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NSC TASK FORCE ON PHYSICS ISSUES OF DIFFERENT TRANSMUTATION CONCEPTS (TFDT)

Summary Record of the Third Meeting

NEA Headquarters, Issy-les-Moulineaux, France
24th and 25th June 1997

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Summary Record of the Third Meeting of the NSC Task Force on Physics Issues of Different Transmutation Concepts (TFDT)

24th and 25th June, 1997

1. The meeting was opened by the Chairman, T. Mukaiyama, who briefly outlined the scope, history, and status of the work of the Task Force. The introduction of participants followed (see Annex 1).

2. The proposed Agenda was approved.

3. R.P. Rulko presented the summary record of the previous TFDT meeting held in January 1997. The summary record was approved without modifications.

4. The next point on the Agenda was the presentation and discussion of the improved and new benchmark results. B. Kochurov presented updated and T. Iwasaki new PWR results.

A. Fast Reactor benchmark

5. The assembly and presentation of the Fast Reactor results was made by T. Wakabayashi. In total, six sets of Fast Reactor solutions had been received, and the main points were as follows:

I. Revised results were provided by JAERI, Japan, using JENDL 3.2 data (K. Tsujimoto, H. Oigawa, T. Mukaiyama;

II. Completed/improved results had been generated by CEA-Cadarache, France, but they were not yet available to the meeting (J. Tommasi);

III. Results by PNC, Japan (T. Wakabayashi);

IV. Completed results were provided by Mitsubishi, Japan (M. Yano, Y. Ohkubo);

V. Toshiba, Japan, submitted revised results, still incomplete but close to being finalised (M. Yamaoka, M. Kawashima);

VI. A new contribution arrived from IPPE, Russia, (A. Tsiboulia et al.).

6. Physics analysis of the Fast Reactor results gave the following general conclusions:

- k_{eff} a function as of burnup:
  - *For reference core with 0 % Minor Actinides (MA)*
    - Very good overall agreement within 0.3 % $\Delta k/(k*k')$, except for the Mitsubishi result. This discrepancy will be explained by Mitsubishi.
  - *For the 2.5 % MA core*
    - Three results (PNC, CEA, JAERI) are very close; Toshiba is slightly lower (within 0.5 % $\Delta k/(k*k')$). IPPE result is a bit higher and Mitsubishi result is a bit lower. These discrepancies will be analysed on the nuclide-by-nuclide basis (also adopted fission spectrum may be responsible for these differences - this will be verified);
  - *For the 5 % MA core*

* The CEA, JAERI, PNC results are very similar, the Toshiba and Mitsubishi results show small deviations, whereas IPPE results are quite different. The shape of the curve is different - the reason for this discrepancy should be explained.

- ♦ Spectral indices:
  - – Very good agreement except for the older CEA results. This problem, probably due to a differently adopted definition of this parameter, will be cleared.
- ♦ Reactivity losses:
  - – Very good agreement with maximum difference within 0.3 % in $\Delta k/(k*k')$ for all three (0 %, 2.5 %, 5 % MA) cores.
- ♦ Isotopic composition variation in function of burnup:
  - – Good agreement for all 23 isotopes considered, except for: Pu238, Pu240, Pu242, Am241, Am243, Cm244, Np237. The reason for the discrepancies for these isotopes will be investigated.
- ♦ Na void reactivity:
  - – Excellent agreement for the 5 results (within 8 %), discrepancy of about 20 % for the IPPE result for all three cores considered (0 %, 2.5 %, 5 % MA).
- ♦ Doppler coefficient of reactivity (total for the core):
  - – Very good agreement within 10 % for all results (usually the discrepancy for this parameter is of the order of 20 % for calculations versus measurements).
- ♦ Doppler components nuclide-by-nuclide:
  - – Good agreement for all cases.

Actions

7. T. Wakabayashi is responsible for assembling, analysing and finalising all Fast Reactor results. He will deal directly with the benchmark participants to obtain any extra information that may be needed. A comparison between experimental and calculated data is very important for the evaluation of the calculation accuracy. For this purpose, T. Wakabayashi will provide the experimental data obtained at JOYO of PNC and at ZPPR of ANL, if these are available.

B. Fast Flux accelerator benchmark

8. Three Fast Flux Accelerator solutions were submitted:

I. G. Youinou, S. Pelloni, P. Wydler, PSI and CEA, (revised solution),

II. T. Nishida, T. Takizuka, T. Sasa, JAERI, Japan, (revised solution),

III. T. Ivanova, V. Batayev, A. Tsiboulia, IPPE, Russia (a new contribution).

9. The results of the accelerator benchmark had been analysed by T. Sasa and were presented at the meeting by T. Mukaiyama.

Main conclusions

10. The main conclusions drawn are as follows:

a) Spallation neutron analysis: good agreement for spallation source yields.

b) Maximum and average heat density in the target shows rather large variations. The reasons will be investigated.

c) Accelerator core calculation summary:

- *Na void coefficient* of reactivity is very similar for the PSI+CEA and the JAERI solutions whereas the IPPE results are significantly different. The reason for this discrepancy will be investigated.
- *Fission capture rate*: good agreement for all solutions.
- *Axial neutron distribution* at r = 150 mm: good agreement for all solutions.
- *Average neutron energy spectrum in core*: excellent agreement.
- k_{eff} *as a function of burnup*: this curve is largely improved in comparison to earlier results (discussed at a meeting in January 1997), but there are still significant discrepancies. The shape of the curve is identical for IPPE and JAERI, but different for PSI+CEA with about 3 % difference in k_{eff} at zero burnup.
- *Time evolution of number densities of Minor Actinide:* excellent agreement for Np237 and Am241 for PSI+CEA and IPPE solutions. Overall, the discrepancy in the results increases as the total MA content increases.
- The description of the IPPE methodology is insufficient and needs to be updated, in particularly the definition of k_{eff} used.

Actions

11. The following actions are necessary:

a) Two more solutions are needed for comparison purposes;

b) Since spallation physics results show good consistency, JAERI will provide an explicit spallation neutron source input for accelerator core calculations, to facilitate calculations and to encourage additional participants.

c) Explanation of the k_{eff} definition is needed: which k_{eff} definition was used by PSI+CEA, JAERI, and IPPE. Justification of a particular choice (advantages/disadvantages) should be given.

d) More information about the radial power shape is needed to interpret the results. Distribution of power in the core region at maximum power 'z' point should be provided.

C. PWR benchmark results

12. The PWR benchmark was redefined following conclusions of the Task Force’s January 1997 meeting. C. Broeders prepared explicit homogenised number densities for 6 standard lattices and 3 wide lattice PWR cases, considering different target burnup (50 GWd/tHM and 33 GWd/tHM) and 0 %, 1 %, and 2.5 % MA content.

13. The following six solutions of this redefined benchmark were received:

I. B.P. Kochurov, ITEP, Russia

II. A. Tsiboulia, G. Yerdev, A. Kotchetkov, IPPE, Russia

III. H. Takano, H. Akie, K. Kaneko, JAERI, Japan

IV. T. Iwasaki, Tohoku University, Japan

V. C. Broeders, FZK, Germany

VI. D. Lutz, IKE, U of Stuttgart, Germany

14. The results of PWR benchmark were assembled and presented to the meeting by R.P. Rulko. The following conclusions were drawn:

a) Overall, the results show consistency well within the limits on multiple Pu recycling established by the NEA Working Party on Plutonium Recycling (WPPR).

b) The k_{inf} verses burnup curve shows three very close results, with the two Russian contributions slightly higher and lower, respectively.

c) Number densities of wastes and derived quantities, such as weights are also very similar for all participants, showing slightly more deviation for some isotopes in both of the Russian solutions. Cross-sections should be checked.

d) Available long term activities of wastes show good consistency (not all solutions included these data).

Actions

15. Actions to be taken:

a) Participants, who submitted incomplete results, are asked to complete their results;

b) Additional information on Doppler and void coefficients of reactivity will be provided by all participants. Takano will specify one or two fuel temperatures for Doppler calculation and void fraction for void coefficient of reactivity calculations, which should be performed for Beginning of Life and End of Life conditions.

c) Minor activities as a function of time should be normalised to 1 metric tonne of discharged fuel, hence given in units of (Bq/tonne).

d) A. Tsiboulia should investigate the reason for a sudden deterioration of his results at burnup above about 22 GWd/tHM.

e) B. Kochurov should check his cross-sections (Np238 in particular) to try to explain some of the discrepancies found in his results.

D. Further activities

16. The meeting decided to freeze new activities until a report of this phase of the benchmark is completed. The following schedule was agreed upon regarding the preparation of the final report:

a. The NEA Secretariat (R.P. Rulko) should receive all missing results/corrections and requested additional information before the end of August 1997. A first draft of the report should be prepared by mid October. T. Wakabayashi will handle all the work related to the Fast Reactor benchmark. C. Broeders will prepare an introductory chapter describing methodology used for preparing homogenised input for UO2 equivalent MOX pin-cell PWR calculations. R.P. Rulko will assemble, tabulate, and graphically represent the PWR results, which will then be passed to the PWR participants for interpretation and text writing. The accelerator part of the benchmark will be written up by JAERI, who will consult with the benchmark contributors regarding the interpretation of the results.

b. The first draft of the report will be discussed at a meeting scheduled for late October or early November 1997 in Paris.

c. Second draft should be produced by the beginning of December 1997 to allow for comments from task force members.

d. The final draft is scheduled to be ready by the end of December 1997.

e. To facilitate interpretation and analysis of the results, all participants should submit:
   - calculation flow-sheet,
   - decay chains used for calculation of time evolution of activities, including branching ratios of Am241 to Am242m and Am242g,
   - description of the fission spectrum: how it is constructed?
   - information on spectrum used for preparation of few group cross-sections for burnup calculations (for example k_{inf} or k_{eff} spectrum, etc.?)
   - information about self-shielding treatment, particularly for Pu240 and Pu242.

f. the NEA Secretariat will be in continuous contact with the Task Force members to assure the execution of this tight schedule.

E. <u>Other business</u>

18. E. Sartori gave an overview of the activities of the WPPR on multiple Pu recycling. The participants clearly identified the difference of objectives between WPPR and TFDT. T. Mukaiyama was invited to participate in the next meeting of the WPPR planned for 25-26 November 1997.

Annex I

List of Participants
Third Meeting of the NSC Task Force on Physics Issues of Different Transmutation Concepts (TFDT)

24th and 25th June 1997

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