

**MEMORANDUM OF UNDERSTANDING
BETWEEN
THE UNITED STATES DEPARTMENT OF ENERGY
AND
JOINT STOCK COMPANY “STATE SCIENTIFIC CENTER –
RESEARCH INSTITUTE OF ATOMIC REACTORS” OF THE RUSSIAN
FEDERATION
FOR COOPERATION ON A FEASIBILITY STUDY FOR IRRADIATION
OF ADVANCED CLADDING MATERIALS**

The United States Department of Energy (hereinafter DOE),
and
**Joint Stock Company “State Scientific Center –Research Institute of Atomic Reactors”
of the Russian Federation** (hereinafter JSC “SSC RIAR”),
collectively referred to herein as the “Participants”,

Have reached the following understanding:

I. Purpose

The purpose of this Memorandum of Understanding (Memorandum) is to set forth the Participants’ understanding concerning the conduct of a “Feasibility Study for Irradiation of Advanced Cladding Materials in the BOR-60 Reactor” (the “Project”), through engagement of the Civilian Research and Development Foundation (CRDF) to perform administrative and financial management of the Project. The Participants contemplate a potential future contract or cooperative agreement for the conduct of irradiation and testing of materials in the BOR-60 reactor.

II. Aims and Objectives of the Project

1. JSC “SSC RIAR” intends to perform the following preliminary work in preparation for possible irradiation tests of advanced cladding materials to be provided by DOE:
 - a) Phase A: Engineering development of design options for the test capsule, identification of candidate positions for the test capsules within the BOR-60 reactor and development of the irradiation test matrix, final cost estimation for fabrication of the test capsule, and initial estimate for irradiation charges, including cost estimates for the following:
 - Receipt of DOE samples;
 - Loading of samples into the test capsule(s);
 - Loading of capsules into the reactor;
 - Monitoring the performance of the samples during their irradiation;
 - Reporting on the samples’ irradiation histories (temperature, fast fluence, and neutron spectrum);
 - Unloading of capsules from the reactor after irradiation;
 - Loading of samples into shipping cask(s) for transport to the United States.

Deliverable: An initial proposal summarizing the results of the preliminary assessments described in the work-scope (Annex #1 attached hereto).

- b) Phase B: Completion of the test capsule development based on the design option chosen by DOE, development of a detailed test plan that meets the target temperature and dose values, a verified cost estimation for irradiation charges including cost estimates for the following:

- Receipt of DOE samples;
- Loading of samples into the test capsule(s);
- Loading of capsules into the reactor;
- Monitoring the performance of the samples during their irradiation;
- Reporting on the samples' irradiation histories (temperature, fast fluence, and neutron spectrum);
- Unloading of capsules from the reactor after irradiation;
- Loading of samples into shipping cask(s) for transport to the United States.

Deliverable: Detailed test plan and funding requirements as specified in the work-scope (Annex #1).

2. The expected duration of Phase A is four (4) months. Thereafter, DOE is to make a decision within one month to choose the design option of the test capsule. The expected duration of Phase B is seven (7) months. The periods of performance can be changed as needed by the Participants' mutual consent.
3. The results of work set forth in Annex #1 related to the accomplished tasks are to be included in the reports to be delivered to DOE upon completing the appropriate scope of work. The detailed content of the reports to be delivered to DOE and terms of their delivery are described in Annex #2 attached to this Memorandum.

III. Project Management

The Participants' points of contact for the Project are:

On behalf of JSC "SSC RIAR" – Mr. A. Novoselov

On behalf of DOE – Mr. A. Griffith.

IV. Financial Terms

1. Financial terms for the Project are to be set forth in a contract between DOE and CRDF and a Grant Assistance Agreement between CRDF and JSC "SSC RIAR." The total project cost is estimated at USD 350,000.00:
 - a) Phase A is estimated at USD 100,000.00;
 - b) Phase B is estimated at USD 250,000.00.
2. The total estimated cost is expected to include the following amounts:
USD 10,000.00 for business trips for Project-related travel of the Project participants;
USD 1,000.00 for procurement of consumable office supplies.
3. Grants are to be administered by CRDF and paid to the JSC "SSC RIAR" personnel engaged in performance of work under the Project on a quarterly-basis (one (1) time a

quarter) on presentation of the JSC "SSC RIAR" Project Manager. Changes in the list of the Project's investigator personnel, other than the amount of daily allowances, are to be the exclusive responsibility of the JSC "SSC RIAR" Project Manager.

V. Project Meetings

The Participants intend to conduct teleconferences on a biweekly basis to discuss the progress of work on the Project.

VI. Intellectual Property Rights

1. JSC "SCC RIAR" intends to utilize its background information (flow diagrams, test capsule design, and test assembly design) for performing activities within the framework of this Memorandum.
2. The Project is not expected to create intellectual property that needs to be protected and allocated. Should this expectation change, the Participants intend to conclude an appropriate written agreement for the protection and allocation of rights to such created intellectual property.

VII. General Considerations

1. Cooperation under this Memorandum may commence upon signature, and continue until completion of the Project.
2. This Memorandum may be modified at any time by the Participants' mutual consent in writing.
3. The Participants may discontinue this Memorandum at any time by mutual consent in writing. Alternatively, a Participant that wishes to discontinue its participation in this Memorandum should endeavor to provide at least 90 days advance written notice to the other Participant.
4. The results generated during the implementation of the Project are intended for use to justify a possible high-fluence irradiation in the BOR-60 reactor to study radiation resistance of structural materials at high damage doses so as to investigate promising materials for civil nuclear reactors.
5. Each Participant should conduct the activities contemplated by this Memorandum in accordance with all applicable laws and regulations to which it is subject, including those related to export control, and international agreements to which its Government is party.
6. This Memorandum does not create any legally binding obligations.

Signed in duplicate.

FOR THE UNITED STATES
DEPARTMENT OF ENERGY:



Date: January 24, 2013
Place: Washington

FOR JOINT STOCK COMPANY "STATE
SCIENTIFIC CENTER – RESEARCH
INSTITUTE OF ATOMIC REACTORS" OF
THE RUSSIAN FEDERATION:



Date: 12.02.2013
Place: Dimitrograd

TECHNICAL PARAMETERS FOR PREPARATION OF A FEASIBILITY STUDY FOR IRRADIATION OF ADVANCED CLADDING MATERIALS

1. The aim of the present work is to perform engineering development of design options of test capsules and to work out irradiation test scenarios that would support irradiation of cladding materials in the BOR-60 reactor to achieve the desired parameters specified by DOE, as well as to provide a cost estimate:

1.1 The feasibility study is to consider how samples of various structural materials (tensile test samples, Transmission Electron Microscope (TEM) samples and 3 pt bend samples) would be subjected to irradiation to achieve target dose values specified for each temperature range as shown in Table 1, or to achieve the maximum dose that could accumulate on the samples by the time the BOR-60 is shutdown to accomplish its further decommissioning.

Table 1

Samples	Irradiation test temperature (°C +/- °C)	Intermediate tests	Target dose
HT-9 (tensile, 3 pt Bend, TEM)	370 +/- 10C		50-100 dpa
14YWT (tensile, 3 pt Bend, TEM)			
NF616 (tensile, 3 pt Bend, TEM)			
9Cr-ODS (tensile, 3 pt Bend, TEM)			
HT-9 (tensile, 3 pt Bend, TEM)	420 +/- 10C	Density	200-400 dpa
14YWT (tensile, 3 pt Bend, TEM)		Density	
NF616 (tensile, 3 pt Bend, TEM)		Density	
9Cr-ODS (tensile, 3 pt Bend, TEM)		Density	
HT-9 (tensile, 3 pt Bend, TEM)	470 +/- 10C		200-400 dpa
14YWT (tensile, 3 pt Bend, TEM)			
NF616 (tensile, 3 pt Bend, TEM)			
9Cr-ODS (tensile, 3 pt Bend, TEM)			
HT-9 (tensile, 3 pt Bend, TEM)	650 +/- 10C		200-400 dpa
14YWT (tensile, 3 pt Bend, TEM)			
NF616 (tensile, 3 pt Bend, TEM)			
9Cr-ODS (tensile, 3 pt Bend, TEM)			

The feasibility study is to consider intermediate measurements for density on the tensile test samples once those samples have achieved dose values that characterize a performance limit of irradiation rigs (IR). Measurements would be performed during replacement of irradiation rigs.

1.2. The feasibility study is to consider irradiation of a number of samples of various types and composition within each irradiation temperature range, as shown in the irradiation test matrix given in Table 2. The compositions of the samples are provided in Table 3.

Table 2

Irradiation test matrix for advanced materials

Irradiation temperature (°C)	S-1 tensile specimen	3- pt Bend	TEM
370±10	5 HT-9, 5 14YWT, 5 NF616, 5 9Cr-ODS	10 HT-9, 10 14YWT, 10 NF616, 10 9Cr-ODS	5 HT-9, 5 14YWT, 5 NF616, 5 9Cr-ODS
420±10	5 HT-9, 5 14YWT, 5 NF616, 5 9Cr-ODS	10 HT-9, 10 14YWT, 10 NF616, 10 9Cr-ODS	5 HT-9, 5 14YWT, 5 NF616, 5 9Cr-ODS
470±10	5 HT-9, 5 14YWT, 5 NF616, 5 9Cr-ODS	10 HT-9, 10 14YWT, 10 NF616, 10 9Cr-ODS	5 HT-9, 5 14YWT, 5 NF616, 5 9Cr-ODS
650±10	5 HT-9, 5 14YWT, 5 NF616, 5 9Cr-ODS	10 HT-9, 10 14YWT, 10 NF616, 10 9Cr-ODS	5 HT-9, 5 14YWT, 5 NF616, 5 9Cr-ODS

Table 3

Compositions of structural materials samples (mass %)

Material	Heat	Cr	C	Si	Mn	W	V	Mo	Ni	Other
HT-9 (typical)	84425	11.8	0.21	0.21	0.50	0.52	0.33	1.03	0.51	
14WYT	ORNL	14.0	---	---	---	2.0	---	---	---	0.22Ti, 0.25
NF616	typical	9.0	0.07	0.10	0.40	1.75	0.20	0.55	---	0.06Nb-0.06N
9Cr-ODS	ORNL	9.0	0.05			2.0	0.20			0.4 Ti

The feasibility study is to consider specimens of the types and dimensions shown in Figures 1-3. The TEM specimens would be contained in a tube TEM specimen holder.

S-1 Tensile Specimen

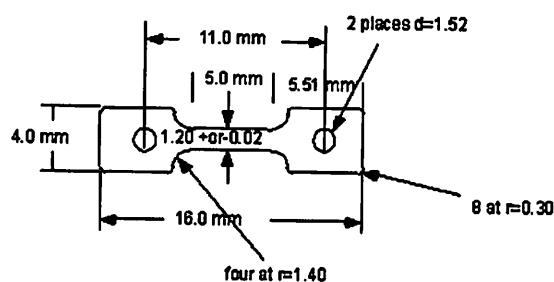
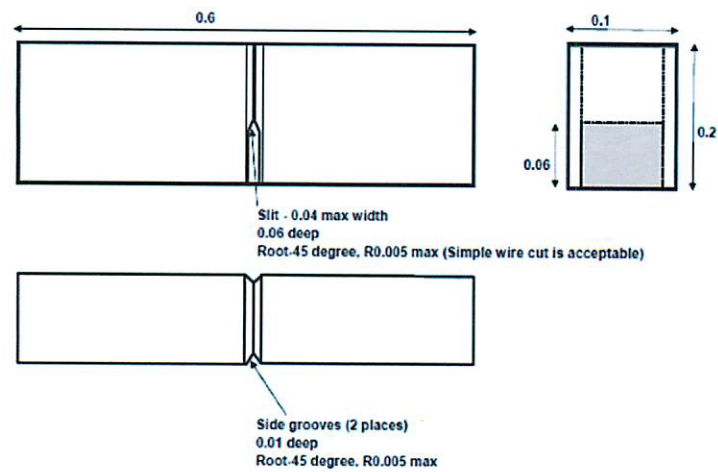


Fig.1 Schematic showing dimensions of the S-1 tensile test specimen. Thickness is 0.75 mm.

Bend Bar

TS-20110503.1



Note:
Unit - Inches
Surface roughness - 32 finish or better

Fig.2. Diagram of 3 pt. bend specimen (dimensions in inches).

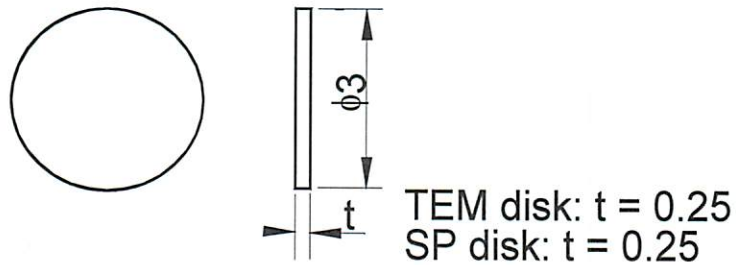


Fig. 3. Diagram of TEM specimen. Dimensions in mm.

CONTENTS OF DELIVERABLE PRODUCTS AND TERMS OF THEIR DELIVERY

A. CONTENTS OF THE REPORTS TO BE DELIVERED TO DOE

I) Phase A: Report “Proposals for Irradiation Experiment”

1. Requirements for irradiation tests
2. IR design
3. Thermocouple probe design
4. Neutronic calculation and calculation of thermal and hydraulic parameters
5. Irradiation test matrices and candidate positions for IR
6. Preliminary cost estimates of work-scope

References

Attachments

II) Phase B: Report “Feasibility Study of Irradiation Experiment”

1. Description of the test capsule chosen by DOE for irradiation tests
2. Detailed plan of irradiation test
3. Verified cost estimation or: Detailed cost estimate of the chosen irradiation test plan

References

Attachments – schematic drawings of the test capsule

B. TERMS FOR DELIVERABLE PRODUCTS DELIVERY

- 1.1. Electronic files of the reports are to be delivered to DOE in Russian and English.
- 1.2. The cost of each report to be delivered is USD 100.00, CPT terms _____, USA (INCOTERMS 2010).
- 1.3. RIAR is to deliver the reports to DOE to the following address U.S. Department of Energy (NE-52), 1000 Independence Ave. SW, Washington DC 20585-1297, USA, in the name of Andrew Griffith / Frank Goldner.