ABB

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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Infobulletin 97-08, "Information Update on the Use of the DELTSTRAT Code for RCS Flow Rate Determination,"

Gentlemen:

As described more fully below, ABB Combustion Engineering (ABB-CE) has issued the subject Infobulletin (attached) to its utility customers, and has recommended that each utility using the DELTSTRAT code evaluate the matters addressed in the Infobulletin for reportability under 10 CFR 21. This report is provided to NRC for informational purposes.

The DELTSTRAT code is used at several ABB-CE plants (St. Lucie Units 1&2, Waterford Unit 3, San Onofre Nuclear Generating Station Units 2&3, and Palisades) to determine RCS flow rate from data taken with a calorimetric flow measurement technique. The code corrects for temperature stratification effects in the RCS hot legs. A hot leg temperature correction is calculated by the code, and is then applied to the measured hot leg RTD temperatures to determine hot leg bulk coolant temperature. The hot leg bulk coolant temperature, along with other inputs, is then used to calculate the RCS flow rate.

In several instances, the code overestimated the hot leg temperature correction and produced a calculated flow rate which was substantially larger than expected. A review of test data and the underlying assumptions for the DELTSTRAT code indicated that improvements in the treatment of certain code inputs could be made which would produce a calculated flow rate that would be closer to the expected value. Infobulletin 97-08 discusses ABB-CE's findings and provides recommendations to DELTSTRAT users for assuring that the code-calculated RCS flow rates are reasonable and accurate.

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ABB-CE has evaluated the matters addressed in the Infobulletin with respect to 10 CFR 21 reportability, and has concluded that insufficient information is available about how individual utilities use the DELTSTRAT code to determine whether the issue is reportable under 10 CFR 21. Therefore, in addition to the recommendations in the Infobulletin, ABB-CE has recommended that each utility using DELTSTRAT evaluate whether the issues addressed in the Infobulletin are reportable under 10 CFR 21 in light of how the individual utility uses the code.

Please do not hesitate to call me or George Hess at (860) 285-8405 if there are questions concerning this matter.

Very truly yours,
COMBUSTION ENGINEERING, Inc.

Ian C. Rickard, Director
Operations Licensing

Attachment: As stated

xc: S. Magruder (NRC)

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Combustion Engineering *Infobulletin*

No. 97-08

Dec. 22, 1997

Information Update on the Use of the DELTSTRAT Code for RCS Flow Rate Determination

Summary: The DELTSTRAT code is used at several ABB-CE plants (St. Lucie 1&2, Waterford 3, SONGS 2&3, and Palisades) to determine RCS flow rate from data taken with a calorimetric flow measurement technique. The code corrects for temperature stratification effects in the RCS hot legs. A hot leg temperature correction is calculated by the code, and is then applied to the measured hot leg RTD temperatures in order to determine hot leg bulk coolant temperature. The hot leg bulk coolant temperature, along with other inputs, is then used to calculate the RCS flow rate.

In several applications, for Cycles 9 through 11 at Calvert Cliffs 2, the code overestimated the hot leg temperature correction and produced a calculated flow rate which was substantially larger than expected. A similar application for Calvert Cliffs Unit 1, Cycle 12 produced an RCS calculated flow rate which appeared to be more reasonable. The overestimation of the RCS flow rate for Unit 2 appears to be related to several factors: 1) unusual temperature trends in some of the hot leg RTD measured temperatures, 2) the impact of a low leakage fuel management scheme with a very peaked core radial power distribution, and 3) isothermal biases for the RTD temperatures.

A review of the Calvert Cliffs test data and the underlying assumptions for the DELTSTRAT code indicated that improvements in the treatment of certain code inputs could be made which would produce a calculated flow rate for Unit 2 that would be closer to the expected value.

This bulletin discusses the findings of the Calvert Cliffs review and provides recommendations to the users for assuring that the DELTSTRAT code calculated RCS flow rates are reasonable and accurate. A listing of all assumptions inherent in the DELTSTRAT code is included here as Attachment #1.

Discussion: There are several assumptions inherent in the formulation of the equations and input for the DELTSTRAT code. One of the assumptions is that the flow mixing factors, which relate how the flows exiting from the core mix with adjoining flows as they proceed into the outlet nozzles and down the hot legs, are invariant with time, power distributions, and relative position of the reactor vessel internals. In the case of Calvert Cliffs 2, for Cycles 9 through 11, the trend of measured hot leg temperatures for channels A and C was unusual. The hot leg temperatures for channels A and C indicated a constant core ΔT for these cycles even though the expected trend, due to the low leakage fuel management, was an increasing core ΔT. Channel B and D hot leg temperatures did show the expected increasing trends with each cycle.

A second assumption used is that the normalized core radial power distribution is an accurate proxy for describing the normalized fuel assembly coolant temperature rise distribution (that is: the ratio of individual assembly to core average coolant temperature rise). This assumption works well for the traditional out-in fuel management schemes used in the earlier fuel cycles for the ABB-CE plants. However, with the more non-uniform radial power distributions inherent in some of today's low leakage fuel management schemes, a better approach for defining the fuel assembly coolant temperature rise is to use an open-core thermal-hydraulic code, such as the ABB-CE TORC code, along with the actual core radial power distribution. The open-core code will determine the open-core effects of mass, momentum, and energy transfers between adjoining fuel assemblies on the coolant temperature rise in each fuel assembly. The assembly coolant temperature rise data can be normalized in the form of assembly to core average temperature rise factors. The normalized assembly coolant temperature rise factors can then be used as input to the DELTSTRAT code (in place of the core radial power distribution).

A third assumption relating to the code inputs involves the measured cold and hot leg coolant temperatures. The measured coolant temperatures are assumed to have any inherent isothermal biases eliminated before being input to the DELTSTRAT code. Removing biases will provide a more accurate set of input to the code and a more consistent picture of the temperature distribution in the RCS piping.

In the Calvert Cliffs Unit 2 situation, it was found that if the Channel A and C temperature data were eliminated, and if open-core exit coolant temperatures were used as input in place of the traditional core radial power factors, the resulting calculated RCS flow rate would be much closer to what was expected. The reasoning for eliminating the Channel A and C data is as follows:

1. The DELTSTRAT code does not have the capability for predicting unusual hot leg temperature trends which may be due to special, localized effects as seen in the case of Calvert Cliffs Unit 2.
2. It is suspected that the measured hot leg temperature trend at Calvert Cliffs Unit 2 is real, but local in nature and may not be representative of the overall temperature distribution in the hot leg.
3. By using only Channels B and D hot leg temperatures, a more traditional temperature distribution was input to DELSTRAT and a lower calculated RCS flow rate was calculated.

Recommendations:

ABB-CE recommends that the users initiate the following actions in order to assess if there are any current operability problems in determining RCS flow rate in their plant(s) when using the DELTSTRAT code with currently used procedures:

1. Review and confirm that the long-term trends (starting from BOC 1) in measured RCS flow rates, as determined with DELTSTRAT, show consistency with any changes in plant hardware on the primary side (i.e., with added SG tube plugging, RCP change-outs, etc.), within the accuracy of the measurement method.

2. Compare current measured RCS flow rates with beginning-of-cycle 1 (BOC 1) values. If today's values are larger than the BOC 1 value by an amount which is greater than the measurement uncertainty, without any corresponding justification from hardware changes to the primary system, then consideration should be given to reducing the RCS flow rate to the BOC 1value. In the case of the digital plants, the flow rate in the Core Operating Limit Supervisory System (COLSS) and Core Protection Calculators (CPC's) would be reduced. For the analog plants, the flow rate measured at the beginning of the current cycle would be reduced.

If recommendation 1 or 2 fails, then proceed with recommendation 3 or 4.

3. Substitute normalized fuel assembly coolant temperature rise fators, as determined by an open-core thermal-hydraulic computer code, in place of a core radial power distribution when preparing input to the DELSTRAT code, or else:

4. Determine a systematic flow bias that will be applied to the flow rate calculated by DELSTRAT with core radial power distribution as input. The flow bias will compensate for the fact that the fuel assembly coolant temperature rise factors are not being used as input.

It is recommended that for future cycles isothermal RTD temperature biases be measured at the start of each new cycle for use in correcting measured RTD temperatures prior to being input to DELTSTRAT. This step is intended to improve accuracy, but is not required to support current operability of the plants.

Applicability: All plants for which the ABB-CE DELTSTRAT code is used to determine RCS flow rate.

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Attachment #1 to Infobulletin No. 97-08

Assumptions used in the DELTSTRAT Methodology

1. Eight hot leg and eight cold leg RTD's (from the safety channels) provide input temperature values.

2. The average of the cold leg RTD readings in each RCS loop is equal to the bulk cold leg temperature in that loop.

3. Hot leg and cold leg isothermal temperature biases are determined and applied to adjust the measured RTD temperatures (individually or collectively).

   This is an assumption which the Infobulletin states is important in obtaining unbiased temperatures for input to DELTSTRAT.

4. The flow mixing data from the ABB-CE Palisades flow model tests apply to all ABB CE 2-loop reactor designs. The flow mixing factors are invariant with time, core radial power distribution, coolant temperatures, and any unusual localized flow conditions in the hot legs.

   This is an assumption which appears to be challenged by the Channel A and C hot leg temperature data trends at Calvert Cliffs Unit 2 during Cycles 9 to 11.

5. The core radial power distribution is a representative proxy for the normalized distribution of fuel assembly coolant temperature rise factors.

   This is an assumption which the Infobulletin states can be improved upon by using a calculated normalized radial distribution of fuel assembly coolant temperature rise factors as input to DELTSTRAT in place of the radial power distribution.

6. Flow mixing in the reactor vessel upper plenum between the two loops is negligible.

7. Complete mixing of the hot leg coolant temperatures occurs at a distance of 18 hot leg pipe diameters downstream of the reactor vessel outlet nozzle exit.

8. The circumferential distribution of hot leg coolant temperature can be described by a cosine variation.

9. The flow in the hot legs may rotate in a solid-body manner as it passes down the length of the hot legs.

10. The velocity distribution in the cross-section of the hot legs for Plant X is the same as existed in the Palisades reactor flow model tests, from which the flow mixing factors were determined.

List of recently-issued Infobulletins:

Number	Date	Title
97-07, Rev 01	12/31/97	Tech Spec on Azimuthal Tilt in Analog Plants
97-07	10/28/97	Tech Spec on Azimuthal Tilt in Analog Plants
97-06	10/21/97	Core Snubbers / Blocks
97-05	10/21/97	Core Ledge Loads
97-04	7/11/97	Potential Error in the Energy Redistribution Factor Used in LOCA Analysis
97-03	6/5/97	Use of Non-Safety (non-Q) Components in Reactor Protection System
97-02	5/23/97	Spurious Recirculation Actuation Signal
97-01, Supl 1	4/9/97	CESEC Decay Heat Model
97-01	4/3/97	CESEC Decay Heat Model
96-02	4/24/96	Steam Generator Sleeve-to-Tube Weld Indications