Duquesne Light Company Beaver Valley Power Station
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July 14, 1999
L-99-112

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

Subject: Beaver Valley Power Station, Unit No. 1 and No. 2
BV-1 Docket No. 50-334, License No. DPR-66
BV-2 Docket No. 50-412, License No. NPF-73
Response to Oral Request for Information Regarding License Amendment Request Nos. 220 and 88 (TAC Nos. MA4616 and MA4617)

On May 18, 1999, the Nuclear Regulatory Commission (NRC) staff met with representatives of the Duquesne Light Company (DLC) and Westinghouse to discuss DLC's License Amendment Request (LAR) Nos. 220 and 88 for Beaver Valley Power Station Units No. 1 and 2, respectively. During this meeting, the NRC staff requested that DLC provide a copy of a letter, DLC-96-310, and Westinghouse Technical Bulletin ESBU-TB-96-07-R0, which are referenced in DLC's LAR Nos. 220 and 88. Enclosure Number 1 contains a copy of letter DLC-99-743 which is a non-proprietary version of DLC-96-310. Westinghouse has modified the original version of the body of the DLC-96-310 letter during the preparation of the non-proprietary version. Three areas were modified in DLC-99-743 to provide additional clarification from the DLC-96-310 version. These areas have revision lines with the letter "C". Two other areas were modified due to editorial changes and are indicated by revision lines and the letter "E". Enclosure Number 2 contains a copy of Westinghouse Technical Bulletin ESBU-TB-96-07-R0.

If the NRC requires additional information concerning this subject matter, please contact Mark S. Ackerman at 412-393-5203.

Sincerely,

Sushil C. Jain

Sushil C. Jain

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A001

c: Mr. D. S. Collins, Project Manager
Mr. D. M. Kern, Sr. Resident Inspector
Mr. H. J. Miller, NRC Region I Administrator

Attachments

DELIVERING QUALITY ENERGY

AFFIDAVIT FOR APPLICATION

OF AMENDMENT

COMMONWEALTH OF PENNSYLVANIA)
) SS:
COUNTY OF BEAVER)

Subject: Beaver Valley Power Station, Unit No. 1 and No. 2
BV-1 Docket No. 50-334, License No. DPR-66
BV-2 Docket No. 50-412, License No. NPF-73
Response to Oral Request for Information Regarding License Amendment Request Nos. 220 and 88

Before me, the undersigned notary public, in and for the County and Commonwealth aforesaid, this day personally appeared Sushil C. Jain, to me known, who being duly sworn according to law, deposes and says that he is Senior Vice President, Nuclear Services of the Nuclear Power Division, Duquesne Light Company, he is duly authorized to execute and file the foregoing submittal or behalf of said Company, and the statements set forth in the submittal are true and correct to the best of his knowledge, information and belief.

Sushil C. Jain

Sushil C. Jain

Subscribed and sworn to before me

on this 14th day of July, 1999

Tracey A Baczek

Notary Public

Notarial Seal
Tracey A. Baczek, Notary Public
Shippingport Boro, Beaver County
My Commission Expires Aug. 16, 2001
Member, Pennsylvania Association of Notaries

ENCLOSURE 1

DLC-99-743

Westinghouse Electric Company LLC

Nuclear Services Division
Box 355
Pittsburgh, Pennsylvania 15230-0355

June 11, 1999
DLC-99-743
NSD-SAE-ESI-99-234

Mr. W. R. Kline, Manager
Nuclear Engineering
Duquesne Light Company
Beaver Valley Power Station
P.O. Box 004
Shippingport, PA 15077-0004

Attention: Mr. Mark Manoleras

Duquesne Light Company
Beaver Valley Units 1 and 2
Overtemperature ΔT and Overpower ΔT Dynamic Compensation Tolerance Position Paper

Dear Mr. Kline:

Duquesne Light has recently requested that the Westinghouse Proprietary classification be removed from information provided in a letter (DLC-96-310) in support of a Technical Specification submittal. The subject letter was reviewed to determine if the proprietary classification could be removed. During this review, two areas were identified as needing additional clarification and were modified.

Please feel free to contact the undersigned if there are any additional questions.

Regards,
WESTINGHOUSE ELECTRIC COMPANY

for/ John DeBlasio
E.A. Dzenis
Customer Project Manager

JJD/kk

cc:

R. A. Hruby
K. J. Frederick
BVRC Central File, SEB-1
M. Manoleras

Attachment
to
DLC-99-743

Duquesne Light has recently contacted Westinghouse with questions on the uncertainties associated with instrumentation for the dynamic compensation terms that are included in the Overtemperature DT (OTDT) and Overpower DT (OPDT) reactor trip functions. Specifically, the dynamic compensation terms in question are the lead/lag on OTDT and the rate lag on OPDT. The Technical Specifications give the same values that were input in the safety analyses. The Beaver Valley Technical Specifications do not include inequalities. Also, the OTDT and OPDT hardware for plants with 7100 series equipment make it impossible to exactly input the Technical Specification values (per the functional requirements the hardware for the time constants is adjustable in increments such that any setpoint can be obtained within ±10%). Thus, the settings for these plants have historically been set as close to the required values as is possible and within ±10%. Note that Beaver Valley Unit 1 has 7100 series equipment and Beaver Valley Unit 2 has 7300 series equipment. E

The purpose of this document is to explain the bases of the dynamic compensation settings assumed in the safety analyses and to provide a discussion of the acceptability of settings for prior and current practices. Also provided are recommendations for how the dynamic compensation terms could be set in the future to avoid any reoccurrence of related questions. This document deals primarily with the lead/lag on OTDT and the rate lag on OPDT but is equally applicable to other dynamically compensated protective functions at Beaver Valley. The low steam pressure protective function is dynamically compensated with a lead-lag function. This lead-lag is assumed in the analyses and the nominal values are assumed in the analysis and are listed in the Technical Specifications. No dynamic compensation is explicitly modeled for any other protective functions in the Beaver Valley non-LOCA safety analyses.

<u>Background Information</u> - Currently, the lead and lag on the OTDT function and the rate lag on OPDT function at Beaver Valley as given in the Technical Specifications are:

Unit 1:

Lead (t_1) = 30 seconds   Lag (t_2) = 4 seconds   Rate lag (t_3) = 10 seconds

Unit 2:

Lead (t_4) = 30 seconds   Lag (t_5) = 4 seconds   Rate lag (t_7) = 10 seconds

The OTDT and OPDT setpoint equations are attached at the end of this document.

When these time constants are assumed in the safety analyses, the values modeled are the nominal values given above. This is consistent with all of the time response values (pure delays and dynamic compensation leads, lags and rate/lags) given in the Technical Specifications that are assumed in the safety analyses. The safety analysis values assumed for actuation setpoints are different from the Technical Specification actuation setpoints by an amount sufficient to cover the calculated static instrument uncertainties but the safety analysis and Technical Specification values for time response constants are identical. C C

Compounding the question is the hardware used to set these values at Beaver Valley Unit 1. The hardware will not allow an exact value to be set and thus, the values at Unit 1 have always been set as close to the Technical Specification values as possible without necessarily being in the conservative direction with respect to the safety analyses. The hardware is designed to allow the settings to be set within ±10% of a desired value.

As is mentioned earlier, similar questions could be asked about the other dynamically compensated protective functions. The only other dynamically compensated protective function explicitly credited in the safety analyses is the Low Steam Pressure function. The lead-lag on Low Steam Pressure assumed in the accident analyses are as follows:

Lead = 50.0 seconds   Lag = 5.0 seconds

The same values are used for both Unit 1 and Unit 2 in the safety analyses and are given in the Beaver Valley Unit 2 Technical Specifications. Note that these parameters are not included in the Beaver Valley

Unit 1 Technical Specifications. For both Unit 1 and Unit 2, these values have historically been set as close to the nominal values given above. This is done for both Unit 1 and Unit 2 despite only being specified in the Unit 2 Technical Specifications.

<u>Westinghouse Position</u> - In non-LOCA safety analyses, most parameters are set to their nominal values. Selected key parameters which are determined to be important to the analysis results are identified and the values used in the analyses for these parameters are set in a conservative fashion to demonstrate that the applicable safety criteria are met. It is Westinghouse's position that this method yields a sufficiently conservative licensing basis and it is not necessary to be conservative for every parameter in every licensing basis analysis. As such, it is concluded that the analyses that model nominal values for the dynamic compensation terms at Beaver Valley are sufficiently conservative and that no additional analyses need to be performed.

If a more conservative position is desired, Westinghouse has provided guidance in the following areas in support of customer requests. One utility asked Westinghouse to identify the direction of conservatism for each of the constants associated with the OTDT and OPDT setpoint equations. They used this information to revise their procedures to ensure that the settings at the plant are conservative with respect to the nominal values assumed in the analyses. Associated with this, a change to the Technical Specifications was proposed to replace the equalities with inequalities to specifically allow these settings to be set in a conservative fashion. The Beaver Valley OTDT and OPDT setpoint equations along with the conservative direction for each of the terms are attached at the end of this document. The conservative direction for the lead and lag on Low Steam Pressure are:

Lead $\geq$ Indicated Value   Lag $\leq$ Indicated Value

A second utility requested reanalysis with a 5% uncertainty band assumed around each dynamic compensation term. Obviously, this resulted in a slight loss in DNBR margin.

<u>Recommendation for Future Consideration</u> - Given the increasing interest in confirming a clear design and operating basis for all safety and licensing analyses, Westinghouse recommends consideration of the NUREG-1431 Technical Specification format with inequalities and a procedural implementation which assures a conservative setting to prevent any further reoccurrence for the need to address this question. Note that the inequalities are recommended to ensure that literal compliance with the Technical Specifications can be demonstrated. The inequalities are not needed to support the safety analysis methodology. | C

<u>Conclusion</u> - The safety analyses assume nominal values for all time constants included in the licensing basis analyses. Uncertainties are applied to actuation setpoints and other key parameters in the safety analyses with the uncertainties applied in the most conservative direction. This methodology results in a conservative analysis. The safety analyses should continue to assume nominal dynamic compensation values, the Technical Specifications should reflect nominal values with the equalities replaced with the appropriate inequalities and the dynamic compensation terms should be set at the plant on the conservative side of the nominal values to ensure that the Technical Specifications are met considering drift and other allowances as deemed necessary.

The safety analyses performed in support of Beaver Valley are consistent with the methods discussed in this document and, thus, conservatively demonstrate that all applicable acceptance criteria are met. The results and conclusions presented in the Beaver Valley UFSAR remain applicable. | E

Beaver Valley OTΔT and OPΔT Setpoint Equations

Beaver Valley Unit 1

$$OT\Delta T * (1)/(1+\tau_4 s) \le \Delta T_o * \{K_1 - K_2 * (1+\tau_1 s)/(1+\tau_2 s) * [T * (1)/(1+\tau_5 s) - T'] + K_3 * (P - P') - f(\Delta I)\}$$

$$OP\Delta T * (1)/(1+\tau_4 s) \le \Delta T_o \{K_4 - K_5 * [(\tau_3 s)/(1+\tau_3 s) * (1)/(1+\tau_5 s) * T] - K_6 * [T * (1)/(1+\tau_5 s) - T''] - f(\Delta I)\}$$

$K_1 \le$ Identified Value*	$K_2 \ge$ Identified Value*	$K_3 \ge$ Identified Value*	$K_4 \le$ Identified Value*
$K_5 \ge$ Identified Value*	$K_6 \ge$ Identified Value*	$\tau_1 \ge$ Identified Value*	$\tau_2 \le$ Identified Value*
$\tau_3 \le$ Identified Value*	$\tau_4 \le$ Identified Value*	$\tau_5 \le$ Identified Value*	$T'' \le$ Identified Value**
$\Delta T_o \le$ Indicated Value**	$T' \le$ Identified Value*, **	$P' \ge$ Identified Value*	

Beaver Valley Unit 2

$$OT\Delta T * (1+\tau_1 s)/(1+\tau_2 s) * (1)/(1+\tau_3 s) \le \Delta T_o * \{K_1 - K_2 * (1+\tau_4 s)/(1+\tau_5 s) * [T * (1)/(1+\tau_6 s) - T'] + K_3 * (P - P') - f_1(\Delta I)\}$$

$$OP\Delta T * (1+\tau_1 s)/(1+\tau_2 s) * (1)/(1+\tau_3 s) \le \Delta T_o * \{K_4 - K_5 * [(\tau_7 s)/(1+\tau_7 s) * (1)/(1+\tau_6 s) * T] - K_6 * [T * (1)/(1+\tau_6 s) - T'') - f_2(\Delta I)\}$$

$K_1 \le$ Identified Value*	$K_2 \ge$ Identified Value*	$K_3 \ge$ Identified Value*	$K_4 \le$ Identified Value*
$K_5 \ge$ Identified Value*	$K_6 \ge$ Identified Value*	$\tau_1 \ge$ Identified Value*	$\tau_2 \le$ Identified Value*
$\tau_3 \le$ Identified Value*	$\tau_4 \ge$ Identified Value*	$\tau_5 \le$ Identified Value*	$\tau_6 \le$ Identified Value*
$\tau_7 \ge$ Identified Value*	$T' \le$ Identified Value*, **	$T'' \le$ Identified Value**	$P' \ge$ Identified Value*
$\Delta T_o \le$ Indicated Value**			

* Value explicitly noted in Table 2.2-1 of the Technical Specifications

** Normalization to the loop specific as found or indicated value as per ESBU-TB-96-07-R1 is strongly recommended.

Although a "direction of conservatism" is identified for OTDT reactor trip function K_2 and K_3 gains, the gains should be set as close as possible to the value contained in the Technical Specifications to ensure that the OTDT setpoint is consistent with the safety analyses.

The scaling of the OPDT and OTDT terms requires gain and bias distributions that involves combining the gains (K_1, K_2, K_3, K_4, K_5 and K_6) and the constant terms T', P' and T".

ENCLOSURE 2

Westinghouse Technical Bulletin ESBU-TB-96-07-R0

ENERGY
SYSTEMS
BUSINESS
UNIT

Westinghouse Technical Bulletin

An advisory notice of a recent technical development pertaining to the installation or operation of Westinghouse-supplied Nuclear Plant equipment. Recipients should evaluate the information and recommendation, and initiate action where appropriate.

P.O. BOX 355, Pittsburgh, PA 15230

Subject TEMPERATURE RELATED FUNCTIONS		Number ESBU-TB-96-07-R0
System(s) RPS/ESFAS AND CONTROL SYSTEM TEMPERATURE RELATED FUNCTIONS		Date November 5, 1996
Affected Plants ALL PLANTS WITH ΔT AND T_{AVG} RELATED FUNCTIONS		S.O.(s)
References See Below	Affects Safety Related Equipment Yes ☒ No ☐	Sheet 1 of 9

References: Reactor Protection System/Engineered Safety Features Actuation System Setpoint Studies, RTD Bypass Elimination reports, Improved Thermal Design Procedure reports and Revised Thermal Design Procedure reports

INTRODUCTION

The Overtemperature ΔT and Overpower ΔT reactor trip functions (OTΔT and OPΔT) are relied upon for many FSAR accident analyses. They are also the most complicated protection functions due to their definition, interactive nature and the number of parameters utilized in their setpoint determinations. These functions rely upon temperature indication to define power (ΔT) and to define where the protection functions lie (T_{AVG}). As a result several effects, e.g., hot leg streaming, changes in hot leg streaming due to burnup dependent radial power redistribution and cold leg streaming (all of which have significant influence on temperature indication), have added complexity to the process of ensuring that these functions have been appropriately calibrated at the plant. The instrument uncertainty calculations and safety analysis assumptions for these functions have varied over the last several years as these effects were addressed.

Additional Information, if Required, may be Obtained from the Originator. Telephone 412-374-5409 or (WIN) 284-5409

Originator

C. R. Tuley

C. R. Tuley, Fellow Engineer
Safety Systems Operations

T.P. Williams /for

E. A. Dzenis, Manager
Safety Systems Operations

Approval

J J Sandrovich

J.J. Sandrovich
Regulatory and Licensing Initiatives

INPO Nuclear Network OE 7063, 1/24/95 (see Attachment 1), (submitted by Pacific Gas and Electric) identified a plant specific instance of a hot leg indicating lower than actual temperature. This had a detrimental influence on the associated OTΔT and OPΔT reactor trips and potentially, the rod control system. Westinghouse worked with PG&E to resolve this concern and was successful with the implementation of an approach which normalized the two protection functions to the loop specific indicated values for ΔT and T_{AVG}. As a result of this effort, discussions with various plants and with the latest information available on streaming effects, it was suggested that a more explicit consideration of the effects of core burnup on changes in temperature distribution within the hot leg should be made in the uncertainty calculations. To assure plant operation consistent with the assumptions of the uncertainty calculations and safety analyses, this document has been published for plant consideration. Even if a specific plant has not observed the phenomena noted in this document in past or current fuel cycles, it may choose to consider the techniques noted in order to address possible future observations.

It should be recognized that the approach utilized in this document recommends changes to surveillance and normalization which, if the temperature variations occur, avoids the need for setpoint and/or safety analysis margin allocation. Alternatively, these effects can be accounted for through explicit assumptions in the setpoint uncertainty or transient analyses calculations.

BACKGROUND

Overtemperature ΔT Trip

The OTΔT trip protects the core from conditions that would cause DNB and limits the range of applicability for the OPΔT trip. Since DNB is a function of temperature and pressure, the trip has historically been interpreted as an absolute trip with defined setpoints. The only parameter that was not considered to be predetermined was ΔT_o, which is the measured ΔT at full power conditions. A simplified version of the basic equation, i.e., no lead/lag constants included, is:

$$\Delta T^{OT}_{SETPOINT} = \Delta T_o[K_1 - K_2(T - T') + K_3(P - P') - f_1(\Delta I)]$$

where: $\Delta T_{SETPOINT}$ is the Overtemperature trip setpoint in °F,
ΔT_0 is the full power ΔT measured for the particular loop/channel,
K_1 is the reference trip setpoint or ΔT multiplier,
K_2 is the penalty or benefit multiplier for deviation from reference T_{AVG},
T' is the reference T_{AVG} in the analysis,
K_3 is the penalty or benefit multiplier for deviation from reference Pressure,
P' is the reference RCS pressure in the analysis (typically 2250 psia), and
f_1 (ΔI) is the power shape penalty function.

It should be noted in this equation and function that conditions that result in DNB margin will cause the trip setpoint to increase. Specifically, a lower T_{AVG} or a higher RCS pressure will increase the trip setpoint.

TEMPERATURE RELATED FUNCTIONS

Overpower ΔT Trip

The OPΔT trip protects the core from overpower transient conditions that could result in excessive kw/ft in the fuel and to limit the range of applicability of the OTΔT trip. This trip is redundant and diverse to the NIS Power Range - High reactor trip, which performs a similar function. A simplified version of the basic equation, i.e., no lead/lag constants included, is:

$$\Delta T^{OP}_{SETPOINT} = \Delta T_o[K_4 - K_5(T) - K_6(T - T'') - f_2(\Delta I)]$$

where: $\Delta T_{SETPOINT}$ is the Overpower trip setpoint in °F,
ΔT_0 is the full power ΔT measured for the particular loop/channel,
K_4 is the reference trip setpoint or ΔT multiplier,
K_5 is the penalty multiplier for the rate of change in T_{AVG},
K_6 is the penalty multiplier for deviation from reference T_{AVG},
T" is the nominal full power indicated (loop specific as measured or as found) T_{AVG} for the channel, and
$f_2(\Delta I)$ is the power shape penalty function (typically set to zero).

It should be noted in this equation and function that conditions that result in margin will not cause the trip setpoint to increase. Specifically, all adjustments to the trip setpoint are reductions based upon deviation from the nominal operating loop conditions.

Application and Calibration

Only the earliest plant protection systems (Foxboro process racks) calculate the OTΔT and OPΔT trips as simplistically as the above equations indicate. These plants are differentiated by control board ΔT indication in °F or °C and instrument spans of 75 °F. Later protection systems (7100 and 7300 series analog process racks and Eagle-21 digital process racks) normalize the ΔT span to percent power, thus in effect dividing both sides of the equation by ΔT_0. This second set of plants is differentiated by control board ΔT indication and instrument spans of 150 % RTP and typically have more lead/lag functions in the equation definitions than the earlier plants.

Due to the nature of the trip functions, Westinghouse procedure recommendations were developed that required the determination and adjustment of ΔT_0 and T" values for each channel. The T' value in the OTΔT trip function was historically set based upon the safety analysis, which is typically the same T_{AVG} value as used in the control system. The T" value in the OPΔT trip function was historically set to the loop specific indicated value.

ISSUES

The following discusses how streaming occurs and what steps should be taken in the uncertainty calculations, the safety analyses and at the plant to address these effects.

Hot Leg Streaming

The water heated in the central regions of the core is directed into the upper internals where mixing occurs. This does not occur to the same extent at the core periphery where the water is not heated to the same temperatures. When directed to the vessel exit nozzles, the water exiting the core does not mix completely, thus resulting in temperature gradients across the hot legs. The magnitudes of the gradients vary, but have been observed to be in the range of 6 to 16 °F. The larger gradients have been noted in the more recent past and are attributed to the larger maximum to minimum core exit temperature differentials associated with aggressive core designs. It has also become apparent that the longitudinal locations of the RTDs or scoops can affect the perception of the bulk average temperature due to the mixing in the hot legs.

Radial Burndown Effects

The general effect noted is that indicated T_{HOT} is typically higher than actual T_{HOT}, particularly at BOL. However, at least one instance of indication lower than actual has been documented at PG&E (see Attachment 1). Also noted is a decrease in indicated T_{HOT} with constant power as the cycle progresses. This is due to the relative decrease in the central core region water temperature from radial power flattening with increasing burnup. Over cycle life, the indicated T_{HOT} can decrease by several °F. This results in a corresponding decrease in indicated ΔT and indicated T_{AVG} also. With protection functions normalized at full power conditions at BOL (currently ΔT_o for OTΔT and OPΔT and T" for OPΔT), these indication decreases are in the non-conservative direction. In addition, there has been no guidance previously provided on when re-normalization should take place to restore the protection functions to within the uncertainty calculation assumptions.

Cold Leg Streaming

Another effect noted in temperature measurement is the streaming in the cold leg for loops with Model 93A reactor coolant pumps. Streaming is present in all cold legs due to the different tube lengths and flows in the Steam Generator U-tubes. The resultant gradient is then reduced by mixing in the cross-over leg and RCP impeller. However, for the 93A RCP, internal vanes in the pump affect mixing such that the temperature gradient is not completely homogenized. For this effect, indicated cold leg temperature may be less than actual temperature. This is non-conservative for a protection system because indicated T_{AVG} may be less than actual T_{AVG} which generates inappropriate margin to trip. The magnitude and significance of this effect is a function of the location of the centerline of the gradient and the placement of the cold leg RTD or scoop. If the RTD is located at the centerline of the gradient and thus indicates the true bulk average temperature of the cold leg, there is no effect. If the centerline of the gradient is offset, the indicated temperature and thus the inferred bulk average temperature, may be lower (or higher) than actual depending on the direction of the gradient.

All of these effects, streaming in the hot leg, the effect of increasing burnup on the streaming in the hot leg and streaming in the cold leg, make determination of absolute temperature to a high degree of accuracy difficult. Normalization of the protection functions can be an effective way to compensate for these effects and minimize operating and analytical margin erosion. The normalization of the various trip functions is discussed in detail below.

Normalization of ΔT_o

Overtemperature ΔT, Overpower ΔT and the Vessel ΔT Equivalent to Power (VΔTEP), which is used in the Steam Generator Water Level - Low-Low Trip Time Delay (TTD), are based on the definition of 100 % RTP for a given loop. The loop specific full power is defined as the indicated ΔT at 100 % system power as determined by a precision secondary side power calorimetric measurement. For OTΔT and OPΔT this value is defined as ΔT_o. This determination is typically made at near 100 % RTP conditions at BOL. Since there can be loop to loop power and/or loop to loop flow variances due to several different causes, it is typical to have a different reference full power ΔT for each loop. The important points to note are; 1) the value of ΔT_o used in the scaling of these functions should be loop specific, and 2) ΔT_o is an indicated value that should define the reference equilibrium full power condition. This value can change as a function of core conditions, since it is dependent on hot leg streaming characteristics, and should be determined on a loop specific basis each cycle. (For two loop plants with two protection channels per loop, the above is applicable on a channel basis. If the indicated ΔT varies between two channels for the same loop, each channel should be scaled per its specific characteristics. For three loop plants with separate control channels for ΔT, the control channels should be treated in a manner similar to ΔT_0 in the protection channels.)

Normalization of T' and T"

Since the OTΔT and OPΔT trip functions are dependent on the measured ΔT value for power and have become relativistic trip functions (as opposed to absolute trip functions) due to streaming in the hot and cold legs for T_{AVG}, it is important to include in the scaling process the indicated, full power, loop specific value for T_{AVG} (T' in OTΔT, T" in OPΔT). This requirement is more apparent for OPΔT since it is an overpower trip that can not recognize full power conditions without explicit normalization at those conditions. It is not as clear for OTΔT, since it is primarily a DNBR trip. However, it should be noted that the safety analyses are performed for a given set of initial conditions for pressure, temperature, power and flow. It is expected that the actual measured conditions of temperature and flow will be conservative with respect to these assumptions, i.e., measured flow is greater than Thermal Design or Minimum Measured Flow and indicated T_{AVG} is equal to the value assumed in the safety analyses. However, operation has been noted for several plants with T_{AVG} significantly lower than assumed in the safety analyses. Also it is typical for the safety analyses to assume loop symmetry, i.e., all loops indicate the same value for T_{AVG}, while the actual plant conditions may indicate a loop to loop asymmetry. Add to these factors recent analyses for some plants supporting operating temperature windows in the range of 10 to 30°F instead of the typical assumption of a single reference T_{AVG} program value (with an associated rod control accuracy about it) and it becomes more important to define T' and T" for the specific set of operating conditions for that cycle for each loop. It is therefore important to utilize the loop specific, indicated, full power T_{AVG} as the input for T' and T".

TEMPERATURE RELATED FUNCTIONS

Due to short term temperature oscillation phenomena, e.g., upper plenum anomaly (see NSAL-92-007), variable power sharing between loops and flow cross-over between hot legs, the steady-state equilibrium values for T_{HOT}, T_{COLD}, ΔT and T_{AVG}, as determined by a time average over three to five minutes (or a period consistent with the transients), should be used for determination of the appropriate scaling input values for ΔT_o, T' and T". These time averaged values should also be used for any loop to loop comparisons that the plant staff may wish to perform and comparison to any Technical Specification requirements.

Surveillance Interval for Verification of ΔT_o

The indicated value for T_{HOT} and thus indicated ΔT and T_{AVG}, is dependent on the hot leg streaming characteristics at the time of normalization. Current plant data indicates that the hot leg streaming characteristics may change substantially over a cycle. Changes in indicated T_{HOT} in the non-conservative direction (resulting in a smaller indicated ΔT) over a given cycle have been observed. This is outside of typical Westinghouse uncertainty calculation assumptions. The magnitude of acceptable change in indicated T_{HOT}, ΔT or T_{AVG} is a function of the uncertainty calculation assumptions and margin for the protection functions. Since the change in indicated T_{HOT} is a function of radial power redistribution, quarterly surveillance of these three parameters is appropriate. More rapid changes in hot leg streaming (as a function of burnup) may require more frequent surveillance of these three parameters. These parameters should be verified to be within uncertainty calculation assumptions.

Verification of T_{HOT} and T_{COLD} When Normalizing ΔT_o, T' and T"

When normalizing the OTΔT, OPΔT and VΔTEP functions to reflect the loop specific, indicated ΔT and T_{AVG} at full power conditions, it should be recognized that two other parameters (loop specific T_{HOT} and T_{COLD}) may also vary. Plant analyses typically assume the control of T_{AVG} (via the automatic rod control system) follows the Tavg program (defined in the PLS document) up to the full power value (defined in the FSAR or RSAC) for the controlling loop. If the plant is in manual rod control, it is assumed that the operator emulates the characteristics and limits of the auto rod control system and follows the same T_{AVG} program. This will assure T_{HOT}, T_{COLD}, ΔT (ΔT_o) and T_{AVG} (T' and T") values within the analyses assumed limits. Two means may be used to verify operation within the limits, 1) verify the plant is in auto rod control and that the control system is functioning appropriately and 2) via visual means (if in manual rod control). This verification may be the use of control board, process computer indication or the Man Machine Interface (MMI) after accounting for indication errors and acceptable process variation. Operation outside the typical rod control system accuracy or not following the T_{AVG} program may result in exceeding upper or lower limits on temperature.

Effect of Full Power Operation at Indicated Loop ΔT Values Less Than Assumed in Uncertainty Calculations

Instrument uncertainty calculations performed for OTΔT and OPΔT are based on projected operation at the design vessel ΔT. The calculations for the channel uncertainty (CSA) and the total allowance (TA) are a function of ΔT span. Typically the instrument span is either a fixed value in °F or a percentage of power (% RTP).

For those calculations utilizing an instrument span based on a percentage of power the following is noted. For a fixed set of input instrument errors (in °F, psig and % ΔI), a decrease in the indicated full power ΔT results in a non-conservative increase in the magnitude of the individual instrument errors in % ΔT span and thus the CSA. There is also an increase in the magnitude of TA, which is beneficial. But the rate of increase in the magnitude of TA is less than the rate of increase in the CSA. Thus operation at an indicated vessel ΔT less than that assumed in the uncertainty calculation is non-conservative (from an instrument uncertainty point of view). Acceptability of operation at a reduced indicated ΔT is a function of the available margin in the OTΔT and OPΔT reactor trips and the magnitude of the difference between the assumed ΔT span in the uncertainty calculation vs the indicated ΔT span. For small changes in span, there may be sufficient margin in the uncertainty calculations to compensate. For larger changes, re-calculation is necessary. As the change is non-linear, a more definitive determination of the acceptable magnitude of indicated ΔT change must be performed on a case by case basis.

For those calculations utilizing a span based on a fixed value, the decrease in vessel ΔT results in a decrease in the total allowance with a subsequent loss of margin. Again, for small changes in the indicated ΔT, there may be sufficient margin to compensate. For larger changes, re-calculation is necessary. As each case is unique, these calculations are typically performed on a case by case basis. Thus it is important for the plant staff to verify setpoint acceptability based on the actual instrument span, vessel ΔT and channel specific scaling on a periodic basis. This is particularly important when hot leg streaming characteristics are projected to change significantly over cycle life.

Verification of Acceptability for a T_{HOT} or T_{AVG} Window

In the performance of uncertainty calculations for Precision RCS Flow calorimetric measurements, the calculation demonstrates a sensitivity to the value of T_{HOT} due to the non-linear characteristics of the Steam Tables. The RCS Flow calorimetric measurement uncertainty is determined at a specific set of nominal full power conditions. Allowances are made for parameter measurement uncertainties and RCS Flow sensitivities are determined for a limited range about the nominal conditions. Significant variance from the assumed nominal conditions can affect the magnitude of calculated sensitivities. It has been determined that changes in T_{HOT} can change the T_{HOT} sensitivity magnitude and thus the RCS Flow calorimetric measurement uncertainty reported in the plant Technical Specifications. From an RCS Flow calorimetric measurement point of view, the extremes of a T_{HOT} or T_{AVG} window should be verified to be acceptable prior to anticipated operation at those extremes. Changes in the minimum RCS Flow required to maintain consistency with safety analysis assumptions may be required. That is, the measurement uncertainty may increase over that previously assumed, thus requiring higher indicated flow values to compensate.

Effects of T_{AVG} Coastdown and Power Operation at Reduced T_{AVG}

A T_{AVG} coastdown with a power reduction following the T_{AVG} reference profile, at the end of a fuel cycle, should not affect the OTΔT, OPΔT and VΔTEP protection functions since the normalization at full power conditions should remain unaffected. However, it should be remembered that a reduction in T_{AVG} will affect the NIS Power Range and Intermediate Range reactor trip and indication functions. With changes in T_{COLD}, the indicated power on the NIS will change (due to increased downcomer water density acting as a shielding increase), even at constant power. The operations staff should be sensitive to this effect when decreasing temperature.

TEMPERATURE RELATED FUNCTIONS

A T_{AVG} coastdown without a corresponding power reduction, i.e., maintenance of full power by reducing T_{AVG} at the end of a fuel cycle, will affect OTΔT, OPΔT, NIS Power Range and Intermediate Range reactor trips. In this situation, T' and T" should be renormalized as noted previously in this document. The NIS Power Range and Intermediate Range indicated powers will also be affected, as noted above. The rod control T_{AVG} reference profile should also be adjusted to reflect the full power operation at the reduced T_{AVG} value if operation in Automatic rod control is desired. Otherwise, rod control should be placed in Manual and the operations staff must emulate the basic characteristics of the rod control system as if it were in Automatic.

RECOMMENDATIONS

To ensure operation consistent with the various assumptions of the safety analyses for the temperature related protection functions (OTΔT, OPΔT, VΔTEP) and to minimize operational margin impact, Westinghouse recommends that the following modifications to plant procedures be considered. Note that depending on the final choices made on operating practices and availability of setpoint margin (if explicit allowances are included in the setpoint uncertainty or transient analyses calculations), modifications to the plant Technical Specifications may be appropriate.

1) The loop specific full power ΔT_o should be extrapolated from measurements in the 75 to 90 % RTP range and confirmed by measurement near 100 % RTP. The OTΔT, OPΔT and VΔTEP protection functions should be scaled, based on the extrapolation results and confirmed prior to extended operation at 100 % RTP. The values for ΔT_o should be determined acceptable via periodic surveillance of the loop specific, full power, indicated ΔT.

2) T' and T", for OTΔT and OPΔT respectively, should reflect the loop specific, indicated, full power T_{AVG} values determined at the beginning of each cycle and adjusted as necessary based on the periodic surveillance of T_{AVG}.

3) T_{HOT}, T_{COLD}, ΔT, T' and T" surveillance and comparisons to Technical Specification values or other acceptance criteria should be performed utilizing time averaged values.

4) Surveillance of T_{HOT}, T_{COLD}, ΔT_o, T' and T" should be performed on at least a quarterly basis.

5) At the time of normalization or surveillance of ΔT_o, T' and T", the loop specific values for T_{HOT} and T_{COLD} should be verified to be within the upper and lower bounds assumed in the safety analyses.

6) Prior to operation at reduced full power loop ΔT values, with respect to OTΔT and OPΔT initial condition assumptions, the effects of such operation on the Channel Statistical Allowance and Total Allowance should be determined and confirmed acceptable.

7) Prior to operation at the extremes of a T_{HOT} or T_{AVG} window, i.e., at full power conditions significantly different than those assumed for RCS Flow calorimetric measurement uncertainty calculations, the effects of such operation on the RCS Flow calorimetric measurement uncertainty calculation should be determined and the minimum RCS Flow required in the Technical Specifications adjusted as necessary.

8) The T_{AVG} reference profile for the rod control system should be adjusted prior to full power operation at T_{AVG} values less than that assumed in the safety analyses. If the T_{AVG} reference is redetermined after reaching full power, rod control should be placed and maintained in Manual until adjustment of the T_{AVG} profile is completed. The associated T' and T" values in the protection system should also be adjusted at the same time.

ATTACHMENT 1

INPO NUCLEAR NETWORK OE 7063, 1/24/95

OE 7063 I MERTOGUL 24-JAN-95 18:01 EST
PACIFIC GAS AND ELECTRIC (PGE)
Subject: Thermal Stratification in the RCS Hot LegsNNRA001A NUCLEAR
NETWORK 09/17/96
Message Retrieval

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= One message has been selected. =
=

Units . . . . Diablo Canyon 1 & 2
Doc Nos 50-275/50-323
Ratings. . . . . 1137 & 1164 MWe
NSSS/AE . . . . Westinghouse/PG&E
Commercial Dates. . . . . 5/7/85 & 3/13/86

Following elimination of RTD bypass piping from the reactor coolant system and installation of Eagle 21 process protection system equipment at the end of Diablo Canyon Power Plant (DCPP) Units 1 & 2 fuel cycle 6, thermal stratification in the RCS hot legs was observed that was in excess of that observed previously by Westinghouse.

The effect of the stratification was to introduce a non-conservative bias in the measured Thot value in one loop of DCPP Unit 1. The non-conservative bias was in turn reflected in the calculated Tave value. The effect of the non-conservatism was to calculate a Tave value that was lower at 100 % power than the actual Tave for the subject loop as determined by primary and secondary calorimetric calculations. This was determined not to be a safety concern at DCPP because DCPP operates with the reactor control system reference Tave (Tref) lower than the maximum value permitted by the Technical Specifications.

In evaluating the effects of the stratification, it was also determined that DCPP was operated with the T' and T" setpoints in the Overtemperature Delta T (OTDT) and Overpower Delta T (OPDT) trip functions equal to the Rod Control System Tref, whereas Westinghouse assumed that loop specific reference values of Tave at 100% power were used for these terms. The purpose of using loop specific values is to make the Tavg-T' and Tavg-T" terms in the OTDT and OPDT trip equations nominally equal to zero at full power, in the presence of any loop-to-loop variations in measured Tave. If loop specific reference values of Tave at 100% power are not used, there is a potential risk of calculating a non-conservative OTDT or OPDT trip setpoint; i.e., with indicated 100% power Tave for a given loop less than the reference T'/T", the required trip could occur late. This potential non-conservative condition applies to all Westinghouse protection systems, because the observed loop-to-loop Thot variations are due to a combination of upper plenum flow asymmetry and hot leg thermal stratification.

DCPP operates with a control rod Tref of 4 degrees F lower than the maximum value permitted by the Technical Specifications. Operating at a lower Tave provided sufficient margin to account for the non-conservative bias in one loop as well as not utilizing loop specific Tave terms in the OTDT and OPDT trip functions. Therefore, the non-conservative effects of not using loop specific T'/T" values were bounded at DCPP. However, a non-conservative condition could exist for other Westinghouse plants which operate with the T' and T" values in the OTDT and OPDT trip equations equal to Tref, rather than loop specific values. To avoid this potential non-conservative condition, loop specific T' and T" values, measured (and updated, if necessary) on a quarterly basis, must be used.

Westinghouse is aware of this issue and is currently evaluating any potential generic implications.

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