time equal to or better than the old bypass piping 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 total OTΔT/OPΔT channel response time of 6.0 seconds remains valid. Evaluation of the effects of the RTD Bypass Elimination on the uncertainties associated

with these setpoints, as well as the Loss of Flow setpoint, supports the continuing validity of the current non-LOCA safety analysis and evaluation assumptions for the above transients.

In summary, the Reference 1, 2, 3 and 4 non-LOCA safety analyses and evaluations applicable to Beaver Valley Unit 2 have been evaluated for the replacement of the existing RTD Bypass System with fast response thermowell mounted RTDs installed in the reactor coolant loop piping. It is concluded that a small increase in RCS temperature uncertainty can be accommodated by margins in the safety analyses to acceptance criteria limits and allocation of generic DNB margin. All other safety analysis assumptions remain valid. The Reference 1, 2, 3 and 4 results and conclusions applicable to Beavery Valley Unit 2 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 has the potential to impact the uncertainties associated with RCS temperature measurement. The following LOCA evaluation considers RCS temperature uncertainties up to 4.1°F. These uncertainties potentially affect the initial conditions assumed in the LOCA analyses. No other aspects of the RTD bypass elimination program impact the LOCA analyses since no credit for any protective functions associated with RCS temperature channels is assumed in the LOCA analyses.

LOCA analyses, as a general rule, have never explicitly used RCS temperature uncertainties as inputs. Early sensitivity studies showed PCT behavior vs. RCS temperature could not be a priori predicted in advance and therefore LOCA analyses have historically been performed using 'nominal' RCS temperatures. Instances of intentional and large RCS Tavg temperature 'windows' have been specifically analyzed to assure that the LOCA analyses have been performed at the limiting initial condition. This generic position was based on an assumed 4.0°F RCS temperature uncertainty. The LOCA evaluations will conservatively address a .1°F change to this basis.

Small Break LOCA

The Small Break analysis of record, which is presented in Reference 1, is a NOTRUMP evaluation model with limiting PCT result of 1399°F. Existing sensitivities using the NOTRUMP evaluation model indicate a maximum sensitivity of approximately 8°F in PCT per each 1°F change in RCS temperature. Thus the penalty incurred due to the .1°F change in the RCS temperature uncertainties is 1°F. The current Small Break LOCA analysis has several other outstanding penalties that are described next.

Reference 5 performed a Safety Evaluation for SG Water Level Instrumentation problems and assigned a 20°F penalty. A recent investigation of current Beaver Valley 2 Auxiliary Feedwater flow capability documented by Reference 6 resulted in a penalty of 530°F. Summing up the various penalties results in an overall evaluated PCT of 1950°F. Since this is below the 10CFR50.46 limit of 2200°F, the RTD bypass elimination effort is acceptable for Small Break LOCA.

Large Break LOCA

The Large Break LOCA analysis of record, which is presented in Reference 1, is a BASH evaluation model with limiting PCT result of 2120°F. Existing sensitivities using the BASH evaluation model indicate a maximum sensitivity of approximately 5.3°F in PCT per each 1°F change in RCS temperature. Thus the penalty incurred due to the .1°F change in the RCS temperature uncertainties is 1°F. The current Large Break LOCA analysis has no other outstanding penalties and thus the current evaluated PCT is 2121°F. Since this is below the 10CFR50.46 limit of 2200°F, the RTD bypass elimination effort is acceptable for Large Break LOCA.

LOCA Hydraulic Forces

The latest position on Beaver Valley Unit 2 hydraulic forces is documented by Reference 7. Sensitivity studies to RCS temperature indicate a bounding sensitivity of .7% increase in forces per each 1°F decrease in RCS temperature. Thus the penalty incurred due to the .1°F change in RCS

temperature uncertainty is a .07% change in forces. This level of increase is compensated for by margin in the overall analysis and additionally is small enough to be insignificant in comparison to the large Leak-Before-Break credit taken in pages 7 and 8 of Reference 7. None of the statements made in Reference 7 are compromised by this RCS temperature uncertainty change and thus the RTD bypass elimination effort is acceptable for LOCA hydraulic forces.

Post-LOCA Long Term Cooling

The Westinghouse licensing position for satisfying the requirements of 10CFR Part 50 Section 50.46 Paragraph (b) Item (5) 'Long Term Cooling' is defined in Reference 8. The Westinghouse evaluation model commitment is that the reactor will remain shutdown by borated ECCS water residing in the sump after a postulated LOCA. Since credit for the control rods is not taken for large break LOCA, the borated ECCS water provided by the accumulators and the RWST must have a boron concentration that, when mixed with other water sources, will result in the reactor core remaining subcritical assuming all control rods out.

RCS temperature has an effect on the calculation through density effects on the initial RCS mass. At representative RCS full power temperatures, the density/RCS mass variation due to a .1°F change in temperature is .015%. This change is extremely small and well beyond the level of accuracy of the calculation. Therefore, the existing calculation results remain valid and thus the RTD bypass elimination effort is acceptable for the Long Term Cooling calculation.

Hot Leg Switchover to Prevent Potential Boron Precipitation Calculation

Post-LOCA hot leg recirculation switchover time is determined for inclusion in emergency procedures to ensure no boron precipitation in the reactor vessel following boiling in the core. This time is dependent on power level, and the RCS, RWST and accumulator water volumes, masses and boron concentrations. As with the Long Term Cooling evaluation, the .015% change in RCS density and mass is insignificant and well beyond the

accuracy of the calculation. Therefore, the existing calculation results remain valid and thus the RTD bypass elimination effort is acceptable for the switchover time calculation.

LOCA CONCLUSIONS

The impact of a maximum RCS temperature uncertainty of 4.1°F associated with the RTD bypass elimination program has been considered for the LOCA events presented. The evaluation was based on a .1°F change in the instrumentation uncertainty as compared with the 4.0°F uncertainty in existence at the time of the analyses. All existing analyses except Small and Large Break LOCA were either not impacted, or negligibly impacted. The Small and Large Break LOCA events were each assigned PCT penalties of 1°F. The evaluated results of all analyses continue to meet existing acceptance criteria, including Small and Large Break LOCA total accumulated PCTs of 1950°F and 2121°F, respectively.

All remaining facets of the RTD bypass elimination program have no impact on the evaluated LOCA analyses, therefore, the program is acceptable for LOCA events.

4.5 SGTR EVALUATION

For the Steam Generator Tube Rupture (SGTR) event, the FSAR SGTR analysis was performed using the LOFTRAN program. The primary to secondary break flow was assumed terminated at 30 minutes after initiation of the SGTR event. The major factors that affect the radiological doses of an SGTR event are the amount of fuel failure, the amount of primary coolant transferred to the secondary side of the ruptured steam generator through the ruptured tube and the steam released from the failed steam generator to the atmosphere. An evaluation was completed to determine the effect of RTD bypass elimination on the FSAR SGTR analysis.

RTD bypass elimination could affect the RTD response time and the RCS average temperature uncertainty. It has been determined that the RTD bypass elimination will not change the RTD response time; however the RCS average

temperature uncertainty associated with automatic rod control will increase by 0.1°F. The effect of a 0.1°F increase in the RCS average temperature uncertainty is evaluated.

For the Beaver Valley Unit 2 SGTR design basis analysis, reactor trip is calculated to occur due to a low pressurizer pressure signal. A 0.1°F increase in RCS average temperature would not change this reactor trip function. However, the slight increase in RCS average temperature uncertainty could affect the RCS coolant density and/or reactor trip time thereby impacting the integrated primary to secondary leakage, atmospheric steam release through the ruptured steam generator and DNBR.

The effect of slight changes to the reactor trip time and RCS coolant density are expected to result in a much less than 1% increase to the 30 minute primary to secondary break flow result reported in the Beaver Valley Unit 2 FSAR for the SGTR event. Additionally, any increase to the atmospheric steam release via the ruptured steam generator is expected to be much less than 1% due to any changes in reactor trip time and RCS coolant density. Finally, generic DNB margin has been allocated to offset the temperature increase for all FSAR transient calculations of minimum DNBR, including the SGTR event.

Based on the above evaluation, it is noted that the 0.1°F increase in RCS average temperature uncertainty could result in an increase to the 30 minute primary to secondary break flow and the atmospheric steam release from the ruptured steam generator. Although the offsite radiological doses could consequently increase as a result of these increases, it is judged that this would not constitute an increase in the consequences of the SGTR accident. This judgement is based on the fact that the dose increase would be very small and that the total dose is very low, being well within the NRC definition of a "small fraction" of the 10CFR100 exposure guidelines.

4.6 INSTRUMENTATION AND CONTROL (I&C) SAFETY EVALUATION

The RTD Bypass Elimination modification for Beaver Valley Unit 2 does not functionally change the $\Delta T/T_{avg}$ protection channels. The implementation

of the fast response RTDs in the reactor coolant piping will change the inputs into the $\Delta T/T_{avg}$ Protection Sets I, II, and III, as follows:

1. The Narrow Range (NR) cold leg RTD in the cold leg manifold will be replaced with a fast response NR dual element well mounted RTD in the RCP pump discharge pipe. The signal from this fast response NR cold leg RTD will perform the same function as the existing RTD T_{cold} signal. One element of the RTD will be held in reserve as a spare.

2. The NR hot leg RTD in the bypass manifold will be replaced with 3 fast response NR single element well mounted RTDs in the hot leg that are electronically averaged in the process protection system.

3. Identification of failed signals will be by the same means as before the modifications, i.e., existing control board alarms and indications.

4. Signal process and the added circuitry to the Protection Set racks will be accomplished by additions to the process control (Westinghouse Model 7300) racks using 7300 technology. When one T_{hot} signal is removed from the averaging process, the electronics will allow a bias to be manually added to a 2-RTD average T_{hot} (as opposed to a 3-RTD average T_{hot}) in order to obtain a value comparable with the 3-RTD average T_{hot} prior to the failed RTD. In the event of a cold leg RTD failure, the spare cold leg RTD element will be manually connected to the 7300 circuitry in place of the failed RTD.

   Existing control board ΔT and Tavg indicators and alarms will provide the means of identifying RTD failures. Upon identification of a failed RTD, the operator would place that protection channel in trip (consistent with the time requirements specified in the Technical Specifications), identify and disconnect the failed RTD, and rescale the summing amplifier for a two RTD input condition. The channel would then be returned to service. During this process the plant will be in a partial trip mode and will therefore be in a safe condition.

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 electrical isolators to prohibit faults in the control rack from propagating into the protection racks.

In order to satisfy the control and protection interaction requirements of IEEE 279-1971 Section 4.7, a Median Signal Selector (MSS) will be used in the control channels presently utilizing a high auctioneered T_{avg} or ΔT signal (there will be a separate MSS for each function). The Median Signal Selector will use as inputs the protection grade T_{avg} or ΔT 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.

To ensure proper action by the Median Signal Selector, the present manual switches that allow for defeating of a T_{avg} or ΔT 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 ΔT deviation alarms.

Other than the above changes, the Reactor Protection System will remain the same, as that previously utilized. For example, two out of three voting logic continues to be utilized for the thermal overpower protection functions, with the model 7300 process control bistables continuing to operate on a "de-energize to actuate" principle. Non-safety related control signal inputs will now be derived from protection channels via a Median Signal Selector.

The above principles of the modification have been reviewed to evaluate conformance to the requirements of IEEE 279-1971 criteria and associated 10CFR 50 General Design Criteria (GDC), Regulatory Guides, and other applicable industry standards. 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.

c. The changes will continue to maintain the capability of the protection system to initiate a reactor trip during and following natural phenomena credible to the plant site 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, with appropriate observance of field wiring interface criteria to assure the independence.

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 details of the signal selector implementation are contained in Section 1.3.1.

f. During testing of any protection system input to the Median Signal Selector (e.g. the simulated input signal is either near the top or the bottom of span), a failure in one of the remaining two input signals could potentially result in a control system action that would require protective action. The MSS would select the channel in test or the failed channel instead of the remaining valid channel, potentially resulting in a control protection interaction and violating the requirements of IEEE 279-1971 Section 4.7.

   It has been determined that the rod control system is the only control system that could result in an adverse system interaction. Hence, to preclude such an interaction it is necessary to place the control rod system in manual prior to the initiation of the test.

On the basis of the foregoing evaluation, it is concluded that the compliance of Beaver Valley Unit 2 to IEEE 279-1971, applicable GDCs, and industry standards and regulatory guides has not been changed with the I&C modifications required for RTD bypass removal.

4.7 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 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 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 single 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 structual interferences 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 thermowell will be located in an installation boss. A thermowell design will be used such that the thermowell will be positioned to provide an average temperature reading. 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. 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).

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 pipe stub, 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.

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.

4.8 TECHNICAL SPECIFICATION EVALUATION

As a result of the calculations summarized in Section 3.0, several protection functions' Technical Specifications must be modified. The affected functions and their associated Trip Setpoint information, are noted on Table 3.1-11.

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. However, DLCo always has the option of making setpoint adjustments. If desired, system performance can be verified by performing a series of plant tests (e.g., step load changes, load rejections, etc.) following installation of the new RTD system. Control system setpoints can then be adjusted based on the results of the tests. 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 Beaver Valley Unit 2 design meets all safety, licensing and control requirements necessary for safe operation of this unit. 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. Updated Final Safety Analysis Report, Beaver Valley Power Station Unit 2, Revision 1.

2. WCAP-10961-P, "Steamline Break Mass/Energy Releases for Equipment Qualification Outside Containment", Westinghouse Electric Corporation (Proprietary), October 1985.

3. WCAP-9226-P, "Reactor Core Response to excessive Secondary Steam Releases", Westinghouse Electric Corporation (Proprietary), January 1978.

4. Westinghouse Letter, DLW-89-847, Jen to Tonet, Subject: Impact of Cable IR on OPΔT, December 19, 1989.

5. Westinghouse Letter, DLW-89-647, Jen to Tonet, Subject: JCO for Increased SG Narrow Range Level Shifts, May 15, 1989.

6. Duquesne Light Letter, ND2MNE: 4790, Tonet to Jen, Subject: AFW flow data, 5/26/89.

7. WCAP-11522, "Response to NRC Questions on the LOCA Hydraulic Forces Analysis of BVPS-2", Westinghouse Electric Corporation.

8. WCAP-8339, "Westinghouse ECCS Evaluation Model Summary", Westinghouse Electric Corporation.

APPENDIX A

DEFINITION OF AN OPERABLE CHANNEL AND
HOT LEG RTD FAILURE COMPENSATION PROCEDURE

RTD BYPASS ELIMINATION

FOR

BEAVER VALLEY 2

DEFINITION OF AN OPERABLE CHANNEL AND
HOT LEG RTD FAILURE COMPENSATION PROCEDURE

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DEFINITION OF AN OPERABLE CHANNEL

The RTD Bypass Elimination modification uses the average of 3 RTDs in each hot leg to provide a representative temperature measurement. In the event one or more of the RTDs fails, steps must be taken to compensate for the loss of that RTD's input to the averaging function. In the event of this type of RTD failure this procedure could be envoked.

Single RTD Failure

Hot Leg: All three hot leg RTDs must be operable during the period following refueling from cold to hot zero power and from hot zero power to full power. During the heat up period the plant operators will be [

]^{a,c} Typically this data is recorded at initial 100% power and, thereafter, during the normal protection channel surveillance interval.

Once [ ]^{a,c} any hot leg can then tolerate a single RTD failure and still remain operable. If the situation arises where a single hot leg RTD failure occurs a bias value must be applied to the average of the remaining two valid RTDs. [

]^{a,c}

The plant may operate with a failed hot leg RTD at any power level during that same fuel cycle. It is permissible to shutdown and startup during the cycle without requiring that the failed RTD be replaced. [

]^{a,c}

The Median Signal Selector will eliminate any control system concerns, the Tavg and ΔT signal associated with the loop containing the failed hot leg RTD will most likely not be the Median Signal chosen as the input to the control systems. If another hot leg RTD fails in a different loop the utility should operate using manual control. Manual control is recommended so that the operator can control the plant based on the best measurement available. If automatic operation is continued the control system may choose the biased channel due to the positive (or zero) bias application. This means the control system will perceive a higher Tavg than actually exists at reduced power and the plant will operate at reduced temperatures. While this is not necessarily undesirable it does reduce the total plant megawatt output. The use of automatic control can be considered based on utility power requirements.

Cold Leg: If the active cold leg RTD fails, then that RTD should be disconnected from the 7300 cabinets. The installed spare RTD should then be connected in the failed RTD's place.

Double RTD Failure: Inoperable Channel

Hot Leg or Cold Leg: If two or more of the three hot leg RTDs or both cold leg RTD elements fail in the same loop then that channel is considered inoperable and should be placed in trip. Operation with only one valid hot leg RTD is not presently analyzed as part of the licensing basis.

PROCEDURE FOR OPERATION WITH A HOT LEG RTD OUT OF SERVICE

The hot leg temperature measurement is obtained by averaging the measurements from the three thermowell RTDs installed on the hot leg of each loop. [

]^{a,c}

In the event that one of the three RTDs fails, the failed RTD will be disconnected and the hot leg temperature measurement will be obtained by averaging the remaining two RTD measurements. [

]^{a,c}

The bias adjustment corrects for [

]^{a,c} To assure that the measured hot leg temperature is maintained at or above the true hot leg temperature, and thereby avoid a reduction in safety margin at reduced power, [

]^{a,c}

An RTD failure will most likely result in an offscale high or low indication and will be detected through the normal means in use today (i.e., T_{AVG} and ΔT deviation alarms). Although unlikely, the RTD (or its electronics channel) can fail gradually, causing a gradual change in the loop temperature measurements. [

.]a,c

The detailed procedure for correcting for a failed hot leg RTD is presented below:

[ ]a,c

a,c

[ ] a,c

APPENDIX

CALCULATION OF HOT LEG TEMPERATURE BIAS

a,c