TECHNICAL EVALUATION REPORT for

DUKE POWER COMPANY THERMAL-HYDRAULIC STATISTICAL CORE DESIGN METHODOLOGY; APPENDIX D: OCONEE PLANT SPECIFIC DATA

(DPC-NE-2005(P), Appendix D)

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Attachment

SUMMARY

With the corrections to Table D-2 and D-4 provided in the DPC response to the RAI (see Reference 1), the plant specific data for Oconee presented in Appendix D of DPC-NE-2005P are appropriate for use in the SCD analysis. The parameters are for cores containing Mark-B11 fuel, and transition cores containing both Mark-B10 and Mark-B11 fuel assemblies.

BACKGROUND

The Duke Power Company (DPC) statistical core design (SCD) methodology as documented in Topical Report DPC-NE-2005P-A was granted approval by the Nuclear Regulatory Commission on February 24, 1995. This approval acknowledged that the statistical core design methodology is direct and general enough to be widely applicable to any pressurized-water reactor (PWR), with the following restrictions:

(1) The VIPRE-01 methodology for thermal-hydraulic analysis must be approved for use with the core model.

(2) All correlations, including the critical heat flux (CHF) correlation, are subject to the conditions in the VIPRE safety evaluation report (See Reference 2).

(3) The methodology is approved for use in Duke Power Company plants only.

In addition to the above restrictions, DPC is required to justify on a plant-specific basis the uncertainties and distributions used for each application. The selection of statepoints used for generating the statistical design limit must also be justified to be appropriate, on a plant specific basis.

The Topical Report DPC-NE-2005P-A includes an Appendix A with plant specific data for the Oconee plant with Mark-B10 fuel assemblies (B&W fuel), using the BWC critical heat flux correlation to determine the MDNBR limit. The current submittal, Appendix D, is for Mark-B11 fuel assemblies, analyzed using the BWU-Z critical heat flux correlation. The purpose of Appendix D is to provide the required justifications for the specific uncertainties and distributions used in the application, and for the selected statepoints used to generate the statistical design limit.

EVALUATIONS

The presentation of the plant-specific data for Oconee with Mark-B11 fuel is exceedingly terse in Appendix D. This made it extremely difficult to evaluate the justification for any changes in the plant specific data, or the selection of the set of statepoints used in the analysis. In response to a request for additional information (see Reference 1), DPC provided additional documentation of the means of justifying the specific uncertainties for the Mark B-11 core.

There are four major changes in the plant specific parameters used in the analysis of the Oconee core with Mark-B11 fuel (compare Table D-4 of the submittal with Table A-2 of DPC-NE-2005P-A, Appendix A). The core flow uncertainty is larger, the Fq parameter is also larger, the hot channel factor area uncertainty is unchanged (despite significant changes in the geometry), and the parameter Fq" has been omitted entirely from the analysis. These changes were merely reported in the original submittal, and no justification was given. However, additional information supplied in response to the RAI provided adequate justification for the changes. The change in the flow uncertainty is the result of re-calculating the Chapter 15 transients for Oconee with Mark-B11 fuel using the BWU-Z correlation for combinations of 4, 3, and 2 pump operation. The parameter Fq is based on the rod power hot channel factor

supplied by the fuel vendor and the approved value of the radial peak uncertainty. The hot channel factor area uncertainty is based on information supplied by the fuel vendor and will be verified by inspection of the final fuel assemblies and components. The specific value of -3.00% for Oconee bounds particular acceptance criteria for the fuel, and cannot be exceeded without invoking additional analyses to determine the effect on the statistical design limit (see Table 7 of DPC-NE-2005P-A).

Omitting the parameter Fq" from the analysis was justified by DPC based on work by other fuel vendors (specifically, in WCAP-8202 and CENPD-207) showing that local heat flux spikes as great as 20% above the local nominal heat flux do not have any noticeable effect on the minimum DNBR. DPC believes that this effect is generic to PWR fuel, and states that it was confirmed to be applicable to Mark-B11 fuel by the fuel vendor. In addition, the parameter Fq" calculated by the vendor is much smaller for this fuel than for Mark-B10 fuel (a value of 1.41% for Mark-B11, compared to 2.08% for Mark-B10.)

The additional information supplied by DPC shows that it is justifiable to omit the parameter Fq" from the SCD analysis of the Oconee plant with Mark-B11 fuel. However, the assertion that the parameter can be omitted in analysis of PWR fuel in general is too broad. Fuel designs developed in future might conceivably have a different sensitivity to this parameter, and DPC should be required to evaluate its applicability to each new fuel design. If it can be omitted for a particular fuel design, DPC must provide justification for such omission, as required by the SER for DPC-NE-2005P-A.

The discussion in Appendix D of the treatment of transition fuel cycles, when Mark-B10 and Mark-B11 fuel would be co-resident in the core, is extremely vague and incomplete. In response to the RAI, however, DPC provided additional details to clarify the method of determining the transition core penalty and implementation of the options for its application. It appears that the methodology used will capture the largest penalty applicable to a specific core design.

Appendix D contains no discussion of the applicability of the BWU-Z CHF correlation to Mark-B11 fuel in mixed cores. This is a serious oversight, since there are marked local pressure drop differences between the Mark-B10 and Mark-B11 fuel assembly designs, even though the overall pressure drop is essentially the same. The local differences (due to differences in the grid design) will result in subchannel flow distributions in the vicinity of the spacer grids that are significantly different from the distributions in a uniform core of Mark-B11 fuel only. Since the BWU-Z CHF correlation is based on data for Mark-B11 fuel only, it is not obvious that the correlation is applicable to cores containing both B-10 and B-11 fuel.

Additional information supplied by DPC referenced CHF testing by the fuel vendor[1] with a 5x5 test assembly simulating mixed core conditions (BAW-10143P-A). For the conditions tested, there was no significant change in the accuracy of the BWC correlation for the bundle modeling a mixed core, compared to results obtained for bundles modeling a uniform core.

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[1]Framatome Cogema Fuels, formerly Babcock & Wilcox Fuel Company.

This is evidence that the mixed core conditions do not result in local conditions in the subchannel that are outside the range of the CHF correlation. Thermal-hydraulic calculations with the VIPRE code show that the geometry corresponding to a mixed core of Mark-B10 and Mark-B11 fuel produces local velocity distributions that differ from a uniform core by only about one-fifth as much as the most severe conditions encountered in test data reported in BAW-10143P-A. Based on these factors, DPC concludes that the BWU-Z correlation is also applicable to mixed cores.

This argument has several weaknesses. It is based on data for Mark-B10 fuel, not Mark-B11, and the correlation used to evaluate the data was the BWC correlation, not the BWU-Z correlation. Because CHF correlations are *ad hoc* fits to data sets rather than models based on the physical behavior of the system, there is no reason to suppose as a general rule that what is true of one fuel design and CHF correlation will be true of another fuel design and its CHF correlation. In this particular case, however, it can be argued that there are two main reasons to expect the BWU-Z correlation to behave in essentially the same manner as the BWC correlation for a mixed core of B-10 and B-11 fuel. First, the fuel designs are from the same vendor, and have similar physical geometry. Second, the CHF correlations share a common developmental path, have similar form, and show similar fit to their respective databases. In addition, DPC reports that thermal-hydraulic calculations show the non-uniformities for mixed B-10/B-11 cores will in general be much smaller than the conditions tested using the BWC correlation in the bundle modeling a mixed core for Mark-B10 fuel.

For this case, DPC has shown that the BWU-Z CHF correlation can be expected to be applicable to mixed cores of Mark-B10 and Mark-B11 fuel. However, this conclusion should not be interpreted as laying to rest the generic issue of the applicability of CHF correlations to mixed core geometries. This issue must be examined for each transition to new fuel, to determine if the mixed core non-uniformities result in local hot channel conditions outside the range of applicability of the CHF correlation. At a minimum, subchannel thermal-hydraulic calculations are needed to determine the magnitude of the most severe local velocity depression in the hot channel. Test data obtained in bundles modeling a mixed core may be necessary in some cases to fully resolve the issue.

The description of the range of applicability of the BWU-Z CHF correlation for system pressure was not presented appropriately in the original submittal. Additional information supplied by DPC corrected this deficiency, and a revised version of Table D-2 is included in the response to the RAI (see Reference 1). This table shows that the design limit DNBR of 1.199 is applicable to conditions between 700 and 1000 psia. Below 700 psia, the design limit DNBR is 1.59. In addition, the response states that if a statepoint with pressure below 1000 psia is encountered in an SCD analysis for Oconee, the applicable design limit DNBR will be used and the impact of the higher correlation standard deviation on the statistical design limit will be calculated. If the SDL for the new statepoint is greater than the licensing limit, the higher SDL will be used when analyzing the lower pressure conditions. This procedure is in accordance with the approved methodology, as described in DPC-NE-2005P-A.

RECOMMENDATIONS

The plant specific data for Oconee with Mark-B11 fuel and for transition cores containing Mark-B10 and Mark-B11 fuel is appropriate for use in the SCD analysis, based on the justifications provided in the DPC response to the RAI (see Reference 1). This includes the corrections to Table D-2 and D-4 provided in the DPC response to the RAI. However, approval of these parameters for Oconee with Mark-B11 fuel does not constitute generic approval of all matters in Appendix D pertaining to the SCD analysis. Specifically,

- Omission of the parameter Fq" from the SCD analysis of the Oconee plant with a new fuel design must be justified for each particular case. Acceptance of its omission in the case of Mark-B11 fuel does not constitute a general approval of its removal from the parameters to be considered in this methodology.
- The applicability of a particular CHF correlation to mixed core geometries is an issue that must be examined for each transition to new fuel, to determine if the mixed core non-uniformities take the local hot channel conditions outside the range of applicability of the CHF correlation.

The methodology requires that the approved CHF correlation for a given fuel design must be used in the SCD analysis for the Oconee plant. As of this writing, the proposed CHF correlation for Mark B-11 fuel (the BWU-Z correlation, submitted as Appendix E in Addendum 1 of BAW-10199P) is under review and has not yet been approved by the NRC. Any changes to the CHF correlation or restrictions in its application as a result of the NRC review must be evaluated for effects on the application of the correlation to Mark-B11 fuel. If the CHF correlation range of applicability is changed, the SCD analysis must be revised in accordance with the modification, and the correlation must not be used outside the parameter range specified in the safety evaluation report (SER) for application to Mark-B11 fuel.