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Enclosure 1

COOPER NUCLEAR STATION

NON-PROPRIETARY REPORT

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"Decay Heat Evaluation for CNS"

GE Nuclear Energy

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Decay Heat Evaluation

for

Cooper Nuclear Station

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1. Introduction

A new evaluation of the relative decay power has been made for Cooper Nuclear Station based upon the ANSI/ANS-5.1-1979 Decay Heat Standard (reference 1). Since the previous evaluation of decay heat (revision 0 of this document), the methodology has been improved. The purpose of the improvement was to include two new small terms to account for miscellaneous actinides and activation products consistent with the recommendations of SIL 636 (Reference 8). The ANSI/ANS-5.1-1979 standard explicitly accounts for the two most prominent actinides, U239 and Np239, but requires the User to evaluate and include the effects of all other actinides as well as the effects of miscellaneous structural activation products. Individually these actinides are negligible, but many together can add up to a non-negligible amount of decay heat. Likewise, there are a number of structural (Zirconium) and fuel isotopes (including Gadolinium) which together are non-negligible.

* Proprietary information to the General Electric Company has been deleted.

In section 2 of this document, the fuel cycle parameters and assumptions which provide a basis for the decay power evaluation are provided. Based on these inputs, the fuel dependent parameters utilized by the standard are identified and listed in section 3. Section 4 contains a description of the model used in evaluating the neutron capture effect and a discussion of the methods used to qualify and verify the model. In section 5, the calculation of the relative decay power is described and the results tabulated. Additional sources of heat after shutdown, namely fuel relaxation energy and metal-water reaction are not considered in this document (although they were evaluated in revision 0 of this report). Appropriate values consistent with this document may be found in Reference 9. It is understood that these additional sources of heat after shutdown are to be included by the User, as appropriate. Finally, in section 6, the conclusions are presented.

NRC Information Notice IN96-39 (reference 7), concerning the wide variation in decay heat estimates throughout the industry, was considered in the preparation of this report. It is believed that the wide variation which was observed was due either to misapplication of the ANS standard or to extremely conservative interpretation. To avoid the former situation, the methods and procedures used herein, have been carefully design reviewed and the calculations verified. The later situation has been avoided by very careful application of the standard to Cooper Nuclear Station, while still retaining an appropriate degree of conservatism.

2. Fuel Cycle Input Parameters and Assumptions

The decay heat table was based on the following fuel cycle assumptions, which were derived from the material in reference 2:

The decay heat table is also applicable to other fuel product lines, since decay heat evaluations are not very sensitive to the specific fuel type involved. However, this information is required in order to determine the input parameters to the decay heat standard.

As a guide to understanding the impact of these parameters, it should be noted that increasing the average exposure will increase decay heat, although at a slow rate (less than 1% increased heat for every 10,000 MWd/T of additional exposure). Likewise, an increase in the core average time at power (irradiation time) also results in an increase in decay heat. For irradiation periods greater than 4 years, this increase is very slight (less than 1% for each additional year).

3. Fuel Dependent Parameters

Fissions in materials other than Pu^{239} and U^{238} are included with U^{235} as required by the standard.

4. Evaluation of the Neutron Capture Effect (NCE)

5. Calculation of the Total Decay Heat

The decay heat table based on these inputs and the ANSI/ANS-5.1-1979 decay heat standard is shown in . The first column in the table is the shutdown or cooling time. The second column shows the unadjusted decay heat for the given cooling time and the third column the uncertainty. In the fourth column, the decay heat is shown with two sigma of uncertainty added. The final column is the integral of the decay heat (including the two sigma uncertainty) from time zero up to the cooling time. The trapezoidal rule of integration was used, thus producing a conservative, upper bound on the integral.

6. Conclusions

References

1. "American National Standard for Decay Heat Power in Light Water Reactors", ANSI/ANS-5.1-1979.

2.

3.

4.

5. Croff, A. G., "A User's Manual for the ORIGEN2 Computer Code", ORNL/TM-7175, July 1980.

6. Ludwig, S. B. and Renier, J. P., "Standard and Extended Burnup PWR and BWR Reactor Models for the ORIGEN2 Computer Code", ORNL/TM—11018, December 1989.

7. "Estimates of Decay Heat Using ANS 5.1 Decay Heat Standard May Vary Significantly", NRC Information Notice, IN96-39.

8. GE Nuclear Energy Services Information Letter (SIL) Number 636, Revision 1, June 6, 2001.

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