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|  | PROJECT PROPOSAL | #3635 |

I. Summary Project Information

1. Project Title and Taxonomy

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| **Full title:** | Scale experimental investigation of the thermal and structural integrity of the VVER pressure vessel Lower Head in severe accident | | | |
| **Short title:** | | VVER Vessel in Severe Accident | | |
| **Technology area:** | | | FIR-NSS, FIR-REA, FIR-MOD, FIR-EXP, FIR-MAT, PHY-STM | |
| **Category of technology development:** | | | | Basic Research, Technology Development |

2. Project Manager

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| --- | --- | --- | --- | --- | --- | --- | --- | --- |
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3. Participating Institutions

3.1. Leading Institution

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Short reference:** | | | | | MPEI | | | | | | |
| **Full name:** | | | State educational establishment of the higher education RF "Moscow Power Engineering Institute" (Technical university) | | | | | | | | |
| **Street address:** | | | | 14, Krasnokazarmennaya | | | | | | | |
| **City:** | Moscow | | | | | | | **Region:** | |  | |
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| **Governmental Agency:** | | | | | | Federal agency on education of Russian Federation | | | | | |

3.2. Other Participating Institutions

Participant Institution 1

|  |  |  |  |  |  |  |  |  |  |  |  |
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| **Short reference:** | | | | | EDO GP | | | | | | |
| **Full name:** | | | Federal State Unitary Enterprise “Experimental and Design Organization “GIDROPRESS” | | | | | | | | |
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| **City:** | Podolsk | | | | | | | **Region:** | | Moscow district | |
| **ZIP:** | 142103 | | | | | | | **Country:** | | | RUSSIA |
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| **Title:** |  | | | | | | | **Position:** | | Deputy Director | |
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| **Governmental Agency:** | | | | | | Federal Atomic Energy Agency | | | | | |
| **Sub-manager:** | | | | Valery P. SEMISHKIN | | | | | | | |
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Participant Institution 2

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| **Short reference:** | | | | | IGiL | | | | | | |
| **Full name:** | | | Lavrentyev Institute of Hydrodynamics of the Siberian Branch of the Russian Academy of Sciences | | | | | | | | |
| **Street address:** | | | | 15, Lavrentyev pr. | | | | | | | |
| **City:** | Novosibirsk | | | | | | | **Region:** | |  | |
| **ZIP:** | 663090 | | | | | | | **Country:** | | | RUSSIA |
| **Name of Signature Authority:** | | | | | | | Alexandr A. KOROBKIN | | | | |
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| **Governmental Agency:** | | | | | | The Siberian Branch of the Russian Academy of Sciences (SO RAN) | | | | | |
| **Sub-manager:** | | | | Oleg V. SOSNYN | | | | | | | |
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| **E-mail:** | | lbi@ngs.ru , lbi2@ngs.ru | | | | | | | | | |

4. Foreign Collaborators/Partners

4.1. Collaborators

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Institution:** | | | | Department of Engineering Physics, College of Engineering, University of Wisconsin | | | | | | |
| **Street address:** | | | | | 1500 Engineering Drive | | | | | |
| **City:** | Madison | | | | | **Region/State:** | | | | Wisconsin |
| **ZIP:** | WI 53706 | | | | | **Country:** | | | USA | |
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| **Institution:** | | | | Division of Nuclear Power Safety, Department of Physics, Royal Institute of Technology | | | | | | |
| **Street address:** | | | | | AlbaNova University Center, Roslagstullsbacken 21 | | | | | |
| **City:** | Stockholm | | | | | **Region/State:** | | | |  |
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| **E-mail:** | | | NamDinh@safety.sci.kth.se | | | | | | | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Institution:** | | | | Institute of Nuclear Technology, Institute of Nuclear Safety System, Incorporated | | | | | | |
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| **City:** | Fukui 919-1205 | | | | | **Region/State:** | | | |  |
| **ZIP:** |  | | | | | **Country:** | | | JAPAN | |
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| **Institution:** | | | | Material and Components Safety Department, Institut fur Sicherheitsforschung, Forschungszentrum Rossendorf | | | | | | |
| **Street address:** | | | | | Bautzner Landstr. 128 | | | | | |
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| **Title:** | | Dr. | | | | **Position:** | | Head of Materials and Components Safety Department | | |
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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Institution:** | | | | Mechanical & Nuclear Engineering, The Pennsylvania State University | | | | | | |
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| **Person:** | | | Fan-Bill Cheung | | | | | | | |
| **Title:** | | Professor, ANS & ASME Fellow | | | | **Position:** | |  | | |
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| **E-mail:** | | | Fxc4@psu.edu | | | | | | | |

4.2. Partners

None

5. Project Duration

36 months

6. Project Location and Equipment

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| --- | --- |
| **Institution** | **Location, Facilities and Equipment** |
| **Leading Institution** | The experimental test facility and experimental investigations on the heating, mechanical behaviour and failure of the VVER vessel scale models will be carried out at the test cell #5 located in building of the MPEI thermal power plant. Some of the research experimental equipment and installations were placed on that area before, and it are dismantled now. The test cell #5 requires reconstruction and repair for the future experimental equipment’s placement and for carrying out the scale experiments. Experimental test facility to be built will incorporate the experimental protective box, heating system, control and data acquisition system (DAS), ancillary equipment and systems (gas, water, electricity systems etc.). The working space of the test installation will consist of the scale model (mock up) of the VVER reactor pressure vessel (RPV) lower head (LH), heater, cooling system, measurement sensors and devices (temperature, displacement, pressure), support systems’ armature (gas, water and electricity etc.). Additional transformers, as well as control devices for them need to be mounted for the electric heating system; also the special model’s heater and supporting cooler devices need to be built for that purpose. It is necessary to create or to purchase appropriate DAS and control system. Scale VVER LH models must be fabricated from the 15Kh2NMFA vessel steel according to the regular treatment technology used for the VVER reactor pressure vessel fabrication. Administrative rooms in the “T” building of MPEI (rooms #307 and 308) will be used for analytical works and project’s management within the project. It is necessary to purchase supplementary computers and software for carrying out the numerical simulations and analytical works. It is essential to provide for office equipment (fax, Xerox, slide projector etc.) and for communication service too. Also it is necessary to reconstruct and to repair the experimental space (cell #5) in the MPEI thermal power plant building as well as the administrative area (rooms #307 and 308) in the “T” building. It is planned, the numerical simulations on the heating and mechanical behaviour of the VVER scale models (pre- and post-tests calculations) will be carried out by means of domestic computer codes ATM-VVR and NARAL/ FEM, and by commercial code ANSYS also. |
| **Participant Institution 1** | Work within the project will be carried out in rooms #309, 601, 608 of the administrative building. Numerical calculations on the assessment and choosing of the severe accident’s scenarios in the VVER will be accomplished by means of the RELAP/SCDAP and MELCOR codes. Numeric simulations of the heating and structural analysis of the VVER LH models (pre- and post-tests calculations) will be provided by means of the domestic thermomechanical codes. |
| **Participant Institution 2** | It is planned the rooms of the main administrative building IGiL (rooms #122, 229 and 340) will be used as well as experimental areas of the IGiL static strength lab for the purpose to work during the project. It is necessary to repair rooms #122, 229, 340 and the areas of the static strength lab too. The high-temperature creep tests will be carried out on the test equipment and machines of the own projects as well as on the Zwick/Roell, Instron test machines (with furnace). It is essential to modernize the test equipment and heating furnaces for carrying out the high-temperature material property testing of the VVER vessel steel (modernization of the control systems and test machines loading, and also of the heating furnaces and gas system). It is necessary to purchase additional computers and software as well as office equipment (fax, Xerox, slide projectors etc) and communication service devices. |

7. Total Project Effort

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| **Total number of participants** | 40 |
| **Number of weapon scientists and engineers** | 13 |
| **Total project effort (person\*days)** | 9622 |
| **Total project effort of weapon scientists and engineers (person\*days)** | 4875 |

8. Financial Information

8.1. Estimated Project Costs

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| **Estimated total cost of the project (US $)** | 567640.0 |
| *Including:* |  |
| **Payments to Individual Participants** | 283777.0 |
| **Equipment** | 66000.0 |
| **Materials** | 11000.0 |
| **Other Direct Costs** | 173820.0 |
| **Travel** | 25000.0 |
| **Overhead** | 8043.0 |

8.2. Funding Sources

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| **Estimated total cost of the project (US $)** | 567640.0 |
| *Financial Sources:* |  |
| **Requested from the ISTC** | 567640.0 |
| **Other financial source 1** | 0.0 |
| *Non-Financial Sources:* | 0.0 |
| **Non-financial source 1** | 0.0 |

9. Summary of the project

Present project is associated with the peaceful uses of atomic energy and it is aimed on the considerable enhancement safety of the nuclear power plants with the VVER reactors due to the unique experimental findings on the heating, structural behaviour and rupture of the VVER vessel scale models in the severe accident (SA) conditions. It is well known, the safety assessment of the operating and new generation reactors is based on the computer simulation of the SA phenomena by means of the numerical SA codes. The verification and validation of them against the corresponding experimental data is the indispensable condition for such work. Analysis of the reactor vessel integrity is the key moment in the overall safety analysis of the reactor installations.

It is known, that exists a possibility of the melt relocation and accumulation in the lower head (LH) of the reactor vessel during SA for the vessel-type reactors (VVER, LWR, PWR). In that case the vessel plays the role of the main barrier to prevent the radioactive materials release to environment. Interaction of the corium and vessel steel is accompanied by heating and melting of the vessel wall, as well as by formation of the low-melting eutectics in the contact zone. Beside that, heating of the vessel steel to more than 500 C leads to the essential decreasing of its strength properties. Analysis of the native and foreign investigations on the vessel behaviour and failure during SA revealed the high-temperature creep of the vessel steel is the main cause of their deformation and failure.

Comprehensive study of several aspects (heating, deformation, failure etc.) of the reactor vessels behaviour in SA was the principal item of many foreign research programs in particular, VIP (Vessel Investigation Project, OECD), LHF and OLHF Projects (Sandia Lab., USA), CORVIS (PSI, Switzerland), FOREVER-experiments (the Royal Institute of Technology, Sweden), MOSES etc. Experimental results received in the course of those investigations, are very important from the view-point of the possibility of validation and verification of the computer SA codes and mathematical models of the studied phenomena (creep, failure of the vessel steel etc). The basic element of the researchs mentioned before was the experimental study of the reactor pressure vessel (RPV) scale models behaviour during its heating and creep deformation. Never before similar combined experimental and analytical works on VVER vessel, concerned with its heating, creep and failure in the SA were done in Russia.

**The overall objective** of this project is the experimental and numerical investigation of the scaled VVER LH reactor vessel models within transient thermal and its overpressure loading which correspond to realistic SA scenarios accompanied by the high-temperature heating, creep deformation of the reactor vessel.

More specifically, major project tasks are: 1) to design and build up the experimental test facility and to carry out the tests on the scale (up to ~1:5) models of the VVER vessel lower head in SA conditions; 2) to carry out the material property creep tests with the samples from the 15Kh2NMFA vessel steel on more than 30 hours time range and temperature above 700 C. These experiments will allow to receive the creep diagrams and refine the mechanical properties of VVER steel including the high-temperature creep parameters at 750-1050 C and the constitutive creep model of this steel; 3) to carry out the numerical pre- and post-test calculations of the scale experiments with VVER vessel models.

**The urgency and necessity** of the suggested project is determined by: a) a lack of the experimental data on the VVER vessel deformation and failure in SA because of the high-temperature creep phenomenon. These experimental data are necessary to straighten out the real behaviour of the VVER vessel during SA, as well as for the verification of the computer SA codes (native and western commercial). The given results will allow more adequately estimate the influence of the associated processes (the vessel creep effect, thermal and mechanical loads etc.) to a lifetime and VVER RPV behaviour during SA; b) achievement of the project’s tasks will permit to reduce noticeably the conservatism of the numerical simulations associated with VVER safety, and also to elaborate and to carry out all necessary actions to control the SA; c) the creep test results of the samples from 15Kh2NMFA vessel steel shall permit to define more precisely and to complete available data on creep and failure, and also to clarify the creep model of this steel; d) the results of this project will become the base of the next stage of the investigations associated with development of the core-catcher constructions for localization of the core material both inside the VVER vessel and beyond it. Experimental control of the work efficiency of the different core-catcher constructions would be possible test by using of experimental equipment of suggested project.

**The leading participant** of the project is the team from MPEI-TU (NPP Department). This team for more than 10 years carried out the complex of works concerned with different thermo physical aspects of the events obtained during the design-basis and beyond the design-basis accidents in NPP. For realization of those tasks the special computational programs were designed for numerical simulations of studied phenomena, in particular, the thermomechanical codes ASHTER-VVER and ATM-VVR, as well as NARAL and NARAL/FEM codes. The numerical investigations of the reactor pressure vessels behaviour of the VVER-440, VVER-640 and VVER-1000 in SA were carried out by means of these computer codes. It is supposed to use ATM-VVR code as the basic code for pre- and post-test thermomechanical numerical simulations in present project. The members of the team also have essential experience in the preparatory and pursuance of the high-temperature research and experiments.

Experimental and Design Organization **"GIDROPRESS" (EDO “GP”)** as a work co-executor is the representative of the organization, that is the head designer of the VVER reactors. The primary task of this team is the analysis and choosing the severe accident scenarios and tests conditions of the scale experiments with VVER vessel models. Members of this team are highly skilled and have the long-term experience of the carrying out the design-analytical works on the SA for the NPP with VVER by means of domestic (BISTRO, RATEG/SVECHA/GEFEST) and commercial SA codes (MELCOR and RELAP/SCDAP). The experience of the EDO "GIDROPRESS" staff will give the possibility to choose substantially the accident scenarios, to carry out pre- and post-test simulations and to develop the tasks of the planned scale experiments.

Static Strength laboratory of Lavrentyev Institute of Hydrodynamics **(“IGiL")** of the Siberian Branch of the Russian Academy of Sciences (SO RAN), as a second co-executor of this work, is one of the oldest labs in Russia which are working in the field of high-temperature testing of the metals and metal alloys. During the last five years lab staff together with MPEI received fundamentally important results on the high temperature creep testing of the VVER vessel steel. Some of group’s investigations are concerned with construction of the adequate creep models of testing materials, as well as with high-temperature testing of the machine-building and special items’ fragments.

Suggested project fully conforms the principal purposes of the ISTC and will permit especially to integrate former weapons scientists from Russia into the international scientific community. It will also make its contribution to self-sustaining civilian activities.

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|  | PROJECT PROPOSAL | #3635 |

II. Detailed Project Information

1. Introduction and Overview

Present project is associated with the peaceful uses of atomic energy and it is aimed on the considerable enhancement safety of the nuclear power plants with the VVER reactors due to the unique experimental findings on the heating, structural behaviour and rupture of the VVER vessel scale models in the severe accident (SA) conditions. The safety assessment of the operating and new generation reactors is based on the computer simulation of the SA phenomena by means of the numerical SA codes. The verification and validation of them against the corresponding experimental data is the indispensable condition for such work.

It is known, that exists a possibility of the melt relocation and accumulation on the lower head (LH) of the reactor vessel during SA with core meltdown in the vessel-type reactors (VVER, LWR, PWR). In that case the vessel plays the role of the main barrier to prevent the radioactive materials release to environment. Furthermore, a model of the vessel deformation and failure has determinative influence on the course of the SA next stages. That’s why the analysis of the reactor’s vessel integrity during SA with partial or total core meltdown is the key moment in the overall safety analysis of the reactor installation. Interaction of the corium and vessel steel during the similar accidents is a very complicated process accompanied by heating and melting of the vessel wall, its deformation, as well as by formation of the low-melting eutectics. Beside that, heating of the vessel steel to more than 500 C leads to the essential decreasing of its strength properties. Analysis of the native and foreign investigations on the vessel behaviour and failure during SA revealed the high-temperature creep of the vessel steel is the main cause of the vessel deformation and failure.

The analysis of the well-known accident on the Three Mile Island NPP in USA (TMI-2, March 28, 1979) showed that the relocation more than 20 tons of the melting core fragments to RPV lower head led to its intensive heating (more than 700 C) and vessel deformation. Further analysis of that accident proved the urgency of the deep analytical and experimental investigations aimed on the study of the creep and failure conditions of the LH RPV during SA in the safety assessment of the operating and new generation NPP [1,2]. So, the safety substantiation of new generation reactor EPR (French-German European Pressurized Water Reactor)– Olkiluoto-3 in Finland, has been based on the wide range international cooperation in the network of the European programs (4-th and 5-th framework programs of the EU) and OECD [3-4].

Comprehensive analytical and experimental studies of several aspects (heating, structural integrity etc) of the reactors vessel behaviour in SA were the principal item of well-known international research programs and projects [5-9], in particular, VIP (OECD), LHF and OLHF Projects (Sandia Lab., USA), CORVIS-PSI (Paul Sherrer Institute, Switzerland), FOREVER-experiments (the Royal Institute of Technology, Sweden), ARVI Project (Assessment of Reactor Vessel Integrity), the EUROCORE concerted action (European Group for analysis of Corium REcovery concepts), MOSES Project etc. Experimental results received in the course of those investigations, are very important from the view-point of the validation and verification of the SA computer codes and mathematical models of the studied phenomena (creep, failure of the vessel steel etc).

The main tasks of the foregoing investigating programs, concerned with the heating, deformation and failure of the reactor vessel included, as a rule, the follows:

a) experimental investigation of the heat up, creep deformation and failure of the scale reactor vessel models. Scale vessel models (with max geometrical scale up to ~1:5) were manufactured from the original reactor vessel steels. In the course of the experiments the temperature state was registered, and also time, creep deformation and failure of the vessel models were recorded. The heating of the studied vessel models run up to more than 600 C by means of the special heaters. In particular, in LHF/OLHF experiments the vessel models heated through the induction heater, and in the FOREVER and CORVIS experiments the heating of the vessel models was achieved by the liquid molten pool, heated by special electric heater. Never before similar combined experimental and analytical works on VVER vessel, concerned with investigation of its heating, creep and failure in the SA were done in Russia;

b) material property tests to determine the constitutive creep models and ordinary mechanical characteristics of various western reactor vessel steels. The main objective of these tests was to receive input data for development of adequate creep models of each of tested steels. The creep models were implemented in the structural mechanical codes for numerical simulation of the creep behaviour of the western type RPV during SA;

c) the verification of the mathematical models both as the structural thermo-mechanical codes against data received in the course of the RPV scale tests.

**The overall objective** of this project is the experimental and numerical study of the VVER LH reactor vessel scale models within transient thermal and its overpressure loading which correspond to realistic SA scenarios accompanied by the high-temperature heating, creep deformation of the reactor vessel. In this context the project efforts are focused on the following problems:

1) the designing and construction of the test facility for test examinations of the VVER vessel scale models (up to ~1:5) on the conditions which correspond to SA in VVER. Experimental facility to be built includes: working space, scale model and its heater, control and experimental information gathering system (DAS), support systems (gas, water systems, video monitoring devices etc.);

2) manufacturing of the VVER LH reactor vessel scale models. Material and technology, as well as thermal treatment have to correspond the same conditions of the regular VVER vessels manufacturing;

3) pursuance of the material creep test experiments with samples from the VVER vessel steel on more than 30 hours time range and temperature above of 700 C to receive the creep data for refinement of the constitutive creep model and ordinary mechanical characteristics of this steel;

4) the carrying out the scale experiments with VVER vessel models on the high-temperature heat-up and creep deformation of the vessel;

5) the mathematical treatment and analysis of scale experiments, carrying out the numerical pre- and post-test structural analyses of scale experiments with vessel models by means of domestic (ATM-VVR etc.), and also by well-known commercial codes (ANSYS, MELCOR, RELAP/SCDAP) for validation of the mathematical models implemented in these codes.

**The necessity** of suggested project is determined by:

a) a lack of the experimental data on the VVER vessel deformation and failure because of the high-temperature creep phenomenon of the vessel steel. These experimental data are necessary to straighten out the real behaviour of the VVER vessel during SA, as well as for the verification of the computer SA codes (domestic and foreign). The given results will allow more adequately estimate the influence of the associated processes (the vessel creep effect, thermal and mechanical loads etc.) on a lifetime and behaviour of VVER vessel;

b) achievement of the project’s tasks will permit to reduce noticeably the conservatism of the numerical simulations associated with VVER safety, and also to elaborate and to carry out all necessary actions for SA management strategy;

c) the material property creep tests of the 15Kh2NMFA vessel steel samples shall permit to define more precisely and to complete available data on its creep and failure, and to clarify the constitutive creep model and ordinary mechanical characteristics of this steel also;

d) the results of this project will become the base of the next stage of the investigations associated with development of the core-catcher constructions for localization of the core material both inside the VVER vessel and beyond it. Further, the experimental control of the work efficiency of the different core-catcher constructions would be possible due to the use of experimental equipment of present project.

For more than 10 years the NPP Department staff (MPEI-TU) carried out the complex of research works in the network with the enterprises of Russian Federal Atomic Energy Agency concerned with thermal physical aspects of the SA events in the NPP. The special computer codes were developed for numerical simulation of studied phenomena within above mention investigations, in particular, the ASHTER-VVER and ATM-VVR codes [10-12] for structural analysis of the VVER RPV, as well as the NARAL and NARAL/FEM codes for numerical simulation of the molten pool behaviour. The numerical analyses of the VVER-440 vessel behaviour during SA with molten pool formation were carried out by means of these codes. The previous version of the program (ASHTER-VVER) was used for the high-temperature creep and failure simulations of the VVER-640 and VVER-1000 vessels during the design-basis and beyond the design-basis accidents [10-12].

For the purpose of carrying out the tasks of the present project, it is supposed to use the ATM-VVR as the main computer code for pre- and post-test thermomechanical analyses of the VVER vessel scale models . Creep model, implemented in this program, gives the possibility to simulate the vessel steel creep until its failure, which permits to combine the stress-strain state and failure problems. Ideology of using similar approach for the high temperature creep modeling of the RBMK fuel channel pressure tubes was fulfilled earlier in the ATM-TK (ASHTER-TK) computer code [13-14]. Members of the MPEI team also have essential experience in the preparatory work and carrying out the high-temperature testing [15-17]. In particular, in the course of the RBMK PT models testing the unique heaters were produced, that gave the possibility to reproduce the accident-heating conditions during beyond the design-basis accidents in RBMK.

The Static Strength laboratory of Lavrentyev Institute of Hydrodynamics (“IGiL”) of the Siberian Branch of the Russian Academy of Sciences (SO RAN) is one of the oldest labs in Russia, which are working in the field of high-temperature testing of the metals and metal alloys. During the last five years lab staff received fundamentally important results on the high temperature creep of the VVER vessel steel [18]. Some of group’s investigations are concerned with construction of the adequate creep models of testing materials, as well as with high-temperature testing of the machine-building fragments [19-21].

Experimental and Design Organization "GIDROPRESS" (EDO “GP”) as a work co-executor is the representative of the organization, that is the head designer of the VVER reactors. The primary task of this team is the analysis and choosing the SA scenarios and testing conditions of the scale experiments with VVER vessel models and interpretation of the experimental results. Members of this team are highly skilled and have a long-term experience of the carrying out the design-analytical works on the SA for the VVER-440, VVER-1000 by means of domestic (BISTRO, RATEG/SVECHA/GEFEST) and commercial codes (MELCOR and RELAP/SCDAP) [22-27].

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2. Expected Results and Their Application

In the course of fulfillment of the given project it is supposed to receive the following results:

1) experimental data on the creep behaviour, heat up and failure of the VVER vessel scale models that will enlarge the current knowledge about the VVER behaviour and the essence of the governing thermal and creep processes during this SA stage;

2) experimental data received in the course of the VVER vessel model tests will be used as a basis for verification of the thermo-mechanical numerical codes (native and western commercial), which are used in the safety assessment in SA and SA management strategy for NPPs with vessel type reactors;

3) the material property creep test results of the 15Kh2NMFA vessel steel samples will permit to obtain an additional material property of the VVER vessel steel. Also these data will be used as a basic to define more precisely and to complete available data on creep and failure, and also to clarify the constitutive creep model of this steel;

4) data of the VVER vessel scale model tests will give the possibility to perform preliminary comparison of the computing possibilities of the numerical thermo-mechanical codes;

5) the results of this project will become the base of the next stage of the investigations concerned with development of the based core-catcher constructions for localization of the core material both inside the VVER vessel and beyond it. Experimental study of the work efficiency of the different core-catcher constructions would be possible due to the use of experimental equipment of suggested project.

2.1. Sustainability Implementation Plan

2.1.1. Results to be promoted

- experimental data on the tests of the VVER lower head scale models within its heat up, creep deformation and failure on the conditions which correspond to realistic accident scenarios in VVER;

- material property creep and failure data of the 15Kh2NMFA vessel steel at temperature above 700 C and test time more than 30 hours.

2.1.2. Uniqueness of results

The uniqueness of the project’s results is proved by lack of the experimental data on the VVER vessel deformation and failure during SA, which are very important for understanding of the governing creep and thermal processes in the VVER RPV during SA, as well as for verification of the computer SA codes used for the safety assessment of the NPPs with vessel type reactors (VVER, PWR, LWR).

2.1.3. Demand for results

Potential consumers of the project’s results are the development and design organizations of Russia working on the design and safety assessment of the NPP with VVERs. In particular, one of them is FDO “GIDROPRESS”, the Head designer of the VVER reactors and one of the project participants.

2.1.4. Expected income

Profit on the project results will be determined first of all by the created infrastructure (experimental facility, control system and DAS etc), which can be used for carrying out next high thermal tests of the reactor components, such as the scale models of the core-catchers etc.

2.1.5. IPR situation

Scientific ideas and new design-technological solutions, received during the present project, will be protected due to patenting.

2.1.6. Additional developments

Now a lot of the domestic both as foreign organization need the results of this project. This is proved by participation of the leading Russian teams (FDO “GP” etc.) and foreign collaborators in this project.

2.1.7. Plan of implementation

Profit draft of the project is not worked out by now.

2.1.8. Additional licenses or permits

The project results realization may demand additional permissions and licenses of the corresponding organizations, supervising the nuclear power installations in Russia, and also high-pressure utilities (similar to the former “Kotlonadzor”).

2.1.9. Business network

The project results realization supposes the participation of the development and design organizations of Russia working on the design and safety assessment of the NPP with VVER, as well as Russian Atomic Energy Agency support.

3. Meeting ISTC Goals and Objectives

Suggested project completely meets the basic principles and purposes of the ISTC and will permit especially:

1) to redirect the gifts and experience of Russian weapons scientists to peaceful activity;

2) to integrate Russian weapons scientists into the international scientific community;

3) to contribute to the nuclear safety strengthening of current and new generation NPPs with VVER.

4. Scope of Activities

The work in the course of this project might be presented in the form of several interrelated tasks and, which in their turn consist of the subtasks series. Below, MPEI, GP, and IGiL denote the participant groups of Moscow Power Engineering institute (MPEI), Federal Experimental and Design Organization “GIDROPRESS” (EDO “GP”) and Lavrentyev Institute of Hydrodynamics of the Siberian Branch of the Russian Academy of Sciences.

Task 1

|  |  |  |
| --- | --- | --- |
| **Task description and main milestones** | | **Participating Institutions** |
| **Task “A”: analytical studies that include: the choosing of the accident scenarios and test conditions of the scale experiments; carrying out of the pre- and post-tests of the scale experiments; final R&D report issue** | | 1-“MPEI”  2-EDO “GP”  3- |
| **Description of deliverables** | | |
| 1 | SA scenarios and SA conditions will be reproduced during the scale experiments with VVER vessel models | |
| 2 | Expected thermal and deformation behaviour of the vessel models (as a result of the pre-test calculations) during the scale tests, and the post-test calculation results of the performed experiments on the VVER vessel scale models | |
| 3 | The intermediate reports on the choice of the accident scenarios and conditions of the scale experiments. The final R&D report issue. The articles on the tests results and post-test calculations of the performed experiments | |

Task 2

|  |  |  |
| --- | --- | --- |
| **Task description and main milestones** | | **Participating Institutions** |
| **Task “B”: development and manufacturing of the experimental test facility and supporting systems for the VVER scale vessel models testing** | | 1-“MPEI”  2-  3- |
| **Description of deliverables** | | |
| 1 | The operation factors and main requirements of the experimental test facility and supporting systems. Technical project and design documentation for development of the experimental installation, test space and supporting systems. Produced experimental test facility and its components | |
| 2 | Technical project and design documentation for the VVER vessel models manufacturing. Produced VVER vessel models (4 pieces) | |
| 3 | The design documentation for the fabrication of the heater with specified properties. The produced heater for the test model heating | |
| 4 | Produced technical project and design documentation for development of the test facility control system and DAS. Produced test facility control system and DAS with proper software. Its assembling on the test installation | |
| 5 | Re-planning and repair of the experimental site and administrative areas in a building “T” | |

Task 3

|  |  |  |
| --- | --- | --- |
| **Task description and main milestones** | | **Participating Institutions** |
| **Task “C”: carrying out of scale experiments on the VVER vessel model** | | 1-“MPEI”  2-EDO “GP”  3- |
| **Description of deliverables** | | |
| 1 | The protocols of the scale experiments with VVER vessel models | |

Task 4

|  |  |  |
| --- | --- | --- |
| **Task description and main milestones** | | **Participating Institutions** |
| **The task “D”: the manufacturing and material creep testing of the samples from VVER vessel steel and material property creep testing of the samples cut from the tested VVER vessel models** | | 1-“IGiL”  2-“MPEI”  3- |
| **Description of deliverables** | | |
| 1 | The test specimens fabricated of the original VVER vessel steel and manufactured from the vessel models after experiments | |
| 2 | The protocols of the high temperature material property creep tests of the VVER vessel steel specimens | |

5. Role of Foreign Collaborators/Partners

Role and type of foreign Collaborator participation in present project will be determined according to the ISTC governing documents. It is supposed, the participation of the Collaborators in this project will be carried out in the following forms:

- the information exchange during project implementation;

- joint seminars, workshops, meetings, consultations;

- verification of results using independent methods and/or equipment. It is expedient a participation of Collaborators on the carrying out the pre- and post-test simulations of the scale experiments with vessel models by means of the available SA computer codes. The results both pre- and post-test numerical simulations fulfilled by means of the various codes will preliminary allow to compare their numerical accuracy and predictive abilities. Other forms of collaboration are possible and above-stated forms of Collaborators participation in the project will be complemented in case of necessity.

6. Technical Approach and Methodology

1) **Task "À"**. The numerical simulations associated with choosing the accident scenarios and test conditions of the VVER scale vessel models, will be carried out by means of the RELAP/SCDAP and MELCOR codes. Within the framework of the project is planned to consider three SA scenarios in VVER, which conditions will be reproduced on the scale experiments with vessel models. Pre-test simulations of the vessel models behaviour during scale experiments for the chosen SA scenarios will be carried out by means of the various codes (ATM-VVR, ANSYS etc) at the project participants disposal. The creep and ordinary mechanical characteristics of the VVER vessel steel obtained up to 1100 C will be used within the numerical calculations. Both the thermal history of the tested vessel model and the load conditions during scale experiments will be used as the basis for post-test numerical simulations. The mechanical characteristics of the vessel steel updated in view of the results received within the material property tests in the Task "D" will be taken into account in post-test simulations. It is necessary to add, that the computer thermomechanical codes on the disposal of “MPEI” and “GP” teams are based on a finite element method.

2) **Task "B"**. Development and manufacturing of the experimental test facility and supporting systems for the VVER scale vessel models testing are associated with decision of a number of the constructional and technological problems. The heater is a central component of discussed experimental test facility. The heater construction thus will work on extreme temperature conditions (more than 1500 C) during the course of a few tens hours. Because of this, the serviceability preservation of the heater will be provided by using of the special materials (ceramics etc) and refractory alloys. The heater design and its main parameters will be determined on base of the scale model testing conditions. The development and creation of the experimental installation and its auxiliary systems will assume a realization of the appropriate design works, manufacturing of the details and units of the installation, and also their assembling. It is supposed, that the additional appropriate experts and organizations will involved in performance of these tasks.

The separate attention is deserved with development and manufacturing of the VVER vessel scale models. It is supposed, that the vessel scale models will be made of the original VVER steel. Material and technology, as well as thermal treatment have to correspond the same conditions of the regular VVER vessels manufacturing. The additional efforts should be directed on the providing of appropriate cooling conditions of the top part of scale model in course of an experiment, where the auxiliary constructive elements (the electrical and gas systems etc.) will be placed.

For realization of the control by test facility and data gathering during the testing it is necessary to develop the control and data acquisition (DAS) systems. It is planned to use not less than 4 channels for control by the electrical, gas and water systems, and not less than 50 channels - for experimental data gathering (temperature, vessel displacements etc) during testing. On the basis that there are the heavy test conditions (first of all, it is a high temperature), the special requirements will be placed to displacement gauges which will fix the outer model surface displacements in course of the testing.

The similar demands will be made for the video & monitoring systems, which installation is planned on the experimental test facility too.

3) **Task "C"**. The study of the VVER vessel behaviour in SA conditions through the experimental and numerical investigation of the vessel scale models behaviour (the thermal and structural analyses) within transient thermal and overpressure loads. In this context the project efforts are focused on the carrying out of three tests on the scaled VVER vessel models. The various heating conditions, structure loading and cooling conditions of the model will be simulated in each of these tests. It is planned, the outer surface of the model will be cooled by air only.

The preparation of each experiment will include the mounting of the experimental vessel model, its equipment by necessary measuring devices and delivering to installation of the electrical power, inert gas, control and DAS systems. The dismantle and inspection of the tested vessel model will be made after realization of each test. The experimental data received as a result of the test fulfillment, will be used for carrying out the post-test simulations. The steel bars will be cut from the vessel model after testing for further manufacturing of the samples intended for the material property creep tests.

4) **Task "D"**. The considered project stage is concerned with determination of the creep characteristics and ordinary mechanical properties of the VVER vessel steel (15Kh2NMFA) at temperature above 700 C on the time range more than 30 hours. The necessity of similar study is dictated by the absence the enough complete creep data of this steel on the time range more than 10 hours because the creep diagrams of the mentioned steel were obtained as a rule only for the time range up to 10 hours within previous investigations. Within the framework of present project it is supposed to carry out the material property tests of this steel for two cases of the sample fabrication: the test specimens fabricated of the original VVER vessel steel (case #1) and manufactured of the vessel models after testing (case #2). The results of the 2-nd case tests will allow to estimate the influence of the prior heating and accumulative damage (as a result of the creep of the vessel model during the test) on the creep strength of the VVER vessel steel.

7. Technical Schedule

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Quarter 1** | **Quarter 2** | **Quarter 3** | **Quarter 4** | **Quarter 5** | **Quarter 6** | **Quarter 7** | **Quarter 8** | **Quarter 9** | **Quarter 10** | **Quarter 11** | **Quarter 12** | **Person\*days** |
| **Task 1**  **(Task “A”)** | SA scenarios. Test conditions of the scale experiments. Seminar |  |  | Seminar |  | Pre-test results. R&D Report |  |  |  | Seminar |  | Post-test results.  Report. Publication |  |
| **Person\*days** | **330** | **340** | **255** | **280** | **255** | **252** | **0** | **290** | **240** | **240** | **245** | **195** | **2922** |
| **Task 2**  **(Task “B”)** |  | Technical projects. Design documentation |  |  |  | Produced Supporting and Control & DAS systems | Produced test facility and assembled the 1-st vessel model |  |  |  |  |  |  |
| **Person\*days** | **240** | **345** | **380** | **355** | **380** | **345** | **275** | **0** | **0** | **0** | **0** | **0** | **2320** |
| **Task 3**  **(Task “C”)** |  |  |  |  |  |  |  | The 1-st test. Protocol of the testing.  Seminar | The 2-nd test. Protocol of the testing. | The 3-rd test. Protocol of the testing. Seminar |  |  |  |
| **Person\*days** | **0** | **0** | **0** | **0** | **0** | **0** | **0** | **835** | **630** | **630** | **0** | **0** | **2095** |
| **Task 4**  **(Task “D”)** |  | Material test Samples (1-st series) |  |  |  |  | Creep Data testing  (1-st series) |  |  | Material test Samples (2-nd series) |  | Creep Data testing (2-nd series). Report |  |
| **Person\*days** | **155** | **240** | **240** | **240** | **240** | **190** | **160** | **0** | **255** | **205** | **180** | **180** | **2285** |
| **TOTAL** | **725** | **925** | **875** | **875** | **875** | **787** | **435** | **1125** | **1125** | **1075** | **425** | **375** | **9622** |

8. Personnel Commitments

8.1. Individual participants

Leading Institution: MPEI

Category I (weapon scientific and technical personnel)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Name** | **Birth**  **Year** | **Scientific Title** | **Weapon**  **Expertise Ref.** | **Function in project** | **Daily rate**  **(US$)** | **Total days** | **Total grants**  **(US$)** |
| PORTYANNOY Anatoly G. | 1948 | Ph. D. | 4.9 | Designing and development of the heater's construction and auxiliary systems of the test facility. Testing of the vessel models | 30.0 | 613 | 18390.0 |
| ZAHARKIN Igor I. | 1936 | Ph. D. | 4.9 | Preparation of the test facility for experiments. The temperature analyses of the vessel models during testing | 30.0 | 367 | 11010.0 |
| MALCEV Vladimir G. | 1939 |  | 4.9 | The thermal analysis of the vessel models during testing. Preparation the test facility for experiments. Post-test examination of the models | 30.0 | 306 | 9180.0 |
| POLIONOV Viktor P. | 1941 | Ph.D. | 4.9 | Preparation and carrying out the scale experiments. Thermal analysis of the scale models | 30.0 | 490 | 14700.0 |
| SOROKIN Alexander P. | 1948 | Dr. | 4.9 | Preparation and carrying out the scale experiments. Pre- and post-test analysis of scale experiments | 30.0 | 428 | 12840.0 |
| BOGOMOLOV Valery N. | 1939 | Ph.D. | 4.9 | Preparation the test facility and carrying out the experiments | 30.0 | 245 | 7350.0 |
| IVANOV Evgeny F. | 1939 | Ph.D. | 4.9 | Preparation the test facility and carrying out the scale experiments. Post-test examination of the scale models | 30.0 | 306 | 9180.0 |
| BOGOSLOVSKAYA Galina P. | 1951 | Ph.D. | 4.9 | Preparation and carrying out the experiments with the VVER vessel models | 30.0 | 245 | 7350.0 |
| KALEDIN Vladimir O. | 1963 |  | 1.1 | Designing and development of the heater of the model. Pre- and post-test analyses of the scale experiments | 30.0 | 605 | 18150.0 |
| SLITKOV Mikhail N. | 1948 | Ph.D. | 1.1 | Preparation and carrying out the scale experiments. Post-test examination of the scale models. Manufacturing of the test samples from the vessel models after its testing | 30.0 | 600 | 18000.0 |
| **Total:** | | | | | | **4205** | **126150.0** |

Category II (other scientific and technical personnel)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Name** | **Birth**  **Year** | **Scientific Title** | **Function in project** | **Daily rate**  **(US$)** | **Total days** | **Total grants**  **(US$)** |
| LOKTIONOV Vladimir D. | 1960 | Ph.D. | Project Manager | 35.0 | 660 | 23100.0 |
| RASSOKHIN Nikolay G | 1923 | Dr., Prof. | The scientific adviser | 35.0 | 86 | 3010.0 |
| DANILOV Vladimir L. | 1945 | Dr., Prof. | The analysis and interpretation of the creep tests of the VVER steel | 30.0 | 67 | 2010.0 |
| MUKHTAROV Erkin S. | 1965 | Ph.D. | Pre- and post-test thermal analysis of the vessel scale models | 30.0 | 100 | 3000.0 |
| ORLOV Vitaly A. | 1972 | Ph.D. | Development of the SA scenarious and conditions of the vessel models testing. Pre- and post-test analyses of the scale tests. Preparation and carrying out the scale experiments | 30.0 | 440 | 13200.0 |
| KHASANOV Renat K. | 1939 |  | Preparation and carrying out the scale experiments | 25.0 | 120 | 3000.0 |
| YAROSHENKO Nikolay I. | 1965 |  | Project Sub-manager. Pre- and post-test simulations of the scale experiments. Preparation of the test samples from the vessel model after scale experiments for creep testing | 33.0 | 363 | 11979.0 |
| KUZNETCOV Vasily D. | 1941 | Professor, Ph.D. | Development of the accident scenarious and conditions of the vessel scale tests | 30.0 | 100 | 3000.0 |
| SIDOROV Alexandr S. | 1955 | Ph.D. | Development of the scenarious of the vessel scale tests. Preparation and carrying out the scale experiments | 30.0 | 150 | 4500.0 |
| ISTOMINA Svetlana V. | 1972 | Ph.D. | Pre- and post-test structural analyses | 30.0 | 100 | 3000.0 |
| SHVETC Alexandr V. | 1976 | Ph.D. | Development of the videomonitoring system. Preparation and carrying out the scale tests | 30.0 | 100 | 3000.0 |
| **Total:** | | | | | **2286** | **72799.0** |

Supporting Personnel

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Number of persons** | **Function in project** | **Daily rate**  **(US$)** | **Total days** | **Total grants**  **(US$)** |
| 1 | The secretary | 20.0 | 140 | 2800.0 |
| 1 | Translater | 20.0 | 150 | 3000.0 |
| **Total:** | | | **290** | **5800.0** |

Participant Institution 1: EDO GP

Category I (weapon scientific and technical personnel)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Name** | **Birth**  **Year** | **Scientific Title** | **Weapon**  **Expertise Ref.** | **Function in project** | **Daily rate**  **(US$)** | **Total days** | **Total grants**  **(US$)** |
| BANYUK Gennadiy F. | 1946 | Ph.D. | 4.9 | The scientific adviser | 22.0 | 250 | 5500.0 |
| SEROSHTAN Sergey I. | 1954 |  | 4.9 | Pre- and post-test thermal analyses of the vessel scale models | 25.0 | 214 | 5350.0 |
| STOBECKY Andrey A. | 1973 |  | 4.9 | Post-test examinations of the vessel scale models | 25 | 206 | 5150.0 |
| **Total:** | | | | | | **670** | **16000.0** |

Category II (other scientific and technical personnel)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Name** | **Birth**  **Year** | **Scientific Title** | **Function in project** | **Daily rate**  **(US$)** | **Total days** | **Total grants**  **(US$)** |
| SEMISHKIN Valery P. | 1947 | **Ph.D.** | Project Sub-manager | 33.0 | 236 | 7788.0 |
| PODSHIBYAKIN Vladimir V. | 1938 | Ph.D. | Development of the SA scenarious in VVER and conditions of the vessel scale models testing | 30.0 | 70 | 2100.0 |
| PAGETNOV Vladimir V. | 1953 | Ph.D. | Analyses of the SA scenarious in VVER and preparation of the initial data for numerical simulations | 30.0 | 240 | 7200.0 |
| FRIZEN Evgeny A. | 1974 | Ph.D. | Pre- and post-test structural analyses of the vessel scale models | 30.0 | 200 | 6000.0 |
| SOROKIN Yuriy S. | 1955 |  | Pre- and post-test temperature analyses of the scale models | 25.0 | 72 | 1800.0 |
| MERKUN Oleg G. | 1976 |  | Post-test examination of the vessel models | 25.0 | 128 | 3200.0 |
| CHURKIN Andrey N. | 1973 |  | Pre-test temperature analyses of the vessel scale models | 25.0 | 72 | 1800.0 |
| VOLKOV Valdimir V. | 1947 |  | Post-test structural analysis of the vessel models | 25.0 | 76 | 1900.0 |
| **Total:** | | | | | **1094** | **31788.0** |

Supporting Personnel

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Number of persons** | **Function in project** | **Daily rate**  **(US$)** | **Total days** | **Total grants**  **(US$)** |
| 1 | Preparation of the R&D reports and protokols | 20 | 100 | 2000 |
| **Total:** | | | **100** | **2000.0** |

Participant Institution 2: IGiL

Category II (other scientific and technical personnel)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Name** | **Birth**  **Year** | **Scientific Title** | **Function in project** | **Daily rate**  **(US$)** | **Total days** | **Total grants**  **(US$)** |
| SOSNIN Oleg V. | 1926 | **Dr., Prof.** | Project Sub-manager | 33.0 | 250 | 8250.0 |
| GOREV Boris V. | 1947 | Dr. | Material property testing of the VVER vessel steel | 30.0 | 225 | 6750.0 |
| LYUBASHEVSKAYA Irina V. | 1964 | Ph.D. | Material creep testing of the vessel steel | 30.0 | 260 | 7800.0 |
| TSVELODUB Igor Yu. | 1952 | Dr., Prof. | Analysis of the creep tests of VVER vessel steel and development of the creep model | 30.0 | 160 | 4800.0 |
| **Total:** | | | | | **895** | **27600.0** |

Supporting Personnel

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Number of persons** | **Function in project** | **Daily rate**  **(US$)** | **Total days** | **Total grants**  **(US$)** |
| 1 | Preparation of the material property tests of the VVER vessel steel | 20.0 | 82 | 1640.0 |
| **Total:** | | | **82** | **1640.0** |

8.2. Managerial responsibilities



9. Financial Information

9.1. Estimated Project Costs (US $)

|  |  |
| --- | --- |
| **Estimated total cost of the project** | 567640.0 |
| **Leading Institution** | 457070.0 |
| **Participant Institution 1** | 55800.0 |
| **Participant Institution 2** | 54770.0 |

9.1.1. Payments to Individual Participants (US $)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Institution** | **Category I** | **Category II** | **Supporting personnel** | **Total** |
| **Leading Institution** | 126150.0 | 72799.0 | 5800.0 | 204749.0 |
| **Participant Institution 1** | 16000.0 | 31788.0 | 2000.0 | 49788.0 |
| **Participant Institution 2** | 0.0 | 27600.0 | 1640.0 | 29240.0 |
| ***Subtotal:*** | | | | 283777.0 |

9.1.2. Equipment

|  |  |  |
| --- | --- | --- |
| **Institution** | **Equipment description** | **Cost (US $)** |
| **Leading Institution** | 1) Purchase of personal computers, office and communication equipment (15000.0 $); 2) Purchase of thermocouples, strain and displacement gauges (14000 $); 3) Reconstruction and repair of the experimental areas (S = 70 m2) and working rooms (two rooms by the common area S = 40 m2) - 25000.0 $ | 54000.0 |
| **Participant Institution 1** |  | 0.0 |
| **Participant Institution 2** | 1) Purchase of personal computers, office and communication equipment (4000.0 $); 2) Modernization and repair of the test machines - 8000.0 $ | 12000.0 |
| ***Subtotal:*** | | 66000.0 |

9.1.3. Materials

|  |  |  |
| --- | --- | --- |
| **Institution** | **Materials description** | **Cost (US $)** |
| **Leading Institution** | Consumption materials and subjects of logistics connected with reconstruction and repair of an experimental space and installation of the auxiliary systems (electrical, gas, water, control and DAS etc); 2) repair and restoration of the heating device of the experimental test facility after tests; 3) Consumption office materials | 10000.0 |
| **Participant Institution 1** |  | 0.0 |
| **Participant Institution 2** | Consumption office materials | 1000.0 |
| ***Subtotal:*** | | 11000.0 |

9.1.4. Other Direct Costs

|  |  |  |
| --- | --- | --- |
| **Institution** | **Direct costs description** | **Cost (US $)** |
| **Leading Institution** | 1) Internet, telephone/fax communications and computer services, release of the reports and publications, transportation of the equipment - 5000 $; 2) Energy, inert gases, water etc. - 5000 $;  3) Subcontracts connected with:  a) mechanical preparation of the material test samples from the VVER vessel and cutting/manufacturing of the test samples from the vessel models after scale experiments – 9000.0 $; b) development of the construction and manufacturing of a heater – 27000.0 $; c) development of the project, manufacturing, assembling of experimental test facility and auxiliary systems (gas, electrical, water) on an experimental site – 63820.0 $; d) development of the design / engineering specifications and manufacturing of the vessel scale models (4 pieces) - 19000.0 $; e) Development of the project and creation of the control and DAS systems. Installation of the systems on an experimental test facility -40000.0 $ | 168820.0 |
| **Participant Institution 1** |  | 0.0 |
| **Participant Institution 2** | 1) Internet, telephone/fax communications and computer services, release of the reports and publications, transportation of the equipment; 2) Energy, inert gases, water etc. | 5000.0 |
| ***Subtotal:*** | | 173820.0 |

9.1.5. Travel costs (US $)

|  |  |  |  |
| --- | --- | --- | --- |
| **Institution** | **CIS travel** | **International travel** | **Total** |
| **Leading Institution** | 4000.0 | 10000.0 | 14000.0 |
| **Participant Institution 1** | 1000.0 | 4000.0 | 5000.0 |
| **Participant Institution 2** | 2000.0 | 4000.0 | 6000.0 |
| ***Subtotals:*** | *7000.0* | *18000.0* | 25000.0 |

9.1.6. Overhead (US $)

|  |  |  |
| --- | --- | --- |
| **Institution** |  | **Amount** |
| **Leading Institution** |  | 5501.0 |
| **Participant Institution 1** |  | 1012.0 |
| **Participant Institution 2** |  | 1530.0 |
| ***Subtotal:*** | | 8043.0 |

9.2. Funding Sources

|  |  |
| --- | --- |
| **Estimated total cost of the project (US $)** | 567640.0 |

9.2.1. Financial Sources

|  |  |  |
| --- | --- | --- |
| **Financial Source** | **Written confirmation (Y/N)** | **Amount**  **(US $)** |
| **Requested from the ISTC** |  | 567640.0 |
| Other financial source 1 | none | 0.0 |

9.2.2. Non-Financial Sources

|  |  |  |  |
| --- | --- | --- | --- |
| **Source** | **Short description of contribution** | **Written confirmation (Y/N)** | **Estimated**  **amount**  **(US $)** |
| none |  | none | 0.0 |

9.2.3. Submitted for Funding to Program Beside the ISTC

none

10. Intellectual Property Statement

The rights for intellectual property that are generated during the course of the project will be regulated by the laws of **the Russian Federation** and by the procedures, which have been developed by the ISTC.

The general conditions on Intellectual Property Rights as described in the Model Project Agreement will be observed.

11. Monitoring and Auditing Statement

In accordance with Article VIII of the ISTC Agreement, project recipients will give to the Center and to each Party which wholly or partly finances a project the right of access to carry out on-site monitoring and audit of all activities of the project. Project agreements will specify the portions of facilities, equipment, documentation, information, data systems, materials, supplies, personnel, and services which will concern the project and therefore will be made accessible for monitoring and audit. Project recipients shall have the right to protect those portions of facilities that are not related to the project.

12. Supporting Information

none