ENCLOSURE 5

Studsvik Scandpower Report
"GARDEL BWR – Cooper Nuclear Station
Power Distribution Uncertainties"
(Report No. SSP-07/405-C, Rev. 1)

Non-Proprietary Version

Cooper Nuclear Station
NRC Docket 50-298, License DPR-46

Studsvik™ Scandpower

Report: SSP-07/405-C Rev. 1
NON-PROPRIETARY

GARDEL BWR – Cooper Nuclear Station

Power Distribution Uncertainties

Shaun Tarves
2007.05.11
09:03:41 -04'00'

Prepared by: ______________________ ______
Shaun Tarves — Date

Digitally signed by David Dean
Date: 2007.05.11 03:47:29
-04'00'

Reviewed by: ______________________ ______
David Dean — Date

Jerry Umbarger
2007.05.11 11:16:15 -04'00'

Approved by: ______________________ ______
Jerry Umbarger — Date

Revision History

Revision Number	Description	Date
0	Original	February 2007
1	Mark proprietary information with double brackets	May 2007

Abstract

This document describes the methodology used to evaluate the uncertainties in the adaptive relative power distribution within GARDEL. These uncertainties are dependent on the quality of the simulation model employed, as well as on the reactor's instrumentation uncertainties.

By utilizing the symmetric TIP positions in Cooper Nuclear Station (CNS), the measurement uncertainties, and indirectly, the calculational uncertainties, can be obtained.

The adapted power is based on calculated power adjusted with observed differences between calculated and measured TIP response. By regarding the adapted power as a weighted average of measured and calculated power, a basis for evaluating the overall uncertainty is established.

The power distribution uncertainties are explored using a variety of perturbed simulation cases to emulate modeling errors. The first method requires a set of idealized cases, in which the calculated TIP values are fed back into SIMULATE to demonstrate the ability of the adaption model to reduce bundle power uncertainty. The second method uses the plant-measured TIP values to power-adapt perturbed and unperturbed cases to more realistically assess he adaption model. The decrease in difference between the adapted power for the perturbed and unperturbed cases drives the overall uncertainty reduction.

Finally, because TIP+LPRM-adaption is used in online monitoring, the additional uncertainty contribution from LPRM drift and the impact of basing the adaption on the prior TIP calibration is determined.

Uncertainties when all TIP machines are in service:

σ_{nodal} = [[ ]]

σ_{radial} = [[ ]]

Uncertainties with one out-of-service TIP machine:

σ_{nodal} = [[ ]]

σ_{radial} = [[ ]]

Table of Contents

1. Purpose and Scope

This document describes the methodology used to evaluate the uncertainties in the adaptive relative power distribution within GARDEL. These uncertainties are dependent on the quality of the simulation model employed, as well as on the reactor's instrumentation uncertainties.

The adapted power is based on calculated power adjusted with observed differences between calculated and measured TIP response. By regarding the adapted power as a weighted average of measured and calculated power, a basis for evaluating the overall uncertainty is established in section 2.

By utilizing the symmetric TIP positions in CNS, the measurement uncertainties, and indirectly, the calculational uncertainties, are obtained in section 3.

The power distribution uncertainties through adaption are assessed in section 4 using a variety of perturbed simulation cases to emulate modeling errors. The first method requires a set of idealized "baseline" cases, in which the calculated TIP values are fed back into SIMULATE as measured data to illustrate how well the adaption can recover from a known perturbation. The advantage of this method is that the "true" values are available and the ability to recover can be studied.

The second method uses the plant-measured TIP values to power-adapt perturbed and unperturbed cases. The decrease in difference between the adapted power for the perturbed and unperturbed cases drives the overall uncertainty reduction. Both methods can be utilized to assess the impact of one TIP machine being out of service.

In online monitoring, TIP+LPRM-adaption is used. Therefore, the additional uncertainty contribution from LPRM drift and the impact of basing the adaption on the prior TIP calibration is determined in section 5 by developing a TIP-calibration uncertainty to account for the LPRM-to-

TIP correction that GARDEL-BWR regularly performs. There are two effects that have to be considered; the drift of the LPRM detectors, and the fact that the shape of the TIP deviations from the last TIP calibration is employed in the time between TIP calibrations. By using the recorded GARDEL data, a good estimate of the total impact of these two effects can be obtained by comparing the adapted power immediately before a TIP calibration with the adapted power immediately after a TIP calibration.

Finally, all uncertainty pieces are combined to obtain the overall uncertainty in section 6.

The methodology employed is based on the observed differences in the TIP measurements and was applied to analyze Cooper Nuclear Station cycle 21-23 data.

2. Normal Distribution Statistics

Total bundle power uncertainty is comprised of a calculational uncertainty piece and a measurement uncertainty piece, which are assumed to be independent of each other. To develop a methodology for combining these uncertainties, we use the following definitions:

$$X_t = \mathit{true\ parameter}$$
$$X_m = \mathit{measured\ parameter}$$
$$X_c = \mathit{calculated\ parameter}$$
$$\varepsilon_m = \frac{X_m - X_t}{X_t} = \mathit{measurement\ error}$$
$$\varepsilon_c = \frac{X_c - X_t}{X_t} = \mathit{calculation\ error}$$
$$\varepsilon_{mc} = \frac{X_m - X_c}{X_m} = \mathit{observed\ difference}$$

The unbiased estimator for the variance of a normal-distributed variable is given by

$$\sigma^2 = \left(\frac{N}{N-1}\right)s^2$$

where

$$s^2 = \frac{1}{N}\sum_{i=1}^{N}\left(x_i - \bar{x}\right)^2$$

Thus,

$$\sigma^2 = \frac{\sum_{i=1}^{N}\left(x_i - \bar{x}\right)^2}{N-1} \qquad (2.1)$$

Using the definitions prescribed above, the expected value of the respective errors, $\bar{x}$, for N independent measurements of ε, is given by

$$\overline{x} = \frac{\sum_{i=1}^{N} \varepsilon_i}{N}$$

As ε_m and ε_c were assumed to be independent, the following relationship exists and will serve as the basis for total bundle uncertainty calculations,

$$\sigma_{mc}^2 = \sigma_m^2 + \sigma_c^2 \tag{2.2}$$

<u>Assumption 1: The adapted power can be considered to be a weighted average of measured and calculated values</u>

The value of adapted power in any location can be expressed as a weighted average of measured power and calculated power:

$$X_a = (1 - S_m)X_c + S_m X_m \tag{2.3}$$

Equation (2.3) cannot be applied immediately, since we do not have direct access to the measured nodal and bundle powers. Moreover, the values of S_m and $1 - S_m$ will vary by core location. To distinguish these local values from the core-wide average, we use $\overline{S_m}$ $\overline{1 - S_m}$ to denote core-average values.

If the uncertainties in the measurement are independent of the uncertainties in the calculation, the variance of X_a, σ_a, can be expressed as:

$$\sigma_a^2 = \left(\overline{1 - S_m}\right)^2 \sigma_c^2 + \overline{S_m}^2 \sigma_m^2 \tag{2.4}$$

We will determine the variance of the TIP adapted power by evaluating $\overline{1 - S_m}$ (section 4) and conservatively assume that $\overline{S_m} = 1$.

Assumption 2: The predicted-to-measured TIP response ratio provides a measure of the deviation in the predicted power from the true power

The adaption model in GARDEL/SIMULATE assumes that the measured-to-calculated TIP ratio, $TIPRAT$, provides an accurate measure of the relative deviation in calculated power in the surrounding bundles:

$$\frac{APOW1}{POWC} \propto \frac{TIPMEA}{TIPCAL} = TIPRAT$$

where

$APOW1$ = TIP-adapted power (also denoted as $POWM$)

$POWC$ = Predicted (calculated) power

$TIPMEA$ = Plant-measured detector response

$TIPCAL$ = Predicted (calculated) detector response

This is reiterated in a more formal fashion in equation (4.1) in section 4, the TIP-adapted power equation.

The calculation of uncertainties for the adaptive method relies on the assumption that the TIP deviations provide a measure of the nodal power deviations. This is a reasonable assumption, since, in principle, the calculation of the flux can be made with the same accuracy throughout the core. The uncertainty on the calculation of the reaction rates in the instrument tubes is of the same magnitude as that on the calculation of the flux, and hence the power, in the fuel pins.

The uncertainty for calculating the average power in a node is smaller than in the pins, since the pin-power calculations are summed over all the pins in the node. This means that the estimate of σ_c for the predicted (calculated) TIP response, as derived in chapter 3, constitutes a conservative estimate of the uncertainty of the calculated nodal power.

Since each measurement location in the core may have a unique value of S_m that can satisfy equation (2.4), estimating the effective value of the core-wide distributions, $\left(\overline{1-S_m}\right)$ and $\overline{S_m}$, will be crucial.

We will assess the effective value of $\left(\overline{1-S_m}\right)$ by using the adaption model in two variations of a perturbation method:

1. The calculated TIP values from a "baseline" case will be used to power-adapt a series of perturbed cases to illustrate the capabilities and limitations of the adaption model. A measure of the effectiveness of this adaption will be used to define the distribution, $(1-S_1)$.
2. The actual plant-measured TIP values will be used to power-adapt a set of base cases and a series of corresponding perturbed cases to establish the ability of the adaption model to recover the expected result. A measure of the effectiveness of this adaption will be used to define the distribution, $(1-S_2)$.

For the strategy outlined above, it is straightforward to estimate the impact of one out-of-service TIP machine.

Note that when we analyze equation (2.4) for the purpose of determining the uncertainty, $\left(\overline{1-S_m}\right)$ and $\overline{S_m}$ will be treated like two variables A and B, and conservative estimates for the two variables will be generated so $\left(\overline{1-S_m}\right)+\overline{S_m} = A+B>1$. A conservative estimate of 1.0 for $\overline{S_m}$, the weighting of the measurement uncertainty, will be used.

3. Measurement and Calculation Uncertainties

A central part of the uncertainty analysis is determining σ_m and σ_c, the uncertainties associated with the measurement and the calculation. As shown in Figure 3-1, the core design and detector layout in CNS is quite advantageous. The large number (13) of symmetric or close-to-symmetric instrument locations provides a good statistical basis for the estimation of the measurement uncertainties.

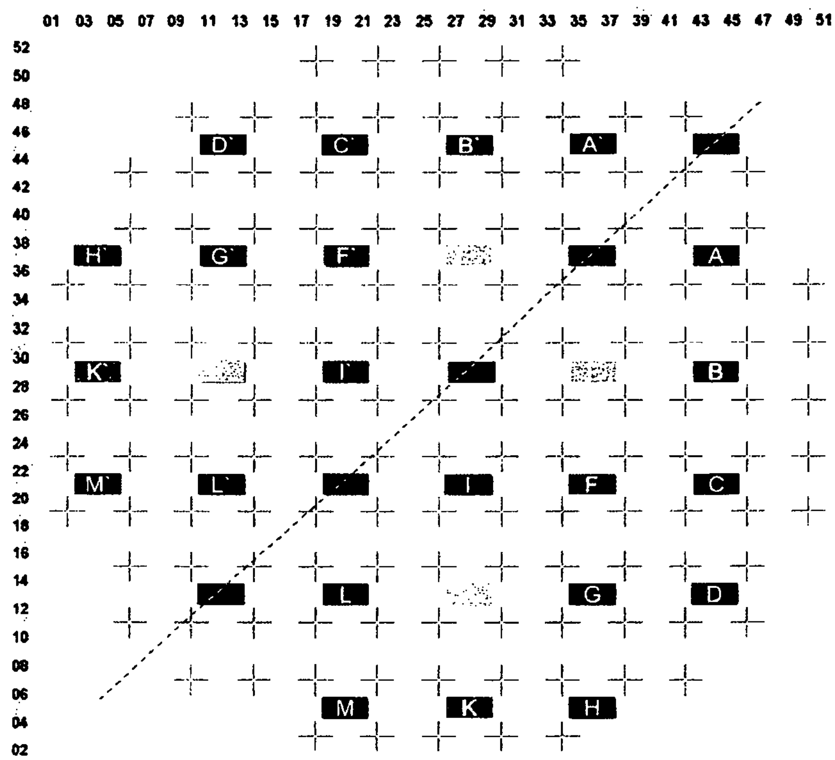


Figure 3-1. Cooper Nuclear Station Core Layout

The uncertainty in the measured TIP response is assessed using a method that takes advantage of the symmetric detector locations in the core. Assuming that TIPs *x* and *x'* are symmetric, then

$$\sigma_m = \frac{1}{\sqrt{2}} std\left[\frac{\sum_{i \in symmetric\ TIPs}\left(TIPMEA_i^x - TIPMEA_i^{x'}\right) - \left(TIPCAL_i^x - TIPCAL_i^{x'}\right)}{N}\right] \tag{3.1}$$

where

N = Total number of symmetric TIPs in the core

In the above method, the term $\left(TIPCAL_i^x - TIPCAL_i^{x'}\right)$ accounts for slight asymmetries that exist during operation.

When σ_m is determined from the measurements, σ_c can be determined from equation (2.2). Results of this calculation are presented in Table 3-1 for 44 TIP measurements in CNS cycles 21-23.

	3-D	2-D
σ_{mc}	[[ ]]	[[ ]]
σ_m	[[ ]]	[[ ]]
σ_c	[[ ]]	[[ ]]

Table 3-1. Uncertainties on Measured and Calculated Detector Response

The calculational uncertainty, σ_c, is the calculational uncertainty of the predicted (calculated) TIP response. As noted in chapter 2, this provides an estimate of the uncertainty of the calculated pin powers and a conservative estimate of the calculated nodal power.

4. TIP-Adapted Power Uncertainties

The adaption model in GARDEL/SIMULATE assumes that the measured-to-calculated TIP-signal ratio, $TIPRAT$, provides an accurate measure of the relative deviation in calculated power in the surrounding bundles. $TIPRAT$ is expanded to non-instrumented locations by radially weighting the instruments up to five fuel assemblies away from the current bundle. $TIPRAT$ is then applied to $POWC$ to calculate $APOW1$, the TIP-adapted, relative nodal power distribution as follows, c.f. Reference 1:

$$APOW1_n^k = POWC_n^k \frac{\sum_{l=1}^{m} TIPRAT_n^l w_n^l}{\sum_{l=1}^{m} w_n^l} \tag{4.1}$$

where

$APOW1$ = TIP-adapted power (also denoted as $POWM$)

$POWC$ = SIMULATE-3-predicted (calculated) power

$TIPRAT$ = Ratio of measured-to-predicted relative reaction rate in the detector location

k = Node index

n = Bundle index

w = Weighting factor for the l^{th} TIP surrounding bundle n

GARDEL uses a weighting-factor array based on the following equation:

[[

]]

The adaption model will take into account bundles up to five positions away from the instrument, yielding the weighting-factor matrix shown below.

[[

]]

$TIPRAT$ remains constant between TIP measurements and GARDEL's adaptive post-processor calculates $APOW1$ after each SIMULATE core supervision calculation (typically once per hour at stable reactor conditions). The purpose of the $APOW1$ calculation is to eliminate deviations in the calculated power distribution observed in the latest TIP comparison.

One limitation to this method is that deviations in non-instrumented assemblies will only partially affect $TIPRAT$. The relative gamma or thermal neutron flux in an instrumented location is affected by the contributions from the four neighboring fuel assemblies. The power deviation in a particular node will be the result of the node's intrinsic deviation plus the contribution from the deviations in its neighboring nodes. It is apparent that the detectors cannot supervise any local deviation that may take place in the non-instrumented assemblies; however, the supervision system is strong in detecting global deviations.

4.1 The Perturbation Method

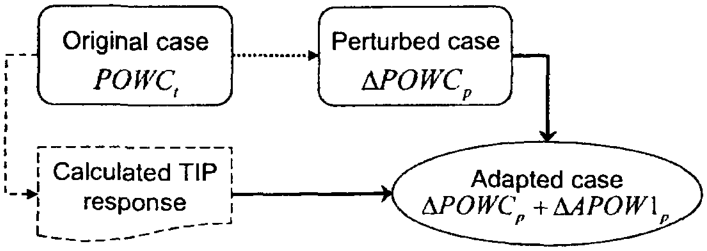
To estimate the weighting of the calculational uncertainty in the adaption model, $\left(\overline{1-S_m}\right)_{overall}$, a number of cases have been simulated for which input parameters have been perturbed to emulate errors in the calculation scheme. All of these cases have been evaluated for two different scenarios:

1. The calculated TIP responses from the baseline case have been used as "measured" signals for the adaption that is performed on the perturbed case.
2. The actual measured TIP responses have been used for the adaption that is performed on the perturbed case.

Each method will assess the ability of the adaption model to compensate for a perturbation in an effort to characterize the calculational component of the overall uncertainty. The following "global" parameters have been disturbed: [[

]]

Method 1



Uncertainty components:

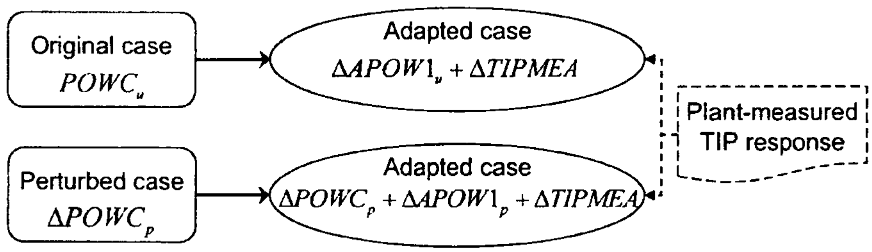
$POWC_t$ = Calculated power, unperturbed baseline case, i.e. "true power"

$\Delta POWC_p$ = Difference between calculated power in the perturbed case and $POWC_t$

$\Delta APOW1_p$ = Difference between TIP-adapted power in the perturbed case and $POWC_t$

By first idealizing the cases using the calculated TIP values and assuming the plant has measured the TIP values perfectly, the experiment becomes more controllable. All deviation from the original case is due to the perturbation and the TIP response calculation. That is, the assessment of the adaption model compensation is directly proportional to the deviation of $\Delta POWC_p + \Delta APOW1_p$ from zero. In this way, the individual mechanisms of the adaption model can be understood without having to account for errors introduced by plant measurements.

Method 2



Uncertainty components:

$POWC_u$ = Calculated power, unperturbed case

$\Delta APOW1_u$ = Difference between TIP-adapted power in the unperturbed case and $POWC_u$

$\Delta POWC_p$ = Difference between calculated power in the perturbed case and $POWC_u$

$\Delta APOW1_p$ = Difference between TIP-adapted power in the perturbed case and $POWC_p$

$\Delta TIPMEA$ = Uncertainty introduced by plant-measured detector response

The second method more realistically models the ability of the core to adjust for a perturbation. The additional uncertainty introduced by using the plant-measured TIP response means that less of the total overall uncertainty can be compensated for by the adaption model. In areas of low power, the plant-measured TIP response to the perturbation will not be as strong as in areas of higher power. Because the adaption model is based on measured TIP values, this has the net effect of lowering the ability of the adaption model to correct for perturbations. In the case of method two, the recovery capability is directly proportional to the deviation of $\Delta POWC_p + \Delta APOW1_p$ from $\Delta APOW1_u$.

4.2 Method 1: Calculated TIP Responses Used for Adaption

After adaption, the average remaining error $\left(\overline{1-S_1}\right)$ is estimated by:

$$\left(\overline{1-S_1}\right) = \frac{std(APOW1_p - POWC_t)}{std(POWC_p - POWC_t)} \tag{4.2}$$

where

$APOW1_p$ = TIP-adapted power, perturbed case (adapted using calculated response from baseline case)

$POWC_t$ = Calculated power, unperturbed baseline case, i.e. "true power"

$POWC_p$ = Calculated power, perturbed case

Table 4-1 shows the average and standard deviation of $\left(\overline{1-S_1}\right)$ for a variety of perturbations on all available cases (38 TIP-calibrations over 3 cycles).

Perturbation case	***All TIP Machines in Service***		***One TIP Machine Out of Service***	
	$avg\left(\overline{1-S_1}\right)$	$std\left(\overline{1-S_1}\right)$	$avg\left(\overline{1-S_1}\right)$	$std\left(\overline{1-S_1}\right)$
[[ ]]	[[ ]]	[[ ]]	[[ ]]	[[ ]]
[[ ]]	[[ ]]	[[ ]]	[[ ]]	[[ ]]
[[ ]]	[[ ]]	[[ ]]	[[ ]]	[[ ]]
[[ ]]	[[ ]]	[[ ]]	[[ ]]	[[ ]]

Table 4-1. $(1-S_1)$ **for various perturbed cases, adapted with calculated TIP values.**

4.3 Method 2: Measured TIP Responses Used for Adaption

After adaption, the average remaining error $\left(\overline{1-S_2}\right)$ is estimated by:

$$\left(\overline{1-S_2}\right)=\frac{std(APOW1_p - APOW1_u)}{std(POWC_p - POWC_u)} \quad (4.3)$$

where

$APOW1_p$ = TIP-adapted power, perturbed case (adapted using measured response)

$APOW1_u$ = TIP-adapted power, unperturbed case (adapted using measured response)

$POWC_p$ = Calculated power, perturbed case

$POWC_u$ = Calculated power, unperturbed case

Table 4-2 shows the average and standard deviation of $\left(\overline{1-S_2}\right)$ for a variety of perturbations on all available cases (38 TIP-calibrations over 3 cycles).

Perturbation case	*All TIP Machines in Service*		*One TIP Machine Out of Service*	
	$avg\left(\overline{1-S_2}\right)$	$std\left(\overline{1-S_2}\right)$	$avg\left(\overline{1-S_2}\right)$	$std\left(\overline{1-S_2}\right)$
[[ ]]	[[ ]]	[[ ]]	[[ ]]	[[ ]]
[[ ]]	[[ ]]	[[ ]]	[[ ]]	[[ ]]
[[ ]]	[[ ]]	[[ ]]	[[ ]]	[[ ]]
[[ ]]	[[ ]]	[[ ]]	[[ ]]	[[ ]]

Table 4-2. $(1-S_2)$ **for various perturbed cases, adapted with calculated TIP values.**

Both methods produce consistent results. Method 2 was used to evaluate $\left(\overline{1-S_m}\right)_{overall}$, since it provides a more realistic description of the real situation in the plant. In order to obtain a conservative estimate, 2σ is added to the estimate of $\left(\overline{1-S_m}\right)$.

$$avg\left(avg\left(\overline{1-S_m}\right)\right)+2std\left(avg\left(\overline{1-S_m}\right)\right)$$

where

$avg\left(\overline{1-S_m}\right)$ =The average of $\left(\overline{1-S_m}\right)$ over all TIP calibrations

Results are given in equations (4.4) and (4.5) below, cf Table 4-2:

All TIP machines in operation:

$$\left(\overline{1-S_m}\right)_{overall} = [[\qquad]] \tag{4.4}$$

One TIP machine out of service:

$$\left(\overline{1-S_m}\right)_{overall} = [[\qquad]] \tag{4.5}$$

This Page Is Intentionally Blank

5. LPRM+TIP-Adapted Power Uncertainties

GARDEL continuously uses the incoming LPRM detector signals with following purposes:

1. Apply an LPRM correction to the power distribution in order to evaluate $APOW2$, the LPRM+TIP-adapted power distribution.
2. Perform a verification of the applicability of the LPRM depletion modeling by comparing the incoming LPRM signals versus the deviations observed during the latest TIP calibration.

In addition, GARDEL includes a detector depletion model to account for sensitivity changes between TIP/LPRM calibrations.

5.1 LPRM Handling During TIP/LPRM Calibrations

Immediately after a TIP/LPRM calibration was accepted, GARDEL will evaluate the LPRM-to-TIP reference ratio, $PRMREF$, as

$$PRMREF = \frac{LPRMCAL}{LPRMMEA}$$

where

$LPRMCAL$ = Predicted LPRM signal computed **using an LPRM-type detector**

$LPRMMEA$ =Predicted LPRM signal computed **using a TIP-type detector**

$PRMREF$ is a snapshot of the expected calculation-to-measurement deviations in the LPRM positions at the TIP calibration times. At the axial locations of the LPRMs, $LPRMMEA$ is equal to $TIPMEA$.

GARDEL also maintains $PRMSCF$, the LPRM calibration factors, so that

$$PRMSCF = \frac{TIPMEA}{PRM}$$

where

PRM = Un-calibrated, plant-measured LPRM signals

This calculation is an attempt to capture the drift in LPRM signal since it was last calibrated to match the TIP signal. If an LPRM spans a node boundary, an average of the measured TIP values in the two nodes containing the detector is taken.

GARDEL also resets all depletion calibration factors, $PRMDCF$, to 1.0 and begins updating them again after the calibration.

5.2 LPRM Handling Between TIP/LPRM Calibrations

Although the LPRMs are calibrated to produce the same signal as the TIPs independent of detector type, they cannot be directly compared to predicted (calculated) LPRM signals. The LPRM signal must first be corrected for possible mis-calibration, depletion effects, and computed reaction rate if the detector types are different.

GARDEL evaluates a pseudo-LPRM signal, $LPRMP$, as

$$LPRMP = PRM \times PRMREF \times \frac{PRMSCF}{PRMDCF}$$

where

PRM = Un-calibrated, plant-measured LPRM signals

$PRMREF$ = LPRM-to-TIP reference ratio

$PRMSCF$ = LPRM signal calibration factors

$PRMDCF$ = LPRM depletion calibration factors

The pseudo-LPRM signal can now be compared to the calculated LPRM signal to define $PRMRAT$, the LPRM adaption distribution

$$PRMRAT = \frac{LPRMP}{PRMCAL}$$

where

$LPRMP$ = Measured LPRM signal, corrected

$PRMCAL$ = Calculated LPRM signal

5.3 LPRM+TIP-Adapted Power Distribution Uncertainties

To evaluate the LPRM+TIP-adapted relative power distribution, $PRMRAT$ is used to evaluate an LPRM-based $TIPRAT$ distribution, $TIPRAT_{PRM}$, as

$$TIPRAT_{PRM}(z) = TIPRAT(z) \times PRMRAT(z)$$

where

z = Axial node index

$PRMRAT(z)$ values are evaluated by linear interpolation in between the four LPRM levels

$TIPRAT_{PRM}$ is applied in the same way as $TIPRAT$ to obtain $APOW2$, the LPRM+TIP-adapted relative power distribution

$$\begin{aligned} APOW2 &= TIPRAT_{PRM} \times POWC \\ &= PRMRAT \times TIPRAT \times POWC \\ &= PRMRAT \times APOW1 \end{aligned}$$

Note that immediately after a TIP/LPRM calibration, $TIPRAT_{PRM} \approx TIPRAT$ and $APOW1 \approx APOW2$. This makes the additional uncertainty in going from $APOW1$ to $APOW2$ easy to assess from data. Immediately after a TIP calibration, the additional uncertainty is small and it grows continuously until the next calibration. A good estimate of the maximum *additional* uncertainty due to the transition from $APOW1$ to $APOW2$ can be obtained by calculating the standard deviation of the difference in $APOW2$ immediately before and after the TIP calibration

$$\sigma_{D\_T}^{-} = std\left[(APOW2^{-} - APOW2^{+}) - (POWC^{-} - POWC^{+})\right] \quad (5.1)$$

where

$\sigma_{D\_T}^{-}$ is the uncertainty immediately before a TIP calibration due to LPRM drift and the fact that $TIPRAT$ used for the adaption is from the last calibration

$APOW2^{-}$ = $APOW2$ immediately before a TIP calibration

$APOW2^{+}$ = $APOW2$ immediately after a TIP calibration

$POWC^-$ = $POWC$ immediately before a TIP calibration

$POWC^+$ = $POWC$ immediately after a TIP calibration

For practical reasons, the real time between "immediately before" and "immediately after" the TIP calibration is up to twenty-four hours. The term $(POWC^- - POWC^+)$ is included to account for the changes in core conditions during this time. For the available data,

$$\sigma_{D\_T}^{nodal} = [[\qquad]] \tag{5.2}$$

where

$\sigma_{D\_T}^{nodal}$ is the expected additional nodal uncertainty due to LPRM drift and variation in $TIPRAT$

Correspondingly, the additional bundle uncertainty is,

$$\sigma_{D\_T}^{bundle} = [[\qquad]] \tag{5.3}$$

where

$\sigma_{D\_T}^{bundle}$ is the expected additional bundle uncertainty due to LPRM drift and variation in $TIPRAT$

6. Overall Uncertainty

The overall uncertainty for LPRM+TIP-adapted power immediately before a TIP calibration is determined by the following equation:

$$\sigma_{APOW2} = \sqrt{(1-S_m)^2 \sigma_c^2 + S_m^2 \sigma_m^2 + \sigma_{D\_T}^2} \tag{6.1}$$

	Nodal	Bundle	Equation
σ_m	[[ ]]	[[ ]]	(3.1)
σ_c	[[ ]]	[[ ]]	(2.2)
$\sigma_{D\_T}^{nodal}$	[[ ]]	[[ ]]	(5.1)

Table 6-1. Summary of uncertainties

Combining the results from Table 6-1, equations (4.4), (4.5) and equation (6.1), the overall uncertainties for the LPRM+TIP-adapted nodal and bundle power, with all TIP machines in service and one TIP machine out of service are given below:

All TIP Machines in Service		*One TIP Machine Out of Service*	
Nodal	*Bundle*	*Nodal*	*Bundle*
[[ ]]	[[ ]]	[[ ]]	[[ ]]

Table 6-2. Overall LPRM+TIP-adapted power uncertainties

This Page Is Intentionally Blank

7. References

1. "SIMULATE-3 Adaptive Model for BWR On-Line Core Monitoring", *STUDSVIK/SOA-96/19* (1996).

2. "ADPS3B Program Description", *SSP-04/430, rev. 1* (2006).

3. "Qualification of Reactor Physics Methods for Application to Monticello," (*NSPNAD-8609 Rev. 2).*

This Page Is Intentionally Blank

ENCLOSURE 6

10 CFR 2.390 Affidavit from Studsvik Scandpower, Incorporated

Cooper Nuclear Station
NRC Docket 50-298, License DPR-46

Affidavit

I, Thomas Smed, state as follows:

1. I am President of Studsvik Scandpower, Inc. (SSP) and have reviewed the information described in paragraph 2 which is sought to be withheld.
2. The information sought to be withheld is contained in the attachment, "GARDEL BWR-Cooper Nuclear Station Power Distribution Uncertainties," dated May 11, 2007. SSP proprietary information is indicated by enclosing it in double brackets. The basis for proprietary determination is provided in paragraph 3.
3. In making this application for withholding of proprietary information of which it is the owner, SSP relies on the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4), and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10CFR 9.17(a)(4) and 2.390(a)(4) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information".
4. The information sought to be withheld is considered to be proprietary for the following reasons:
   - Information that discloses a process, method and supporting data and analyses, where prevention of its use by SSP's competitors without license from SSP constitutes a competitive economic advantage over other companies;
   - Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

5. To address the 10 CFR 2.390 (b) (4), the information sought to be withheld is being submitted to NRC in confidence. The information is of a sort customarily held in confidence by SSP, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by SSP, no public disclosure has been made, and it is not available in public sources. All disclosures to third parties including any required transmittals to NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence.
6. The information identified in paragraph 2 is classified as proprietary because it contains details of SSP's power distribution uncertainties methodology. The development of the methods used in these analyses was achieved at a significant cost to SSP.
7. Public disclosure of the information sought to be withheld is likely to cause substantial harm to SSP's competitive position and foreclose or reduce the availability of profit-making opportunities. The power distribution uncertainties methodology is a part of SSP's GARDEL core monitoring system, and its commercial value extends beyond the original development cost.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

SSP's competitive advantage will be lost if its competitors are able to use the results of the SSP's experience.

The value of this information to SSP would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive SSP of the opportunity to exercise its competitive advantage to seek an adequate return on its investment.

I declare under penalty of perjury that the foregoing affidavit and the matters stated therein are true and correct to the best of my knowledge, information and belief.

Executed at Newton, Massachusetts, this 11th day of May 2007.

Thomas Smed
Studsvik Scandpower, Inc.