CP&L

Carolina Power & Light Company
Robinson Nuclear Plant
3581 West Entrance Road
Hartsville SC 29550

Serial: RNP-RA/99-0213

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United States Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

H. B. ROBINSON STEAM ELECTRIC PLANT, UNIT NO. 2
DOCKET NO. 50-261/LICENSE NO. DPR-23

LICENSEE EVENT REPORT NO. 1999-002-00
INCORRECT GAIN SETTINGS FOR DELTA-TEMPERATURE TRIPS

Ladies and Gentlemen:

The attached Licensee Event Report revision is submitted in accordance with 10 CFR 50.73. If you have any questions regarding this matter, please contact Mr. R. L. Warden.

Sincerely,

TDWalt

T. D. Walt
Plant General Manager

ALG/alg

c: L. A. Reyes, NRC, Region II
R. Subbaratnam, NRC, NRR
NRC Resident Inspector, HBRSEP

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NRC FORM 366 (6-98) — U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER)

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TITLE (4)
Incorrect Gain Settings for Delta-Temperature Trips

EVENT DATE (5) MONTH	DAY	YEAR	LER NUMBER (6) YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	REPORT DATE (7) MONTH	DAY	YEAR	OTHER FACILITIES INVOLVED (8) FACILITY NAME	DOCKET NUMBER(S)
10	04	1999	1999	- 002 -	00	11	03	1999		

OPERATING MODE (9): 0
POWER LEVEL (10): 000

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR (*Check one or more of the following*) (11)

	20.2201(b)		20.2203(a)(2)(v)	X	50.73(a)(2)(i)		50.73(a)(2)(viii)
	20.2203(a)(1)		20.2203(a)(3)(i)		50.73(a)(2)(ii)		50.73(a)(2)(x)
	20.2203(a)(2)(i)		20.2203(a)(3)(ii)		50.73(a)(2)(iii)		73.71
	20.2203(a)(2)(ii)		20.2203(a)(4)		50.73(a)(2)(iv)		OTHER
	20.2203(a)(2)(iii)		50.36(c)(1)		50.73(a)(2)(v)		Specify in Abstract below or
	20.2203(a)(2)(iv)		50.36(c)(2)		50.73(a)(2)(vii)		in NRC Form 366A

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER
H. K. Chernoff, Supervisor, Licensing/Reg. Programs	843-857-1437

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX
N/A									

SUPPLEMENTAL REPORT EXPECTED (14)

YES (if yes, complete EXPECTED SUBMISSION DATE)	X NO	EXPECTED SUBMISSION DATE (15)	MONTH	DAY	YEAR
	X				

ABSTRACT (Limit to 1400 spaces, i.e. approximately fifteen single-space typewritten lines) (16)

On October 4, 1999, at approximately 1900 hours, the H. B. Robinson Steam Electric Plant, Unit No. 2 was in the defueled condition. The calibration data sheets for the Overpower Delta-Temperature (OPDT) trip setpoint were found to contain non-conservative gain settings for dynamic compensation of the setpoint. The cause was a failure to incorporate gain settings from scaling calculations for the OPDT setpoint into calibration procedures. Additionally, it was discovered that scaling calculations for the Overtemperature Delta-Temperature (OTDT) trip setpoint were not incorporated correctly into procedures and contained an error. As a result, the dynamic compensation for the OTDT setpoint was non-conservative below about 65 percent reactor power. Both conditions have been found to be bounded by the safety analyses. The scaling calculations, calibration procedures, and gain settings for the Delta-Temperature trip setpoints have been corrected. A change to the calculation control procedure will be made to require an impact review when calculations are changed. This event is reported in accordance with 10 CFR 50.73(a)(2)(i)(B) as a condition prohibited by Technical Specifications.

I. DESCRIPTION OF EVENT

On October 4, 1999, at approximately 1900 hours EDT, the H. B. Robinson Steam Electric Plant (HBRSEP), Unit No. 2 was in the defueled condition (i.e., no MODE). The system engineer for the Reactor Protection System (RPS) (EIIS System Code: JE) was developing a spreadsheet model of the Overpower Delta-Temperature (OPDT) reactor trip circuit (EIIS System Code: JE) as a trouble shooting aid. The model could be used to predict voltages anywhere in the OPDT trip circuit. When attempting to model the transient response of the OPDT trip circuit, the system engineer discovered that the calibration data sheets for the derivative amplifiers (i.e., TM-412E, TM-422E, and TM-432E) (EIIS Component Code: AMP) required incorrect voltage gain settings. The voltage gain required by procedure was 1.000 and the correct setting should be greater than or equal to 1.150. The effect of this error was to non-conservatively reduce the dynamic compensation of the OPDT trip for rapidly developing transients.

The error on OPDT setpoint becomes more pronounced for faster moving transients. However, the overall compensation for these times is large, such that the time delay in the non-conservative trip versus the required trip setpoint becomes small. Within the region that the OPDT setpoint is greater than Delta-T actual (i.e., period > approximately 30 seconds), the error in compensation is within the Technical Specifications requirements. Scaling calculations, completed in 1991, originally established the gain setting value for the OPDT at 1.150. This is the earliest time that non-compliance with the Technical Specifications can be established. For rapidly developing plant transients that have occurred since 1991, the OPDT trip setpoint was higher than required by Technical Specifications. Because the actual OPDT setpoint did not comply with Technical Specifications setpoint requirements, this condition is reportable in accordance with 10 CFR 50.73(a)(2)(i)(B) as a condition prohibited by Technical Specifications.

In response to this condition, a corrective action was initiated to review the scaling calculations against the dynamic compensated reactor trips (i.e., Overtemperature and OPDT trips). During the review, it was discovered that scaling calculations for the lead/lag amplifiers (i.e., TM-412E, TM-422E, and TM-432E) (EIIS Component Code: AMP) for the Overtemperature Delta-Temperature (OTDT) trips (EIIS System Code: JE) were not properly incorporated into the procedures or into the plant. The effect of this error is to limit the dynamic compensation of the OTDT trip on an increasing average temperature (i.e., T_{avg}) to a penalty of about 41 degrees F. Since the OTDT trip setpoint is about 78 degrees F, an increasing T_{avg} would have reduced the setpoint, taking into account saturation of the amplifiers, to 37 degrees F. However, a reactor trip would occur from the OTDT trip before the lead/lag controller saturated if initial power levels were above 64 percent Rated THERMAL POWER (RTP). Additionally, the original scaling calculations developed in 1991 had an error in the gains to the lead/lag amplifiers such that if the scaling calculations were implemented in the plant as originally calculated in 1991, the lead/lag amplifiers could still saturate for conditions in which the initial THERMAL POWER level was less than about 17 percent RTP, and the OTDT trip setpoint would not have met the Technical Specifications requirements. The saturation condition of the OTDT lead/lag amplifiers was a design deficiency that existed in the original OTDT system. For THERMAL POWER levels 64 percent RTP and below, the OTDT trip setpoint would have been higher than required by Technical Specifications.

Because the actual OTDT setpoint did not comply with Technical Specification formula requirements, this condition is also reportable in accordance with 10 CFR 50.73(a)(2)(i)(B) as a condition prohibited by Technical Specifications.

II. CAUSE OF EVENT

The cause of the error in the OPDT setpoint was a failure to implement fully scaling calculations developed in 1991 into the plant as a modification or procedure change. Scaling calculations developed in response to Licensee Event Report (LER) 91-009-01, “Overtemperature Delta Temperature Channels Inoperable due to Summator Module Lag Constants,” identified the correct gain for the derivative amplifiers. Had this calculation been incorporated into the plant as a modification or change to procedures, the correct gain for the derivative amplifiers would have been reflected in procedures.

The calibration data sheets affecting the OPDT setpoint in Process Instrument Calibration procedure (PIC)-605, “Hagan Lead/Lag Controller,” contained the wrong gain setting for the derivative amplifiers for the OPDT trip. The incorrect gain used in procedures was apparently a carryover from historical data annotated on calibration data sheets and maintained on work tickets which were subsequently placed into PIC-605 in 1995. Prior to this date, calibration data sheets for the derivative amplifiers were not contained in procedures. The responsible engineer did not ensure that the scaling calculations developed in 1991 were incorporated into the revision to PIC-605. As a result, the calibration data sheets did not agree with the derivative amplifier gain requirement in the 1991 scaling calculations.

The cause of the error in the OTDT setpoint was also a failure to implement fully scaling calculations developed in 1991 into the plant as a modification or procedure change. Additionally, the original scaling calculations developed in 1991 did not ensure a reactor trip would occur before saturation of the lead/lag amplifiers for the full range of reactor power levels as recommended in Westinghouse Technical Bulletin NSD-TB-91-09-R0, “Over Temperature Delta-T (OTDT) Scaling.” Also, the scaling calculations developed in response to LER 91-009-01 identified the saturation problem with the lead/lag amplifiers, but the calculations were not fully implemented in the plant. The responsible engineer did not ensure that the scaling calculations developed in 1991 were incorporated into calibration data sheets in Loop Calibration Procedures LP-001, “Overpower, Overtemperature Delta-T Protection Channel I,” LP-002, “Overpower, Overtemperature Delta-T Protection Channel II,” and LP-003, “Overpower, Overtemperature Delta-T Protection Channel III.” Although the only documentation available is the calculation itself, it is concluded that this error was an oversight on the part of the responsible engineer.

A deficiency in procedure MOD-002, “Design Calculations,” did not require the responsible engineer to perform an impact review of the change on plant procedures or equipment parameters when developing or revising plant calculations. This deficiency contributed to both conditions regarding the Delta-T trips.

III. ANALYSIS OF EVENT

The Overpower and Overtemperature protection system setpoints include effects of fuel densification and the rated thermal output on core safety limits. The setpoints in the Technical Specifications ensure that the combination of power, temperature, and pressure will not exceed the core safety limits.

A. OPDT Reactor Trip Setpoint

Background

The derivative amplifiers are used to provide a dynamic adjustment to the OPDT reactor trip setpoint. Under steady state plant conditions, these modules have no effect on the OPDT setpoint. If T_{avg} is increasing, then this module adds an additional penalty to (i.e., decreases) the setpoint, which will cause the plant to trip at a lower T_{avg} than would otherwise be the case. When T_{avg} stops increasing, then the setpoint penalty decays to zero in about 20 seconds. If T_{avg} is decreasing, the module has no effect because the penalty only applies if T_{avg} is increasing.

The derivative amplifiers are amplifiers that implement the Laplace transform formula for the OPDT reactor protection system trip. The setpoint for this trip is listed in Technical Specifications as stated below.

"The OPDT Function Allowable Value shall not exceed the following Nominal Trip Setpoint by more than 3.17 percent of Delta-T span.

$$\Delta T_{SETPOINT} \leq \Delta T_0 \left\{ K_4 - K_5 \left[\frac{(t_3 S)}{(1 + t_3 S)} \right] T - K_6 (T - T') - f(\Delta I) \right\}$$

Where: ΔT_0 is the indicated ΔT at RTP, degrees F.
S is the Laplace transform operator, sec^{-1}.
T is the measured RCS average temperature, degrees F.
$K_4 \leq 1.06$
$K_5 \geq 0.02$/degrees F for increasing T_{avg}
0/degrees F for decreasing T_{avg}
$K_6 \geq 0.00277$/degrees F when $T > T'$
0/degrees F when $T \leq T'$
$t_3 \geq 9$ sec
$f(\Delta I)$ = as defined in Note 1 for Overtemperature ΔT."

The purpose of the differential term for the K_5 constant in the equation is to compensate for the delay from the change in temperature of the core to the time that the temperature measurement occurs in the Reactor Coolant System (RCS) (EIIS System Code: AC) loops and includes instrument time delay.

The Updated Final Safety Analysis Report (UFSAR) states that the OPDT reactor trip prevents power density anywhere in the core from exceeding the fuel power density corresponding to fuel center line melt and includes corrections for axial power distribution, change in density, and heat capacity of water with temperature, and dynamic compensation for piping delays from the core to the loop temperature detectors. The specified setpoints meet this requirement and include allowance for instrument errors.

Safety Analyses That Credit the OPDT Trip

Although the OPDT trip function is required by Technical Specifications Section 3.3.1, it is an additional trip which is available and is not used for UFSAR Chapter 15 safety analyses. Chapter 15.0.7 of the UFSAR states, “If credit were taken in the analysis for such trips the results of the events would be further mitigated with less challenging results. It is, therefore, conservative not to credit the additional trips.”

Safety Significance of OPDT Saturation Condition

The error in gain setting of the differential amplifiers in the OPDT setpoint had the effect of under-compensating the trip setpoint for rapidly developing transients, i.e., the trip setpoint was reduced by the transient conditions less than that required by Technical Specifications. Under limiting assumptions, had a rapidly developing RCS temperature transient occurred, automatic actuation of the mitigating features associated with the OPDT trip would have been delayed. However, rapidly developing transients are protected by other trips. As described in UFSAR Section 7.2.1.2.1, “Reactor trips on nuclear overpower and low reactor coolant flow are provided for direct, immediate protection against rapid changes in these parameters.” Since the OPDT trip setpoint is not credited in the accident analyses, and other trips protect the plant under the conditions in which the error in the gain setting has its greater effect, this error has minimal safety significance, and the error in gain setting for the differential amplifiers in the OPDT setpoint was bounded by the accident analyses.

The effect of the error in the OPDT trip has been evaluated by the Fuel Vendor, Siemens Power Corporation (SPC), and SPC has confirmed that the error had no effect on the safety analyses.

B. OTDT Reactor Trip

Background

The lead/lag amplifiers are used to provide a dynamic adjustment to the OTDT reactor trip setpoint. Under steady state plant conditions, these modules apply a setpoint penalty which is proportional to the amount that T_{avg} is above the 100 percent RTP T_{avg}. If T_{avg} is increasing, then this module adds an additional penalty to (i.e., decreases) the setpoint, which will cause the plant to trip at a lower T_{avg} than would otherwise be the case.

The lead/lag amplifiers are amplifiers that implement the Laplace transform formula for the OTDT reactor protection system trip. The setpoint for this trip is listed in Technical Specifications as stated below.

"The Overtemperature Delta-T Function Allowable Value shall not exceed the following Nominal Trip Setpoint by more than 2.96 percent of Delta-T span.

$$\Delta T_{setpoint} \le \Delta T_0 \left\{ K_1 - K_2 \left[\frac{(1 + \tau_1 S)}{(1 + \tau_2 S)}\right](T - T') + K_3(P - P') - f(\Delta I) \right\}$$

Where: ΔT_0 is the indicated ΔT at RTP, degrees F.
s is the Laplace transform operator, sec^{-1}.
T is the measured RCS average temperature, degrees F.
T' is the reference T_{avg} at RTP, $\le$ 575.4 degrees F.
P is the measured pressurizer pressure, psig
P' is the nominal RCS operating pressure, $\le$ 2235 psig
$K_1 \le 1.1265$ $K_2 = 0.01228$/degrees F $K_3 = 0.00089$/psig."

The purpose of the lead/lag term for the K_2 constant in the equation is to compensate for the delay from the change in temperature of the core to the time that the temperature measurement occurs in the Reactor Coolant System (RCS) loops including instrument time delay.

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Safety Analyses That Credit the OTDT Trip

The OTDT trip function is provided to ensure that the design limit Departure from Nucleate Boiling Ratio (DNBR) is met. The inputs to the OTDT trip include pressurizer pressure, coolant temperature, axial power distribution, and reactor power as indicated by loop Delta-T assuming full reactor coolant flow. Protection from violating the DNBR limit is assured for those transients that are slow with respect to delays from the core to the measurement system. The OTDT trip function uses each loop's Delta-T as a measure of reactor power and is compared with a setpoint that is automatically varied with the following parameters:

a. Reactor coolant average temperature-the trip setpoint is varied to correct for changes in coolant density and specific heat capacity with changes in coolant temperature;
b. Pressurizer pressure-the trip setpoint is varied to correct for changes in system pressure; and
c. Axial power distribution-f(Delta-I), the trip setpoint is varied to account for imbalances in the axial power distribution.

Dynamic compensation is included for system piping delays from the core to the temperature measurement system and Resistance Thermal Detector (RTD) response time. The lead/lag function is generated by the lead-lag controller for T_{avg} dynamic compensation. Function f(Delta-I) 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.

The Loss of External Electrical Load event in the UFSAR is the limiting safety analysis for the OTDT trip. Three cases are analyzed, the maximum RCS pressure case, the maximum secondary pressure case, and the minimum DNBR case. The OTDT trip is not credited in the maximum RCS pressure case.

The maximum secondary side pressurization case initiates with a turbine control valve closure. In this case, the OTDT occurs at 18.93 seconds and the peak secondary pressure of 1202 psia occurs at approximately 20 seconds.

The minimum DNBR case is initiated in the same manner as the maximum secondary side pressurization case. Steam line pressure increases until the secondary side safety valves open at 12.9 sec. The pressurization of the secondary side results in decreased primary-to-secondary heat transfer and a substantial rise in cold leg temperature. The average primary temperature increases about 28 degrees F, peaking at 16.0 seconds. The rapid increase in primary side temperatures result in a large insurge into the pressurizer, compressing the steam space and pressurizing the primary system. OTDT trips the reactor with rod insertion commencing at 13.9 sec.

The OTDT trip is also credited in the Uncontrolled Control Rod Assembly Bank Withdrawal at Power event in the UFSAR. This event is defined as resulting from an uncontrolled control bank withdrawal at power. The event could be caused by misoperation of the most reactive control rod banks that move together withdrawing at up to the maximum rate. The reactor protection trip system is designed to protect the specified acceptable fuel design limits. In this analysis, the OTDT and power range (high setting) high flux trips are the principal trip functions. The OTDT trip function protects against Departure from Nucleate Boiling (DNB). For the limiting case, slow bank withdrawal initiates at full power, and reactivity increases. Power increases steadily in response to the reactivity increase, until the reactor trips. Coolant temperatures also increase steadily, because of the primary-to-secondary system power mismatch. The pressure increase from coolant expansion and pressurizer insurge is limited by the primary Power Operated Relief Valves, with the pressurizer pressure peaking at 2278 psia. The high flux and OTDT trip setpoints are both reached at 56.8 seconds, and rod insertion began at 57.3 seconds. The calculated DNBR reaches a minimum value of 1.20 at 57.5 seconds.

The OTDT trip is also credited in the dropped Rod Cluster Control Assembly (RCCA) event in the UFSAR. The event initiates by a minimum-worth dropped rod. After the rod reaches the bottom of the core, a turbine runback signal occurs. The turbine load demand ramps down to 70%. The average coolant temperature initially decreases in response to the power reduction caused by the dropped rod, but later increases due to the reduced secondary load demand. Reactor scram on OTDT occurs at 35.9 seconds.

Safety Significance of OTDT Saturation Condition

In the accident analyses described above, the OTDT trip operates as discussed above for THERMAL POWER levels above 64 percent RTP. For accident analyses in which the OTDT was credited, the THERMAL POWER assumption was 100 percent RTP. At lower power levels, the OTDT trip would have been delayed. The delay in trip increases as the initial assumed THERMAL POWER is reduced. Since analyses are performed at limiting conditions the effect of the delay could not be quantified. However, because the dominant variable in the OTDT trip setpoint is the operating Delta-T, the setpoint is proportionally reduced at reduced THERMAL POWER, the dynamic compensation of the lead/lag amplifiers is proportionally reduced at reduced THERMAL POWER, and the operating margin to analyzed operating limits is increased at reduced THERMAL POWER. Therefore the delay in OTDT trip is bounded by the accident analyses.

The effect of the error in the OTDT trip has been evaluated by the Fuel Vendor, SPC. For the limiting loss of external electrical load analysis, the maximum value of the T_{avg} penalty in the dynamic compensation term of the OTDT trip at the time of the analyzed time of the OTDT trip was less than the saturation point of the lead/lag amplifiers. Therefore the error in the gain settings for the lead/lag amplifiers is bounded by the accident analyses.

IV. CORRECTIVE ACTIONS

The gains for the OPDT derivative amplifiers were corrected to comply with Technical Specifications.

The calibration sheets in procedures were corrected to reflect the correct gain for the derivative amplifiers in the OPDT trip.

The errors in the scaling calculation for the OTDT trip were corrected to agree with the recommendations of Westinghouse Technical Bulletin NSD-TB-91-09-R0, "Overtemperature Delta-T (OTDT) Scaling," dated January 6, 1992.

The OTDT lead/lag amplifiers were corrected to avoid saturation at the full range of THERMAL POWER levels.

The calibration sheets in procedures were corrected to revise the gain for the lead/lag amplifiers for the OTDT trip as specified in the scaling calculations.

MOD-002, "Design Calculations," will be revised and appropriate training will be provided to engineers on the procedure change by December 20, 1999. The procedure revision will require that the preparer of calculations perform an impact review and initiate action which will result in changes to procedures impacted by a calculation or its revision.

V. ADDITIONAL INFORMATION

A. Failed Component Information:

There were no component failures associated with this event.

B. Previous Similar Events:

A review of LERs in the past three years found no previous occurrences similar to this event in which the calculations for the Delta-T trips were not fully implemented in the plant or procedures. However, LER-1997-07-01, "Condition Outside Design Basis Due to Inoperable Over Power Delta Temperature Channels," involved incorrect calibration procedures for the summators affecting the K_6 factor in the OPDT trip. The cause of the 1997 event was inadequate programmatic controls leading to personnel error. Calibration acceptance data was annotated by hand on a calibration data sheet and the sheet would be copied for use during the next calibration. Although not conclusively determined, it is likely that while the calibration sheets were being revised, the low limit setpoint was not carried over to the new sheets. The cause of the current event was a failure to fully implement calculations into calibration procedures, and an error existed in the calculations. While the causes of the two events are different, had the corrective actions to the 1997 event been broader, the incorrect gain settings in the Delta-T setpoints may have been identified at that time.