EVALUATION OF POSSIBLE REVISIONS TO REQUIRED FEATURES OF 10 CFR 50 APPENDIX K

G. Norman Lauben
Safety Margins and Systems Analysis Branch
Division of Systems Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research

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BACKGROUND

1. RES proposed to develop a set of sensitivity studies to determine how much of the conservatism in Appendix K was tied up in the decay heat requirement. It was expected to be design specific and dependent on the specific licensee or applicant's current approved ECCS model. Another important reason for these studies was to assure that there were no surprising interactions with other features contained in various approved Appendix K models.

2. NRR requested RES to also evaluate more realistic decay heat models.

3. RES stated that it would make maximum use of existing studies. Where needed RES performed additional sensitivities.

4. 10 CFR 50.46 allows two options for calculating ECCS performance using either:

   (1) A model in conformance with the required and acceptable features of Appendix K (1974 ECCS rule), or:

   (2) A realistic model with evaluation of modeling and input uncertainties so that there is a high level of probability that the ECCS criteria would not be exceeded (1989 ECCS rule change). It should be noted that by electing to use the realistic option, an applicant/ licensee/ vendor can choose any defensible realistic models, evaluate and combine uncertainties and obtain the maximum benefit.

   (3) A third option (described in SECY-83-472) is available which allows reduction in non-Appendix K specified conservatisms as long as a "best estimate" analysis is also provided to justify the proposed reduction. GE and W took advantage of this option for several plants.

RES EVALUATION PROCESS

- RES evaluated the effect of allowing more realistic models for decay heat and metal water reaction in Appendix K analyses. In particular:

  1. Would the model changes result in any significant risk changes?

  2. What is the reduction in <u>conservatism</u> associated with separate or combined model changes?

  3. What is the retained conservatism as a result of the changes?

  4. Are there any surprising interactions with other features contained in ECCS evaluation models?

- Any modification to Appendix K should use simple decay heat and/or metal water reaction models with an appropriate uncertainty for each model.

- RES has chosen to evaluate the 1979 ANS decay heat standard and the Cathcart-Pawel metal water reaction model, since they are referenced as acceptable models in Reg. Guide 1.157 (Best Estimate Calculations of ECCS Performance,1989).

- Other decay heat and metal water models would be possible candidates, but they are similar in magnitude to the selected models.

REDUCTION IN CONSERVATISM AND RETAINED CONSERVATISM

- To evaluate the reduction in conservatism and the retained conservatism of using more realistic models for a sufficient sampling of plant types the information should include:

  1. A current Appendix K calculation,

  2. One or more Appendix K calculations using the more realistic decay heat and/or metal water models. For NRC and contractor analyses, those models include appropriate uncertainties, and

  3. A best estimate calculation that meets the requirements for the realistic option of 50.46.

- The difference in results between 1 and 2 is a measure of reduction in conservatism achieved by using less conservative models.

- The difference in results between 2 and 3 is a measure of retained conservatism.

- Some additional analyses will also be performed to estimate the increase in thermal power available by utilizing more realistic decay heat and metal water reaction models.

- RES solicited information from industry to facilitate this effort.

SUMMARY OF RESULTS

1. The average benefit in 5 "Appendix K" large break comparison studies of using a best estimate decay heat model compared to ANS71 X 1.2 was about 358F. The numbers ranged from 168F to 462F and depends on the time of PCT. In 2 "best estimate" permutations with early PCT the benefits were 41F and 48F.

2. The average decay heat benefit in 5 small break studies was 432F with numbers ranging from 248F to 712F.

3. The average benefit in 4 large break studies of using Cathcart-Pawel vs. Baker-Just metal-water reaction model was 59F with numbers ranging from 45F to 73F. The effect is extremely temperature dependent.

4. If a decay heat credit is already taken, one large break calculation showed a metal water reaction model benefit of only 2F because the temperature was already low.

5. Little margin exists between Appendix K calculations and approved BE analyses for two W PWRs (~220F). Since the average Appendix K large break decay heat benefit was 358F, the margin could disappear, if this benefit were allowed.

6. The margin appears to be larger for BWRs, but NRR has applied a 600F PCT penalty to the GE 83-472 model (SAFER/GESTR).

IMPLEMENTING THE 1979 ANS DECAY HEAT STANDARD

- The 1979 standard is more accurate but more complex than the 1973 standard.
- The two standards can be represented by the following equation:

$$P = \frac{P_t}{Q}\left[M \times G(t,T,\Psi) \times \Sigma F_i(t,T) + F_{HE}(t,T,R) \right]$$

Where:

P	=	total decay power	(Megawatts)
P_t	=	maximum reactor power during operation	(Megawatts)
Q	=	recoverable energy per fission	(Mev/fission)
M	=	uncertainty multiplier	
G	=	neutron capture factor	
t	=	shutdown time	(Seconds)
T	=	operating time	(Seconds)
Ψ	=	fissions per initial fissile atom	
F_i	=	decay power per fissionable nuclide	(Mev/fission)
F_{HE}	=	decay power for actinides	(Mev/fission)
R	=	atoms of U239 produced per fission	

IMPLEMENTING THE 1979 ANS DECAY HEAT STANDARD (CONTINUED)

- Following are values used for the current Appendix K or suggested for the revised version

Parameter	73 standard	Appendix K	79 standard	Suggested Appendix K
P_t	total	total	segmented	maximum (example 3)
Q	200	200	user justified	200 (example 3)
M	1.2 (table 1)	1.2 (table 1)	Eq. 12 & 13	1.1 (example3)
G	N/A	1.0	Eq. 11	Eq. 11
T	∞	∞	user justified	4 years (example 3)
Ψ	N/A	N/A	user justified	1.0 (example 3)
F_I	F_{235}	F_{235}	1,2 or 3 isotopes	F_{235} (example 3, table 7)
F_{HE}	Eq. 3,4	Eq. 3,4	Eq. 14,15,16	Eq. 14,15,16
R	user	?	User justified	1.0 (RELAP5 default)

- All material and suggested values (except R) are referenced in the two consensus standards.
- Spatial and temporal core segmentation is discussed and allowed in the 79 standard based on reload patterns and power history, but adds complexity to calculation.
- IN 96-39 recognized complexity and variations in implementation and sometimes significant variation in results.
- It is suggested that burnup be limited to 80 Gwt/Mtu on the peak rod.

PRELIMINARY SUGGESTIONS AND OBSERVATIONS

1. Other proposals described in this workshop for risk-informing 50.46 are closely related to removing conservatisms in Appendix K. The results of this study should be factored into the overall process of risk-informing Part 50.

2. Potential replacements for the Baker-Just metal-water reaction model will have only a small effect (about 15% as much as the decay heat benefit). Substantial modification as a result of the high burn-up review are also likely. A change might also require a change in the 17% metal-water limit.

3. A methodology should be considered that addresses known non-conservatisms in Appendix K models and provides for assessment of the remaining overall conservatism after Appendix K model changes are made.

4. Piecemeal modification to Appendix K was rejected in 1986-7 and does not encourage the development and use of best estimate analysis methods, which, in the long run, are much more consistent with the philosophy of risk-informed realistic regulation.

5. The suggested modification to the decay heat standard attempts to maintain a similar philosophy of safety and conservatism that was thought to exist in the original Appendix K while allowing for improvement in the state-of-the-art.

6. Feedback would be helpful regarding all suggestions especially items 2 and 3 on this slide and all of the parameter selections on the decay heat implementation slide.