UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO AMENDMENT NO. 40 TO FACILITY OPERATING LICENSE NPF-35

AND AMENDMENT NO. 33 TO FACILITY OPERATING LICENSE NPF-52

DUKE POWER COMPANY, ET AL.

DOCKET NOS. 50-413 AND 50-414

CATAWBA NUCLEAR STATION, UNITS 1 AND 2

INTRODUCTION

By letter dated July 22, 1987, and supplemented by letters dated May 26, August 31, October 1, October 30, November 19 and December 14, 1987, Duke Power Company, et al., (the licensee) requested amendments to Facility Operating License Nos. NPF-35 and NPF-52 for the Catawba Nuclear Station, Units 1 and 2. The proposed amendments would revise the Technical Specifications due to changes in the reactor trip system and engineered safety features response times to accommodate the removal of the Resistance Temperature Device (RTD) bypass system and the installation of replacement RTDs in thermowells located directly in the hot leg and cold leg piping. This system will use narrow range fast response resistance temperature detectors (RTDs). This design modification is to overcome major drawbacks of the RTD bypass system which lacked reliability (leakage from valve packing or mechanical joints) and resulted in high radiation doses during the performance of maintenance around the RTD bypass system.

The substance of the changes noticed in the Federal Register on December 2, 1987 and the proposed No Significant Hazards determination was not affected by the licensee's letter dated December 14, 1987, which clarified certain aspects of the request.

EVALUATION

Currently, the hot and cold leg temperatures are measured by RTDs inserted into reactor coolant bypass loops. A bypass loop from upstream of the steam generator to downstream of the steam generator is used for the hot leg RTDs and a bypass loop from downstream of the reactor coolant pump to upstream of the pump is used for the cold leg RTDs. The RTDs are located in manifolds and are directly inserted into the reactor coolant bypass loop without thermowells. Each RTD manifold (one hot leg and one cold leg manifold per reactor coolant loop) contains two narrow-range RTDs: one for protection and control system inputs and one as a spare. Flow into each hot leg bypass loop is provided by three scoops located at 120° intervals around the hot leg pipe perimeter to take account of temperature variation across the pipe due to hot leg streaming. The action of the coolant pump provides well-mixed coolant in the cold leg bypass using a single tap into the cold leg.

Each loop's pair of RTDs (one in the hot leg and one in the cold leg) is used to provide inputs for protection system functions based on the average loop temperatures (Tavg = $(T_{HOT} + T_{COLD})/2$) and the loop differential temperature (delta T = $T_{HOT} - T_{COLD}$). Protection functions based on these inputs are: overtemperature delta T and overpower delta T reactor trips with their associated (non-Protection) rod stop and turbine runback actions, low Tavg main feedwater isolation, and low-low Tavg (P-12) steam dump block signals.

Each loop's pair of RTDs is also used to provide inputs for control system functions based on the average loop temperature and the loop differential temperature. Control functions based on these inputs are: turbine loading stop from auctioneered low Tavg; rod, steam dump and pressurizer level control from auctioneered high Tavg; rod insertion limit alarms from auctioneered high delta T and Tavg.

In the proposed modified system, the hot leg temperature inputs from each reactor coolant loop will be developed from three fast response, narrow range RTDs mounted in thermowells located within the three existing RTD bypass manifold scoops (except for Loop B where two of the three thermowells will be mounted in the scoops, but the third thermowell, because of structural interference, will be located 8.5 inches downstream of the existing scoop in an independent boss). An outlet port is provided at the end of each scoop and the thermowell is positioned so that the RTD sensing element is located near the middle inlet hole of the scoop. The objective of this design is to ensure that the temperature sensed by the RTD is close to that of the previous scoop flow.

One RTD per loop will be mounted in a thermowell located at the existing penetration for the bypass loop into the cold leg. Additionally, a new penetration will be added to each cold leg for a spare thermowell-mounted, narrow range RTD. The RTDs are placed in thermowells to allow replacement without draindown. The thermowells, however, increase the response time.

Each hot leg temperature input for protection system functions will be developed by electronically averaging the signals from the three new fast response, narrow range RTDs. This averaged input will replace the single input from the currently installed hot leg RTD. Each cold leg input for protection system functions will be provided by the new fast response, narrow range RTD which replaces the currently installed cold leg RTD. In the event of a hot leg RTD failure, the electronics allow a bias developed from historical data for the failed RTD to be manually added via a potentiometer to the remaining two RTD signals in order to obtain an average value comparable to the three-RTD average prior to failure of the one RTD. If a cold leg RTD fails, the spare cold leg RTD can be used instead. The failure of an RTD would be detected by the Tavg or delta T deviation alarm.

Inputs for the control system functions will be provided, through isolators, from the average loop temperatures and loop differential temperatures calculated by the protection system. This aspect of the design has not been changed; only the use of three hot leg RTDs instead of one per loop to provide an average hot leg temperature is different.

The RTD modifications affect plant accident analysis by changing the RTD response time and hot leg temperature measurement uncertainty. In the licensee's July 22, 1987 submittal, the overall response time of the new thermowell RTD hot leg temperature measurement system is given as 7.0 seconds, made up of 5.5 seconds for the RTD thermowell combination and 1.5 seconds for the electronic delays. The increase over the 4.0 second response time for the bypass system was principally due to slow conduction through the thermowell. Because of the increased channel response time, there are no longer delays from the time when fluid conditions in the reactor coolant system (RCS) require an overtemperature delta T or overpower delta T reactor trip until the trip actually takes place. However, as reported in the licensee's submittal of July 22, 1987, the original safety analyses for the bypass RTD system conservatively assumed a response time of 8.0 seconds and this response time was found to be acceptable.

In the supplemental submittal of November 19, 1987, the licensee changed the RTD response time from 7.0 to 8.0 seconds. The 8.0 second response time provided one second of added margin in the analyses.

Recent testing at another plant after completion of a similar RTD bypass system removal modification has resulted in response times slightly greater than anticipated. Also, as noted in NUREG-0809 (Reference 1), extensive RTD testing has revealed degradation of RTD response time with aging. In accordance with the guidance in NUREG-0809, the licensee in its November 19, 1987 submittal revised Technical Specification (TS) 4.3.1.2 to provide for response time testing of all RTDs once per 18 months. The testing method specified is the Loop Current Step Response (LCSR) method, which is the approved in-situ method for measuring RTD response time.

Since the safety analyses referenced in the licensee's July 22, 1987 submittal found that the 8.0 second response time was acceptable, no additional analyses are required to justify the proposed revision to 8.0 seconds.

With regard to the effect of the plant modification on the uncertainty of the temperature measurements, the new method of measuring each hot leg temperature with three thermowell RTDs manufactured by the RdF Corporation, used in place of the RTD bypass system with three scoops, has been analyzed to be slightly more accurate. The new RTD thermowell with measurement at one point may have a small streaming error relative to the former scoop flow measurement because of a temperature gradient over the 5-inch scoop span. However, this gradient has been calculated to have a small effect. Also, since possible temperature uncertainties from imbalanced scoop flows are eliminated, the overall result is more reliable. In addition, since the new method uses three RTDs for each hot leg temperature measurement, it is statistically a more accurate temperature measurement than the former method which used only one RTD for each hot leg temperature measurement. Therefore, the current values of nominal setpoints for the Catawba Technical Specifications are still valid.

There has been no change in the present RTD temperature deviation alarms which include both a Tavg and a delta T deviation alarm. This alarm system compares the Tavg or delta T signals to a pre-set threshold value. This value is nominally set to + or - 2°F and is adjusted during startup and subsequent operation such that it is just beyond the range of normal operating variations.

The method to be used by the licensee for calibrating the RTDs at each refueling prior to startup is the Westinghouse recommended RTD cross-calibration method at heatups after each refueling. This procedure requires multiple measurements at three or four different temperatures. To date, Westinghouse has evaluated the data from over 400 RTDs using this technique, and several repeat tests performed one to three years apart have not shown any indication of drift in only one direction. The results of the tests indicate that the RTDs drift less than was assumed for uncertainty calculations for the protection system. The procedure sensitivity is sufficient to discern a random drift of less than 1.0°F by one or several RTDs. If a drift is noticed, either the calibration of the resistance to voltage converter for the affected RTD would be adjusted to account for the shift, or, if the drift is appreciable, the RTD would be declared inoperable and would be replaced.

Since both the old and new methods of coolant temperature measurement have an inherent streaming inaccuracy, accounted for in the staff's safety analyses, it is not appropriate to compare the new method to the old method and declare any differences as errors. It is possible, however, to compare the normalized full power delta T measured before and after the modification. It is expected that the delta T readings will be very similar once any secondary side measurement errors, such as feedwater flow, have been factored into the power calculation. If there were any dramatic differences between the two delta T readings, it would indicate that a problem existed with one of the measurement methods. The licensee will perform a comparison of the temperature indications after the modification with measurements prior to the modification. The NRC will be notified of the results of this comparison including any explanation of variations larger than expected.

Non-LOCA accident analyses are affected by the plant modifications primarily through their effect of increasing RTD response time. Only those events which rely on the Overtemperature and Overpower delta T (OTDT and OPDT) reactor trips are impacted. The accidents in FSAR Sections 15.1 to 15.6 were examined and the following non-LOCA accidents affected by the longer response time were reanalyzed: (1) the Uncontrolled Rod Cluster Control Assembly (RCCA) Withdrawal; (2) uncontrolled boron dilution at power; and (3) the Steamline Rupture at Power. The applicant stated that the LOFTRAN computer code was used for the analysis of these events.

The first accident, Uncontrolled RCCA Withdrawal, is described in Section 15.4.2 of the FSAR. For this event, the High Neutron Flux and Overtemperature delta T reactor trips are assumed to provide protection against DNB. This event was analyzed with the increased time constants and lead/lag changes. Plots of DNBR versus time were provided which showed that the DNBR criterion was met for this accident.

For the Boron Dilution at Power event, manual operation, as described in Section 15.4.6 of the FSAR, the time from initiation of the event to reactor trip is determined from the Uncontrolled RCCS Withdrawal at Power analysis. The licensee stated that based upon the results of the Uncontrolled RCCS Withdrawal at Power analysis, the conclusions presented in the FSAR for the Boron

Dilution at Power event, manual operation, remain valid, i.e., there is greater than 15 minutes from the time of an alarm until the total loss of shutdown margin occurs.

For the Steamline Rupture at Power event the analysis included the increased response time and lead/lag changes. The analysis showed that the design basis as described in WCAP-9226-Rev. 1, "Reactor Core Response to Excessive Secondary Steam Release", January 1978, has been met.

The effect of the increase in RTD response time on the FSAR Chapter 15 Loss of Load/Turbine Trip event is analyzed for both beginning and end of life conditions in Section 15.2.3 of the FSAR. No credit for reactor trip on turbine trip is assumed in the safety analyses. Therefore, reactor trips on high pressurizer pressure, overtemperature delta T, and low-low steam generator water level reactor trips provide the necessary protection for this event during the starting mode. For the Loss of Load/Turbine Trip analyses presented in the FSAR, increased RTD response times were assumed for the Catawba positive moderator temperature coefficient (MTC) safety evaluation. For all four cases analyzed, reactor trips occurred on either a high pressurizer pressure or low-low steam generator water level signal. An overtemperature delta T signal was never generated prior to reactor trip. Therefore, the analyses currently presented in the Catawba FSAR, based on the positive MTC safety evaluation, have adequately addressed the increased RTD response time resulting from the RTD bypass elimination.

The impact of the increased RTD response time on the FSAR Chapter 15 non-LOCA accident analyses has been evaluated. For the events impacted, it was demonstrated that the conclusions presented in the FSAR remain valid.

The elimination of the RTD bypass system impacts the uncertainties associated with RCS temperature and flow measurement. The effect of these uncertainties on the LOCA evaluation was considered. The magnitudes of the uncertainties in the RCS inlet and outlet temperatures, thermal design flow rate and the steam generator performance data used in the LOCA analyses are such that the conclusions of the previous analyses will not be affected. Past sensitivity studies concluded that the inlet temperature effect on peak clad temperature is dependent on break size. As a result of these studies, the LOCA analyses are performed at a nominal value of the inlet temperature without consideration of small uncertainties. The RCS flow rate and steam generator secondary side temperature and pressure are also determined using the loop average temperature (Tavg) output. These nominal values used as inputs to the analyses are not affected by the RTD bypass elimination. It is concluded that the elimination of the RTD bypass piping will not affect the LOCA analyses input and hence, the results of the analyses remain unaffected. Therefore, the plant design changes due to the RTD bypass elimination are acceptable from a LOCA analysis standpoint without requiring any reanalysis.

The RCS flow measurement uncertainty after the RTD bypass removal modifications was analyzed using the methodology in WCAP-11169 Rev. 1, "RCS Flow Uncertainty for Shearon Harris Unit 1," October 1986. This analysis used the plant-specific instrumentation for the Catawba Plant. The results of the analysis indicated that the flow measurement uncertainty was reduced from the current value of ±2.1% (not including a 0.1% penalty for feedwater venturi fouling allowance) to a new value of ±1.7% (including the cold leg elbow taps and excluding feedwater venturi fouling). Much of this reduced uncertainty is from the statistical advantage of using three RTDs for the hot leg temperature measurement in the new method rather than the one in the former method. The licensee has chosen not to request any plant specification changes to take advantage of the reduced flow uncertainty. Since the 2.1% allowance is conservative, its retention is acceptable.

The staff's review and evaluation of the plant's instrumentation and controls is based upon Sections 7.2 and 7.3 of the SRP. Those sections state that the objectives of the review are to confirm that the reactor trip and engineered safety features actuation system satisfy the requirements of the acceptance criteria and guidelines applicable to the protection system and will perform their safety function during all plant conditions for which they are required. Since the staff's review indicates that the modified system does not functionally change the reactor trip and engineered safety features actuation systems (except three hot leg RTDs are utilized instead of just one), the staff's original evaluation conclusions for these systems, as documented in Section 7 of the SER for Catawba Units 1 and 2 (NUREG-0954), remain valid. Based on this and the licensee's statement that the new hardware for the RTD bypass elimination has been qualified to WCAP-8587, "Methodology for Qualifying Westinghouse WRD Supplied NSSS Safety Related Electrical Equipment," the staff finds the plant modifications to eliminate the RTD bypass manifold and to install fast response RTDs directly in the reactor coolant system hot and cold legs to be acceptable.

As a result of the plant modifications and new instrumentation associated with the removal of the existing RTD bypass manifold and replacement by fast response RTDs, the following changes to the plant's Technical Specifications were proposed:

Change 1 - Include new additional entries for the Total Allowance, Z and Sensor Error for Functional Unit 7, Overtemperature delta T, in Table 2.2-1 of "(8.9#)," "(5.41#)," and "(2.65#)" respectively.

Change 2 - Include new, additional entries for the Total Allowance, Z and Sensor Error for Functional Unit 8, Overpower delta T, in Table 2.2-1 of "(4.9#)," "(1.24#)," and "(1.7#)" respectively.

Change 3 - Include new additional entries for Z and Allowable Value for Functional Unit 12, Reactor Coolant Flow-low, in Table 2.2-1 of "(1.41#)" and "(88.8%#)" respectively.

Change 4 - On page 2-4 add a new footnote "# Applicable upon deletion of the RTD Bypass System."

Change 5 - Include new additional entries for t_1, K, and t_4 in NOTE 1 to Table 2.2-1 of "(12#)," "(1.38#)" and "(22#)" respectively.

Change 6 - Include a new, additional entry, "(3.0%#)," for the allowable value for overtemperature delta T contained in NOTE 2 to Table 2.2-1.

Change 7 - Include a new, additional entry, "(2.6%#)," for the allowable value for overpower delta T contained in NOTE 4 to Table 2.2-1.

Change 8 - On page 2-10 add a new footnote "# Applicable upon deletion of RTD Bypass System."

Change 9 - On page B 2-5 under "Overtemperature delta T," add "(1) (with the RTD Bypass System installed)" to the first sentence between "to" and "piping." Also add "or (2) (with the RTD Bypass System removed) thermal delays associated with the RTDs mounted in thermowells (about 5 seconds)," before "and pressure" in the first sentence.

Change 10 - On page B 2-5 under "Overpower delta T," add "either" to the second sentence between "for" and "piping." Also add "(with the RTD Bypass System installed), or instrumentation delay associated with the loop temperature detectors (with the RTD Bypass System removed)," between "detectors" and "to" in the second sentence.

Change 11 - On page 3/4 3-1 add a sentence stating that: "The response time of RTDs associated with the Reactor Trip System shall be demonstrated to be within their limits at least once per 18 months."

Change 12 - Include a new, additional entry, "(8#)," for the response times for Functional Unit 7, Overtemperature delta T, and Functional Unit 8, Overpower delta T, in Table 3.3-2.

Change 13 - On page 3/4 3-7 add a new footnote "# Applicable upon deletion of RTD Bypass System.

Change 14 - Include new, additional entries in Table 3.3-4 for the Total Allowance, Z, Sensor Error and Allowable Value for Functional Unit 5.c, Tavg-Low, of "(6.0#)," "(0.71#)," "(0.8#)" and "(561°F#)" respectively.

Change 15 - Include a new, additional entry in Table 3.3-4 for the Allowable Value for Functional Unit 18.c, Low-Low Tavg, P-12, of "(550°F#)."

Change 16 - On page 3/4 3-36 add a new footnote "# Applicable upon deletion of RTD Bypass System."

Changes 1, 2, 3, 5, 6, 7, 14, and 15 above are new values based on revised instrumentation uncertainties resulting from the bypass manifold elimination. These new values were calculated using essentially the Westinghouse setpoint methodology as previously approved by the staff for Catawba and for generic use (NUREG-0717, SER for Virgil C. Summer Nuclear Station) as documented in the licensee's letter dated July 22, 1987. The staff finds these changes acceptable. Change 11 provides an additional surveillance to verify that the RTDs associated with the Reactor Trip System remain within their limits. On the basis that this change would ensure RTD operability, the staff finds it acceptable.

Changes 4, 8, 9, 10, 13, and 16 are editorial changes necessary to accommodate the removal of the RTD bypass manifold and the situation where removal of the bypass manifold has been completed on only one of the two units. On the basis that these changes add clarity and conciseness to the plant's technical specifications, the staff finds them acceptable.

Change 12 is acceptable because an RTD response time of 8.0 seconds has been found to be acceptable in previous safety analyses.

The staff has reviewed the fabrication and inspection methods described in WCAP-11308, Rev. 2, RTD Bypass Elimination Report for Catawba Units 1 and 2, September 1987 for the replacement of the RTD bypass system with the new RTD thermowell system. This change requires modifications to the hot leg piping, the hot leg scoops, the crossover leg bypass return nozzle, the cold leg piping and the cold leg bypass manifold connection. The new thermowells, caps and penetrations will be fabricated in accordance with the ASME Code, Section III, Class 1. The welding will be by approved procedures and inspected by penetrant testing per the ASME Code Section XI. In accordance with Article IWA-4000 of Section XI, a hydrostatic test of the new pressure boundary welds will be carried out.

The staff finds that the mechanical safety of the proposed RTD thermowells system fabricated, examined and tested as described above is acceptable.

The licensee has estimated the occupational radiation exposure for the RTD bypass modification in the submittal of October 30, 1987. The estimate is based on anticipated stay times for each major subtask and estimated dose rates. The annual estimates per unit are given in the table below.

	Subtask	Manhour Estimate	Dose Estimate (Person-Rem)
(1)	Preparation for RTD bypass modification	33	1.0
(2)	Shielding Installation/ Removal	64	9.6
(3)	Remove/Replace pipes, hangers, electrical interferences, etc...	417.5	10.4
(4)	Modify the RTDs	100	12.0
	Total per loop	614.5	33.0
	Total per unit (4 loops)	2458 man-hours	132.0 person-rem

The dose avoided through reduced maintenance and operational requirements is the order of 50 to 100 person-rem per unit per year. Comparing this to the total one-time dose of 132 person-rem for the RTD replacement operation, a net savings of several thousand person-rem over plant life can be projected.

An estimate of the curies of beta and gamma radioactivity contained on the RTD components to be removed (piping, insulation, hangers, rupture restraints, valves and instrumentation) is 5.26 curies per unit. The expected total volume of this radwaste is 574 cubic feet.

Based on the above and on the licensee's radiation protection and ALARA programs previously evaluated and found to be acceptable in Chapter 12 of the SER, the staff concludes that the RTD bypass removal is acceptable from the radiological viewpoint.

ENVIRONMENTAL CONSIDERATION

These amendments involve changes to the installation or use of facility components located within the restricted area as defined in 10 CFR Part 20. The staff has determined that the amendments involve no significant increase in the amounts, and no significant change in the types, of any effluents that may be released offsite and that there is no significant increase in individual or cumulative occupational exposures. The NRC staff has made a determination that the amendments involve no significant hazards consideration, and there has been no public comment on such finding. Accordingly, the amendments meet the eligibility criteria for categorical exclusion set forth in 10 CFR 51.22(c)(9). Pursuant to 10 CFR 51.22(b) no environmental impact statement or environmental assessment need be prepared in connection with the issuance of these amendments.

REFERENCES

(1) NUREG-0809, Safety Evaluation Report, Review of Resistance Temperature Detector Time Response Characteristics, August 1981.

(2) NUREG/CR -4928, Degradation of Nuclear Plant Temperature Sensors, June 1987.

(3) K. R. Carr, An Evaluation of Industrial Platinum Resistance Thermometer Temperature - Its Measurement and Control in Science and Industry, ISA publication, Vol. 4. Part 2, 1972, pages 971-982.

(4) B. W. Mangum, the Stability of Small Industrial Platinum Resistance Thermometers, Journal of Research of the NBS, Vol. 89, No. 4, July-August 1984, Pages 305-350.

CONCLUSION

The Commission made a proposed determination that the amendments involve no significant hazards consideration which was published in the Federal Register (52 FR 45885) on December 2, 1987. The Commission consulted with the state of South Carolina. No public comments were received, and the state of South Carolina did not have any comments.

We have concluded, based on the considerations discussed above, that: (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, and (2) such activities will be conducted in compliance with the Commission's regulations, and the issuance of these amendments will not be inimical to the common defense and security or to the health and safety of the public.

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AMENDMENT NO. 40 TO FACILITY OPERATING LICENSE NPF-35 - Catawba Nuclear Station, Unit 1
AMENDMENT NO. 33 TO FACILITY OPERATING LICENSE NPF-52 - Catawba Nuclear Station, Unit 2

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