

# **MEMORANDUM OF UNDERSTANDING**

**FOR SCIENTIFIC CO-OPERATION  
BETWEEN TECHNICAL CO-ORDINATORS  
OF RESEARCH PROJECTS  
SPONSORED BY DOE AND EURATOM**

Friday, June 3, 2005

1. Idaho National Laboratory hereinafter referred to as INL, the lead nuclear energy laboratory of the DOE sponsored project Advanced Fuel Cycle Initiative (AFCI), located at: Idaho Falls, Idaho. United States of America, and represented in this technical collaboration by Dr. Kemal Pasamehmetoglu, Fuel Development National Technical Director for AFCI [kop@inl.gov], and authorised by the U.S. DOE as technical co-ordinator of this sponsored research for the purpose hereof,

and

2. Forschungszentrum Karlsruhe GmbH, hereinafter referred to as FZK, as technical co-ordinator of the Euratom sponsored integrated project EUROTRANS, whose registered office is at: Forschungszentrum Karlsruhe, Hermann von Helmholtz Platz 1, 76344 Eggenstein-Leopoldshafen, FR Germany, and represented by Dr. Joachim Knebel, [Head Programme NUKLEAR] [ipeurotrans.knebel@nuklear.fzk.de] and duly authorised by the consortium of partners of the referred FP6 project for the purpose hereof,

**Hereinafter referred to individually or collectively as the "Parties"**

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## 0 PREAMBLES

WHEREAS the "Technical Exchange and Co-operation Arrangement between the U.S.DOE and EURATOM in the Field of Nuclear Related Technology Research and Development" (DOE/EURATOM Arrangement) represents the frame for various possibilities of co-operation, at programme and project levels.

WHEREAS the provisions of this DOE/EURATOM Arrangement are applicable to this MoU.

WHEREAS the annex A of the DOE/EURATOM Arrangement presents examples of areas, in which scientific co-operation between specific DOE project and corresponding parallel FP6 project is possible.

WHEREAS the DOE programme on nuclear fission research, Advanced Fuel Cycle Initiative is addressing specific areas of the referred annex A.

WHEREAS, the Sixth Framework Programme (FP6) of the European Atomic Energy Community for nuclear research and training activities (Council Decision 2002/668/Euratom of 3 June 2002; OJ L232), adopting a specific program (Euratom) for Research and Training on Nuclear Energy (Council Decision 2002/837/Euratom of 30 September 2002; OJ L294) and concerning the Rules for the participation of undertakings, research centres and universities in the FP6 implementation (Council Regulation Euratom 2322/2002 of 5 November 2002; OJ L355) is addressing areas referred in annex A.

WHEREAS specific items of both the DOE sponsored project Advanced Fuel Cycle Initiative (AFCI) and the Euratom sponsored project EUROTRANS represent areas of annex A.

**Therefore it is hereby agreed as follows:**

## 1 Art.1. DEFINITIONS

Consortium	Signatories to a FP6 project
DOE	U.S. Department of Energy
EU	European Union
EURATOM	European Atomic Energy Community
FP6	Sixth Framework Programme of EURATOM
MoU	Memorandum of Understanding
Parties	Technical co-ordinators in this MoU

## 2 Art.2. PURPOSE OF THE MEMORANDUM OF UNDERSTANDING

The main purpose of establishing this MoU is to agree on the terms of a specific co-operation between partners of the DOE project Advanced Fuel Cycle Initiative (AFCI) and the consortium of the FP6 project EUROTRANS.

## 3 Art.3. SCIENTIFIC / TECHNICAL SCOPE OF THE CO-OPERATION

The areas of scientific co-operation covered by this MOU are identified in Annex 1. This MoU is coupled to the Consortium Agreement of the European Commission (FP6) sponsored project and to a DOE funded technical programme.

## 4 Art.4. MISCELLANEOUS

### 4.1 MoU Term

This MoU will enter into force upon signature and shall remain in force as long as both projects -referred in Art.2- continue. Conditions for extension can be agreed among the Parties.

### 4.2 Language

This MoU is drawn up in English, which shall govern all documents, notices and meetings for its application and/or extension or in any other way relative hereto.

  
Dr. Kemal Pasamehmetoglu

U.S. Technical Co-ordinator  
in Pocatello Idaho  
on June 3, 2005

  
Dr. Peter Fritz

Member of the  
Executive Board  
of FZK

  
i.v. Joachim U. Knebel.

Dr. Joachim U. Knebel

FP6 EUROTRANS Co-ordinator  
in Pocatello Idaho  
on June 3, 2005

## Annex 1:

The **EURATOM FP6 Integrated Project EUROTRANS** (European Research Programme for the Transmutation of High Level Nuclear Waste in an Accelerator Driven System) of the European Commission aims to work towards procuring a dedicated transmuter of high level nuclear wastes on the basis of an accelerator driven system (ADS). The strategic outcome of EUROTRANS is expected to provide a state-of-the-art, reliable basis for the assessment of the technical feasibility of transmutation by ADS and a first estimate of the cost of an ADS based transmutation system. It is also expected to provide important input elements to authorities to decide whether to embark on the conceptual engineering design of an ADS for transmutation and its eventual construction after completion of this project.

The **U.S. DOE Advanced Fuel Cycle program** is exploring multiple options for managing the spent nuclear fuel while transitioning to the next generation of nuclear energy systems. ADS is one of the options that are being considered, if the waste amounts are to be reduced to eliminate the needs of additional repositories in the U.S.

### **Technical Collaboration**

The areas of technical collaboration in the transmutation area are:

- 1. Design of Transmutation facilities,**
- 2. Coupling of ADS components,**
- 3. Advanced fuel development,**
- 4. Development of materials and coolant technologies and**
- 5. Basic nuclear data.**

The following are the planned activities for collaboration in the above areas.

### **I. Design of Transmutation facilities:**

EUROTRANS project aims to develop an advanced design of a linear proton accelerator driven, windowless 50 to 100 MWth sub-critical system XT-ADS (eXperimental facility demonstrating the technical feasibility of Transmutation in an Accelerator Driven System). Pb-Bi eutectic (LBE) is used as a core coolant and spallation target material. The core is designed to operate with standard MOX driver fuel that is capable of handling a few minor actinide (MA) oxide fuel assemblies. A conceptual design of the European Facility for Industrial Transmutation (EFIT) is also made in which Pb is used as a core coolant and spallation material. EFIT is loaded with U-free transmutation dedicated oxide fuel, having same fundamental design characteristics as XT-ADS. The XT-ADS with initial loading of standard MOX fuel, is intended to be a test-bench for the main components and operation scheme for the EFIT and will govern its future design effort. A safety study and an economic assessment of the two designs will also be carried out.

The U.S. does not have a dedicated effort on the design of an accelerator driven transmuter but continues to perform research in the areas that affect the ADS design. In addition the U.S. is considering construction of an accelerator driven Materials Test Station that can be used for the proof of performance of materials and fuels. At present, until a decision is made on the U.S. fuel cycle, U.S. is expected to fund this effort at a low level to participate in the design reviews and to provide consultation for accelerator and target design in support of the ADS design.

### **II. Coupling of ADS components:**

EUROTRANS project aims to provide validated experimental input from relevant experiments at sufficient power (20-100 kW) on the coupling of an accelerator, a spallation target and a sub-critical blanket in order to assist the design of XT-ADS and EFIT. These experiments should provide design input on the dynamics and

experimental techniques of such a coupled system with feedback effects, together with shielding, safety and licensing issues. More detailed activities of the work in this area of EUROTRANS will be specified after the completion of a feasibility study in the early part of the project.

The U.S. Reactor-Accelerator Coupling Experiments (RACE) project is a university transmutation research project contributing to the DOE Advanced Fuel Cycle Initiative (AFCI). It is a series of accelerator-driven subcritical systems (ADSS) experiments that will be conducted at the Idaho State University, at the University of Texas (UT) at Austin, and at Texas A&M University. Collaborators from UNLV and University of Michigan are also involved. These systems will include a zero-power subcritical assembly at ISU, a 1-MW TRIGA reactor at UT-Austin and a 1-MW TRIGA modular core at Texas A&M. In these experiments source neutrons will be produced by photo-nuclear reactions in heavy-metal targets driven by transportable electron linacs in the 20-40 MeV range. The RACE project is divided in four phases, Phase I: ISU RACE, Phase II: UT-Austin RACE, Phase III: Texas A&M RACE, and proposed Phase IV: RACE-PLUS upgrade.

### **III. Advanced fuel development**

EUROTRANS plans to design a reference fuel for the EFIT selected among the list of potential refractory candidates (oxide composite, nitride) according to performance, safety, fabricability and reprocessability criteria. The planned studies include:

- Fuel modelling in normal and transient operation and fuel design in consistency with the ETD/EFIT core.
- Safety behaviour of fuel in accident conditions.
- Out-of-pile property measurements (thermal, mechanical, chemical) on oxide and nitride TRU-fuels.
- Fabrication, characterization and irradiation tests of oxide CERCER and CERMET for Phénix.
- Irradiation and PIE of oxide and nitride TRU-fuels in HFR and R2.

The U.S. plans to develop, test and analyze metal and nitride fuels containing TRU for transmutation applications. The development includes:

- Laboratory scale fabrication of the metal and nitride fuels including an assessment of the implications for commercial scale fabrication by analyses
- Characterizing the metal and nitride fuels with different compositions and using various fabrication parameters
- Irradiation of metal and nitride fuel samples in the Advanced Test Reactor (ATR) in Idaho
- PIE on metal and nitride fuel irradiated in ATR
- Fabrication, characterization and shipment of metal and nitride fuel for PHENIX irradiation (FUTURIX-FTA)
- First principle modeling of irradiation performance for transmutation fuels

#### **IV. Development of materials and coolant technologies**

The work of EUROTRANS in this area is devoted to the development and assessment of structural materials and heavy liquid metal technologies for transmutation systems.

The activities are:

- Reference materials (AISI 316L and T91 steels) and operating conditions.
- Reference materials characterisation in HLM.
- Reference Materials irradiation studies.
- Advanced thermal-hydraulics & measurement techniques.
- Large – scale integral tests
- MEGAPIE related studies:

The U.S. scope of work will be to develop, test and analyze lead-alloy coolant technology and irradiation effects on structural materials with emphasis on high-energy radiation damage (ADS and fast reactor applications) with high helium and hydrogen production in the structures. The research activities include:

- Testing long term corrosion behaviour of various materials in the U.S. LBE loops

- Testing various implementation sensor technologies for oxygen control in lead-alloy coolant for various thermal-hydraulic conditions
- Development and testing various instrumentation in the U.S. LBE loops
- Modeling the thermal-hydraulics of lead-alloy cooled systems
- Developing calibration standards
- Assessment of irradiation, and spallation and activation products on corrosion behavior
- Structural testing of irradiated materials in hot-cells
- Modeling of high-energy particle irradiation on structural materials
- Maintenance and update of Materials Handbook
- Continue to support MEGAPIE related analyses and testing at ~1 FTE level
- Engineering-scale lead/lead-bismuth test facility being planned in INL

## **VI. Basic nuclear data**

The activities of EUROTRANS in this area are:

- Measurement of new nuclear data for the simulation of the neutron transport on Pb and Bi
- Measurement of new nuclear cross section of certain minor actinides
- To improve the existing nuclear data libraries for Pb, Bi and selected Pu and Ma isotopes
- To improve the high energy nuclear models
- To develop procedures and implement in simulation codes to propagate nuclear data uncertainties to final reactor and cycle parameter estimations
- To identify the most needed nuclear data and the required precision for the simulation of industrial scale transmutation ADS
- To validate the existing and newly developed codes and nuclear data with integral experiments information

The U.S. scope of work will be to continue to measure and evaluate various cross-sections relevant to transmutation scenarios. Part of the effort also includes model

development for the MCNPX and other supporting codes and models. The specific activities include:

- Nuclear Cross-Section Measurements critical isotopes of Pu, Np, Am, and Cm.
- Nuclear Data Evaluations and updating of the Evaluated Nuclear Data File (ENDF)
- Upgrading of Nuclear Code Development - MCNPX and VARIANT for accuracy, speed, and usability for system studies, design analyses, and safety analyses
- Materials Cross-Sections - This activity will measure gas production in structural materials and fuels and benchmark atomic displacement calculations.
- Benchmark Nuclear Codes - This task will benchmark key code suites to long-cycle burnup data available from fast and thermal flux systems to improve the accuracy for transition fuel cycle, equilibrium fuel cycle, and Gen IV performance prediction and design.

### Reporting

For all areas of collaboration, progress will be reported jointly by the DOE technical leads and the EUROTRANS consortium on a regular basis, consistent with established practice of the US DOE and EURATOM Sixth Framework Program.

### Meetings

It is agreed to have regular technical collaboration meetings, alternating between the USA and Europe, twice a year.

### Technical Contact Persons

N°	Title	US-DOE	EURATOM
I	Design of transmutation facilities	LANL (Mike Cappiello)	SCK.CEN (Hamid Aït Abderrahim)
II	Coupling of ADS components	ANL (Georges Imel)	FZK (Joachim U. Knebel)
III	Advanced fuel development	INL (Rorry Kennedy)	CEA (Sylvie Pillon)
IV	Development of materials and coolant technologies	LANL (Ning Li)	FZK (Concetta Fazio)
V	Basic nuclear data	LANL (Eric Pitcher)	CIEMAT (Enrique Gonzalez)