Decay Heat Changes to 50.46 and Appendix K

Meeting with Stakeholders Regarding
Potential Changes to 50.46 Criteria
and
Evaluation Model Requirements

June 28, 2002

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THE 1994 ANS DECAY HEAT STANDARD

- The decay heat requirements in Appendix K and the best estimate guidance in Regulatory Guide 1.157 could be replaced with requirements and guidance based on the 1994 ANS decay heat standard.

- The Appendix K option in 50.46 currently requires fission product decay heat be modeled using the draft 1971 ANS standard with a multiplier of 1.2 and the assumption of infinite irradiation. A separate paragraph in Appendix K requires consideration of Actinide decay heat.

  - An alternative would permit the use of the 1994 ANS decay heat standard, which involves more sophisticated uncertainty methods and a greater number of options left to the user.

  - The 1994 ANS standard considers more recent available data and methods.

  - Model options in the 1994 standard have been identified and studied.

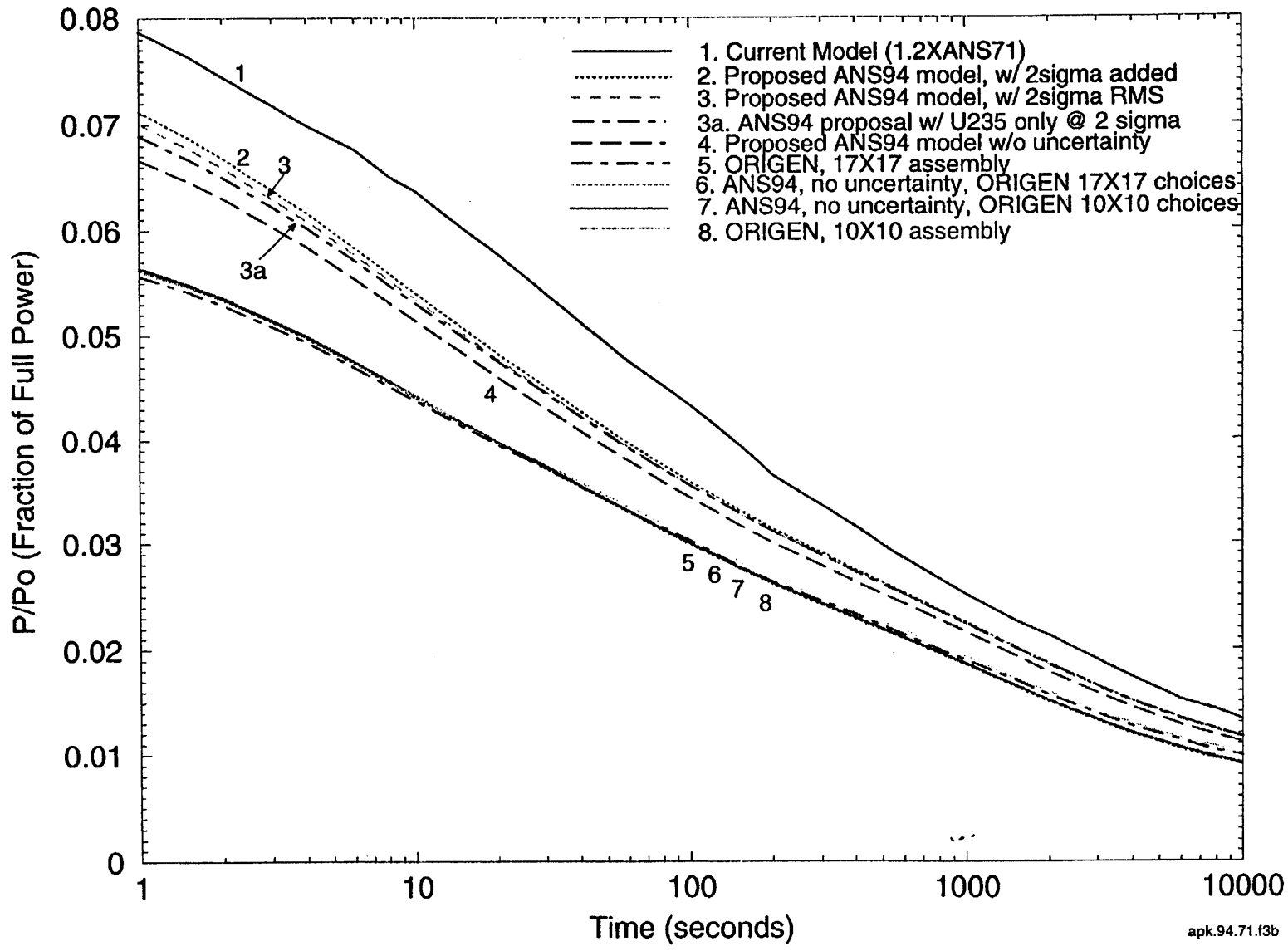
- The performance based realistic evaluation model option in 50.46 would allow use of the 1994 standard today. Specification of the 1994 standard as an acceptable method in Regulatory Guide 1.157 would facilitate its use.

ASSUMPTIONS FOR NINE DIFFERENT DECAY HEAT CALCULATIONS

Case No.	Model	Multi-plier	Oper-ating Time	Fiss. Frac-tions	Capture Time (Sec.)	Ψ	Fission Energy MeV/f.	Acti-nide Yield	Iso-tope Tables	Isotopic Uncer-tainties
				Current Appendix K						
1	ANS73	1.2	∞	100% ^{235}U	N/A	N/A	N/A	0.7	N/A	N/A
				Appendix K Proposals						
2	ANS94	2σ,add	∞	Note 3	2.e8	1.0	200	0.7	Note 7	Note 8
3	ANS94	2σ,RMS	∞	Note 3	2.e8	1.0	200	0.7	Note 7	Note 8
3a	ANS94	2σ	∞	100% ^{235}U	2.e8	1.0	200	0.7	Note 7	Note 9
4	ANS94	mean	∞	Note 3	2.e8	1.0	200	0.7	Note 7	N/A
				Best Estimate						
5	ORIGEN[1]	mean	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	N/A
6	ANS94	mean	ORIGEN[5]	Note 4	1.2e8[5]	1.0	ORIGEN[5]	.514[5]	Note 7	N/A
7	ANS94	mean	ORIGEN[6]	Note 4	1.2e8[6]	1.0	ORIGEN[6]	.508[6]	Note 7	N/A
8	ORIGEN[2]	mean	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	Calc.	N/A

Note 1 17X17 PWR assembly
Note 2 10X10 BWR assembly
Note 3 Assumes fissioning fractions are 90% ^{235}U and 10% ^{238}U
Note 4 Cycle average values from ORIGEN calculations for four isotopes
Note 5 From 17X17 PWR ORIGEN calculation
Note 6 From 10X10 BWR ORIGEN calculation
Note 7 23 decay group exponential fits for F(t,∞) in ANS94 standard
Note 8 Used curve fits from Figures 1 and 2
Note 9 Used curve fit from Figure 1

Appendix K Decay Heat Comparison



ANS94 DECAY HEAT FEATURES & COMPARISONS

1. Standard fission product decay heat tables and individual uncertainties are OK-

   A. Requires lattice physics calculation to determine time and space dependent fissioning istopic fractions. *ORIGEN values vs. 100% $^{235}U \cong 6\%$ effect*

   B. Operating time *ORIGEN 3 cycle assumption vs. $\infty \cong 2\%$ effect*

2. Recoverable fission energy, Q_i *ORIGEN values vs. 200 MeV/fission $\cong$ 4% effect*
   (ANS94 future recommendation - Specify Q_i)

3. Uncertainty *ORIGEN (none) vs. 2σ for 100% $^{235}U \cong 4\%$ effect*

4. Fission product neutron capture - Standard uses 25 year old "correlation". May be non-conservative between 4000 and 10,000 seconds. Becomes conservative using tabular "G" values after that. (ANS94 future recommendation - Improve Specification)

5. Actinides -

   A. ^{239}U & ^{239}Np decay - ^{239}U production/fission
   ORIGEN value vs. 0.7 $\cong$ 3% effect

   B. Actinides that are not explicitly considered in ANS standard
   ORIGEN calculation vs. no consideration

Shutdown time(sec)	*220*	*1800*	*6000*
Effect	*-2%*	*-3%*	*-4%*

   (ANS94 future recommendation - Include other actinides)

6. Increment from NRC Appendix K ANS94 recommendations to 1.2XANS71 $\cong$ 10-20%

SUGGESTIONS/RECOMMENDATIONS

- "Grandfather" the current Appendix K decay heat requirements.

- Add an Appendix K option to use the 1994 ANS standard with pre-selected "choices" (probably in a regulatory guide.)

- Choices which are equivalent to Case 3a are:

  1. Assume ^{235}U is the only fissioning isotope.
  2. Assume infinite operating time.
  3. Assume 200 MEV/fission recoverable energy.
  4. Use Equation 11 in the standard for neutron capture effect for shutdown times less than 10^4 seconds. Use 2.e8 seconds operating time for this equation. Use 1.0 as the value for Ψ.
  5. Use Table 13 in the standard for neutron capture for shutdown times greater than or equal to 10^4 seconds.
  6. Apply Section 4 in the standard for the decay heat contribution for ^{239}U and ^{239}Pu. Use a value of 0.7 for R.
  7. Use a 2σ value of uncertainty for ^{235}U. Along with options 1 and 2, this obviates the need to consider methods to combine uncertainties.

- Use of the new Appendix K option would be subject to a model review as required in 50.46. A model review is prudent to assure retention of sufficient remaining conservatism in any revised Appendix K model in which a substantial amount of conservatism has been removed. This subject is discussed in more detail by Steve Bajorek.

- Allow use of the 1994 ANS standard in best estimate Reg. Guide 1.157