International Atomic Energy Agency
INTEROFFICE MEMORANDUM

To:	All Members of the RCC-NA Subcommittee	Date:	2002-01-09
		Reference:	
Through:	Mr. W. Burkart DDG-NA	Clearance:	Ms. A.M. Lorenz AA-NAPC
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Subject: **Proposal for a Co-ordinated Research Project (CRP)**

The attached is the proposal for a Co-ordinated Research Project on

"Evaluated Nuclear Data for the Thorium-Uranium Fuel Cycle"

Proposal for a Co-ordinated Research Project (CRP)

1. *Title of CRP*: Evaluated Nuclear Data for the Thorium-Uranium Fuel Cycle

2. *Background Situation Analysis (Rationale/Problem Definition)*

Past developments in nuclear technology have been streamlined towards the utilisation of uranium in thermal reactors and fast reactors in order to improve the utilisation of natural uranium resources. After the accident at Three Mile Island and Chernobyl, opposition to nuclear technology became very strong: restructuring of the industry to reduce energy consumption was progressively implemented, and new reserves of natural gas and oil were discovered. Thus, the continued development of nuclear technology almost stopped, apart from safety-related issues. The lack of an increase in demand for nuclear fuel removed the urgency to develop fast breeder reactors. Furthermore, when considering economic and safety aspects, such reactors had no advantages compared to conventional thermal reactors. Therefore, development of this technology stopped in a significant number of countries including France, which was the most advanced in the field and had a full-scale fast breeder reactor in operation for some time.

With increasing awareness of the global changes to the environment, nuclear power is slowly re-gaining its position as an appropriate option for energy supply with negligible emission of greenhouse gases. This position is subject to the condition of increased inherent safety, reduction of the risk of fissile material proliferation and a viable solution to the problems of long-term radioactive waste disposal. New concepts of nuclear technology for power production are being investigated to satisfy these needs. Thorium-based nuclear fuel cycle offers many advantages:

- Neutron capture in ^{232}Th yields ^{233}U, which is a highly efficient nuclear fuel. A thermal breeder (or near-breeder) reactor concept based on thorium fuel is feasible.
- The build-up of long-lived higher actinides, which are the main source of long-term residual radioactivity in the waste, is much smaller in thorium fuel. This fact can be used with advantage in the design of critical as well as subcritical accelerator-driven systems.
- Thorium fuel is more proliferation-resistant due to highly radioactive constituents, which can not be separated out by chemical means. Handling of such material in improvised clandestine laboratories is practically impossible.
- World reserves of thorium are much larger than reserves of uranium.

Due to the above advantages there is rising interest in innovative fuel cycle concepts based on thorium fuel. Unfortunately, due to the previous lack of interest in thorium fuel cycle, the quality of nuclear data for the relevant materials is lower than for the comparable materials in the uranium or mixed oxide (plutonium) fuel cycle. In some cases the uncertainties in the nuclear data are a factor of three larger than the target accuracies set by the designers [Summary Report on the Consultants' Meeting on *Assessment of Nuclear Data Needs for Thorium and Other Advanced Cycles*, Vienna, 26-28 April 1999, INDC(NDS)-408, Aug.1999].

Numerous activities are in progress in many countries that anticipate the use of thorium-based fuel for accelerator-driven systems (ADS) applicable to power production and radioactive waste transmutation [Proc.of IAEA TC Meeting, *Feasibility and Motivation for Hybrid Concepts for Nuclear Energy Generation and Transmutation*, Madrid, 17-19 Sept.1997, IAEA-TC-9033, 1998]. Active design effort is taking place on an advanced heavy

reactor concept in India that uses thorium fuel [AGM, *Long-Term Needs for Nuclear Data Development*, Vienna, 28 Nov.- 1 Dec. 2000, INDC(NDS)-428, Aug.2001]. Important new experimental measurements of cross sections of materials relevant to the Th-U fuel cycle have been reported or are in progress [Int.Conf. on Nuclear Data for Science and Technology, Tsukuba, 7-12 Oct. 2001, proceedings to be published]. These data have to be evaluated, verified and validated on integral benchmarks to ensure valid design calculations. There is a definite need for improved evaluated nuclear data and the International Nuclear Data Committee (INDC) endorsed the project *Nuclear Data for Th-U Fuel Cycle* with *high priority* at 22nd meeting on 11-14 May 1999. Therefore it is proposed to initiate the project as a co-ordinated research project, which also appears in the IAEA Programme and Budget and in the financial plan for the year 2002.

The project is related to other IAEA activities. The Nuclear Power Division organized a series of meetings [*Thorium Fuel Utilization: Options and Trends*, Working Material from three IAEA Meetings held in 1997, 1998 and 1999]. The Department of Energy also organized a Meeting of Senior Officials from Member States on the International Project on Innovative Nuclear Reactors and Fuel Cycles INPRO (Vienna, 27-28 Nov 2000), which is also relevant to the topic.

3. *Overall Objective*

The overall objective of the IAEA CRP on evaluated nuclear data for thorium-uranium fuel cycle is:

- To incorporate newly available experimental information into evaluated nuclear data files, which can be processed and used by designers of nuclear plants.
- To activate available human resources and to facilitate interaction and sharing of work to complete the task defined in the previous item in a timely and professional manner.
- To produce improved evaluated nuclear data files that will allow more accurate design calculations of innovative fuel cycle concepts involving the thorium-uranium fuel cycle.

4. *Specific Research Objective (Purpose)*

The nuclides of primary interest for evaluation are: ^{232}Th, ^{231,232}Pa and ^{232,233,234,236}U. Activities within the CRP will include:

- Critical assessment of the available experimental information with emphasis on new data and renormalization to modern standard cross-sections (if necessary).
- Evaluation of experimental data, derivation of resonance parameters (where relevant), completion of data with the results of nuclear model calculations and formatting of the data in ENDF-6 format.
- Verification of the formatted data to ensure that they are formally correct, internally consistent and that they truly represent the experimental data, from which they were derived.
- Processing of the data into application libraries for validation purposes. Preliminary validation of processed data on existing externally provided benchmark test cases (if available).

5. *Expected Research Output (Results)*

The main output of the project will be new and improved evaluated data files for the primary nuclides of interest, including documentation of the details of the evaluation process, experimental data included in the evaluation, nuclear model codes, etc.

The basic data will be thoroughly checked for formal correctness and internal consistency to make sure they are processable. In addition, processed libraries will be generated for some commonly used transport codes to enable partial data validation.

The data will be distributed to the users through the Web and on CD-ROMs using standard retrieval software of the NDS for ENDF-formatted files.

The new evaluated data files will improve the accuracy of the data and provide narrow uncertainly estimates that will at least reduce the gap between observed and target uncertainties in the nuclear data. The new data will enable the designers to estimate more accurately the necessary safety margins in new conceptual designs.

6. *Relationship to sub-programme objective*

The proposed CRP is directly related to the objective of the Sub-programme D1 – "Nuclear and Atomic Data" for years 2002-2003, namely: *To contribute to the safe and economic application of nuclear technologies in Member States by ensuring convenient access to accurate and reliable nuclear and atomic data for energy and non-energy applications*. It constitutes the major part of the project "Data for the Th-U Fuel Cycle" within this sub-programme.

7. *Action Plan (Activities)*

Activity	*2002*	*2003*	*2004*	*2005*
1. Constitute the CRP, select participants (finalize all by January 2002). Participating countries: Belarus, China, European Union, Japan, Republic of Korea, Roumania, Russia, and USA. Prepare CRP working plan via e-mail communication, plan work under individual research contracts and agreements and begin work	X			
2. Organize 1st RCM (November 2002) to discuss and co-ordinate plans for further work on evaluation, file assembly, verification and benchmarking, on level of co-operation needed to come to consistent conclusions and first results obtained by participants	X			
3. Organize 2nd RCM (Mar 2004) to review the results achieved, to discuss the recommendations on the evaluation methodology in view of preliminary benchmark results			X	
4. Organize 3rd RCM (final, September 2005) to consider and review the preliminary benchmarking results and discuss the details of the final presentation of the results				X
5. To prepare and submit for publication the final report with the results of CRP. To create Web access to the new library of the Th-U fuel cycle materials and to prepare for distribution on CD-ROMs (December 2005)				X

8. *Inputs*

(a) Financial Resources

Item	*2002*	*2003*	*2004*	*2005*
Research Contracts	25,000	25,000	25,000	
RCMs	18,000		18,000	18,000
Publication				2,000
Total	**43,000**	**25,000**	**43,000**	**20,000**

Total for the CRP: $ 131,000

9. *Assumptions*

No outside factors, which could prevent the implementation of the proposed CRP, are foreseen at this time. A minor drawback could be the delay in the "n-TOF" project of cross section measurements at CERN, which would provide a useful contribution to the available experimental database. It is expected that the project will proceed in time so that the experimental results will be available for inclusion in the evaluations.

10. *Logical Framework*

Narrative Summary	***Objective Verifiable Indicators***	***Means of Verification***	***Important Assumptions***
Overall objectives: To make best use of human resources and to use newly available experimental information to produce improved evaluated nuclear data files that will allow more accurate design calculations of innovative fuel cycle concepts involving the thorium-uranium fuel cycle	New evaluated nuclear data files are produced	Availability of the new evaluated nuclear data files	None
Specific objectives: To produce new evaluated data files for nuclides: ^{232}Th, ^{231,232}Pa and ^{232,233,234,236}U. To perform data file verification and partial validation through limited benchmarking	Reports are prepared describing the evaluations, their verification and partial validation	Availability of reports	National support provided to participants
Outputs: 1. New or improved evaluated data files for the primary nuclides of interest. 2. Documentation on the details of the evaluation process, experimental data included in the evaluation, nuclear model codes etc. 3. Reports from the data verification and validation process	New evaluated nuclear data files are produced. Reports are prepared describing the evaluations, their verification and partial validation	Review of the documentation	None
Activities: 1) Constitute the CRP, select participants, prepare CRP working plan and begin the work	1) Research contracts and Agreements awarded	1) Approval of Contracts and Agreements by RCC	1) Suitable proposal submitted
2) Organize 1st RCM to discuss and co-ordinate plans for further work on evaluation, file assembly, verification and benchmarking, on level of co-operation needed to come to consistent conclusions and first results obtained by participants	2) 1st RCM held (Nov. 2002)	2) RCM summary report, CRP Progress Reports	2) None
3) Organize 2nd RCM to review the results achieved, to discuss the recommendations on the evaluation methodology in view of preliminary benchmark results	3) 2nd RCM held (March 2004)	3) RCM summary report, CRP Progress Reports	3) None
4) Organize 3rd (final) RCM to consider and review the preliminary benchmarking results and to discuss the details of the final presentation of the results	4) 3rd RCM held (Sept. 2005)	4) RCM summary report, CRP Progress Reports.	4) None
5) To prepare and submit for publication the final report with the results of CRP. To create Web access to the new library of the Th-U fuel cycle materials and to prepare for distribution on CD-ROMs	5) Evaluated data prepared and report submitted for printing	5) Data library and CRP Final Report	5) None

11. *Brief Summary for the Agency's Bulletin*

The Co-ordinated Research Project on "Evaluated Nuclear Data for the Thorium-Uranium Fuel Cycle" is organized to produce the library of evaluated neutron cross section data for transactinide nuclei important for the Th-U fuel cycle. The data files will undergo verification and partial validation prior to their release. Application libraries for some commonly used neutron transport codes will also be provided. The library will be distributed through the Web and on CD-ROMs.

Appendix 1

List of Potential Participants of the CRP
"Evaluated Nuclear Data for the Thorium-Uranium Fuel Cycle"

1. Belarus, Radiation Physics and Chemistry Problems Institute, (V. Maslov) Minsk, Sosny: Evaluation of data for ^{232}Th, and ^{233}U in the fast energy region (**Contract**).

2. China, Institute of Atomic Energy, CNDC, Beijing: Review and evaluation of fission product yields for ^{232}Th, ^{231,232}Pa and ^{232,233,234,236}U (**Contract**).

3. Europe, n-TOF co-ordinator for evaluation of experimental data (H. Leeb): Evaluation of experimental data resulting from the n-TOF facility (Research agreement).

4. India, BARC (R.Srivenkatesan): Results of post-irradiation examination of thorium fuel to prepare burnup benchmark. (**Contract**).

5. Japan, JAERI, (T. Fukahori): Resonance parameter evaluation, intercomparison of evaluation methods (Research agreement).

6. Roumania: (M. Sin), Evaluation of ^{231,233}Pa in the fast energy region (**Contract**)

7. Republic of Korea, KAERI, Nuclear Data Evaluation Laboratory, Taejon: Evaluation of data for ^{232,236}U (Research agreement).

8. Russia, Institute of Physics and Power Engineering, Obninsk (A. Ignatyuk): Analysis of available experimental data and benchmark experiments and improvement of evaluations for materials relevant to the Th-U fuel cycle (**Contract**).

9. Switzerland, PSI (S. Pelloni), Benchmarking (Research agreement).

10. U.K., Imperial College (Sami Kafala): Evaluation of experimental data for ^{232}Th, and ^{233}U, intercomparison of evaluation methods (Research Agreement).

11. USA, Oak Ridge National Laboratory (L. Leal): Resonance parameter evaluation of nuclides for which new sufficient high resolution measurements are available (Research Agreement).

12. USA, Los Alamos National Laboratory, (M. Chadwick): Experimental cross section averaging and determination of covariance matrices for ^{232}Th, and ^{233}U (Research Agreement).

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Appendix 2

Justification for Inclusion of 2 Research Agreements with Researchers from the same country

The tentative tasks assigned to the research groups from the USA are:

- Oak Ridge National Laboratory: resonance parameter evaluation.
- Los Alamos National Laboratory: evaluation of experimental data and covariance matrices.

The group at Oak Ridge is the most experienced in this field. The major evaluation code SAMMY has been developed at this laboratory and the proposed research topic is in line with their currently planned activities. There is no adequate substitute for this group.

The research group at Los Alamos has significant experience in evaluating experimental data and producing evaluated covariance files. The alternative group from the Vienna Technical University is engaged in other activities (including an IAEA CRP) and cannot participate for formal, technical and practical reasons. The proposed research is in line with the current activities of the group from Los Alamos; therefore, this group is the most suitable candidate to perform the research.