NEACRP-A-1039
NEANDC-A- 260

Summary Record of the

NEACRP/NEANDC TASK FORCE MEETING ON DECAY HEAT PREDICTIONS

NEA Data Bank, 21st and 22nd September 1989

Present:

J. Blachot	France	
K. Dickens	USA	
B. Duchemin	France	
T. England	USA	
E. Fort	France	
G. Gillet	France	
M. James	U.K.	
H. Klapdor	F.R. Germany	
C. Nordborg	NEA	Secretary
C. Reich	USA	
G. Rudstam	Sweden	Chairman
K. Tasaka	Japan	
A. Tobias	U.K.	

The Chairman opened the meeting, and welcomed the participants to this second meeting of the Task Force.

Adoption of the agenda

The proposed agenda was adopted.

Review of Actions

The list of actions from the last meeting were reviewed and the ones that had not been fulfilled were retained.

INTEGRAL DATA

G. Rudstam distributed a report containing data from his recent experiments in Studsvik. Average β and γ energies had been measured and spectral information for a large number of isotopes had also been obtained.

New integral data for β, γ, and total decay heat from Winfrith would be published in the near future.

A. Tobias presented his report "Derivation of Decay Heat Benchmarks for ^{235}U and ^{239}Pu by a Least Squares Fit to Measured Data". The same least squares technique as used in the ANS standard had been employed and the analysis had taken into account both statistical and systematic uncertainties, including correlations. In addition to including a larger number of measurements than were considered in the ANS analysis, it differed from the ANS standard in its exclusion of calculated results. Inconsistencies between the input data and the resulting least squares result had resulted in increased uncertainty assignments for those data sets with the largest contribution to χ-square. The ^{235}U analysis had been repeated separately for the calorimetric and spectroscopic decay heat measurements and gave an indication of the calorimetric determinations being systematically higher by 1 to 2 percent. It was noted however, that this difference was insignificant at the 95 percent confidence level. The report was found very valuable, and it was suggested that, if more manpower were available, a more detailed study should be made of each experiment.

K. Dickens reported on the discrepancy between the Los Alamos and Oak Ridge integral experiments, and pointed out that at the time of the measurements, they had tried very hard to find an explanation, but failed. It was quite clear that the discrepancy would only be resolved by a new experiment having substantially improved accuracy. Any new experiment with "normal" uncertainty would be of no use.

Other possible sources for the discrepancy were reviewed, and it was concluded that neither the actinide nor the delayed neutron contribution was important at short or medium cooling times.

The importance, for the utilities, to accurately predict the decay heat was stressed. Figures of the order of 1,000,000 US dollars/percent and plant were mentioned.

It was concluded that the integral data were discrepant, and thus no single decay heat measurement could be selected as the benchmark. It was possible to use either the ANS standard or the data presented in the report by A. Tobias. K. Tasaka reported that the Tokyo experiment was used as a benchmark in Japan, as they knew this experiment and associated uncertainties very well.

SUMMATION CALCULATIONS

G. Rudstam reported on a comparison using his own experimental data in a summation calculation with the integral data of K. Dickens. Very good agreement had been found for the β part, whereas the γ part showed some discrepancies.

B. Duchemin presented a report that stressed the critical effect of data for a few selected isotopes. An example was shown of a calculation of the γ heat from a fission pulse on ^{239}Pu for different values of the average γ energy for ^{102}Tc. Values from 80 keV to 1.2 MeV have been used in different evaluated libraries, giving drastically different results for the decay heat (1.2 MeV giving the best result compared to measurements). T. England reported on the results from a pulse calculation of ^{232}Th, using a average γ value of 1.2 MeV for ^{102}Tc, which showed very good agreement with the Japanese measurement. It was concluded that the mass region around 100 was very important especially for the ^{239}Pu calculation, but these isotopes were very hard to measure. It was agreed to recommend a re-measurement of the Tc-isotopes, for example in the Lohengrin facility.

It was nevertheless felt that the measurement of only a few isotopes would not completely solve the situation. There were at least a 10 to 20 important isotopes for which data were considered uncertain. The improved agreement from the ENDF/B-VI evaluations, was due to a combination of many new data both experimental and theoretical (for example average energies), fission yields and branching ratios.

K. Dickens presented a paper comparing measured energy spectra by G. Rudstam with those extracted from ENSDF (Evaluated Nuclear Structure Data File). The agreement was not always very good. It was concluded that the ENSDF data had a tendency to overestimate the high energy end of the β spectra, especially for isotopes with high Q_β values. The intensities did not always add up to 100 in ENSDF. The report gave an indication of which isotopes should be studied more carefully.

The evaluation activity for fission yields were presented by M. James (JEF) and T. England (ENDF).

THEORETICAL DATA

H. Klapdor briefly described the theory behind the β-strength function which had been used in his calculation of half-lives, average energies, antineutrino spectra etc. A more complete presentation had been given at the last meeting of the Task Force. A new improved theory (QRPA) had recently been developed and so far only half-lives had been calculated. Average β and γ energies would also be calculated later. Calculations using experimental data for the well known isotopes and theoretical data for other isotopes had been in very good agreement with experiments by Dickens and Akiyama especially for the β part of the decay heat.

C. Reich commented that, while this model might, on the average, predict well such quantities as half-lives, where in some sense only the overall beta-strength is involved, the decay heat is another matter. Only a relatively small number of nuclides (at most 50-75) are involved and one must predict not some averaged strength but the energies and intensities of the individual β transitions. He pointed out two serious deficiencies in the QRPA model as it is presently formulated: (1) it does not treat first- forbidden β transitions (which are very important for many of the fission product decays); and (2) because it does not treat collective quadrupole states it cannot (except to the ground state) produce β strength to any levels below the pairing gap in doubly even nuclei. (The much discussed case of ^{102}Tc decay was cited as an important example of this latter situation.) He thus cautioned that, whatever successes this model had in half-life prediction, its use to predict realistic average β and γ energies was open to serious question. This situation is compounded by the fact that small changes in the input parameters of the model can yield large differences in the calculated values in many instances.

It was agreed to use the report by B. Duchemin as a base for identifying the isotopes of importance in decay heat calculations for medium cooling times and to study a few of these in more detail. Isotopes of importance for short cooling times should also be identified.

UNCERTAINTY ESTIMATIONS AND SENSITIVITY STUDIES

Not much progress were reported on this item. The program developed by M. James was not yet ready, and the work on a code by B. Duchemin had been interrupted due to manpower problems. G. Rudstam informed the Task Force that his code INVENT included a full treatment of uncertainties.

INTER-COMPARISON OF CODES USED IN SUMMATION CALCULATIONS

C. Nordborg reported on the status of the code comparison, proposed at the NEACRP-NEANDC Specialists' Meeting on Decay Heat Predictions in Studsvik, Sweden 1987. The input data had been sent out in November 1988, and the results were expected before 5 May 1989. By the time of the dead-line, only 3 results had been received, but since then another 8 results of calculations had arrived at the NEA Data Bank. Preliminary results showed that for the case of a fission pulse, most results were within 0.5 percent, whereas the spread was larger for the case of a long irradiation. Obvious mistakes in the use of the codes or errors in reading the input data had been identified, and the results would first be sent to the participants for comments and corrections before the final report could be issued, hopefully in the Spring of 1990.

CONCLUSIONS

The lack of a very good integral benchmark for decay heat calculations, due to existing discrepant experimental data, was noted. The Task Force encouraged new very accurate measurements, but was aware of the cost and manpower involved in such measurements.

The Task Force was unwilling to select any single set, or sets, of measurements as a decay heat benchmark, but drew the attention to the paper by A. Tobias as providing a possible alternative.

The differences seen in the summation calculations were due to the input data used and not to the codes themselves. A few isotopes were identified for further studies, both experimental and theoretical. An outstanding example was ^{102}Tc.

It was recommended that the new versions of, at least, the ENDF and JEF evaluated libraries be used in summation calculations and the results compared, as the libraries use different theoretical data bases.

The Task Force noted the lack of experiments for cooling times longer than a few days, encouraged such experiments to be undertaken.

NEXT MEETING

It was agreed that a new meeting of the Task Force should be held some time during 1990, to review information on spectral data, ^{102}Tc data, and the result of the benchmark testing of the ENDF, JEF, and JENDL libraries. The exact date of the meeting should be decided by the NEA Secretariat in consultation by the Chairman.

ANNEX 1

List of Actions Adopted at the Meeting

1. **G. Rudstam:**	Send, as soon as possible, the tabulated experimental ^{239}Pu γ data by P.I. Johansson to A. Tobias.
2. **H. Klapdor:**	Compare theoretically derived average γ decay energies with the recent experimental data by G. Rudstam. Investigate if the theoretical values could be used to resolve the inconsistencies found for some isotopes.
3. **B. Duchemin:**	Inter-compare estimates of uncertainties quoted in yield and decay data with those quoted in summation calculations. Identify the most important sources of uncertainty in the summation calculations.
4. **All participants:**	Study the list of important isotopes in the report by B. Duchemin and try to improve the data situation for at least a few of the isotopes (e.g. ^{102}Tc).