UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO REVISION OF PIDAL IN-CORE MONITORING CODE

CONSUMERS POWER COMPANY

PALISADES PLANT

DOCKET NO. 50-255

1.0 INTRODUCTION

By letters dated August 6 and October 9, 1996 (Refs. 1 and 2), Consumers Power Company (CPCo) submitted a revision to the Palisades Incore Detection Algorithm (PIDAL) for NRC staff review and approval. CPCo proposed to replace PDQ/XTG with SIMULATE-3, an advanced three-dimensional reactor analysis code. These codes provide input to the PIDAL code regarding determination of theoretical assembly powers, detector conversion constants, and local peaking factors.

2.0 BACKGROUND

PIDAL is capable of determining reactor core power distribution, peaking factors, and local linear heat generation rates (LHGR) on a full core basis. The results of the PIDAL calculations are used to monitor compliance with Technical Specification (TS) requirements related to incore detector operability, excore detector system calibration, and monitoring of power distribution limits.

With the exception of code modifications to accommodate installation of a new Palisades plant computer in 1995, PIDAL-3 is the first revision to the PIDAL code since it was approved by the NRC on April 3, 1992 (Ref. 3). XTG was completely removed from the PIDAL-3 code. PIDAL-3 now uses nodal powers calculated by SIMULATE-3. In PIDAL-3 full core non-depleting rhodium reaction rates are provided by SIMULATE-3 prior to every PIDAL-3 run. Depletion effects are accounted for by a multiplication factor from a polynomial fit describing an exposure dependent self-shielding factor. Previous versions of PIDAL utilized PDQ based local peaking factors or pin to box factors. PIDAL-3 utilizes SIMULATE-3 full core local peaking factors calculated prior to every PIDAL-3 run. PIDAL-3 radial coupling is exclusively full core as opposed to the XTG quarter core coupling which is expanded to full core in PIDAL-2. The SIMULATE-3 full core nodal powers, rhodium reaction rates, and local peaking factors allow PIDAL-3 to effectively measure large quadrant power tilts.

CASMO-3 is a lattice physics code used to determine neutronics input to SIMULATE-3 for pressurized water reactor core performance analyses. CASMO-3 uses a cross section library based on standard ENDF/B-IV cross sections to

ENCLOSURE

determine broad group input for SIMULATE-3. The SIMULATE-3 code is based on a modified coarse mesh (nodal) diffusion theory calculation with coupled thermal hydraulic and doppler feedback. The code solves the two group diffusion equation with fuel assembly homogenization and baffle/reflector modeling. The code also performs core burnup depletion and performs a pin power distribution reconstruction. The two group model solves the neutron diffusion equation in three dimensions and the assembly homogenization employs the flux discontinuity correction factors from CASMO-3 to combine nodal flux shape and the heterogeneous flux distribution. This concept is also applied to the baffle reflector region in both the axial and radial directions to eliminate the need for user supplied albedos or other adjustments at the core reflector interface.

SIMULATE-3 can be used to calculate the three dimensional pin-by-pin power distribution in a manner that accounts for the individual pin burnup and spectral effects. SIMULATE-3 also calculates control rod worth, moderator, Doppler and xenon feedback effects.

3.0 EVALUATION

CPCo performed extensive benchmarking using the CASMO-3/SIMULATE-3 methodology with PIDAL. This effort consisted of detailed comparisons of the calculated results of PIDAL-2 and PIDAL-3 for cycles 9 through 11 for the Palisades plant. An analysis of the uncertainty in the PIDAL-3 peaking factor calculations is also performed for these reference cycles. The derived uncertainties are compared to those currently approved in the Palisades power distribution limits TS. Overall, the changes made to the PIDAL-3 code produced some differences in the output compared to the PIDAL-2 code. This is expected since the fundamental methods used in calculating the coupling coefficients (full core vs. 1/4 core), rhodium reaction rates, and local peaking factors have been changed. Theoretically, the data produced by SIMULATE-3 should have lower uncertainties than PDQ/XTG since SIMULATE-3 is an advanced diffusion theory code utilized on a full core basis.

The uncertainties as calculated by CPCo for PIDAL-3 indicate SIMULATE-3 to have lower uncertainties than PDQ/XTG. The SIMULATE-3 model reduced the overall uncertainties, the mean shifted closer to zero and the degrees of freedom were reduced in the statistical analysis. While incorporation of SIMULATE-3 methods into PIDAL-3 will reduce measurement uncertainties, CPCo has chosen to simply show that the PIDAL-3 uncertainties are bounded by the uncertainties currently stated in the Palisades power distribution limits TS. This is a conservative approach which allows use of PIDAL-3 without revising the Palisades TS.

The factors discussed above demonstrate the ability of CPCo to apply the CASMO-3/SIMULATE-3 computer program package to PIDAL at Palisades. In addition, the staff has previously approved the use of the CASMO-3/SIMULATE-3 code package for a number of utilities to perform in house steady-state physics analyses for similar reactors (e.g., Ref. 4).

4.0 CONCLUSION

Based on the results presented in References 1 and 2 and on the fact that both CASMO-3/SIMULATE-3 and PIDAL-2 have previously been approved by the staff, the staff concludes that the CASMO-3/SIMULATE-3 methodology can be applied to the PIDAL-3 calculations for Palisades core monitoring applications. The accuracy of this methodology has been demonstrated to be sufficient for use in monitoring compliance with TS requirements related to incore detector operability, excore detector system calibration, and monitoring of power distribution limits. Since the licensee has shown that the previously approved uncertainties on power distribution limits stated in the TS bound the uncertainties of the PIDAL-3 calculations, no changes to the Palisades TS are required at this time.

5.0 REFERENCES

1. Letter from T. C. Bordine (CPCo) to Document Control Desk (USNRC) "Request for Approval of Incore Monitoring Code (PIDAL)," dated August 6, 1996.

2. Letter from T. C. Bordine (CPCo) to Document Control Desk (USNRC) "Request for Approval of Incore Monitoring Code (PIDAL) - Request for Additional Information," dated October 9, 1996.

3. NRC Docket Number 50-255, "Palisades Plant - Amendment No. 144 to Facility Operating License No. DPR-20," April 3, 1992.

4. Letter from Steven Bloom (NRC) to T. L. Patterson (Omaha Public Power District), "Use of CASMO-3/Simulate-3 - Fort Calhoun Station, Unit 1," Docket No. 50-285, dated December 16, 1994.

Principal Contributor: G. Schwenk

Date: May 6, 1997