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CEA FISSION PRODUCT RADIOACTIVITY DATA FILE AND ITS ASSESSMENT

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Abstract : The 1987 Version of the CEA radioactivity data bank is just distributed. It contains ENSDF data till september 1987, integral data from RUDSTAM when they improve ENSDF and for isotopes without experimental data, mean energies deduced from the gross beta theory. To assess this file we compare summation calculations with available experimental data at short cooling times the pulse integral measurements of Dickens and Akyiama, at several year cooling times specific experiments. The importance to have better knowledge of some nuclides like strontium and technetium isotopes are stressed.

(Radioactivity, Data file, Decay heat, Summation calculations, Comparison with experiments).

Introduction

For a long time the French CEA has developped a radioactivity data bank and used it to predict residual heat and source term for shielding purposes (1 2 3 4 5).
In the following we indicate first how the last version is built. Then the work which has been undertaken to improve our knowledge of some nuclides which contribute largely to decay heat is emphasized. We also show comparisons with summation or dose rate calculations which are used to assess this library at any cooling time.

Status of the Library

Since the early 70's the CEA has developped a library (6) which has been updated many times. This library contains decay data for all radioactive isotopes ($\simeq$ 2500). The status of the fission product part of this library is given in table 1. It is constitued mainly from ENSDF (7) including the nuclides revised in september 1987.

ENSDF is a computer based file. For masses which correspond to the FP, the information is documented in the Nuclear Data Sheets. Every six months, the evaluated masses are available (Tape, Now on line at NEA). The organization and the structure of this file can be found in a paper of Tuli (9).

The code ENSD2 /10/ transform the ENSDF data set in our own format.
After EDIBIB can read this format, calculates X-rays and Auger electrons and produces more readable tables. It also sums all the energies to get the average energies, and gives the percentage of difference between the sum of average energies and the total decay energy.

This library is improved for about 50 nuclides by using the mean beta energies measured by Rudstam (11) and for about 80 nuclides, mostly without known experimental spectra, by taking the values deduced from the gross structure theory (12).

Table 1 - Content of the CEA F.P. library as end of 1987

Total number of nuclides	725
Stable nuclides	119
Unknow nuclides	69
Total number of β^- rays	9 494
" " β^+ rays	67
" " γ rays	22 235

Studies for decay heat improvement

Works are in progress in order to improve the comparison for pulse fission between integral data and summation calculation.

First, for short cooling time ($t < 200$ sec.), the socalled pandenomium effect (13) may explain the overestimation by summation calculation of beta residual heat. To deal with that question we filled the gap between E1 (Highest known energy level) and Q (available energy in beta transition) by modeling a continuum of levels using a statistical model.

Second, for medium cooking time ($200 < t < 2000$ sec.), the gamma residual heat is underestimated for some fissile nuclei (i.e. Pu 239). In this region where nuclides are well-known we tried to look at the most contributing ones and by comparing several data banks to list those for which new experiments will be worthwhile.

In the first region we defined a class of nuclides called badknown nuclides which deserve a special treatment. We selected these nuclides by the two following criteria :

$$Q < 5 \text{ MeV} \quad \text{and} \quad E1/Q < 0.8$$

In table 2 we give the computed mean beta and gamma energies for the selected nuclides with $E_L/Q < 0.5$. This work is still in progress and the given values are preliminary ones.

In the second region starting from U235 U238 Pu239 thermal pulse calculations made with our standard data bases, we first listed all the nuclides which contributes more than one per cent to the total residual heat at 200 300 500 700 1000 1500 and 2000 s. cooling times. We got about sixty nuclides.

Then we summed the contribution of each nuclide for these seven cooling times and these three fissile nuclei, and ranked the sixty nuclides according to this index. We got then three classes : the most important nuclides, the important nuclides and the less significant nuclides. The nuclides of the first two classes are listed in table 3 with their CEA 87 energies.

Assessment

This fission product library is used either for decay heat calculation, specially for safety purpose, and to determine sources in shipping casks and other shielding problems. For these reasons we assess this library at any cooling times.

For cooling times less than 10000 sec., the figure 1 to 3 show, for Pu239, the thermal pulse beta, gamma and total residual heat for the five following cases :

a : summation calculation with CEA 87 B data base

b : summation calculation with CEA data bases and the mean energies for the selected nuclides of tabla 2 and of Y95 and Tc102F from an earlier version of JEANDL2 (12b)

c : summation calculation with CEA 87 B data bases and the mean energies of Sr93 and Tc102F from JEANDL2 (12a)

d : DICKENS experiments (15)

e : AKIYAMA experiments (16)

All the calculations are made using the yields computed by us with the ENDFB5 cumulative yields and the WAHL formula (3). From the figure 2 one can deduce that the Sr93 and the Tc102F are the most important nuclides to explain the discrepancies. For the Tc102F the mean gamma energy varies from 80 KeV (CEA 87B) to 1,193 MeV and even 1,77 MeV (JEANDL2, 87 and 86).

For the Sr93 the mean gamma energy varies 1,4017 MeV (CEA 87B, Rudstam value) to 1,978 MeV (JEANDL2) and 2,2123 (CEA earlier version). It seems difficult to explain these discrepancies in mean gamma energies by the pandenomium effect only. Having in mind the BR87 case (17) a precise measurement or reevaluation of these nuclides will be very rewarding.

For several year cooling times specific experiments were made. For instance (18) measurements of gamma dose rates outside the TN 12 shipping cask is compared with calculations using our APOLLO and PEPIN code (19 20) for source term calculation and our transport codes ANISN and MERCURE (21 22). The results obtained at contact are shown in figure 4. The discrepancy seen for the fuel element top level is due in part to the control rod motion and to the cobalt content uncertainty. For the fuel element other parts the agreement is very good.

Summary

We expect to have shown here that our library gives for many studies quite satisfactory results. But it seems worthwhile to continue its improvements particularly for nuclei contributing at cooling times less than 10^5 sec. The case of strontium and technetium are specially emphasized.

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TABLE 2. Computed Mean Emergies for Selected Nuclides with E1/Q < 0.50

NUCLIDE *******	E1/Q %	EBM MEV	EGM MEV
SR94	42	0.6055	1.8522
SR97	34	2.4992	1.8997
SR98	10	2.4465	0.4303
Y99	25	2.4447	0.9474
NB99F	4	1.5410	0.0515
NB101	10	1.0838	1.9650
TC108	4	1.8222	3.8256
RH110F	27	2.2338	0.3618
AG118F	34	2.4229	1.0561
AG120F	20	2.3233	0.7640
IN129F	17	3.2147	0.6789
IN130	22	3.0820	2.5590
IN131F	4	2.1351	3.9493
SB134F	29	2.4643	2.9492
TE135	6	2.0116	1.5962
CS143	47	2.3096	0.4080
CS144	37	2.9533	1.5191
CS147	9	1.7472	2.9444
BA144	41	1.0557	0.4571
LA148	42	2.1314	2.1335

TABLE 3. Important Nuclides in the Medium Cooling Time Region with their E1/Q Ratio and CEA87B Mean Energies

NUCLIDE *******	E1/Q %	EBM MEV	EGM MEV
MOST IMPORTANT NUCLIDES			
SR93	99.9	1.0500	1.4017
Y94	73.0	1.8144	0.7724
Y95	91.8	1.527	0.8939
MO101	91.5	0.5284	1.5129
TC102F	64.3	1.945	0.08076
TC104	76.0	1.4543	2.245
TC105	72.8	1.3369	0.7948
XE138	88.6	0.6785	1.1245
CS138F	86.8	1.269	2.361
CS139	94.0	1.647	0.3286
IMPORTANT NUCLIDES			
KR89	95.1	0.850	2.992
RB89	91.2	1.027	2.071
RB90F	92.1	1.857	2.164
SB130F	68.3	0,9464	2.683
SB131	89.0	0.980	0.9556
SB132F	60.0	1.269	2.573
SB133	80.8	0.470	2.8764
TE133F	85.5	0.7075	1.200
LA143	85.6	1.270	0.266

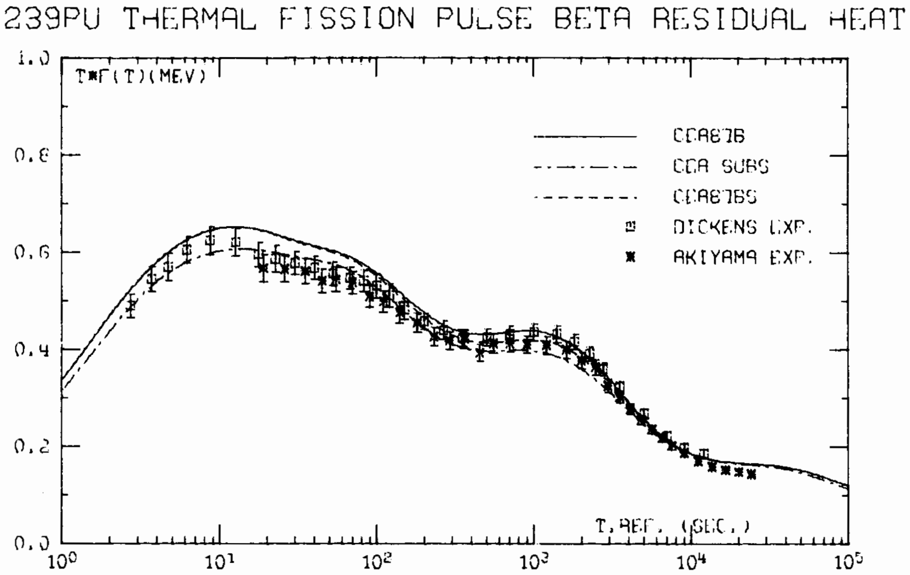

FIGURE 1

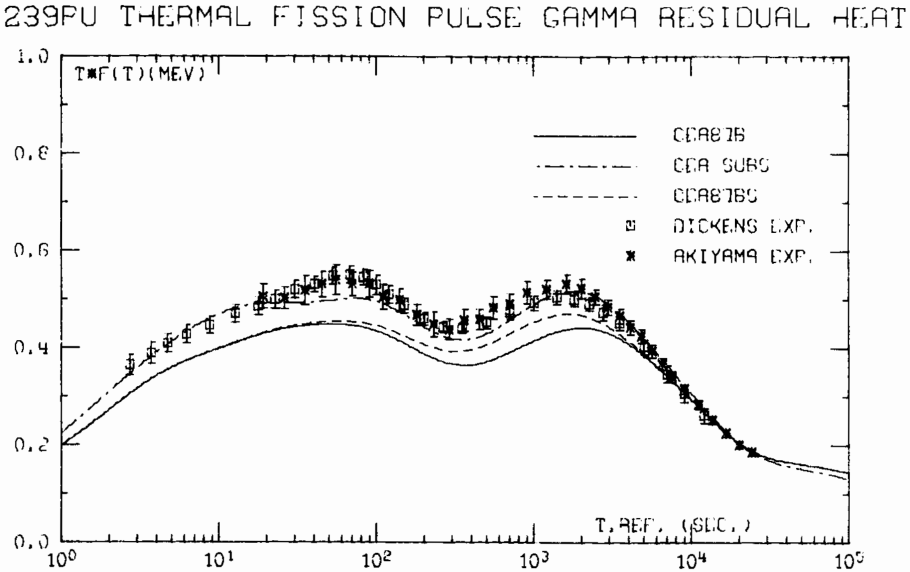

FIGURE 2

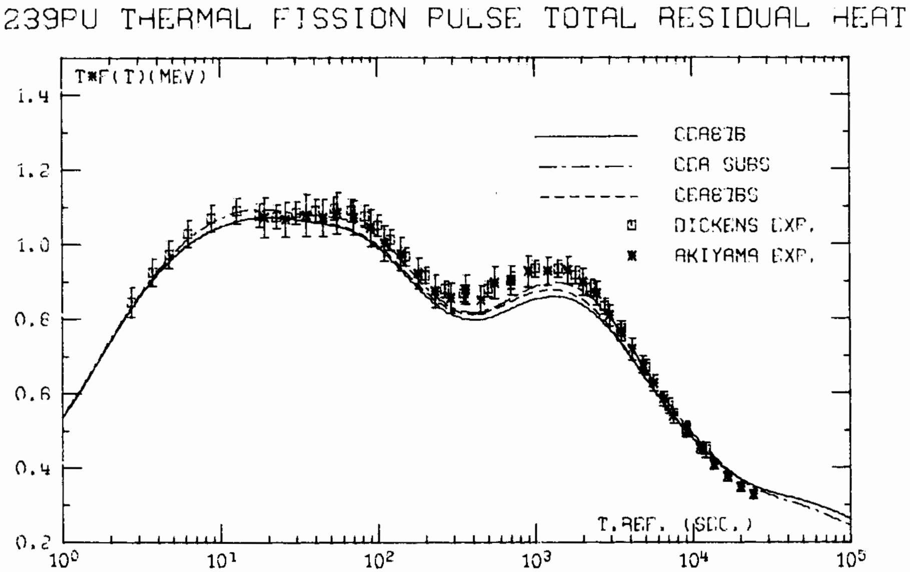

FIGURE 3

Fig. 4_ Comparison between experimental and calculated dose rate values.at 7 cm.