PROJECT ARRANGEMENT NE-02

between
The Department of Energy of the United States of America
and
The Japan Atomic Energy Agency
under the
Implementing Arrangement between the Department of Energy of the United States of America and the Ministry of Education, Culture, Sports, Science and Technology of Japan Concerning Cooperation in the Field of Nuclear Energy-Related Research and Development
for
Cooperation on Fuel Cycle Research and Development and Waste Management

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1. Objective

The Department of Energy of the United States of America (DOE) and the Japan Atomic Energy Agency (JAEA), referred to collectively herein as "Participants",

Acting in accordance with Sections 4 and 5 of the "Implementing Arrangement between the Department of Energy of the United States of America and the Ministry of Education, Culture, Sports, Science and Technology of Japan Concerning Cooperation in the Field of Nuclear Energy-Related Research and Development" of January 7, 2013 (hereinafter referred to as the "Implementing Arrangement"),

Have decided to undertake a cooperative effort under this Project Arrangement to perform fuel cycle and waste management research and development.

2. Scope of Work

The scope of work under this Project Arrangement is as follows:

(1) Separations
  a. Extraction of Uranium from Seawater
  b. Aqueous Separations from Oxide Fuels
(2) Advanced Fuels
  a. Properties, Performance and Analysis
(3) Waste Management
  a. Borosilicate Glass Dissolution Studies

3. Project Management

Each Participant will designate a Project Coordinator and a Principal Technical Contact. The Project Coordinators will be responsible for detailed management, including technical progress reviews, of the cooperation under this Project Arrangement. The Principal Technical Contacts will serve as the points of contact concerning technical details.

The specific tasks to be conducted are identified in Appendix I (Appendix I-1 to Appendix I-4) and key personnel are identified in Appendix II (Appendix II-1 to Appendix II-4) of this Project Arrangement. Both Appendix I and Appendix II will be updated as appropriate.

4. Financial Management

All costs resulting from the work carried out under this Project Arrangement will be the responsibility of the Participant that incurs them. The ability of the Participants to carry out their specific tasks is subject to the availability of appropriated funds.

5. Intellectual Property

With respect to the protection and distribution of intellectual property rights and other rights of a proprietary nature created or furnished in the course of the cooperative activities under this Project Arrangement and the protection of business-confidential information exchanged under this Project Arrangement, the following paragraphs will apply in addition to the paragraphs of the Intellectual Property Annex to the Implementing Arrangement.

5.1 Inventions

For the purpose of this Project Arrangement, "Invention" means any invention made in the course of the cooperative activities under this Project Arrangement which is or may be patentable or otherwise protectable under the laws of Japan, the United States of America, or any third country.

In accordance with paragraph 3.B.(iii)(a) of the Intellectual Property Annex to the Implementing Arrangement, rights to an Invention made as a result of joint research conducted under this Project Arrangement, and allocation of benefits derived therefrom, are provided as follows:

- If an Invention is made solely by a Participant or a contractor (hereinafter referred to as the "Inventor"), the Inventor will obtain all right, title and interest in and to such Invention in all countries.
- If an Invention is made jointly by a Participant/contractor of both Participants, each Participant will obtain all right, title and interest in and to such Invention in its own country. In third countries where both Participants intend to obtain the right to the Invention, the Participants will be joint owners of such rights. The Participants may jointly apply to obtain and/or maintain the relevant rights. The Participants should come to an agreement concerning the costs associated with obtaining and/or maintaining such rights.
- In any country where the Inventor which is entitled to obtain the rights therein decides not to obtain such rights and interests, the other Participant has the right to do so.
- Each Participant will have, in its own country, for its own research and development activities within the scope of work of this Project Arrangement, during the term of this Project Arrangement, a free right of use of Inventions, whether protected or not by intellectual property rights, solely owned by the other Participant and resulting from the joint research performed under this Project Arrangement.

5.2 Copyright

Allocation of rights to an Invention and benefits derived therefrom stipulated in paragraph 5.1 above will be applied *mutatis mutandis* to disposition of rights to copyrighted works created in the course of the cooperative activities conducted under this Project Arrangement.

6. General Consideration

This Project Arrangement is pursuant to and subject to the Implementing Arrangement, which is, in turn, pursuant to and subject to the agreement between the Government of Japan and the Government of the United States of America concerning cooperation in the field of nuclear-related research and development, effected by the Exchange of Notes of March 9, 2012.

7. Commencement, Modification, and Discontinuation

1. This Project Arrangement will enter into effect upon signature by both Participants, continue until the end of September 2020, unless earlier discontinued in accordance with paragraph 7.2, and may be extended or modified by the Participants' mutual written consent, provided that the Implementing Arrangement remains in effect.

2. This Project Arrangement may be discontinued at any time by the Participants' mutual consent in writing. Alternatively, a Participant that wishes to discontinue its participation in this Project Arrangement should endeavor to provide at least sixty (60) days advance notification in writing to the other Participant.

Signed in duplicate.

FOR THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA:

Signature: [signature]

Printed Name: John W. Herczeg

Title: Associate Deputy Assistant Secretary for Fuel Cycle Technologies

Date: Nov 1, 2013

FOR THE JAPAN ATOMIC ENERGY AGENCY:

Signature: [signature]

Printed Name: Kazumi Aoto

Title: Director General, Advanced Nuclear System Research and Development Directorate

Date: Nov. 1, 2013

PROJECT ARRANGEMENT NE-02

APPENDIX I-1

Description of Tasks for Extraction of Uranium from Seawater

1. Outline and Responsibility of Tasks

Although uranium is present in very low concentrations in seawater (3.3 part per billion), the oceans contain over 4,500 million tons of uranium, which would last for centuries even with aggressive nuclear energy growth. Economic extraction of uranium from seawater could ensure a feasible fuel supply for nuclear power for millennia to come. This project will focus on efforts to develop the seawater uranium harvesting method.

The following table describes the primary tasks which define this project.

Activity	**Description**
Task 1	Seawater uranium extraction technology cost analysis
Task 2	Adsorbent materials development by radiation induced graft polymerization
Task 3	Marine testing of the uranium recovery systems

Task 1: Seawater Uranium Extraction Technology Cost Analysis

Technology Cost Analysis – To understand and reduce uncertainties is the primary focus of this cooperation. Factors such as number of loading/elution cycles, material degradation, the location of potential deployment, efficient current velocity for maximum loading/recovery, and potential co-products may be considered.

Task 2: Adsorbent Materials Development by Radiation Induced Graft Polymerization

Adsorbent Materials Development – To optimize the adsorbent manufacturing process is a priority for this cooperation. Polymer fiber sorbent materials such as high-density polyethylene are selected for functional group grafting. Nonwoven materials and braidable fiber spools will be modified by radiation induced graft polymerization to generate the adsorbent materials.

Task 3: Marine Testing of the Uranium Recovery Systems

Marine Testing of Recovery System – Marine testing is a critical step to evaluate the performance of adsorbent materials. To simulate ocean current environments, flow through systems in laboratory settings will be conducted. The sorption capacity and effect of chemical desorption will be studied using natural seawater.

2. Sites

The tasks will be conducted at:

1. Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA
2. Pacific Northwest National Laboratory, Richland, Washington, USA
3. Takasaki Advanced Radiation Research Institute, JAEA, Takasaki, Gunma, Japan

3. Schedule

The following table provides an overview of the duration of each of the tasks that define this project.

Activity	2013 CY	2014CY				2015CY				2016CY				2017CY	
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Task 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Task 2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Task 3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Q# = Quarter -- Q1: January – February, Q2: April – June, Q3: July – September, Q4: October – December

4. Deliverables

The exchanged data under this activity will be used by JAEA and U.S. DOE to support the future research described in the tasks. Data exchange meetings will be conducted on an annual basis as bilateral meetings, alternately in the United States and in Japan. Pre-published data may be exchanged to help in ongoing research.

PROFECT ARRANGEMENT NE-02

APPENDIX II-1
Key Personnel List

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PROJECT ARRANGEMENT NE-02

APPENDIX I-2

Description of Tasks for Aqueous Separations from Oxide Fuels

1. Outline and Responsibility of Tasks

Development of treatment methods of radioactive nuclear wastes is one of the important issues from the standpoint of waste reduction prior to geological disposals. Therefore, the partitioning and transmutation technique and the other related techniques for waste reduction have been studied. In these studies, new ligands for separation of radioactive materials, which seek to improve economical efficiency, and reduce adverse environmental impacts, are key materials. This project will focus on design and development of desired new extractant, based on both theoretical and experimental approaches.

The following table describes the primary tasks which define this project.

Activity	Description
Task 1	Molecular design of new extractants
Task 2	Evaluation of new separation systems in comparison with existing separation systems

Task 1: Molecular design of new extractants

For development of a promising extractant for treatment of waste solution, molecular design studies by coordination and solution chemical studies will be performed to understand fundamental features of metal-ligand complexes through the studies on chemical bond and coordination structures between ligand and metals using X-ray analyses, Nuclear Magnetic Resonance (NMR). Target ions are minor actinides like Am, Cm, Cs, Sr, platinum group elements and the other fission products. This collaboration will be performed mainly through information exchange meeting. In addition, material exchange and personal exchange will be carried out if necessary.

Task 2: Evaluation of new separation systems in comparison with existing separation systems

For the evaluation of performance of extractants, solution and extraction studies using new materials will be performed. In these studies, both sides will share target extractants; experimental conditions and performers for both sides will be jointly decided on to ensure effective collaboration and results. This collaboration will be performed mainly through information exchange meeting. In addition, material exchange and personal exchange will be carried out if necessary

2. Sites

The tasks will be conducted at:

1. Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA
2. Idaho National Laboratory, Idaho Falls, Idaho, USA
3. Argonne National Laboratory, Argonne, Illinois, USA
4. Pacific Northwest National Laboratory, Richland, Washington, USA
5. Kansai Photon Science Institute (Harima District), JAEA, Hyogo, Japan
6. Tokai Research and Development Center, Tokai-mura, Ibaraki, Japan

3. Schedule

The following table provides an overview of the duration of each of the tasks that define this project.

Activity	2013 CY	2014CY				2015CY				2016CY				2017CY			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Task 2		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Q# = Quarter -- Q1: January – February, Q2: April – June, Q3: July – September, Q4: October – December

4. Deliverables

The exchanged data under this activity will be used by JAEA and DOE to support the future research described in the tasks. Data exchange meetings will be conducted on a semi-annual basis as bilateral meetings, alternately in the United States and in Japan. Pre-published data may be exchanged to help in ongoing research .

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APPENDIX II-2
Key Personnel List

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PROJECT ARRANGEMENT NE-02

APPENDIX I-3

Description of Tasks for Advanced Fuels: Properties, Performance and Analysis

1. Outline and Responsibility of Tasks

The goal of this effort is to perform collaborative R&D for evaluation of basic properties and irradiation behavior of oxide fuels. The objectives of the collaboration are to expand the basic properties and performance data and understanding of oxide fuels including employment of advanced experimental techniques, and to contribute to science-based fuel performance analysis technologies through development and application of advanced modeling and simulation. The scope of work is as follows:

Activity	Description
Task 1	**Experiments on basic properties of oxide fuels** including high temperature oxidation behavior and property determination as a function of stoichiometry. This task will also include *in-situ* property determination near and above the fuel melting point.
Task 2	**Development and evaluation of PIE data of advanced oxide fuels** including PIE of the B-14 experiment, advanced PIE analysis of the AFC-2C and -2D experiments, and development of microprobe methods for analysis of irradiated fuels.
Task 3	**Modeling and simulation for describing irradiated fuel characteristics as a function of O/M ratio** will include analysis of the B-14 irradiation using Moose/Bison/Marmot-based advanced simulation.
Task 4	**Planning for irradiation tests of MA-bearing MOX fuel pins** This task will develop a new plan to irradiate MA-bearing MOX fuel pins at fast reactors *Joyo* and *Monju*. This plan will be carried out in intermediate term cooperation.

Task 1: Experiments on basic properties of oxide fuels

Task 1.1 Oxidation behavior at high temperatures and under normal, off-normal/accident conditions

- Oxidation behavior of UO_2, enhanced UO_2, and UO_2 with fission products and fuel system constituents (DOE)

  Oxidation behavior of UO_2, enhanced UO_2, and UO_2 with fission products and fuel system constituents in air and steam condition.

  Design and execution of Raman experiments

- Oxidation behavior of UO_2 and MOX (JAEA)
  Oxidation behavior of UO_2 and MOX investigated at high temperatures as a function of oxygen partial pressure.

Task 1.2 Property measurements in PO_2-controlled atmosphere at high temperatures

- Property measurements of UO_2, enhanced UO_2, and UO_2 with fission products and fuel system constituents (DOE)
  Thermophysical properties of UO_2, enhanced UO_2, and UO_2 with fission products and fuel system constituents

- Property measurements of MOX (JAEA)
  Sintering, O/M change, thermal expansion and Raman measurements of MOX investigated at high temperatures

Task 1.3 In-situ high temperature analysis

- Experiments using neutron, proton and photon sources (DOE)
  In-situ studies for both melt studies and for high temperature defect structures as a function of O/M.

- Experiments by lamp-heating method (JAEA)
  In-situ observations and post mortem analysis of MOX fuel melted in various atmospheres.

Task 2: Development and evaluation of PIE data of advanced oxide fuels

- Advanced analysis of irradiation behavior on AFC-2C/D (DOE)

  Perform and evaluate advanced non-destructive analysis on AFC-2C/D rodlets in which (MA)-MOX fuels with O/M=1.95 and 1.98 were irradiated.

- Development of neutron resonance imaging techniques (DOE/JAEA)

  Development of techniques for nondestructive evaluation of fuel chemistry and structure using neutron resonance.

- Development of microprobe methods for analysis of irradiated fuels (DOE/JAEA)

  Development of handling procedures, standards and analysis techniques for shielded microprobe characterization of irradiated oxide fuels

- PIE of irradiation behavior on B-14 test (JAEA)

  Evaluation of PIE results of the B-14 Joyo irradiation of low density Am-bearing MOX fuels with O/M's of 2.00, 1.98 and 1.96.

Task 3: Modeling and simulation for describing irradiated fuel characteristics as a function of O/M ratio

- Analysis of irradiation performance and development of analytical descriptions of fuel behavior using advanced modeling and simulation techniques (DOE/JAEA)
  Analysis and assessment of the B-14 Am-MOX fuel irradiation characteristics as a function of O/M ratio using MBM with priority on physical properties, fuel and species redistribution, microstructure evolution and thermal profile.

Task 4: Planning for irradiation tests of MA-bearing MOX fuel pins

- MA-bearing MOX fuels have been developed to reduce high level radioactive waste as fuels of sodium-cooled fast reactors. In this task, a new irradiation test plan will be made to carry out transient tests at *Joyo* and *Monju* and to evaluate effect of MA-bearing to power-to melt of MOX fuels. The plan of supply of Np/U oxide raw powder, property measurements, fuel pin fabrication, irradiation test, PIE and analysis of irradiation behavior will be included, which will be carried out in intermediate term cooperation.

2. Sites

The tasks will be conducted at:

1. Los Alamos National Laboratory, Los Alamos, New Mexico, USA
2. Idaho National Laboratory, Idaho Falls, Idaho, USA
3. Tokai Research and Development Center, JAEA, Tokai-mura, Ibaraki, Japan

3. Schedule

The following table provides an overview of the duration of each of the tasks that define this project.

Activity	2013 CY	2014 CY				2015CY				2016CY				2017CY			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Task 2	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Task 3				X	X	X	X	X	X	X	X	X	X	X	X	X	X
Task 4	X	X	X	X													

Q# = Quarter -- Q1: January – February, Q2: April – June, Q3: July – September, Q4: October – December

4. Deliverables

The exchanged data under this activity will be used by JAEA and DOE to support the future research described in the tasks. Data exchange meetings will be conducted on a semi-annual basis as bilateral meetings. Pre-published data may be exchanged to help in ongoing research. Key deliverables are listed in the following table:

Date	Description
Task 1	
April 2015	Summary report of UOX and MOX oxidation behavior at high temperatures and under normal, off-normal/accident conditions
April 2016	Summary report of property measurements in P_{O2}-controlled atmosphere at high temperatures
December 2017	Summary report of high temperature in-situ oxide fuel analysis
Task 2	
March 2016	Summary report of post irradiation examination of the B-14 experiment
December 2017	Summary report of advanced post irradiation examination analysis of the AFC-2C and -2D experiments
Task 3	
December 2017	Analysis and assessment report of the B-14 Am-MOX fuel irradiation characteristics as a function of O/M ratio using advanced modeling and simulation techniques
Task 4	
September 2014	Irradiation test plan of MA-bearing MOX fuels

PROJECT ARRANGEMENT NE-02

APPENDIX II-3
Key Personnel List

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PROJECT ARRANGEMENT NE-02

APPENDIX I-4

Description of Tasks for Borosilicate Glass Dissolution Studies

1. Outline and Responsibility of Tasks

We propose a joint study to improve the understanding of the mechanisms governing glass dissolution in different geological environments, leading to a robust and defensible model for calculating long term radionuclide releases under potential disposal conditions.
For this study the following three tasks are set:

Activity	Description
Task 1	**Identification of alteration rate acceleration mechanism and conditions**
Task 2	**Investigation into the protective nature of glass alteration layers**
Task 3	**Model developments for potential disposal environments**

Task 1: Identification of alteration rate acceleration mechanism and conditions

It can be expected that if environmental conditions in the vicinity of the glass do not prevent solution saturation with respect to silicon near the glass surfaces, the glass alteration rate will drop to the so-called "residual rate". There have been some recent studies, however, suggesting that precipitation of secondary phases, such as iron silicate, magnesium silicate and, especially at alkaline pH, zeolite, strongly increase the glass alteration rate. It is generally presumed that the impact is due to consummation of certain rate controlling species. However there is some evidence that the effect may be more complicated. The alteration rate controlled by the precipitation of secondary phases becomes much higher than the residual rate and this acceleration is referred to as stage III. The scope of work in this task will be to identify the mechanisms responsible for the onset and potential sustention of stage III and then to use those mechanisms to identify the impacts of stage III, the conditions that precipitate the acceleration, and ways to ensure that those conditions will not be met in a repository environment.

Task 2: Investigation into the protective nature of glass alteration layers

Some studies have shown that certain glass alteration layers can be protective or passivating under certain conditions. The protectiveness of the alteration layer is assumed to be attributable to its high density and this density may be diminished by silicon consumption in low silicon solution conditions. The scope of work in this task will be to investigate the protective nature of glass alteration layers in closed or open systems. A closely coupled program of theory, experiment, and modeling will be employed to understand the mechanisms and rates for glass corrosion resulting from the protective nature of alteration layer. If the protective effect of the alteration layer in near field conditions, can be considered the long-term rate will be controlled by diffusion of key elements, such as silicon or hydrogen.

Task 3: Model developments for potential disposal environments

The final stage of study will be to consider the impacts of disposal environments on long-term rate. In this task, models and experiments described in the two previous tasks will be expanded to consider potential engineered barrier system components and ground water compositions. Fully-coupled reactive transport models will be developed and validated for use in performance modeling. These models may be the combined effort of DOE and JAEA, they may be the result of a multi-lateral effort with other participants, or may be unique to the United States or Japan. In any case, they will be developed and validated collaboratively.

2. Sites

The tasks will be conducted at:

1. Pacific Northwest National Laboratory, Richland, Washington, USA
2. Argonne National Laboratory, Argonne, Illinois, USA
3. Savannah River National Laboratory, Aiken, South Carolina, USA
4. Lawrence Berkeley National Laboratory, Berkeley, California, USA
5. Tokai Research and Development Center, JAEA, Tokai-mura, Ibaraki, Japan

3. Schedule

The following table provides an overview of the duration of each of the tasks that define this project.

Activity	**2013 CY**	**2014 CY**				**2015 CY**				**2016 CY**			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Task 1	X	X	X	X	X	X	X	X	X	X	X	X	X
Task 2			X	X	X	X	X	X	X	X	X	X	X
Task 3	X	X	X	X	X	X	X	X	X	X	X	X	X

	2017 CY				**2018 CY**				**2019 CY**				**2020 CY**		
Activity	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
Task 1	X	X	X	X	X										
Task 2	X	X	X	X	X	X	X	X	X						
Task 3	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Q# = Quarter -- Q1: January – March, Q2: April – June, Q3: July – September, Q4: October – December

4. Deliverables

The exchanged data under this activity will be used by JAEA and DOE to support the future research described in the tasks. Data exchange meetings will be conducted on a semi-annual basis. Pre-published data may be exchanged to help in ongoing research.

Date	Description
June 2015	Submit initial research article describing the characteristics of the protective layer in glass.
June 2016	Submit research article describing the mechanism, and to the extent possible, conditions responsible for the on-set of stage III corrosion.
March 2017	Present a technical basis in developing an operational model for safety assessment.
June 2020	Complete a reactive transport code bench-mark to compare and understand any differences in prediction of the models developed by each country.
September 2020	Present a technical basis for improving an operational model for safety assessment.

PROJECT ARRANGEMENT NE-02

APPENDIX II-4
Key Personnel List

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