WESTINGHOUSE PROPRIETARY CLASS 3

WCAP-11081

AMERICAN ELECTRIC POWER
D. C. COOK UNIT 2

RDF RTD INSTALLATION
SAFETY EVALUATION

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TABLE OF CONTENTS

LIST OF TABLES

WESTINGHOUSE PROPRIETARY CLASS 3

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1.0 SUMMARY

These are the results of the D. C. Cook Unit 2 safety evaluation for the installation of RdF RTDs for fuel cycle six. This evaluation demonstrates that the installation of RdF RTDs (with increased and reallocated uncertainties over the currently installed RTDs) will not impact the Safety Analysis Limits assumed, nor the core limits utilized, in the plant's safety analyses. The only significant changes to the plant are the Allowable Values for several protection functions and the indicated Tavg values in the Unit 2 Technical Specifications. Nominal Trip Setpoints in the Technical Specifications remain as specified by the fuel vendor.

2.0 DISCUSSION

At the request of American Electric Power, Westinghouse investigated the impact of the change from Rosemount to RdF RTDs on the D. C. Cook Unit 2 plant. This investigation involved two parts, the first being a determination of the uncertainties for those protection and control functions impacted by the use of the RTDs. The second was an evaluation of the impact of those instrument uncertainties on the plant's safety analyses. Finally, the Technical Specifications were reviewed for impact and change recommendations were made for the areas affected.

In the recent months, Westinghouse has performed a considerable amount of work in the determination of revised uncertainties for RdF RTDs when it was learned that the calibration accuracy used in the setpoint studies for several plants was not being met. As a result of this work, Westinghouse has determined the calibration of the RTD under the RdF calibration laboratory conditions and revised the analysis procedure for evaluation of RTD cross calibration data taken during plant heat-up. The end product of the revised analysis procedure is the verification that each RTD installed in the plant meets a total uncertainty assumption of [ ]$^{+a,c}$.

This uncertainty is composed of [

$^{+a,c}$. For ease of calculation in the Westinghouse methodology, the total uncertainty was split into two parts, an SCA value of [ ]$^{+a,c}$ and an SD value of [ ]$^{+a,c}$.

These RTD uncertainties and the uncertainties for the Foxboro pressure transmitter provided by AEP were then used in the standard Westinghouse methodology for the calculation of instrument channel uncertainties, i.e., the same methodology used for Westinghouse Statistical Setpoint Studies and Improved Thermal Design Procedure (ITDP) instrument uncertainty calculations. The following protection and control function instrument uncertainties were evaluated; Overtemperature Delta-T, Overpower Delta-T, RCS Low Flow Trip, Low-Low Tavg, Rod Control (Tavg input), Pressurizer Pressure Control, and RCS Precision Flow Calorimetric measurement uncertainty. For the protection functions it was determined that the Safety Analysis Limit/Nominal Trip Setpoint relationship was sufficient to accommodate the changed uncertainties without causing changes to the vendor-specified SAL or Nominal Trip Setpoint. However the Allowable values for these functions should be changed as indicated below:

Function	Old Allowable Value	New Allowable Value
Overtemperature Delta-T	4% Delta-T span	3.3% Delta-T span
Overpower Delta-T	4% Delta-T span	2.6% Delta-T span
Loss of Flow	89% design flow	88.9% design flow
Tavg Low-Low	539 degrees-F	538.2 degrees-F

Pages (i), (ii), (iii), and (iv) list the uncertainties in percent of instrument span that were used in the development of the new allowable values.

For the control functions and the reactor coolant system (RCS) flow calorimetric uncertainty the original instrument uncertainties and the revised

values are listed below. Pages (v) and (vi) list the uncertainties in percent of instrument span that were used in the development if the total controller uncertainties.

Original Instrument Uncertainties

Function	Uncertainty	
Pressurizer Pressure Control	[ ]	+a,c
Rod Control (temperature)		
RCS Flow Calorimetric		

Revised Instrument Uncertainties

Function	Uncertainty	
Pressurizer Pressure Control	[ ]	+a,c (1)
Rod Control (temperature)		(2)
RCS Flow Calorimetric		(3)

(1) Due to change to Foxboro transmitters.
(2) Due to change to RdF RTDs.
(3) Due to changes to RdF RTDs and Foxboro transmitter.

The DNB Parameters specification (Table 3.2-1) limit for Tavg was recalculated and the old and new values are listed below.

Mode of Operation	Old Value	New Value
4 loops @ RATED THERMAL POWER	576.7 degrees-F	576.3 degrees-F

Page (vii) lists the uncertainties in percent of instrument span and the procedure used in the development of the new value.

The pressurizer pressure - high and steam generator water level low-low channel uncertainties were recalculated for the change to Foxboro pressure transmitters. It was determined that the Safety Analysis Limit/Nominal Trip Setpoint relationship was sufficient to accommodate the changed uncertainties without causing changes to the Safety Analysis Limit or Nominal Trip Setpoint. The Allowable Values were also recalculated for these functions and the old and new values are indicated below:

Function	Old Allowable Value	New Allowable Value
Pressurizer Pressure - High	2395 psig	2395 psig
Steam Generator Water Level - Low-Low	20% of narrow range span	19.2% of narrow range span

Pages (viii) and (ix) list the uncertainties in percent of instrument span that were used in the development of the new allowable values.

3.0 CONCLUSION

In conclusion, it can be stated that the only impact on the plant due to the installation of RdF RTDs and Foxboro transmitters is the changing of the Allowable Values for the protection functions indicated and the Table 3.2-1 Tavg value in the D. C. Cook Unit 2 Technical Specifications. Attached are the pages of the Technical Specifications that require modification.

OVERTEMPERATURE DELTA-T TRIP

DELTA-T Tavg PRESS DELTA-I

[ ]+a,c

PMA =
SCA =
M&TE=
STE =
SD =
BIAS=
RCA =
M&TE=
M&TE=
RCSA=
RTE =
RD =
SA =

INSTRUMENT SPAN = 93.9 DEGF (150% Power)

SAFETY ANALYSIS LIMIT = 1.3910

ALLOWABLE VALUE = 3.26 % DELTA-T SPAN

MAXIMUM VALUE = [ ]+a,c

NOMINAL TRIP SETPOINTS K1 = 1.2590 K3 = 0.000744

VESSEL DELTA-T = 62.6 DEGF DELTA-I GAIN = 2.20

[ ]+a,c

[ ]+a,c S = 2.45 Z = 4.98 [ ]+a,c T = 3.26

TA = 8.80 [ ]+a,c

OVERPOWER DELTA-T TRIP

	DELTA-T	Tavg
PMA =	[	]+a,c
SCA =		
SD =		
BIAS=		
RCA =		
M&TE=		
M&TE=		
RCSA=		
RTE =		
RD =		]

INSTRUMENT SPAN = 93.9 DEGF (150% Power)

SAFETY ANALYSIS LIMIT = 1.1520

ALLOWABLE VALUE = 2.57 % DELTA-T SPAN

MAXIMUM VALUE = [ ]+a,c

NOMINAL TRIP SETPOINT K4 = 1.0780

VESSEL DELTA-T = 62.6 DEGF

[ ]+a,c S = 1.85 Z = 1.47 [ ]+a,c T = 2.57

TA = 4.93 [ ]+a,c

Tavg-LOW-LOW TRIP

PMA = [

SCA =

SD =

BIAS =

RCA =

M&TE =

RCSA =

RTE =

RD =]

INSTRUMENT RANGE	= 525.0 TO 625.0 DEGF
INSTRUMENT SPAN	= 100.0 DEGF
SAFETY ANALYSIS LIMIT	= 537.0 DEGF
ALLOWABLE VALUE	= 538.2 DEGF
MAXIMUM VALUE	= [—]$^{+a,c}$
NOMINAL TRIP SETPOINT	= 541.0 DEGF

[ ]$^{+a,c}$ S = 0.87 Z = 0.82 [ ]$^{+a,c}$ T = 2.80

TA = 4.00 [ ]$^{+a,c}$

LOW FLOW REACTOR TRIP

	% DP SPAN	% FLOW SPAN
PMA1 =	[	] +a,c
PMA2 =		
PEA =		
SCA =		
SPE =		
STE =		
SD =		
BIASF=		
BIAS1=		
BIAS2=		
RCA =		
M&TE =		
RCSA =		
RTE =		
D =		
BIAS =		]

INSTRUMENT RANGE = 0 TO 110.0 % FLOW

FLOW SPAN = 110.0 % FLOW

SAFETY ANALYSIS LIMIT = 87.0 % FLOW

ALLOWABLE VALUE = 88.9 % FLOW

MAXIMUM VALUE = [ ]+a,c

NOMINAL TRIP SETPOINT = 90.0 % FLOW

[ ]+a,c S = 0.55 Z = 1.54 [ ]+a,c T = 0.96

TA = 2.73 [ ]+a,c

PRESSURIZER PRESSURE CONTROL SYSTEM ACCURACY

SCA = [ ]+a,c

M&TE=

STE =

SD =

BIAS=

RCA =

M&TE=

RTE =

RD =

CA =

ELECTRONICS CSA = [ ]+a,c

CONTROLLER CSA = [ ]+a,c

ROD CONTROL SYSTEM ACCURACY

Tavg TURB PRES

+a,c

SIGMA =

SCA =

M&TE=

STE =

SD =

BIAS=

RCA =

M&TE=

M&TE=

RTE =

RD =

CA =

BIAS=

+a,c

ELECTRONICS CSA =

ELECTRONICS SIGMA =

CONTROLLER SIGMA =

CONTROLLER CSA =

Indicated Tavg for DNB Technical Specification Limit

Tavg span = 100 degrees-F

CSA = [

PMA =

S =

RCA+RD =

IR =

(indicator readability)]+a,c

CSA = [ ]+a,c = 3.16%

Assuming three (3) Tavg channels for averaging,

CSA = [ ]+a,c = 1.82%

DNB Technical Specification Limit =

[ ]+a,c

Full Power Tavg = 574.1 degrees-F (at 3411 MW)

DNB Technical Specification Limit = [ ]+a,c = 576.3 degrees-F

PRESSURIZER PRESS. HIGH
FOXBORO TRANSMITTER

[illegible]A =
PEA =
SCA =
SPE =
STE =
SD =
EA =
BIAS=
RCA =
RCSA=
RTE =
RD =

[ ]+a,c

INSTRUMENT RANGE	=	1700.00	TO	2500.00	PSIG
INSTRUMENT SPAN	=	800.00	PSIG		
SAFETY ANALYSIS LIMIT	=	2410.00	PSIG		
ALLOWABLE VALUE	=	2395.03	PSIG		
MAXIMUM VALUE	=	[ ]+a,c			
NOMINAL TRIP SETPOINT	=	2385.00	PSIG		

[ ]+a,c S = 1.50 Z = 1.12 T = 1.25

[ ]+a,c

TA = 3.12 [ ]+a,c

STEAM GEN. LEVEL-LOW-LOW
MODEL 51 SG,FOXBORO XMITTER

FMA = [ ]+a,c
PEA =
SCA =
SPE =
STE =
SD =
EA =
BIAS=
RCA =
RCSA=
RTE =
RD =

INSTRUMENT RANGE = 0.00 TO 100.00 % SPAN

INSTRUMENT SPAN = 100.00 % SPAN

SAFETY ANALYSIS LIMIT = 0.00 % SPAN

ALLOWABLE VALUE = 19.25 % SPAN

MAXIMUM VALUE = [ ]+a,c

NOMINAL TRIP SETPOINT = 21.00 % SPAN

[ ]+a,c S = 1.50 Z = 7.35 T = 1.75

[ ]+a,c

TA = 21.00 [ ]+a,c

TABLE 2.2-1

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TRIP SETPOINT	ALLOWABLE VALUES
1. Manual Reactor Trip	Not Applicable	Not Applicable
2. Power Range, Neutron Flux	Low Setpoint - $\leq$ 25% of RATED THERMAL POWER High Setpoint - $\leq$ 109% of RATED THERMAL POWER	Low Setpoint - $\leq$ 26% of RATED THERMAL POWER High Setpoint - $\leq$ 110% of RATED THERMAL POWER
3. Power Range, Neutron Flux, High Positive Rate	$\leq$ 5% of RATED THERMAL POWER with a time constant $\geq$ 2 seconds	$\leq$ 5.5% of RATED THERMAL POWER with a time constant $\geq$ 2 seconds
4. Power Range, Neutron Flux, High Negative Rate	$\leq$ 5% of RATED THERMAL POWER with a time constant $\geq$ 2 seconds	$\leq$ 5.5% of RATED THERMAL POWER with a time constant $\geq$ 2 seconds
5. Intermediate Range, Neutron Flux	$\leq$ 25% of RATED THERMAL POWER	$\leq$ 30% of RATED THERMAL POWER
6. Source Range, Neutron Flux	$\leq 10^5$ counts per second	$\leq 1.3 \times 10^5$ counts per second
7. Overtemperature ΔT	See Note 1	See Note 3
8. Overpower ΔT	See Note 2	See Note 4
9. Pressurizer Pressure--Low	$\geq$ 1950 psig	$\geq$ 1940 psig
10. Pressurizer Pressure--High	$\leq$ 2385 psig	$\leq$ 2395 psig
11. Pressurizer Water Level--High	$\leq$ 92% of instrument span	$\leq$ 93% of instrument span
12. Loss of Flow	$\geq$ 90% of design flow per loop*	$\geq$ 88.9% of design flow per loop*

*Design flow is 93,750 gpm per loop.

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TRIP SETPOINT	ALLOWABLE VALUES
13. Steam Generator Water Level - Low-Low	$\geq$ 21% of narrow range instrument span - each steam generator	$\geq$ 19.2% of narrow range instrument span - each steam generator
14. Steam/Feedwater Flow Mismatch and Low Steam Generator Water Level	$\leq 1.47 \times 10^6$ lb/hr of steam flow at RATED THERMAL POWER coincident with steam generator water level $\geq$ 25% of narrow range instrument span - each steam generator	$\leq 1.56 \times 10^6$ lbs/hr of steam flow at RATED THERMAL POWER coincident with steam generator water level $\geq$ 24% of narrow range instrument span - each steam generator
15. Undervoltage - Reactor Coolant Pumps	$\geq$ 2750 volts - each bus	$\geq$ 2725 volts - each bus
16. Underfrequency - Reactor Coolant Pumps	$\geq$ 58.2 Hz - each bus	$\geq$ 58.1 Hz - each bus
17. Turbine Trip		
A. Low Trip System Pressure	$\geq$ 58 psig	$\geq$ 57 psig
B. Turbine Stop Valve Closure	$\geq$ 1% open	$\leq$ 1% open
18. Safety Injection Input from ESF	Not Applicable	Not Applicable
19. Reactor Coolant Pump Breaker Position Trip	Not Applicable	Not Applicable

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

NOTATION

NOTE 1: Overtemperature $\Delta T \leq \Delta T_o \left[K_1 - K_2 \left(\frac{1+t_1 S}{1+\tau_2 S}\right)(T-T') + K_3(P-P') - f_1(\Delta I)\right]$

where:

ΔT_o = Indicated ΔT at RATED THERMAL POWER

T = Average temperature, °F

T' = Indicated T_{avg} at RATED THERMAL POWER $\leq$ (provided by Exxon)

P = Pressurizer pressure, psig

P' = 2235 psig (indicated RCS nominal operating pressure)

$\frac{1+\tau_1 S}{1+\tau_2 S}$ = The function generated by the lead-lag controller for T_{avg} dynamic compensation

τ_1 & τ_2 = Time constants utilized in the lead-lag controller for T_{avg} τ_1 = 33 secs, τ_2 = 4 secs.

S = Laplace transform operator

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

NOTATION (Continued)

Operation with 4 Loops	Operation with 3 Loops
K_1 = 1.259	K_1 = (not provided)
K_2 = 0.01607	K_2 = 0.01607
K_3 = 0.000744	K_3 = 0.000744

and f_1 (ΔI) is a function of the indicated difference between top and bottom detectors of the power-range nuclear ion chambers; with gains to be selected based on measured instrument response during plant startup tests such that:

(i) for $q_t - q_b$ between - 40 percent and + 3 percent, f_1 (ΔI) = 0 (where q_t and q_b are percent RATED THERMAL POWER in the top and bottom halves of the core respectively, and $q_t + q_b$ is total THERMAL POWER in percent of RATED THERMAL POWER).

(ii) for each percent that the magnitude of ($q_t - q_b$) exceeds - 40 percent, the ΔT trip setpoint shall be automatically reduced by 1.8 percent of its value at RATED THERMAL POWER.

(iii) for each percent that the magnitude of ($q_t - q_b$) exceeds + 3 percent, the ΔT trip setpoint shall be automatically reduced by 2.2 percent of its value at RATED THERMAL POWER.

TABLE 2.2-1 (Continued)

REACTOR TRIP SYSTEM INSTRUMENTATION TRIP SETPOINTS

NOTATION (Continued)

Note 2: Overpower $\Delta T \leq \Delta T_o[K_4 - K_5 \left(\frac{\tau_3 S}{1+\tau_3 S}\right) T - K_6 (T - T'') - f_2(\Delta I)]$

where: ΔT_o = Indicated ΔT at rated power

T = Average temperature, °F

T'' = Indicated T_{avg} at RATED THERMAL POWER $\leq$ (provided by Exxon)

K_4 = 1.078

K_5 = 0.02/°F for increasing average temperature and 0 for decreasing average temperature

K_6 = 0.00197 for $T > T''$; $K_6 = 0$ for $T \leq T''$

$\frac{\tau_3 S}{1+\tau_3 S}$ = The function generated by the rate lag controller for T_{avg} dynamic compensation

τ_3 = Time constant utilized in the rate lag controller for T_{avg} τ_3 = 10 secs.

S = Laplace transform operator

$f_2(\Delta I)$ = (provided by Exxon)

Note 3: The channel's maximum trip point shall not exceed its computed trip point by more than 3.3 percent.

Note 4: The channel's maximum trip point shall not exceed its computed trip point by more than 2.6 percent.

TABLE 3.2-1

DNB PARAMETERS

LIMITS

PARAMETER	4 Loops in Operation	3 Loops in Operation***
Reactor Coolant System T_{avg}**	≤ 576.3°F (indicated)	≤ (not provided)
Pressurizer Pressure	≥ 2220 psia*	≥ 2220 psia*

* Limit not applicable during either a THERMAL POWER ramp in excess of 5% RATED THERMAL POWER per minute or a THERMAL POWER step in excess of 10% RATED THERMAL POWER.

** Indicated average of OPERABLE instrument loops.

*** It should be noted that three loop operation using this curve is not currently allowed. The changes contained in this table are for reference only.

TABLE 3.3-4 (Continued)

ENGINEERED SAFETY FEATURE ACTUATION SYSTEM INSTRUMENTATION TRIP SETPOINTS

FUNCTIONAL UNIT	TRIP SETPOINT	ALLOWABLE VALUES
4. STEAM LINE ISOLATION		
a. Manual	Not Applicable	Not Applicable
b. Automatic Actuation Logic	Not Applicable	Not Applicable
c. Containment Pressure--High-High	$\leq$ 2.9 psig	$\leq$ 3.0 psig
d. Steam Flow in Two Steam lines-- High Coincident with T_{avg} --Low-Low	< A function defined as follows: A Δp corresponding to 1.47 x 10^6 lbs/hr steam flow between 0% and 20% load and then a Δp increasing linearly to a Δp corresponding to 110% of full steam flow at full load.	< A function defined as follows: A Δp corresponding to 1.62 x 10^6 lbs/hr steam flow between 0% and 20% load and then a Δp increasing linearly to a Δp corresponding to 111.5% of full steam flow at full load.
	$T_{avg} \geq$ 541°F	$T_{avg} \geq$ 538.2°F
e. Steam Line Pressure--Low	> 600 psig steam line pressure	> 580 psig steam line pressure
5. TURBINE TRIP AND FEED WATER ISOLATION		
a. Steam Generator Water level-- High-High	> 67% of narrow range instrument span each steam generator	> 68% of narrow range instrument span each steam generator