IAEA-03CT12953

TWG-FR/116

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WORKING MATERIAL

Consultancy
to review and finalize the IAEA publication
"Compendium on the Use of Fusion/Fission Hybrids
for the Utilization and Transmutation of
Actinides and Long-lived Fission Products"

VIC, Vienna, Austria

8 - 12 December 2003

Reproduced by the IAEA
Vienna, Austria, 2004

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8-12 December 2003

Vienna International Center, Vienna, Austria

Participants:

Mr. V. Artisyuk, IATE, RF
Mr. Y. Gohar, ANL, USA
Mr. V. Ignatiev, RRC "Kurchatov Institute"
Mr. Y. Kadi, CERN
Mr. B. Kochurov, ITEP, RF
Mr. D. Maes, SCK·CEN, Belgium
Mr. V. Seliverstov, ITEP, RF
Mr. A. Stanculescu, IAEA
Mr. L. Tocheny, ISTC, RF
Mr. J. Uhlir, NRI Rez, CZR
Mr. V. Arkhipov, observer, IAEA

MEETING REPORT

Background

In addition to the traditional fission reactor research, fusion R&D activities are becoming of interest also to nuclear fission power development. There is renewed interest in utilizing fusion neutrons, Heavy Liquid Metals, and molten salts for innovative systems (energy production and transmutation).

Indeed, for nuclear power development to become sustainable as a long-term energy option, innovative fuel cycle and reactor technologies will have to be developed to solve the problems of resource utilization and long-lived radioactive waste management. In this context Member States clearly expressed the need for comparative assessments of various transmutation reactors.

Both the fusion and fission communities are currently investigating the potential of innovative reactor and fuel cycle strategies that include a fusion/fission system. The attention is mainly focused on substantiating the potential advantages of such systems: utilization and transmutation of actinides and long-lived fission products, intrinsic safety features, enhanced proliferation resistance, and fuel breeding capabilities. An important aspect of the ongoing activities is the comparison with the accelerator driven subcritical system (spallation neutron source), which is the other main option for producing excess neutrons.

Apart from comparative assessments, knowledge preservation is another subject of interest to the Member States: the goal, applied to fusion/fission systems, is to review the status of, and to produce a "compendium" of past and present achievements in this area.

The need to strengthen international cooperation in the field of the R&D for utilization and transmutation of actinides and long-lived fission products was emphasized by participants of several international forums:

- Special Scientific Programme on "Use of High Energy Accelerators for Transmutation of Actinides and Power Production", held at the Austria Center in Vienna, on 21 September 1994 in conjunction with the 38th IAEA General Conference;
- International Conferences on Accelerator-Driven Transmutation Technologies and Applications (ADTTA), in 1996, 1999, 2001, and 2003
- International Conferences on Emerging Nuclear Energy Systems (ICENES), in 1996, and 1999

As follow-up activities, the IAEA convened several meetings:

Consultancy on Hybrid Concepts for Nuclear Energy Generation and Transmutation held in Vienna, on 16-17 December 1996, which concluded that:

- an increasing number of groups is entering this field of research;
- many of these groups are not embedded in wider national activities;
- for these groups there is the need for coordinating their efforts and jointly funding projects, as well as for ensuring access to information from nationally or internationally coordinated activities.

Consultancy "Coolant Technologies for Sub-critical Blankets of Fusion/Fission Hybrid Reactors", held in Moscow, Russia, 6-7 July 2000, which suggested that the IAEA initiate activities in the field of fusion/fission hybrids aiming at facilitating international cooperation in this field of growing importance. The consultants recommended to prepare a specific publication in the area of fusion/fission hybrid systems: **"Background report on the use of fusion/fission hybrids for utilization and transmutation of actinides and long-lived fission products"**. The consultants also agreed on the outline of the report, and writing assignments were proposed.

By the end of 2003, the IAEA Secretariat had received 10 contributions dealing with the topics to be included in the report. At this moment, it became obvious that there is the need to

- elaborate the final content of the publication;
- update the title;
- review the contributions and identify the additions still needed;
- elaborate the schedule of preparation and publication of the report.

The present Consultancy was convened in Vienna, 8-12 December 2003, with the purpose to respond to these needs and advance the publication of the report.

The Agenda of the Consultancy included:

1. Information on the background of the meeting, preliminary content of the TECDOC, textbook requirements, need to avoid overlapping in the contributions etc.; (IAEA)
2. Discussion, adjustment and final approval of the content of the TECDOC;
3. Consideration of the necessary additions to the TECDOC;
4. Comprehensive review of individual contributions included/to be included in the TECDOC;
5. Appointment of authors (and co-authors, if necessary) responsible for the compilation of the TECDOC chapters;
6. Schedule for the publication of the TECDOC;
7. Discussion of possible future IAEA activities for the years 2004-2006; identification of the areas of common interest between the fusion and fission communities and of the corresponding

R&D needs to help defining the Agency's supporting role (through information exchange and collaborative R&D); recommendations to the Agency.

1. Information on the background of the meeting
This point was presented by IAEA (see Background above)

2. Content of the TECDOC

The content of the TECDOC was discussed, adjusted and approved (see Attachment 1). The title of the publication was amended to **"Compendium on the Use of Fusion/Fission/Accelerator Based Systems for the Utilization and Transmutation of Actinides and Long-Lived Fission Products",** so as to reflect the changes in the scope of the TECDOC proposed during the discussion of the content.

3. Consideration of the necessary additions to the TECDOC

Several additions were proposed and included in the new list content list of the TECDOC (see Attachment 1).

4. Review of individual contributions

The authors presented their contributions and identified in which part(s) of the TECDOC these contributions could be incorporated (see Attachment 2). Mr. G. Shatalov's remarks were discussed, and authors of the contributions were asked to contact him and respond via E-mail.

5. Appointment of authors (and co-authors, if necessary) responsible for drafting of the TECDOC chapters

Authorship of the TECDOC was reviewed and discussed. For a number of chapters (sub-chapters), responsible authors and co-authors are to be identified and invited. For this purpose, the IAEA Secretariat (A. Stanculescu) and several participants in the meeting will undertake the necessary steps to approach selected specialists and invite them to provide their contributions and services, if needed (see Attachment 3, list of actions to be sent only to concerned persons).

6. Schedule for the publication of the TECDOC

The approved schedule is given in Attachment 4. The authors were strongly requested to provide the contributions not later than by the end of April 2004 to facilitate publication of the TECDOC in 2004. Authors are requested to follow the "IAEA Guidelines for authors" distributed separately.

7. Discussion of possible future IAEA activities for the years 2004-2006

As follow-up actions to the publication of the TECDOC, the consultants formulated the following recommendations with regard to international collaboration activities under IAEA aegis to foster Member States activities in this field:

- Consider publishing the main findings of the "compendium" in general nuclear conferences and/or journals.
- Assess the performance/potential of different technologies for utilizing actinides and transmuting LLFP: based on the compendium, and look into possible scenarios involving all technologies. The criteria for judging the performance/potential are the GIF and INPRO ones, i.e., sustainability, economics, safety/reliability, safeguards/security. The implementation plan

for such an activity should include, as first step, a Technical Meeting during 2005 in preparation of a CRP; to be initiated, as second step, in IAEA's Program and Budget Cycle 2006-2007. The objectives of the CRP are to define the transmutation concepts and scenarios, assess their performance and potential, conclude on required R&D issues). Initiation of such a CRP is justified by the budget allocations (significant resources) and by the existing R&D programmes that indicate in many Member States a rather strong support for long-lived waste transmutation studies (to name just the most important ones: in the US has a major program for AFCI; in the EU plans the implementation of IP-EUROTRANS / IP-EUROPART and MOST in the 6^{th} EURATOM framework program; in Japan, in addition to considerable R&D studies in the fields of sub-critical core design, spallation target technology, accelerator development, and minor actinide fuel development, JAERI is proposing the construction of the Transmutation Experimental Facility (TEF); in the Republic of Korea, KAERI is working on the HYPER concept; in Russia and the CIS, previous, current and planned ISTC projects also indicate strong interest and support for transmutation R&D). Also, the current R&D programs are taken into consideration the progress in the ITER project and its potential for testing transmutation applications.

- Prepare a report on the comparative assessment of the thermo-physical and thermal-hydraulics properties of molten salts for nuclear systems. Implementation mechanism: Technical Meeting, and TECDOC.

Attachment 1

Revised List of Content

Compendium on the Use of Fusion/Fission/Accelerator Based Systems for the Utilization and Transmutation of Actinides and Long-Lived Fission Products **TECDOC Content (Chapters, Topics, responsible authors)**		
	RESPONSIBLE INTEGRATORS	CONTRIBUTORS
1. Summary:	**Y. Gohar, Y. Kadi, A. Stanculescu**	all
2. Introduction:	**Y. Gohar, Y. Kadi, A. Stanculescu**	Artisyuk, Ait-Abderrahim, Ignatiev, Knebel, Kochurov, Monti, Salvatores, Lopatkin, Seliverstov, Shatalov, Wu, Slessarev, Tocheny, Carré
3. Adopted Guidelines and General Aspects of Utilization and Transmutation of Actinides and LLFP ▪ Partitioning Technology ▪ Transmutation Technology ▪ Efficiency ▪ Safety characteristics ▪ Environmental impact	**Y. Gohar, Y. Kadi, A. Stanculescu**	Artisyuk, Kochurov, Shatalov, Kozodaev Seliverstov, Wu, Shmelev, Ignatiev, Kadi, Abderrahim, Monti, Uhlir (+ Laidler – call!, CEA – Madic, FZJ – Filges ! Modolo, Japan – Arai/JAERI), Slessarev

4. Technologies (Descriptions / State of the Art)		
4.1 Advanced/Innovative Critical Fission Systems		
4.1.1 Actinide Utilization Concepts (reference for comparative assessments later)		
▪ Open cycle options (gas cooled reactors, "fertile free for PWR/BWR ?", TIER1, …):	**Ignatiev (liquid), Carré (action on A. Stanculescu)**	CNRS (?), Bowman, Zaetta/Warin/Delpech, Carré
▪ Multiple recycling in thermal/epithermal reactors (APA, CORAIL, AMSTER, MOSART, …):	**Ignatiev (liquid), Carré (action on A. Stanculescu)**	Zaetta/Warin, Garzenne, Kochurov, Uhlir
▪ Multiple recycling in Fast Reactors (Brest, IFR, …)	**Lopatkin (action on Tocheny)**	Kochurov, Lopatkin, Bob Hill, Zaetta/Warin/Delpech
▪ MA utilization as burnable poison and plutonium denaturation	**Artisyuk**	Shmelev
4.1.2 Status of Nuclear Data	**Kadi**	Tocheny, Wu, Igashira, Shubin
4.1.3 Status of the Technology		
Fuel	**Ignatiev (liquid salt), Tocheny (solid fuels)**	Glatz, Pillon, Maershin (RIIAR), V. Orlov, Wallenius
Coolant	**Ignatiev (liquid salt), Tocheny (Pb, Pb-Bi) remark: use IAEA 1289**	Knebel, Monti/Gherardi, V. Orlov, Y. Orlov, P. Kirilov
Structural materials	**Ignatiev (for graphite in molten salt reactors), Tocheny**	Knebel/CNRS, Y. Orlov, V. Orlov

4.1.4 Performance ▪ TRU utilization ▪ LLFP transmutation ▪ Additional waste production ▪ Breeding (or other sustainability feature?) ▪ Unique/specific features	**Ignatiev (liquid), Carre (action on A. Stanculescu), Lopatkin (action on Tocheny), Artisyuk, Kadi, Tocheny (solid fuels), Tocheny (Pb, Pb-Bi)**	same as 4.1.1 in terms of authors of the concepts
4.1.5 Facilities (existing, planned, .)		
▪ Liquid Metal/Salt Loops	**Ignatiev (molten salt), Knebel (for Pb and Pb-Bi, European collaboration), Tocheny, Sekimoto) action on Artisyuk), LANL (action on Gohar)**	
▪ Advanced Actinide Fuel	**Tocheny**	Glatz, Pillon, Maershin
4.1.6 Status of R&D (current, planned, needs,…)		same as 4.1.5
▪ Liquid Metal/Salt Loops	**Ignatiev (molten salt), Knebel (for Pb and Pb-Bi, European collaboration), Tocheny, Sekimoto) action on Artisyuk), LANL (action on Gohar)**	
▪ Advanced Actinide Fuel	Tocheny	Glatz, Pillon, Maershin

4.1.7 Recommendations		same as 4.1.5
▪ Liquid Metal/Salt Loops	**Ignatiev (molten salt),** **Knebel (for Pb and Pb-Bi, European collaboration),** **Tocheny, Sekimoto) action on Artisyuk), LANL (action on Gohar)**	
▪ Advanced Actinide Fuel	Tocheny	Glatz, Pillon, Maershin
4.2 Fusion Driven Systems		
4.2.1 Blanket Design Concepts	**Artisyuk**	Cheng, Gohar, Schmelev, Wu, Shatalov, Perlado
4.2.2 Status of Nuclear Data	**Wu**	Tocheny, ENEA (?), Fischer (FZK), Cheng, Markovsky
4.2.3 Status of the Technology ▪ Fuel ▪ Coolant ▪ Structural materials	**Artisyuk**	Gohar, Wu, Perlado, Shatalov, Moir, Knebel, ENEA (?), Japan (?)
4.2.4 Performance ▪ TRU utilization ▪ LLFP transmutation ▪ Additional waste production ▪ Breeding (or other sustainability feature?) ▪ Unique/specific features	**Artisyuk**	same as 4.2.1 Cheng, Gohar, Schmelev, Wu, Shatalov, Perlado
4.2.5 Facilities (existing, planned, ..)	**ENEA or Japan (action on Gohar**)	Markovsky, ENEA (?), FZK (Fischer, ?), Japan (?)

4.2.6 Status of R&D (current, planned, needs,…)	**ENEA or Japan (action on Gohar)**	same as 4.2.5 Markovsky, ENEA (?), FZK (Fischer, ?), Japan (?)
4.2.7 Recommendations	**ENEA or Japan (action on Gohar)**	same as 4.2.5 Markovsky, ENEA (?), FZK (Fischer, ?), Japan (?)
4.3 Accelerator Driven Systems		
4.3.1 Design Concepts	**<u>Ait-Abderrahim</u>**	Kadi, Monti, Cinotti, Carluec, Kosodaev, Seliverstov, Gohar, KAERI (?), Ogawa, Slessarev
4.3.2 Status of Nuclear Data and Numerical Methods (discuss various energy ranges separately!)	**<u>Kadi</u>**	Mengoni, Leray, Filges, Kochurov, Tocheny, Titarenko, USA (?), KAERI, Igashira
4.3.3 Status of the Technology ▪ Fuel ▪ Coolant ▪ Structural materials ▪ Spallation Target	**<u>Knebel</u>**	Gohar (coolant/target), Ait-Abderrahim, Monti/Gherardi, Glatz, Slessarev, Zaetta, Delpech (GEDEPEON), Ogawa, KAERI, Y. Orlov (coolant, target), Poplavsky, Wu
4.3.4 Performance: ▪ TRU utilization ▪ LLFP transmutation ▪ Spallation Target ▪ Additional waste production ▪ Breeding (or other sustainability feature?) ▪ Unique/specific features	**<u>Ait-Abderrahim</u>**	Same as 4.3.1 Kadi, Monti, Cinotti, Carluec, Kosodaev, Seliverstov, Gohar, KAERI (?), Ogawa, Slessarev, Saito, Schmelev

4.3.5 Facilities (existing, planned,)	**<u>Knebel</u>**	Kozodaev, Seliverstov, Titarenko, Kadi, Ait-Abderrahim, Monti, Gherardi, Tocheny, Chigrinov, Schvetsov (SAD)
4.3.6 Status of R&D (current, planned, needs,…)	**<u>Knebel</u>**	same as 4.3.5 Kozodaev, Seliverstov, Titarenko, Kadi, Ait-Abderrahim, Monti, Gherardi, Tocheny, Chigrinov, Schvetsov (SAD)
4.3.7 Recommendations	**<u>Knebel</u>**	same as 4.3.5 Kozodaev, Seliverstov, Titarenko, Kadi, Ait-Abderrahim, Monti, Gherardi, Tocheny, Chigrinov, Schvetsov (SAD)
5 Comparative Assessment ▪ Actinide utilization ▪ LLFP transmutation ▪ Resource utilization, ▪ Waste generation ▪ Environmental impact	**<u>Gohar, Kadi, Stanculescu</u>**	Each contributor will provide short paragraph
6 Summary Recommendations: ▪ Open Issues ▪ R&D Needs and Facilities ▪ International Collaboration, IAEA Role	**<u>Gohar, Kadi, Stanculescu</u>**	Each contributor will provide short paragraph

Attachment 2

Summary of presentations and obligations

V. Artisyuk

Mr. Artisyuk provided two presentations to reflect the joint contribution with Prof. Korovin (Obninsk State University for Nuclear Power Engineering, Russia) on "Transmutation in Accelerator and Fusion Driven Systems" and with Prof. Shmelev (Moscow Engineering and Physics Institute, Russia) "Potentials of Fusion Hybrids to Support Innovative Nuclear Energy System". In his first presentation he presented the methodology of evaluation of neutron sources oriented for transmutation of fission products, stressing the advantageous neutronics of fusion-driven facilities in transmuting the Long-Lived Fission Products. The advantage is coming from the low energy associated with neutron production. Thus introduction of fusion-driven facilities will not give a strong effect on the configuration of nuclear energy system, with only small part of energy being associated with fusion facilities oriented for LLFP transmutation. Rich neutron economy provides the possibility of transmuting the key LLFP in their elemental form as they appear in spent fuel, thus avoiding the potentially dangerous operations on their isotope separation.
The second presentation concerned with application of advanced fuels doped with actinides to keep the fuel reactivity until high burn-up values. In both fuels under consideration (U-Np-Pu and Th-Pa-U) intermediate nuclide ^{237}Np or ^{231}Pa play the role of burnable poison that reduces the initial fuel reactivity while in the course of fuel irradiation gives nuclides with better fissile properties (^{238}Pu and ^{232}U) which in their turn could be transformed to final fissiles like ^{239}Pu or ^{233}U. The fuel concepts proposed are oriented to developing countries with lack of nuclear infrastructure.

Part of his presentation might be contributed to the sections

- "***3. Adopted guidelines and general aspects of Utilization and Transmutation of Actinides and LLFP***" (general scope of characteristics to estimate transmutation efficiency regardless of the particular type of transmuter);
- "***4.1 Advanced Critical Fission Systems"*** subsection on "***MA utilization as burnable poison***" (Chaser and contributor);
- "***4.2 Fusion Driven Systems***" (Chaser and contributor to the subsection on "Blanket design concept";
- "***5. Comparative assessment***" (Methodology of estimation of environmental impact of transmutation technology";
- ***"6. Summary recommendations"***

Y. Gohar

The first contribution considered fusion option to solve the disposition problems of the spent nuclear fuel and the transuranic elements. The results show that the top rated solution, the elimination of the transuranic elements, can be achieved in fusion reactors. A 334 MW of fusion power from a D-T plasma for thirty years with an availability factor of 0.75 can transmute all the transuranic elements of the 70,000 tons of the US inventory of spent nuclear fuel generated up to the year 2015. In addition, the fusion solution can eliminate the need for a geological repository site, which is a major advantage. Meanwhile, such utilization of the fusion power can provide an excellent opportunity to develop the fusion energy for the future. Fusion blankets with a liquid carrier for the transuranic elements can achieve a transmutation rate for the transuranic elements up to 80 kg/MW.y of fusion power in subcritical system with k_{eff} of 0.98. In addition, the liquid blankets have several advantages relative to the other blanket options. The energy from this transmutation is utilized to produce revenue for the system. Molten salt (Flibe), lithium-lead eutectic, and liquid lead are identified as the most promising transuranic carriers for this application.

The results from this analysis illustrate the potential of the fusion option for solving the disposition problems of the spent nuclear fuel and the transuranic elements. The fusion option deserves a detailed investigation, which defines the different system components, identifies the technical issues that require resolution, proposes schedule and plan to resolve these issues, estimates the total cost of the system to dispose of spent nuclear fuel, and compares cost and schedule with the other options. The initial results show that the fusion option has several unique advantages and excellent performance for performing this function.

The second contribution considered Lead-Bismuth Eutectic and Sodium cooled Tungsten spallation neutron sources to drive actinide and fission product transmuters. A detailed characterization has been performed to study the performance of these target materials as a function of the main variables and the design selections. The characterization includes the neutron yield, the spatial energy deposition, the neutron spectrum, the beam window performance, and the target buffer impact on the target performance. The characterization has considered high-energy proton and deuteron particles for the spallation process. The obtained results quantify the performance of these neutron sources as a function of the design variables.

Summary of Gohar's contributions and the TECDOC parts into which to include them:
- Fusion contribution for section 4.2.1, 4.2.3, and 4.2.4 (provided);
- Spallation target contribution for section 4.3.1, 4.3.3, 4.3.4 (provided);
- Spallation target design for section 4.3.4 (will be provided);
- Comparative section for 5 (will be provided).

V. Ignatiev

The molten salt concept is very important for consideration as an element of future nuclear energy system (self sustainable, low waste production and TRU burner system). This integrated technology because of fluid nature of fuel gives extra flexibility to get simpler back end of the fuel cycle scenarios due to easy fuel preparation, handling and recycling.

Effort was made to examine the conceptual feasibility of molten salt transmuter cores fueled with different compositions of TRU trifluorides from LWR spent fuel. Different conceptual core configurations, solvent systems, as well as different removal cycles for soluble fission products were considered. In this study the main attention has been paid to single stream transmuter system without U-Th support. These results can be put to Chapter 4.1.1, 4.1.4 and 4.154

New experimental data received in our studies feed into the conceptual design efforts. The consideration includes the following Na,Li,Be/F molten salt properties: phase transition behavior, trifluorides / oxides solubility for actinides and lanthanides, viscosity, thermal conductivity, heat capacity, and density. Container material compatibility and graphite behavior for the concept considered are also discussed. These results can be put to Chapter 4.1.4-4.1.7

Y. Kadi

Contribution from CERN

INTRODUCTION: √ - Incentive for transmutation of TRU & LLFP
√ - Role of external source driven systems (ADS in particular).

OBJECTIVES: **x** - Definition of objectives to be reached
x - Discussion on transmutation efficiency of TRU & LLFP from the neutron spectrum, neutron inventory and safety point of view.

TECHNOLOGIES: **x** - Status of nuclear data for TRU & LLFP (**4.1.2**)
x - Status of nuclear data for structural and spallation target material at intermediate and high proton energies (**4.3.2**)
√ - Current ADS concepts (**4.3.1**)
√ - Performance of transmutation capabilities of European Demonstration Facility (EADF-80 and ETD-250) (**4.3.4**)
√ - Description of existing or planned experimental facilities in Europe (**4.3.5**)
√ - Current status of ADS R&D in Europe (**4.3.6**).

COMPARISON: **x** - Comparative assessment of TRU & LLFP transmutation in critical reactors, ADS and Fusion driven systems (**5.0**).

RECOMMENDATIONS: √ - Discussion on the R&D needs and role of International Collaborations (**6.0**).

B. Kochurov

“Neutronics and Transmutation Effectiveness (general aspects)”

Kochurov B.P., Konev V.N., Kwaratzkheli A.Yu., Seliverstov V.V.

Presentation included:

1) The description of some problems of hazardous long-lived nuclides incineration, accumulated in the spent fuel of power reactors. The main contributors to the total inventory of radiotoxicity are plutonium, minor actinides (neptunium, americium, curium) and fission products. The radio toxicity of spent fuel falls down to the level of initial uranium in hundreds of thousand of years. The goal of transmutation is to convert long-lived hazardous isotopes into stable or short-species - p. 2,3 of the Table of content, 2) the description of neutronics in sub critical systems with external neutron sources: the dependence of power on the source intensity and sub criticality level, the changes in short-term behavior of such systems under reactivity exertions, the decrease of delayed neutron fraction in systems with circulating fuel, a potential decrease of accelerator power in systems with one-directional coupling under the same requirements to safety level as to conventional ones - p.4.3.2, 3) application of heavy water reactor (1 GW thermal power) with highly enriched uranium as a burner of LLFP; ^{99}Tc, ^{129}I, ^{79}Se, and ^{151}Sm from 3.6 WWR-1000 can be fully eliminated (converted to stable nuclides) at the same time of WWR operation, the transmutation of ^{90}Sr, ^{126}Sn is doubt full, it is impossible to transmute ^{93}Zr, ^{107}Pd, ^{135}Cs, ^{137}Cs. 4) application of a heavy water reactor for transmutation of americium and use of plutonium as fuel; 20 t of americium can be transmuted in the course of 100 GW.y operation with the conversion factor 0.57 , 5) transmutation of americium in a fast reactor with lead coolant in an equilibrium mode of fuel cycle is described, transmutation rate in BREST-OD-300 (700 MW thermal power) is about 64 kg/year - pp. 4.1.1, 4.1.4, 5.

V. Seliverstov

Electro-Nuclear Neutron Generator-XADS at ITEP

The subject of presentation is the description of the design of the experimental ADS facility with an 36 MeV proton energy, 0.5 MA current proton beam linear accelerator and a heavy water subcritical blanket with thermal power up to 100kW. The facility is being constructed at the Institute of Theoretical; and Experimental Physics (ITEP) (Moscow, Russia), and uses the main elements of the decommissioned ITEP research heavy water reactor for blanket construction and the ITEP linac ISTRA as the driver. The facility constructing is in the middle stage of accomplishing and at the present level of financing it can be started up in 4-5 years. The main goal of the facility is the experimental proving that an subcritical system with external source can reliably operate with the level of safety at least no less than that of the modern project critical reactors with so called natural safety. Some features of the blanket design concept aimed at the safety increasing are presented and the program of planned experiments in support of the safety increasing is briefly described.

Presented material may be used in the items: 4.3.5 Facility and 4.3.6 R&D.

The contributor has to present in more details the part concerning the planned experimental program.

The contributor is ready to take part in the item 4.3.1 Design concepts with providing the description of ADS concept with a high thermal flux level heavy water blanket for TRU destruction.

L. Tocheny

The ISTC is an intergovernmental organization created ten years ago by Russia, USA, EU and Japan in Moscow. The Center supports numerous science and technology projects in different areas, from biotechnologies and environmental problems to all aspects of nuclear studies, including those focused on the development of effective innovative concepts and technologies in the nuclear field, in general, and for improvement of nuclear safety, in particular.

Among almost four thousand projects submitted to ISTC, there are above one fifth of funded and as of yet non-funded projects related to different aspects of nuclear reactor physics, nuclear and radiation safety, reactor and Nuclear Fuel Cycle (NFC) engineering, including technologies for Radio-Active Wastes (RAW) management, transmutation and burial.

Nuclear Fuel Cycle with Transmutation of RAW

Nuclear Data:
Enormous scope of work has been done for measurement, study and modeling of principal nuclear processes leading to transmutation of RAW (about 20 projects). This program includes measurements of results of cascade-type spallation reaction initiated by high-energy protons or other charged particles, cross-section and product yield after fission and other reactions initiated by neutrons in the energy range up to 30 MeV. Nuclear data for large number of actinide isotopes have been measured, evaluated and processed into files. Special attention has been paid to delay neutrons data for minor actinides, important for control systems.

Modelling:

In accordance with global trends the ISTC projects develop transmutation technology both for critical reactor environment and for sub-critical blankets (accelerator and plasma driven). Results of long-term irradiation of samples with MA- minor actinides - in fast reactors and critical stands - will be presented.

Set of integral experiments are supported by ISTC with development and construction of large dimension models of sub-critical blanket with neutron source, such as YALINA program (Minsk-Sosny, project #B-070), SAD program (JINR, Dubna, project #2267). New systems for sub-criticality control (0.95 - 0.98) were suggested and tested.

Materials: Different fuel materials, including molten salt and molten uranium, are studied to be aimed on transmutation efficiency.

Heavy Metal Cooled Reactor and Technology

Principal features of using of lead or lead-bismuth as reactor coolant (neutronic, chemical, thermal, heat/mass transfer processes and hydro-dynamic characteristics) are studied and reviewed through the set of related projects.

Monograph "Natural Safety Fast Neutron Lead Cooled Reactor for Large Scale Nuclear Power" with description of the BREST project basis is prepared for publishing. Critical experiments with nitride fuel are planned on the BFS critical stand in IPPE, Obninsk.

Molten Fuel Reactor Concepts

Chemical and thermal behaviors of molten salts are studied with the special loop, constructed in VNIITF. Experimental program agreed with the MOST program of EU and is underway under close collaboration with EU institutions.

Unique concepts of reactor with melt uranium fuel with extreme heat and neutronic characteristics are demonstrated with detailed engineering, experimental and calculation analysis.

Accelerator Driven Systems

A lot of efforts ware aimed on development of principal components of ADS (target, blanket, accelerator). Basis for this study has been constructed in frames of the #0017 project “Feasibility study of technologies for accelerator based conversion of military plutonium and long-lived radioactive waste”.

The unique in the World pilot installation “Spallation Target System TC-1” has been developed, designed, fabricated and tested. Unit includes the proton beam target (1 MWt power), lead-bismuth circuit with pumps and heat-exchanger. The unique Russian experience of use of lead-bismuth eutectic as coolant in nuclear submarines was implemented at this project. The TC-1 System was shipped to USA, for its further testing and study.

Set of integral experiments are supported by ISTC with development and construction of large dimension models of sub-critical blanket with neutron source, such as YALINA program (Minsk-Sosny, project #B-070), SAD program (JINR, Dubna, project #2267). New systems for sub-criticality control (0.95 - 0.98) were suggested and tested.

Monograph “Proton (ion) Linacs for Accelerator Driven Transmutation Technology (ADTT), Prof. B. Murin, has been issued.

Partitioning (Radio-Chemical Technologies)

A set of projects are carrying out for development and demonstration of methods for extraction of definite radio-active isotopes for their further transmutation.

International Cooperation

Several informal topical Contact Expert Groups (CEGs) have been established by ISTC, the ISTC Parties and foreign collaborator institutions, which co-ordinate group of projects related to definite problems, e.g., “MOX and utilisation of Plutonium as reactor fuel”, “HTGR-M project”, “Transmutation Technologies”, “Severe Nuclear Accidents and Corium Management”.

Objectives of the CEGs are in compliance with the ISTC objectives, namely:
- To evaluate and prioritize project proposals,
- To monitor on-going projects, and
- To review and assess final reports checking specific project objectives.

June 2002 (ISTC, Moscow) – Workshop on RAW transmutation in fusion driven blankets.

[2]) Web-site: <istcinfo@istc.ru

Attachment 3

List of Actions

- Find “chaser” for gas cooled reactors open cycle (Gohar for US/Stanculescu for France)
- Ignatiev to ask Lopatkin to be a contributor for closed cycle fast reactors
- Artisyuk to ask Fukahori about data contributions
- Stanculescu to contact Glatz and Pillon for contributions in 4.1.3 and 4.1.5
- Stanculescu to contact Knebel (responsible chaser) for 4.1.3 and 4.1.5
- Artisyuk to contact Sekimoto on facilities LM / molten salt loops (4.1.5)
- Gohar to contact LANL on facilities LM / molten salt loops (4.1.5)
- Gohar to find out who’s responsible for fusion data at ENEA and others
- Tocheny to contact Markovsky about 4.2.2
- Gohar will contact Perlado
- Gohar to contact with Moir on 4.2.3
- Gohar to identify ENEA in 4.2.3
- Kadi to contact ENEA on 4.2.3 (Agostini, et al.)
- Gohar and Artisyuk to identify the Japanese contribution to 4.2.3
- Gohar to identify contributors and the integrator to 4.2.5 from ENEA, CEA, FZK, and Japan
- Gohar to identify US contact for 4.3.2
- Tocheny will contact and solicit contributions on 4.3.2 from Khlopin Institute, St. Petersburg, Fomushkin (VNIIEF), and Ignatyuk (IPPE)
- Stanculescu to find out whether Knebel is willing to coordinate 4.3.3
- Stanculescu to contact Glatz on 4.3.3
- Tocheny to contact Y. Orlov and Poplavsky on 4.3.3
- Stanculescu to contact Carré on 4.1.1 and on 5 “chaser”
- Tocheny to contact Lopatkin on 4.1.1 fast reactor “chaser

Attachment 4

Schedule for the publication of the IAEA TECDOC "Compendium on the Use of Fusion/Fission/Accelerator Based Systems for the Utilization and Transmutation of Actinides and Long-Lived Fission Products"

- Deadline for the author contributions: end of April 2004
- Deadline for the review of the contributions: end of May 2004
- Deadline for implementing the comments: end of June 2004
- Deadline for integrating the report: end of September 2004
- Deadline for final review, including peer reviewers end of October 2004
- Final review
- Publication: 31 December 2004

Consultancy to review and finalize the IAEA publication
"Compendium of the Use of Fusion/Fission Hybrids for the Utilization and Transmutation of Actinides and Long-Lived Fission Products"

IAEA Headquarters, VIC Vienna, 8 – 12 December 2003

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