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COLLEGE OF ENGINEERING
DEPARTMENT OF NUCLEAR ENGINEER

BERKELEY, CALIFORNIA 94720

August 12, 1982

Dr. Milton S. Plesset
(c/o Paul Boehnert)
Advisory Committee on Reactor Safeguards
United States Nuclear Regulatory Commission
Washington, DC 20555

Dear Milt,

A few days ago I received a copy of the enclosed staff memorandum from one of the members of the ANS Decay Heat Standard Working Group. This analysis by the Core Performance Branch of DSI is consistent in many respects with my comments on the June 16, 17 meeting of the ECCS Subcommittee of ACRS. It is unfortunate that the timing of the memo was such that the staff was not prepared to discuss it at the Subcommittee meeting. It would have been very beneficial and helped to develop a technically sound use of the new Standard in the regulatory process.

I certainly hope that the weaknesses in the GE's submittal do not end up causing further major delays in applying the Standard.

Sincerely,

Virgil

Virgil E. Schrock
Professor

Enclosure

VES:mm

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

JUN 16 1982

MEMORANDUM FOR: Brian Sheron, Chief
Reactor Systems Branch
Division of Systems Integration

FROM: Carl Berlinger, Chief
Core Performance Branch
Division of Systems Integration

SUBJECT: REVIEW OF GE DECAY HEAT PROPOSAL

This is a partial response to your memorandum of April 12, 1982 requesting two reviews related to GE LOCA calculations. Enclosed is a review of the GE proposal to use the new ANS-5.1-1979 decay heat information in LOCA calculations as presented in Amendment 3 to GESSAR II. While this review in no way concurs in the proposal to change evaluation models before a rule modification for Appendix K has been accomplished, it does present requirements for such a change based on perceived Appendix K intent, and an evaluation of the GE presentation in that context. It is concluded that, while in many respects the GE presentation is compatible with these requirements, additional information is needed for an application.

Our response on the "GESTR-LOCA - A Model for the Prediction of Fuel Rod Thermal Performance" will be provided by November 1, 1982.

Carl H Berlinger
Carl Berlinger, Chief
Core Performance Branch
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Enclosure:
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A Review of GESSAR II, Appendix 6A
"Improved Decay Heat Correlation for LOCA Analysis"

Introduction

In Amendment 3 to GESSAR II, presenting changes to section 6 and introducing Appendix 6A, and in the accompanying letter, G. Sherwood (GE) to H. Denton (NRR), December 30, 1981, General Electric has presented material relevant to "a proposal for using the ANSI/ANS-5.1-1979 revised decay heat standard for BWR loss-of-coolant accident (LOCA) analyses." This is a review of the material in 6A related to the technical aspects of calculating decay heat for LOCA. The review does not include or imply approval of the material in 6A related to changes to evaluation models, best estimate modes of calculation, exemptions or power density increases. In addition, the decay heat review is restricted to the LOCA range of shutdown times (less than about 10^4-10^5 seconds) discussed in 6A and should not be extrapolated to greater shutdown times where problems are potentially different. The review concentrates on the technical use of the ANS-5.1-1979 standard as a replacement for the 1971 version required by 10 CFR Part 50, Appendix K without regard to the broader issues involved in such a transfer. It might be regarded as a review based on what the decay heat section of Appendix K would have been if the present information on fission product decay heat had existed at the time of the production of Appendix K.

The review contains sections on:

A. Notation
B. Use of ANS-5.1
C. Difference Between (71) and (79)
D. Parameters Needed to Use (79)
E. Acceptable Parameters
F. GE Parameters and Comparison with Acceptable Parameters
G. Summary and Conclusions

A. Notation

Nuclear energy production following initation of a LOCA event and shutdown involves several different mechanisms. The primary categories of these will be denoted in this review as:

FPDH is fission product decay heat.
239DH is decay heat from the actinides U239 and Np239.
NCDH is the heat from the (delayed) decay of neutron capture products other than the 239 actinides.
DF is the heat from the fissioning of delayed neutrons.
DH is the total decay heat, the sum of the above.

In addition, Q (usually from a given isotope, e.g., Q235) will denote total usable energy from a fission and NC will denote the Q component from neutron capture (both prompt and delayed).

The FPDH from the (K. Shure) representation in ANS-5.1 (1971) will be denoted as (71) or as (71)(T,t) to represent explicit dependence on operating time T (at constant power) and shutdown time t. Thus (71)(∞,t) means infinite operating time. Nominal values will be generally assumed with uncertainties noted explicitly. Thus Appendix K, section I.A.4 is given by 1.2 (71)(∞,t). Similarly use of ANS-5.1 (1979) will be denoted as (79) or (79)(T,t) or (79)(T,t)+2σ.

B. Use of ANS-5.1

Appendix K as developed from the 1972-1973 ECCS hearings requires the use of 1.2(71)(∞,t) for FPDH. This was based on a staff review of the (minimal) information that existed at that time, conclusions that the K. Shure correlation best represented that information, that the uncertainties were such that an additional 1.2 factor (augmented by restrictions to infinite operation) was required to assure a reasonable (if never precisely defined) level of confidence that FPDH would not be nonconservatively represented in the evaluatior model, and that the use of ANS-5.1 (latest version 1971) which used the K. Shu model was a convenient reference.

During the five years following the hearings the information on FPDH was greatly improved. References to the work are given in the Foreword of (79). There were a half-dozen or so good experiments (in the LOCA shutdown time frame) and improved summation calculations, synthesis analyses and uncertainty analyses. Cognizant members of the NRC staff participated in these improvements (several experiments and analysis efforts were NRC-sponsored), reviewed results (e.g., via research review groups), were members of or associated with the ANS-5 subcommittee which developed the combined efforts into a standard (1974-1979), and commented on and indicated approval of draft and final versions of the standard, including an approval without further comment of the September 1978 version (same as the 1979 version).

This approval has been a recognition that the models and data presented in (79) provide a best representation of the FPDH and its uncertainty (in the LOCA range) presently available. Its use, where possible, has been recommende by staff members. This approval, along with indications of requirements for its use, has been indicated previously (to GE) in response to a previous GE proposal for use of the new standard in accident analysis. (A copy of this response is provided in this report as Appendix 1.)

The use of (79) in LOCA analyses was not approved, however. This was based on both the letter and intent of Appendix K, section I.A.4 and on a Commission decision to defer any changes in the required models in Appendix K pending assessment of the overall conservatism of the existing rule (see Appendix 1, last paragraph, also Appendix 2).

C. Differences Between 71 and 79

The ANS-5.1 standards deal only with FPDH and 239DH. The (71) version is very simple, and with two exceptions, completely explicit. It assumes all fissions are from U235 with a Q of 200 MeV/F. It allows finite operation time T; howeve

Appendix K modifies this and requires infinite. It provides a simple uncertainty statement (without definition or basis) which is consistent (for t less than 10^3 seconds) with Appendix K requirements of a 1.2 factor. It specifies the decay parameters for 239DH but requires user input for the production rate of 239. The FPDH information is given in tabular form but most LOCA codes use (with permission) an eleven exponential approximation, not in (71).

The (79) version treats 239DH essentially the same and this will not be discussed further. The treatment of FPDH is (potentially) much more complex, however. The differences in information presented are as follows:

1. It provides new best estimate U235 information based on the new experiments, summation calculations and synthesis analyses. It is given in tabular form and also in a twenty-three exponential form.
2. It also provides similar information for U238 and U239.
3. It requires the user to provide values for Q for the three (fissile) isotopes, whereas (71) requires use of 200 MeV/F for Q.
4. It supplies (tabular) values for uncertainties for the three isotopes based on the synthesis analysis used to develop the best estimate values. These are indicated as being one sigma values from a normal distribution. (A 23 exponential version of these uncertainties can be found in LA-8041-MS, Table A-III.)
5. It supplies a formula (requiring user-supplied data) or tabular values for corrections to FPDH for neutron captures in fission products.
6. Similar to (71) it provides for a finite operation time (or complex operation.)

An indication of the quantitative nature of some of the elements of potential changes are given in Figure 1, Page 6:

1a. compares new isotopes best estimates to old U235. There is as much as a 6 percent decrease in U235 in part of the LOCA range, but less or even an increase in other parts. There is a much larger decrease from Pu239, ranging from 10 to 20 percent.

1b. makes the same comparison with a 2σ uncertainty included and comparing these values to 1.2 (71)(∞,t). A large decrease of about 15 to 30 percent is provided by U235 and Pu239.

1c. provides a comparison (of nominal values) with the combined isotopic effects for reactor operation with burnup assuming operation at constant power for the indicated times (1 to 48 months). Isotopic changes with burnup approximately correspond to a BWR-3 fuel assembly. The comparison is for isotopic effects only since the same finite time T is used for both (71) and (79). The indication is that new FPDH data provide decreases of about 5 to 15 percent.

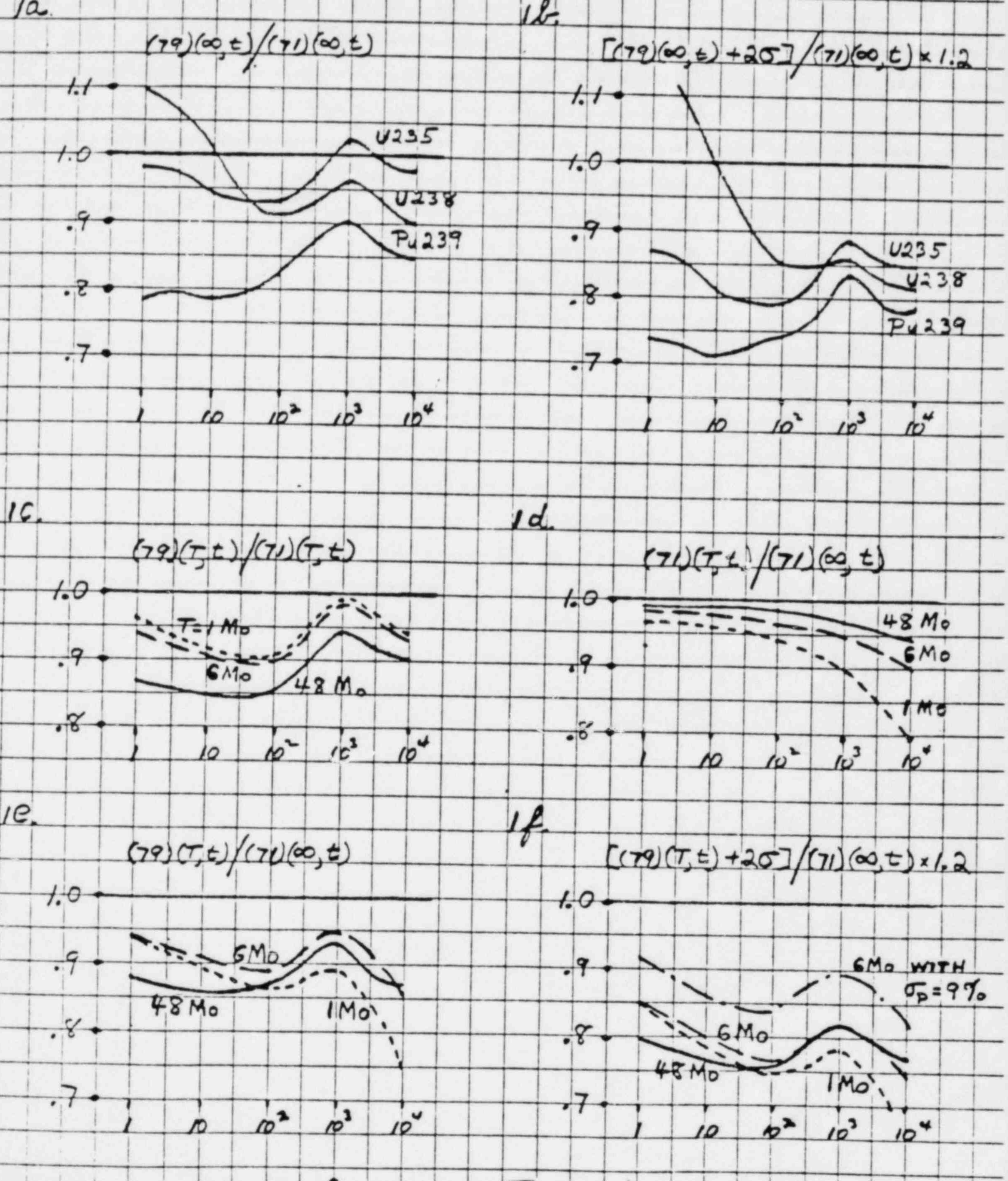
1d. indicates the decreases provided by just the use of finite operating time rather than infinite. The trend is somewhat complementary to that in 1c. The reductions are of the order of 1 to 10 percent.

1e. combines the effects of 1c. and 1d. to give a best estimate comparison between (71) and (79) for a BWR-3 assembly. The result is about a 10 percent decrease. (Also note that larger T values do not always produce larger FPDH.)

1f. makes the comparison using 2σ augmented values for (79) vs. Appendix K. The result is about a 20 to 25 percent decrease in FPDH as a bottom line for the comparison. (The curve with σ_p=9% will be discussed later.)

FIGURE 1

SKETCHES OF RELATIONSHIPS BETWEEN (79) AND (71) FP



C. Parameters Needed to Use (79)

The full application of (79) for FPDH is potentially much more complex than Appendix K which provides no options and a single universal result (for fraction of initial power). Assuming the information in (79) is to be used, including finite operating time, decisions must be made on the modes of use and parameters must be supplied, outside of (79), to implement the determination of FPDH and 239DH, as well as other components of DH. The following areas need to be treated:

1. The power history, either for the whole reactor core or for a local region of the core, to be assumed for the application.
2. The fission fraction for each of the (79) isotopes as a function of the operating time within the power history for the core region of interest. This is reactor, cycle, time in cycle and fuel type dependent. It should be noted that (79) assumes, conservatively, that fissioning isotopes other than 235, 238 and 239 (e.g. Pu 241) are to be represented by U235.
3. Q values for each fissile isotope used. This requires the determination of the basic energy parameters of fission and the determination of the neutron capture contribution, which, too, is usually reactor, cycle, and time in cycle dependent. The latter requires determination of neutron capture probabilities in each reactor constituent as a function of operating history and the resulting energies of decay, both prompt and delayed.
4. The selection of tabular or formula method for the neutron capture correction to FPDH and parameters for the latter.
5. Production rate R of U239 during the last several weeks of assumed power history, which is also reactor, cycle and time dependent.
6. Parameters for components of DH other than those treated by (79). These include source magnitude, decay and energy parameter for NCDH and the results of appropriate reactor kinetics calculations for DF.

7. <u>Uncertainties</u> in each parameter of DH. Assuming that uncertainties are to play a role in the determination of a suitable DH for use in Regulatory LOCA calculations in keeping with the intent of Appendix K, the following areas must be considered:

   a. Elements of DH components to be included. Certain components dominate DH (e.g. FPDH) and primary elements affecting those components require primary attention. Prominent among such elements is power density uncertainty. That and direct FPDH uncertainty as given by (79) tend to dominate any uncertainty analysis, particularly where a combinatorial approach is used. Usually elements such as power history and components such as DF are conservatively developed and require no additional uncertainty factor.
   b. Magnitudes and distributions of the uncertainties. (79) supplies part of this for FPDH. Others must be determined.
   c. Uncertainty levels (e.g. 1σ vs 2σ or 3σ) to be required and combinations to be allowed (e.g. square root of squares vs linear addition of elements). (79) suggests a square root formulation but does not give an uncertainty level. (However, this is a Regulatory determination and properly not part of the standard.)

In all of the above areas one would expect to find simplications as an inevitable part of model and parameter selection with generic broadening of parameters to cover a range of reactor conditions.

E. <u>Acceptable Parameters</u>

Because of the potential complexity in using (79) and the resulting variety of simplifications which are desirable and inevitable, there are many possibilities for model-parameter selection. These can't all be covered in detail here. We will provide, however, some comments on generally acceptable models, sources, and parameters which can be used, recognizing that variants may be considered:

1. Power History
   With the new FPDH information it is reasonable to remove at least some of the requirements for infinite operation which had been used to provide

additional conservatism in Appendix K. (It is also necessary for a basis to use realistic isotopic fission fractions.) There are two levels of relevant finite operation, (1) time frames (order of weeks or months) related to burnup and (2) time frames (order of hours) related to power maneuvering. The former, related to either whole core or local analyses, is relatively easy to define and use. The latter, usually related primarily to local analyses (since peaking factors are usually maximum only as a result of power changes and only for a relatively short time), are much more difficult to define and bound for a Regulatory calculation. They are less related to BWR operation than to PWR and will not be considered further here.

FPDH from finite time operation can generally be conservatively bounded by assuming continuous operation at a limiting power (density) for a time necessary to achieve a given burnup. Other power histories (generally more realistic) involving longer time frames as a result of periods of reduced power will have lower FPDH. If there is a nonconstant limit, e.g., the G.E. MAPLHGR which varies with burnup, this is still true with the variable limit in the calculation. It is also true with the final limit if the limit is monotonically increasing with burnup, but not strictly true if it is decreasing. However, in most cases of interest the limit varies sufficiently moderately and slowly that it is a reasonable approximation (since in the LOCA time range the FPDH is dominated by the last several weeks of operation, e.g., for T=2 years, constant power, and t=100 seconds, 95 percent is from the last week).

Thus, for most applications a power history at a limiting power (core or local) for a relevant time T (usually corresponding to a burnup) is acceptable for FPDH, a steeply decreasing limit might have to be examined more clearly and other power histories would need to be justified on an individual basis. For 239DH, saturation (occurring in about a week) should generally be assumed unless otherwise justified. NCDH may be treated the same as FPDH. It is assumed that the power limits are the licensed and Tech Spec reactor power and appropriate local power densities. The role of uncertainty in these limits will be discussed shortly.

2. Fission Fractions

The fraction of fissions from the three isotopes of (79) for the relevant power history may be calculated with standard core and lattice physics methods. Since the fraction for U238 does not vary significantly and all fissions not U238 and Pu239 are assumed to be U235, the only significant variable is the U239 fission rate. The sensitivity of the result is generally not large since a change from U235 to Pu239 is a reduction of about ten percent (Figure 1a or 1b), and thus, a change of ten percent in fission fraction assignment is only a one percent change in FPDH. Thus there is little strain on the capabilities of the physics codes and variations due to core and lattice parameters (e.g., enrichment, void content) can be easily (generically) bounded. Furthermore, although the complete history of the fission fractions should theoretically be followed, since the (LOCA) FPDH is dominated by the last weeks of operation, the isotope inventory of that time frame alone can generally be used and frequently considered constant. For core average calculations, core average burnup, T and fission fractions can be used with no significant deviation from region sums (e.g., see results in LA-8041-MS, table VI).

The above approximations are generally acceptable but submittals should discuss the approximations and characteristics used and the bounding of parameters.

3. Q

The determination of Q for each isotope (and effective averages via the fission fractions) requires an accurate source for the nuclear energetics parameters of the fission process and a calculation of the neutron capture component contribution. The staff has previously used the information in ANL-7748 for the fission parameters, but presently the most up-to-date synthesis of the fission energetics is given in the EPRI report NP-1771. Its results have been included in the ENDF/B-V data library. The fission energies from initial and chain yield mass-balance minus neutrino energies have been determined to within 0.1 percent.

The neutron capture contribution is reactor parameter dependent and must be calculated from the probabilities for and energetics of capture in reactor materials. We have estimated this for typical reactor states. For a BWR, without much variation over cycle life, the results, along with fission energy, are:

$Q235 = 193.8 + {\sim}8 \simeq 202$ MeV/F

$Q238 = 195.0 + {\sim}11 \simeq 206$ MeV/F

$Q239 = 199.9 + {\sim}11 \simeq 211$ MeV/F

This may be up to one percent less for reactors (particularly PWRs at BOC) with a larger fraction of captures in boron (because of the relatively low capture energy).

The above values are considered acceptable (reduced by one percent for PWRs at BOC).

4. Neutron Capture Correction to FPDH

The formula given in (79) for the neutron capture effect will generally be used since it gives values smaller than those from the table. It is a function of t, T, burnup and enrichment. It is a one percent or smaller correction for most frequently encountered values of these parameters. It can be easily generically bounded by chosing a suitably small value of enrichment, and could be further bounded for some applications by a maximum choice for other parameters.

5. 239DH Production Rate,R

R is determined from the same physics lattice calculations used to determine fission fractions. The 239DH contribution to DH is about 5 to 15 percent of FPDH in the LOCA range, increasing with t and burnup, the latter from increased relative production rate. The calculation of R is straightforward and DH is not very sensitive to variations. However, since R may vary from about 0.5 to 0.9 per fission, a simple bounding value would not generally be used, but a bounding value as a function of burnup would be expected.

6. NCDH and DF

The NCDH contribution is primarily from actinides other than 239 and from structural elements. Both are generally expected to be minor contributors in the LOCA range. They require a determination of materials in structures and corresponding capture rates and build-up of actinides and a determination of decay parameters. The methods are straightforward. The results are reactor and burnup dependent but are easily generically bounded, frequently at zero.

The DF contribution is determined from standard core kinetics calculations, frequently generically, with bounding parameters for voiding and scram. It contributes over ten percent to DH for up to the first ten seconds after shutdown (for the big break), and over one percent for as much as 100 seconds.

7. Uncertainties

The subject of uncertainty requirements to be used with the transfer to (79) is, at present, the most difficult part of the review. With Appendix K in its present form the uncertainty requirement is explicit and simple. With (79) it is more complex and the switch to new information requires a reexamination of the subject and decisions have to be made on the form and content of FPDH uncertainty.

The available guidance is limited. The study of LOCA calculations and their uncertainty, leading to a rule-making process to change aspects of Appendix K, which has been indicated as Commission policy (see Appendix 1, last paragraph, and Appendix 2), is as yet not completed. That study and rule is a necessary (although possibly not sufficient) requirement for a definitive statement on the uncertainty to be provided.

Lacking that, one must use the insight that went into the development of Appendix K, along with uncertainty reviews that have arisen periodically since then. The latter have included:

(1) the review of the Westinghouse "maxiconvolution" proposal (statistically combining power density and FPDH uncertainties) which was accepted as a concept but rejected at the time, as in Appendix 1, because of the Commission decision on no changes until rule-making is complete (see Appendix 2, letter, R. Mattson to T. Anderson), and

(2) the studies on combination of uncertainties, including power density, particularly for BWRs, partially at the request of the ACRS ..."to judiciously and explicitly include power distribution uncertainties in ECCS evaluation models". (see Appendix 3, memo, F. Schroeder to E. Case). This study and ACRS request was a response to the concern that developed after the ECCS hearings when it was (belatedly) recognized that the requirement to use Tech Spec limits for power density did not include a power density uncertainty requirement for BWRs (unlike PWRs).

It would be impossible to go into detail on these insights, so only the following summary of conclusions is given. It is concluded that it was the intent to:

(1) provide for an uncertainty increment for any significant element contributing to the determination of LOCA DH. The primary elements contributing, (then and now) are FPDH and power density, and

(2) this uncertainty was to provide assurance that the DH used in analyses was not unconservative, but it was not to provide explicit additional margins for other parts of the calculations, and

(3) while the level of assurance was never explicitly defined, the general concept was primarily related to about a 95/95 probability/confidence level, and

(4) this level should apply to the overall value of DH (exempting simplifying boundary determinations) so that statistical combining of uncertainties should apply.

This leads to the following conclusions on acceptable elements, magnitudes, levels and combinations.

(1) Elements: FPDH uncertainties and power level (for whole core calculators) or power density uncertainties should be included. FPDH power histories and fission fractions and DF should generally be provided via bounding states (but this is not an absolute requirement) with no uncertainty contribution (or credit). Uncertainties for Q, R and NCDH should be considered, although with combination, their contribution is generally minor.

(2) Magnitudes: The FPDH uncertainties as given in (79) should be used, and these range from about four to eight percent of FPDH at a 2 σ level at expected fission fractions in the LOCA range. The uncertainties for Q and R and NCDH should be developed, but each appear to be about one percent or less of FPDH. The reactor power level uncertainty should continue to be two percent as in Appendix K. The local power density uncertainty should be that commonly used at present for PWR LOCA analyses, while for BWRs the uncertainty for MAPLHGR needs to be developed. At present, it would appear to be similar to the TIP uncertainty used in MCPR limit analysis and thus, for reload cores, about nine percent for 1σ and thus eighteen percent at 2σ (required since a confidence level has not been developed, see 3).

(3) Level: The intent should be 95/95, but where the confidence level of the uncertainty is not explicitly justified a 2σ level should be assumed. This includes the FPDH uncertainties of (79) which are based on a small number of experiments and for which a confidence level was not developed, and the MAPLHGR uncertainty.

(4) Combination: The uncertainties may be combined in a square root of sum of squares representing a statistical combination of independent uncertainties.

Note that figure 1f includes a (six month) curve with a σ_p=9% (2σ=18%) power density uncertainty (σ_p) statistically combined with FPDH uncertainty. The reduction gained by use of (79) is reduced significantly.

Inv of
loca + fuel
uncertainties.

F. GE Parameters and Comparisons With Section E

GE, in Appendix 6A, has not presented either an explicit generic DH (or even FPDH) set of values or set out a specific, detailed path to produce a generic or reactor specific set of values. Rather they have presented a discussion of elements of the subject with examples, indicating generic values may be possible and that details "must be addressed on a plant-specific basis." Thus it is not possible to make a complete point-by-point comparison with each of the previously indicated acceptable parameters and models, and thus a complete review of the subject. We will, however, review the GE discussions and examples to the extent possible and indicate where information or specificity is lacking.

1. GE does not give an explicit statement as to power histories to be used for specific LOCA applications, but does indicate likely compatibility with acceptable histories from Section E. They do give results, in an example, for various values of T (burnup) and t, but primarily to show the relatively small variation of FPDH in the LOCA t range as a function of T and thus the lack of sensitivity to burnup (as is also indicated in Figure 1e and 1f). They also present examples of varying power level histories to show lack of sensitivity to power history. However, a specific commitment to a generic set of values, or to a history to be used has not been made. Any application of (79) would have to provide such a commitment, which is compatible with Section E.

2. GE does not discuss nor give examples of fission fractions used in their analyses, including the frequency of change of fission fractions with burnup. They do present results to show the insensitivity of values to the parameters of void fraction and enrichment, which would affect fission fractions. A previous (1978) GE topical report on the subject of FPDH (NEDO-20566-6) provided examples of fission fractions which could be used in an analysis, but there is no indication of its application in 6A. A specific application should discuss the fission fraction parameters and approximations used and the basis for their use. Because of the lack of sensitivity to many details generic values could be generated, but it would be necessary to provide a discussion of the parameter selection process.

3. The information given in 6A on Q values is not quite complete. Values are given for the fission energies of each isotope and these are compatible with those of Section E. (They are slightly smaller and thus conservative). No explicit NC components are given, however. There are values for NC given in NEDU-20566-6 (which is not referenced in 6A), and those are similar to or conservative compared to Section E values. There are example values given in 6A for lattice average Q values which are a function of fission fraction as well as NC. Those values are in reasonable agreement with staff estimates. Thus, overall, the GE determination of Q values appears acceptable, but a more explicit display of NC values should be provided.

4. The values for the neutron capture correction to FPDH presented by GE as an example are acceptable. There is no specific statement, however, on the use of a single generic value or assembly specific values. An indication of parameters used would be needed in a specific application.

5. GE provides no information on R values used in 6A, although indicating that they are a function of burnup. Suitable descriptions of R values and usage were given in NEDO-20566-6 but that is not referenced in 6A. Such a discussion or reference should be provided in an application. GE does use a saturated initial condition for the 239DH calculation.

6. GE does provide some discussion of an NCDH investigation in 6A, with sufficient indication of results to conclude that these contributions are minor and have been acceptably determined.
For DF in 6A, GE references the description of the kinetics calculations in the ECCS topical report NEDE-20566-P and provides a table of DF values for a generic bounding case. The kinetics calculation is standard and acceptable. However, the results given appear to be incompatible with the reactivity functions implied in the topical report, Figure I.A.2-6, beyond 5 seconds. The given DF values imply a reactivity insertion, particularly after 10 seconds, of greater than -100 dollars, well beyond the approximate -40 dollars of the topical report. The indicated difference can result in DF differences equivalent to one to ten percent of FPDH for t from 10 to 100 seconds. An explanation is required.

7. A primary difference between the GE presentation and Section E is in the area of uncertainty. 6A states that it is GE's intent..."to use a nominal evaluation of the decay heat source". In light of the evaluation in Section E, this is unacceptable.

GE does present some information on uncertainties for FPDH, Q, R and NCDH and indicates that a square root combination would be used if any application calls for including the uncertainty. There is no mention of the primary component of the DH uncertainty, however, the local power density. To be compatible with Section E, information would have to be presented providing and justifying a value for this uncertainty, along the lines indicated in Section E, and it would have to be included in the total DH values.

G. Summary and Conclusions

GE has presented a proposal to change aspects of the decay heat determinations for LOCA calculations, using the new ANS-5.1-1979 standard. This review, which in no way concurs with the general concept of the proposal to change evaluation models before a rule modification for Appendix K has been accomplished, nevertheless, has presented requirements for such a change based on perceived Appendix K intent, and an evaluation of the GE presentation in that context.

A change from an (existing) Appendix K requirement for DH, in an application or in a Regulatory environment where it is acceptable to consider such a change, and the implied concomitant change in associated elements, generally involves a large increase in complexity. This increase is in both developing and reviewing the models and parameters required to implement the change. This review has explored some of these complexities and has indicated features and values which could provide acceptable parameters. GE has, in Appendix 6A, presented discussions and examples which are, for the most part, generally compatible with these features and values, but which are frequently less specific and detailed than would be needed to approve an application of the information, either generally or on a case-by-case basis. The needed information, some of which is in the (unreferenced) GE report NEDO-20566-6, has been described in Section F.

Apparently the most significant area of disagreement and required modification and information is uncertainty. GE pays minimum attention to the subject and in fact indicates that best estimate values will be used in analyses. While such an approach may possibly be deemed acceptable following a future rule-making process, it is not at all presently compatible with the intent of Appendix K. Thus it is necessary, at present, for GE to present information on the complete uncertainty picture, including power density uncertainty, along the lines given in Section E, and to use approved uncertainty factors in any required LOCA analyses.

References

1. Proposed ANS Standard, "Decay Energy Release Rates Following Shutdown of Uranium-Fueled Thermal Reactors", approved by Subcommittee ANS-5, October 1971.

2. Proposed ANS Standard 5.1, "Decay Heat Power in Light Water Reactors", April 1979 Revision.

3. LA-8041-MS, "TMI-2 Decay Power", T. R. England and W. B. Wilson, October 1979, LASL.

4. NP-1771, Final Report, March 1981, "Fission Energy Release for 16 Fissioning Nuclides", R. Sher and C. Beck, Stanford University for EPRI.

5. NEDO-20566-6, June 1978, "Decay Power and Gamma Transport Models in ECCS Calculations".

6. NEDE-20566-P, March 1975, G.E. Analytical Model for LOCA Analysis.