ISTC # 1950b

WORK PLAN FOR THE PERIOD OF PROJECT EXTENSION
for 5 months from 01.07.2006 till 30.11.2006 (Q13 and 14)

1. Project title: Phase diagrams for multicomponent systems containing corium and products of its interaction with NPP materials (CORPHAD)**.**

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3. Expected results:

The knowledge about phase diagrams of corium and corium-based mixtures is essential for numeric modeling of corium interaction with structural and construction materials of reactor unit, concrete pit and core catcher. The phase diagrams of multi-component systems are calculated using thermodynamic computer codes and software-oriented databases developed on the basis of experimental measurements.

At present there is a deficiency of experimental data on phase diagrams of the systems, which include uranium-bearing corium. This is explained by the following factors:

- difficulties in performing experimental studies including high-temperature (up to 3300 K) chemically-aggressive corium melts; there are just a few test facilities in the world available for such studies;
- new construction and structural materials used in the newly-developed NPP designs; e.g. they include a new class of sacrificial materials for severe accident management;
- new phenomena possible during the in- and ex-vessel stages of a severe accident have been discovered; these phenomena influence the molten pool structure and characteristics, e.g. the effect of U and Zr extraction by molten steel from the suboxidized corium melt, which has been detected during the “Rasplav-3” tests within the OECD/MASCA Project, the phenomena has been predicted by [Hofmann, 1976], [Gueneau, 1999] and [Parker, 1982].

Due to the mentioned factors there is a pressing need in experimental data on phase diagrams; and getting them is the main goal of Project # 1950.2 (CORPHAD). Its implementation will bring the essential experimental data on phase diagrams of binary, ternary, quaternary (including the data on suboxidized systems with miscibility gap) and prototypic multi-component systems, which will be used for refining numeric codes, optimization and complementing data bases:

- concentration curves of liquidus and solidus temperatures;
- coordinates of reference points: eutectics, distectics and others;
- solubility limits of components in the solid phase;
- temperature-concentration domains of the miscibility gap.

Additional time will be necessary in order to systematize, analyze studied phase diagrams (in particular in the suboxidized region) and prepare reports; to develop and test the methodology for getting characteristics of the system inside the miscibility gap; to conduct two potentially explosive tests for “average” compositions of the UO_2-SiO_2 system.

1. Scope of work

4.1. The Work plan of Project № 1950.2 foresees the identification of 50 reference experimental points for the phase diagram construction. By the present moment ~ 85 points have been determined for binary (UO_2-FeO; ZrO_2-FeO; $Fe_2O_3(Fe_3O_4)$-SiO_2) and ternary (UO_2-ZrO_2-FeO; U-O-Zr; Zr-O-Fe; U-O-Fe) systems; 15 points are planned to be found during the investigation of remaining unstudied systems before the end of the project. In view of the larger number of planned experiments additional time will be required for the systematization and analysis of experimental information and for preparing publications.

4.2. In accordance with recommendations of collaborators the studies of ternary systems (U-O-Zr) (Zr-O-Fe) (U-O-Fe) are performed in the melt region having low oxygen potential, the experimental data about it have been practically nonexistent. In the course of the current project implementation the methodology for preparing oxidic-metallic melt in a cold crucible has been refined and a method for measuring liquidus temperature has been developed, which substantially differs from the methodology used for oxidic melts. The methodology includes a complex of physicochemical analyses, the scope of which requires much more time than originally foreseen for the studies of the mentioned systems.

4.3. Project collaborators have recommended to conduct investigations aimed at the development of experimental methodology for studying the mushy zone, which corresponds to the equilibrium between the liquid and solid phases, so-called tie-lines of the compositions. The successful implementation of this work will open new possibilities for studying the phase diagram in a previously unexamined domain and , in the opinion of collaborators, it can be one of the research directions in case of a project continuation with appropriate funding. During the additional 5-month period it is proposed to develop and test the methodology of studies in the mushy zone.

4.4. In accordance with the decision of CORPHAD-2 Steering Committee made at the meeting in Dimitrovgrad (Russia) on September 14, 2004, which was recorded in Protocol № 4, it was recommended to conduct experiments with the UO_2-SiO_2 system in the end of the project, after the main experimental matrix is completed, because they present a potential hazard. Experiments in the high-temperature region enriched with UO_2 may result in explosions due to the intensive SiO_2 release, and experiments in the silicon domain are problematic because of a high specific resistance of the melt and difficulty of its production by the IMCC method. For this reason the additional 5-month period is proposed for 2-3 tests with “average” compositions.

To summarize, the 5-month period of project extension will be used for the following activities:

- the completed studies will be systematized and analyzed; reports and publications will be prepared in cooperation with collaborators;
- 2 tests with “average” compositions of the UO_2-SiO_2 system will be conducted;
- methodology of constructing tie-lines in the mushy zone will be developed and tested;
- draft of work plan and experimental matrix for the budgeted project prolongation will be discussed with collaborators.

Additional work will be carried out in the framework of Tasks 1, 2 and 3.

Task 1.Studies of binary systems. The additional time will be used for studying the UO_2-SiO_2 system in the region of “average” compositions (2 tests).

Task 2.Studies of ternary systems and phase diagrams of metal-oxide systems (U-Fe-O), (U-Zr-O), (Zr-Fe-O). The additional time will be used for data systematization, analysis and preparation of deliverables; development and trial of methodology for constructing tie-lines in the mushy zone; discussion of experimental matrix for the new budgeted project extension with collaborators.

Task 3.Studies of the U-Zr-Fe-O system in the miscibility gap aimed at the determination of its temperature-concentration region at low oxygen potential and quasi-equilibrium compositions at different temperatures. The additional time will be used for data systematization, analysis and preparation of deliverables; discussion of experimental matrix for the new budgeted project extension with collaborators.

Task 1

Description and main stages	Participating institutions
Studies of binary oxidic systems. Stages implemented in additional time: 1.6. Preparation and performance of 2 experiments with the UO_2-SiO_2 system. 1.7. Physicochemical analysis of samples. 1.8. Pre- and posttest calculations using thermodynamic codes.	NITI
Deliverables	
Report	

Task 2

Description and main stages	Participating institutions
Studies of ternary systems and phase diagrams of metal-oxide systems (U-Fe-O), (U-Zr-O), (Zr-Fe-O) Stages implemented in the additional time: 2.1. Integrated analysis and summary of experimental data. 2.2 Development and trial of methodology for the construction of tie-lines in the mushy zone. 2.3 Approval of the experimental matrix for the budgeted project extension.	NITI
Deliverables	
Reports on different systems, Annual Report (3rd year), Report on the proven methodology of tie-line construction, experimental matrix approved by collaborators, publications	

Task 3

Description and main stages	Participating institutions
Studies of the U-Zr-Fe-O system in the miscibility gap aimed at the determination of its temperature-concentration region at low oxygen potential and determination of quasi-equilibrium compositions at different temperatures Stages implemented in the additional time: 3.1. Integrated analysis and summary of experimental data. 3.2. Discussion of experimental matrix for the budgeted project extension.	NITI
Deliverables	
Report on the system, Final Report on the project, experimental matrix approved by collaborators, publications	

5. Reportable results

Technical and financial reports will be submitted to ISTC in the end of 8, 9, 10, 11, 12, 13 and 14th quarters. Annual reports will be prepared in the end of the 2nd and 3rd years. Final project report and Work plan for the budgeted project extension approved by collaborators will be produced in the end of the additional period.

6. Technical schedule

	Quarter 13 and14	Man-days
Task 1	Report	
Man-days	**1400**	**1400**
Task 2	Report, publications	
Man-days	**919**	**919**
Task 3	Report, publications	
Man-days	**900**	**900**
TOTAL	**3219**	**3219**

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