Request for Additional Information (RAI)
NEDE-33083P, Supplement 1, "TRACG Application for ESBWR Stability Analysis"

10. MCNP is used to determine biases and uncertainty in void coefficient. What is the accuracy of the MCNP calculations? Monte Carlo calculations involve some finite number of histories, which implies some uncertainty for the results. The microscopic cross-sections data base used by the Monte Carlo calculation also has some uncertainty associated with it. The burnup calculation that identifies the concentrations for the isotopes at a given burnup has uncertainty. The uncertainty in the burnup calculation translates to an uncertainty in the Monte Carlo calculation. There is an uncertainty associated with the manufacturing tolerances for the fuel rods in terms of enrichment fraction, etc. How are these uncertainties included into the ESBWR instability calculations? TRACG includes internal biases and uncertainty for the k-infinite void coefficient based on the differences between MCNP and GE lattice code simulations. This implies that the MCNP calculations are exact. Has the uncertainty in the MCNP calculations been included in these TRACG internal biases and uncertainty functions?

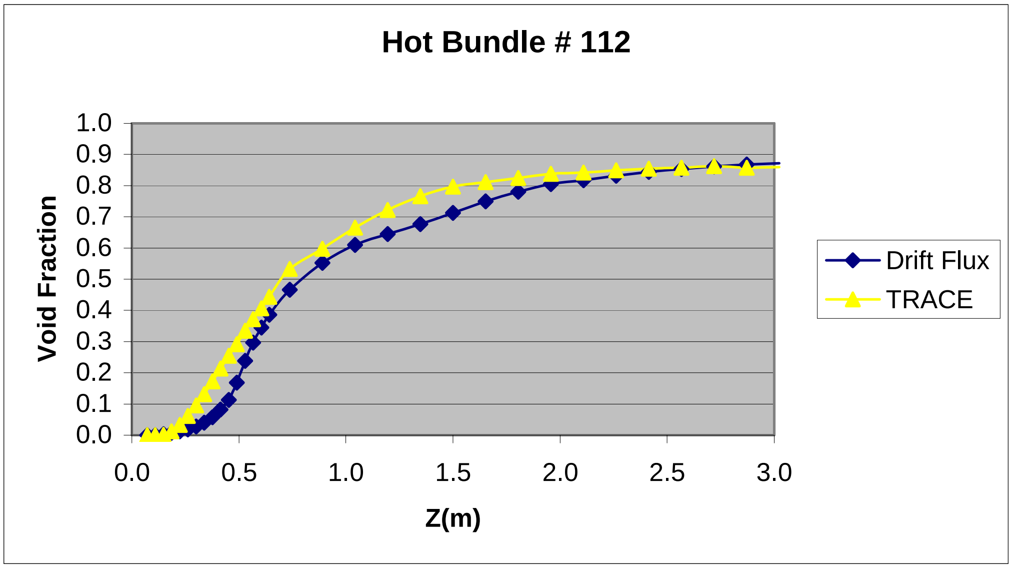
11. The biases and uncertainty in void coefficient is based on comparing the results for the TGBLA06 and MCNP01 calculations for 11 different lattices at different void fractions and exposures. Is the GE14 design one of the 11 different lattices? Are the biases and uncertainties associated with the GE14 design bounded by the response surface developed for the 11 different lattices?

12. Is there any voiding calculated in the water rods during a typical ESBWR instability calculation with TRACG? There is some core bypass voiding calculated in the periphery of the core due to the down flow at the top of the core bypass. The biases and uncertainty in void coefficient is based on assuming the water rods and core bypass are at zero void fraction. Is the additional uncertainty in reactor kinetics associated with water rods voids and/or core bypass bounded by the response surface used by TRACG?

13. NEDE-33083P, Supplement 1 page 5-11 lower tie-plate leakage (drilled holes) has an uncertainty of 5%, while on the same page the sharp-edge orifice for water rod has uncertainty of 10%. Why is the uncertainty of the flow through drilled holes less than the uncertainty for a calibrated sharp-edge orifice?

14. BOC is bounding exposure for channel decay ratio. MOC is bounding exposure for core decay ratio. What about a clean core (i.e. zero exposure) rather than an equilibrium cycle? Have any calculations been completed for completely fresh core (i.e. zero exposure)?

15. As part of the staff’s review your interfacial drag models in TRACG, a calculation was performed that predicts void fraction as a function of elevation in the hot bundle. This was performed using TRACE and a standalone drift flux calculation that uses the models in Ref. 1. The staff found that the results were slightly different. This was expected since there are modeling differences between TRACE and the TRACG models in Ref. 1.



TRACG uses the Rouhani-Bowring model[2] for the energy distribution in subcooled boiling while TRACE uses the Lahey's mechanistic model[3]. The models are essentially the same, except the TRACE model does not include the pumping factor.

TRACG Model:

$q_l = q_w$ if $h_l < h_{ld}$.

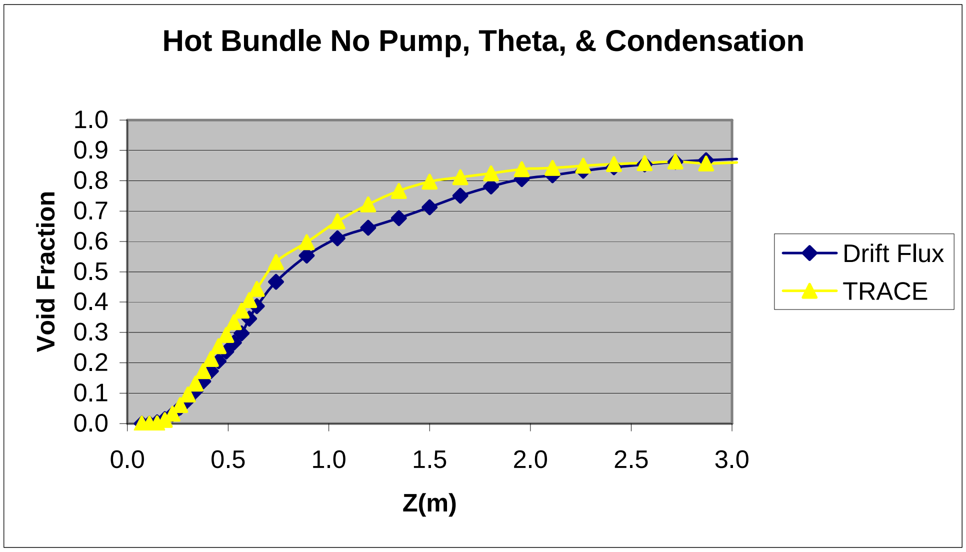
$$q_l = q_w\left[\left(\frac{h_f - h_l}{h_f - h_{ld}}\right)\left(1+\left(\frac{h_l - h_{ld}}{h_f - h_l}\right)\left(\frac{\varepsilon}{1+\varepsilon}\right)\right)\right] \quad \text{if } h_l > h_{ld}$$

The TRACE model has ε set to zero (i.e. the pumping factor).

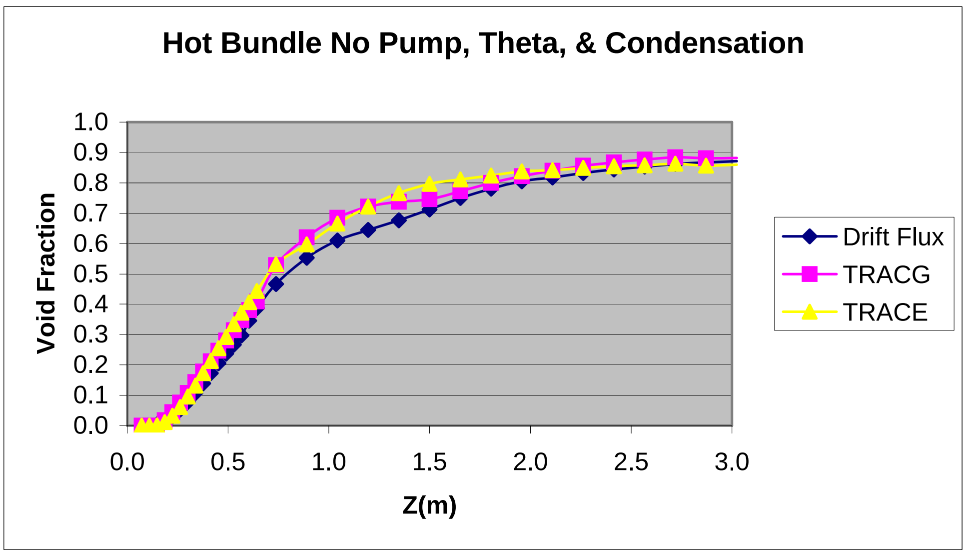
Another difference is that TRACE does not include the theta factor for modification[4] of Co in the subcooled boiling regime, while the TRACG model description indicates that this factor is included.

$$C_{o,sb} = C_o\left(\frac{h_l - h_{ld}}{h_f - h_{ld}}\right)$$

The standalone drift flux model was modified to set the pumping factor to zero, remove the theta factor for modification[4] of Co in the subcooled boiling regime, and ignore condensation in the subcooled boiling regime. The cases were re-run and the two results agree quite well.



These void fraction profiles were then compared to the TRACG data in the MS Excel file MFN 05-014 Channel Data.



This also agreed quite well, which was not expected. The staff expected that in the subcooled region the TRACG data would agree with the drift flux model in the prior to the modifications since that model is using the same models in Ref. 1.

Please provide the following so that the staff may understand or resolve the differences:

a) Confirmation that the pumping factor and theta factor are used in TRACG.

b) Axial power profile for the ESBWR hot bundle at steady-state.

c) Location of the grid spacers and the form loss used for the grid spacers and the flow area for the grid spacers.

d) Provide a density wave propagation time based on the TRACG results.

16. Fig. 3-11 in Ref. 5 indicates that for the Sirius test at 72 bars pressure the density-wave oscillations have a period > 10 seconds. The height of the core for the Sirius test is ~1.7 m compared to 3.0 m for the ESBWR. The ESBWR calculated power oscillations have a period ~1.3 seconds. The time period of the power oscillations in the ESBWR are related to the time required for a density wave to transport through the core. However, the density wave oscillations for the Sirius test with a shorter core have a period that is approximately an order of magnitude larger than the time period for the ESBWR power oscillations. It is assumed that the longer time period for the Sirius test is because the Sirius test is at constant power and therefore the density wave oscillation includes the time associated with a density wave propagating through the chimney. Please provide an explanation for the time period associated with the density wave oscillations in the Sirius test.

References:

1) J.G.M. Andersen, et al, “TRACG Model Description,” NEDE-32176P, Revision 2, Class 3, December, 1999.

2) R.T. Lahey, *Two-Phase Flow in Boiling Water Reactors*, NEDO-13888, July 1974.

3) R. T. Lahey, “A Mechanistic Subcooled Boiling Model,” Proc. of the Sixth International Heat Transfer Conference, 1, Toronto, Canada, 1978, pp 293-295.

4) J.A. Findlay and G.E. Dix, “BWR Void Fraction Correlation and Data,” NEDE-21565, January 1977.

5) J.R. Fitch, et al, “TRACG Qualification for ESBWR,” NEDC-33080P, August, 2002.

6) ESBWR Design Description, NEDC-33084p, Class III, DRF 0000-0007-3896, August, 2002.