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|  | EUROPEAN COMMISSION  DIRECTORATE-GENERAL ‘RESEARCH’ | INTERNATIONAL  SCIENCE AND  TECHNOLOGY  CENTRE |  |

## NON PROLIFERATION THROUGH SCIENCE AND CO-OPERATION

**CONTACT EXPERT GROUP**

**on**

**SEVERE ACCIDENT MANAGEMENT**

**(CEG-SAM)**

**MINUTES OF THE 12th MEETING**

**St.Petersburg, Russian Federation**

**Atomenergoproekt, SPEAP**

**Scientific Research Design Institute**

**September 11-13, 2007**

Meeting Location: Conference room hotel “Morskoy Vokzal”

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| Dissemination level: RE  PU: public  RE: restricted to EC and a group specified by the CEG-SAM members  CO: confidential, only for EC and CEG-SAM members |

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Final minutes, March 5, 2008 CEG-SAM / M-12

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| Subject: 12th Meeting of the ISTC  “Contact Expert Group on Severe Accident Management” (CEG-SAM)  Place: Conference room hotel „Morskoy Vokzal“, St.Petersburg, Russia  Date: September 11-13, 2007  Participants: 42 participants of 27 organizations from 11 countries:  Mr. H.J.Allelein GRS, Cologne  Mr. E.Altstadt FZD, Dresden-Rossendorf  Mr. G.Azarian AREVA NP, Paris  Mr. D.Bottomley EC, DG JRC / ITU, Karlsruhe  Mr. G.Cenerino IRSN, Fontenay aux Roses  Mr. B.Clement IRSN, Cadarache  Mr. G. Ducros CEA, Cadarache  Mr. M.Fischer AREVA NP, Erlangen  Mr. S.Güntay PSI, Villigen  Mr. L.E. Herranz CIEMAT, Madrid  Mr. P.Hofmann Consultant, Karlsruhe (**secretary**)  Mr. M.Hugon EC, DG-RTD / J.4, Brussels (**chairman**)  Mr. Z.Hozer AEKI, Budapest  Mr. Ch. Journeau CEA/DTN, Cadarache  Mr. M. Krause AECL, Chalk River, Canada  Mr. J.S.Lamy EdF, Clamart  Mr. A. Miassoedov FZK, Karlsruhe  Mr. F.Oriolo Pisa University, Pisa  Mr. J. Stuckert FZK, Karlsruhe  Mr. K.Trambauer GRS, Garching  Mr. W.Tromm FZK, Karlsruhe  Mr. S.Bechta RIT-NITI, Sosnovy Bor  Mr. V.Bezlepkin SPAEP, St.Petersburg  Mr. V.Baklanov IAE NNC PK, Kurchatov-City, RK  Mr. S. Bogatov RRC KI, Moscow  Ms. L.Degjareva NPO LUCH, Podolsk  Mr. A. Goryachev RIIAR, FRD, Dimitrovgrad  Mr. V. Granovsky NITI, Sosnovy Bor  Mr. V.Khabensky RIT-NITI, Sosnovy Bor  Mr. V.Khvoshchinsky RRI-KI, Moscow  Mr. A.Kisselev IBRAE, DNS, Moscow  Mr. A.Kondrashenko RFNC-VNIIEF, Sarov  Mr. V.Loktionov MPEI-TU, Moscow  Ms. E.Malysheva IAE NNC PK, Kurchatov-City, RK  Mr. V.Nalivaev NPO LUCH, Podolsk  Mr. A.Palagin JRC / ITU, Karlsruhe  Mr. V.Semishkin OKB GIDROPRESS, Podolsk  Mr. V. Strizhov IBRAE, Moscow  Mr. L. Tocheny ISTC, Moscow (**co-chairman**)  Mr. M.Veshchunov IBRAE, Moscow  Ms. T. Yudina IBRAE, Moscow  Mr. V.Zhdanov IAE NNC, Kurchatov-City, RK  Distribution list: Mr. J.M.Silva Rodríguez DG-RTD  (Shortened version Mr. Z. Stancic DG-RTD  of the minutes) Mr R. Burmanjer DG-RTD / D.3  Mr. J.Sanders DG-RTD / D.3  Mr. P. Fernández Ruiz DG-RTD / J  Mr. A. Perez Sainz DG-RTD / J.1  Ms. I. Torne DG-RTD / J.1  Mr. S. Webster DG-RTD / J.2  Mr. R.Schenkel DG-JRC  Mr. P. Frigola DG-JRC / 2  Mr. G. Sadler DG-JRC / 2  Intranet of Unit J.2  Mr. N. Jousten ISTC, Moscow  Mr. W. Gudowski ISTC, Moscow  EU CEG-SAM members  Contact person: Mr. M. Hugon Tel.: +32 2 296 5719 – DG-RTD / J.2 |

Revised final agenda of the meeting see Annex 1, list of participants see Annex 2.

The Saint Petersburg Scientific Research Design Institute (Atomenergoproekt), St.Petersburg, Russian Federation, organized the 12th CEG-SAM meeting on September 11-13, 2007. The meeting location was the conference room of the hotel “Morskoy Vokzal” in St.Petersburg.

The CEG-SAM meeting is divided into restricted and extended sessions. The restricted sessions are to discuss internal matters and the status of current ISTC projects. The extended sessions are dedicated to presentations of the progress of on-going ISTC projects and of new or revised ISTC/STCU proposals by scientists from the Russian Federation, the Republic of Kazakhstan and the Ukraine.

The unofficial opening session of the meeting took place in the headquarter of the Saint Petersburg Scientific Research Design Institute (SPAEP). S.Onufrienko, the director of SPAEP, welcomed the CEG-SAM members and presented an overview on the activities of Atomenergoproekt. The company Atomenergoproekt has been involved in the design and construction of heat power plants since 1929 and in nuclear power plants since 1951. More than 89 electric power stations were commissioned in Russia and the republics of the former USSR. There are also 26 power plants in operation in 11 foreign countries which were designed by the institute. Currently the institute is working at the detailed design and construction of a sodium cooled power unit (BN-800) at Beloyarsk and two VVER-1200 power units at Sosnovy Bor. About 70% of the Russian nuclear power plants were developed by SPAEP. S.Onufrienko mentioned that between Russia and China exists a close co-operation in the field of fast sodium cooled reactors.

S.Swetlov (SPAEP) gave in addition a short presentation of the research activities of SPAEP that include severe reactor accident studies up to the meltdown of the reactor core, the development of active and passive hydrogen burning systems, the development of core catcher and of ex-vessel cooling systems.

The chairmen M.Hugon and L.Tocheny used the opportunity to express their thanks to V.Bezlepkin and S.Onufrienko from SPAEP who kindly offered to organize and host the 12th CEG-SAM meeting in St.Petersburg.

**Restricted session**

**Topic #1:** Welcome and opening remarks

The chairman M.Hugon opened the first part of the restricted session and welcomed the EU participants of the 12th CEG-SAM meeting of the Contact Expert Group on Severe Accident Management (CEG-SAM) of the International Science and Technology Centre (ISTC).

L.Tocheny delivered greetings from the Director of ISTC N.Jousten and the Deputy Director W.Gudowski to the CEG-SAM. They think that the CEG-SAM is a good example for a programmatic approach for new ISTC projects and ideas.

**Topic #2:** Adoption of the agenda of the 11th CEG-SAM meeting

The presentation of A.Miassoedov (topic #6) should also be given in the extended session to inform the Russian and Kazakh scientists on the current status of the ISTC CEG-SAM webpage (topic #11b). With these changes, the appended agenda (see Annex 1) was accepted.

**Topic #3:** Approval of the minutes of the previous 11th CEG-SAM meeting in Dresden, Germany, March 7-9, 2007.

The secretary took into account the comments received on the draft minutes by E.Altstadt, D.Bottomley, G.Ducros, G.Cenerino, and Ch.Journeau as well as by S.Bechta and M.Veshchunov in the revised minutes dated June 20, 2007. The revised minutes were then approved by the CEG-SAM members without any additional changes at the CEG-SAM meeting in St.Petersburg, September 11, 2007.

**Topic #4:** Discussion of the “Specific action list” of the 11th CEG-SAM meeting in Dresden, Germany

Action 11/1: D.Bottomley and Ch.Journeau will write the two advice notes for the CHESS-2 # 3702 and the STCU # 4207 project proposals. *Action successfully completed.*

Action 11/2: E.Altstadt and S.Güntay will write the CEG-SAM opinion on the ISTC project proposal #3635, while Ch.Journeau will send it to SARNET WP10.2 for an official advice. Deadline: March 23, 2007. *Action completed. The project was funded without the comments of CEG-SAM.*

Action 11/3: Y.Dutheillet and K.Trambauer will write the draft opinion on the PARAMETER project proposal (# 3690). *Done, comments had been obtained.*

Action 11/4: L.Tocheny will contact Sarov to investigate the status of the grant on MCCI. *A.Kondrashenko will give a presentation. L.Tocheny mentioned that all nuclear activities are under official restriction concerning the transfer of the nuclear related results. Strong export control procedures were established, that means, the institutes need special licenses and the receiver of the results should not distribute the obtained results. All ongoing projects such as PARAMETER and VERONIKA have to follow the new rules. Several participants expressed concerns with this situation and asked whether the EC or the ISTC could take action to improve this situation and how their organizations could help these actions.*

Action 11/5: M.Hugon will discuss the new procedure concerning foreign collaborators with J.Sanders in DG RTD (Koreans participate in METCOR-P without paying).

*Letters of Support have to be sent to ISTC to become a foreign collaborator (see Action 11/6). Switzerland is considered like an EU Member State for research activities and can participate without payment. Korea can participate as foreign collaborator in METCOR-P without payment because it has not been withdrawn from the list of foreign collaborators during negotiations.*

Action 11/6: General procedure for “Letters of Support” (LoS).

The collaborators should send the letter of support and/or advice by E-mail and by air mail to the Executive Director of ISTC, Norbert Jousten, with scanned copies by E-mail or by fax to the CEG-SAM chairmen M.Hugon (EC) and L.Tocheny (ISTC), the secretary P.Hofmann, and R.Burmanjer and J.Sanders (EC).

Action 11/7: GRS will host the CEG-SAM web page.

*Action successfully completed, thanks to K.Trambauer (GRS) and A.Miassoedov (FZK).*

Action 11/8: Establish restricted access rules to the CEG-SAM web page for the foreign collaborators from non EU countries, which are not funding ISTC projects (a possibility is not to give them access to the web site at all and the ISTC Secretariat to send them directly the documents of the projects in which they are foreign collaborators).

*Action successfully completed (see topic #6).*

**Topic #5**: Future prospects of ISTC

M.Hugon gave a presentation on ISTC projects contact expert groups (CEG). The objective is to provide a mean of contact between various experts involved in project conception, selection and recommendations, implementation, subsequent optimization of project results, to foster exchange of information between various ISTC projects, and to promote the possibilities of future or joint research through the ISTC. Results of SARNET activities are periodically presented to CEG-SAM members.

The transmission of ISTC proposals and project reports related to SAM to SARNET topical co-ordinators is well established. Project proposals are sent to SARNET topical coordinators for comments. The procedure is effective and iterative and was applied for example on the ISTC projects VERONIKA and METCOR-P. ISTC programmes are taken into account in the definition of SARNET Severe Accident Research Priorities (SARP Group). The data and results of ISTC projects are available for model/code validation and are filling gaps in knowledge. This results in an optimisation of research efforts.

In addition, a list of ISTC/STCU projects recommended by the CEG-SAM was presented and updated.

The future trend for both ISTC and STCU funding from EC will be in 2007 about 25 M€, in 2008 about 15 M€, and in 2009 about 8 M€. L.Tocheny mentioned that because of the increase of prices in Russia the envisaged amount of money would not be sufficient to support ISTC projects in the future. On the other hand, there will be no future for a 100% funding of projects as presently. Russian organizations should contribute more financially to ISTC projects in the future. L. Tocheny indicated that some costs that are not taken into account in the ISTC project budget (as fees for the use of existing facilities) are considered to correspond to a Russian co-funding of current projects.

**Topic #6**: Status of the official ISTC CEG-SAM webpage

A.Miassoedov gave a short presentation on the layout of the ISTC CEG-SAM webpage that is hosted by GRS (Garching, Germany) portal and is now fully operational (http://cegsam.grs.de). He developed a new structure for the webpage where all documents (project proposals, advices, work plans, progress reports) will be collected under the ISTC project number. The access procedure to the web site for CEG-SAM members and ISTC project coordinators was described. There will be a unique user name and password for each user and different read /write permissions for the different users. Russian and Kazakh project managers should provide information (name and e-mail address) to A. Miassoedov/K.Trambauer to be included in the users list. After that they will have full access permissions for their projects web-pages. They will be exclusively responsible for updating the project documentation/deliverables and the upload of presentations from project progress meetings.

The CEG-SAM members will have full access to minutes (restricted and open sessions) and all stored documents. There will be special access rights for non-European members for the project in which they participate. It will be restricted to two names per institute per project.

**Topic #7**: Report by the secretariat

M.Hugon mentioned that the funding for the Euratom FP7 in nuclear fission and radiation protection is only increased by taking into account inflation with respect to FP6. He then recommended the participation of Russian organizations in FP7 without Euratom funding.

**Topic #8**: Update on the information exchange and interaction between ISTC CEG-SAM and SARNET

The presentation was shifted to topic #11a.

**Topic #9**: Preliminary discussion of new ISTC project proposals

The new ISTC project proposals will be presented under topics #21 to #28. There was no time to discuss the proposals in detail in the first restricted session. Therefore, it was done under topic #30.

# Extended session

**Topic #10**: Welcome of the Russian and Kazakh colleagues; approval of the shortened minutes of the 11th CEG-SAM meeting in Dresden; adoption of the agenda

M.Hugon opened the extended session of the meeting and welcomed the Russian and Kazakh participants and expressed his thanks to V.Bezlepkin and his co-workers from the Scientific Research Design Institute (SPAEP) who kindly offered to organize and host the 12th CEG-SAM meeting in St.Petersburg.

L.Tocheny delivered greetings to the participants from ISTC.

The revised shortened minutes of the 11th CEG-SAM meeting, distributed to the Russian participants in June 2007, were accepted without any additional changes. The planned presentation from V.Protsak (topic #23) could not be given since he was not able to attend the meeting. The agenda was then approved and adopted with this change.

**Topic #11a:** Update of the information exchange and interaction between ISTC CEG-SAM and EC-SARNET

B. Clément (IRSN) presented the SARNET update. Up to now the interaction between CEG-SAM and EC-SARNET works well and the EC-SARNET recommendations were considered in the final work programmes of the various ISTC project proposals. The results of ISTC projects are used by foreign collaborators in the frame of SARNET.

The interaction between EC-SARNET and CEG-SAM brings mutual benefits and further assures a critical mass of expertise for ISTC proposals addressing specific issues in the SAM area. The objective of the interaction is the resolution of still-pending questions that are important for reactor safety, and the knowledge transfer for safety application.

The Severe Accident Research Priorities (SARP) had been just revised and it is recognized that the ISTC projects can be very valuable in filling in the gaps in the knowledge. The ISTC projects PARAMETER, VERONIKA, VVER-QUENCH and large-scale MCCI facility are some examples of such valuable contributions. A status of the revision, as of summer 2007 (nearly completed) was briefly given.

6 issues remain open with high priority, 3 issues with medium priority, and 5 issues remain open with low priority and could be closed after finalizing the related activities.

The 6 issues with **high priority** are: 1) Combined research on core coolability during reflood and debris cooling in lower head. 2) Combined research on ex-vessel melt pool configuration during MCCI and ex-vessel corium coolability by top flooding. 3) Combined research on melt relocation into water and ex-vessel FCI. 4) Research on hydrogen mixing and combustion in containment. 5) Research on oxidising impact on source term. 6) Combined research on iodine chemistry in RCS and in containment.

The 3 issues remaining with **medium priority are:** Research activities on hydrogen generation during reflood, on the integrity of RPV by external vessel cooling and on direct containment heating.

The 5 issues with **low priority** are: Research on corium coolability in external core catcher, on corium release following vessel rupture, on dynamic and static behaviour of containment, on aerosol behaviour impact on source term and on core reflooding impact on source term.

**Topic #11b**: Status of the official ISTC CEG-SAM webpage

The presentation of A.Miassoedov, given under topic #6, was repeated to inform the Russian and Kazakh colleagues how to use the CEG-SAM webpage. He stressed especially the responsibility of the ISTC project managers to keep the webpage continuously updated.

**On-going project presentations**

**Topic #12:** Status report on the ISTC project # 1648.2 “Examination of VVER fuel behaviour under severe accident conditions, Quench state” (VVER-QUENCH)

Part 1: A.Goryachev (RIIAR) presented the status of the project that consists of three stages. Stage A: Study of the irradiated fuel rod segment behaviour under re-flood conditions to determine the hydrogen generation and fission product release. Stage B: conduct of one integral quench experiment with 31 VVER fuel element simulators. Stage C: development of models and codes to describe VVER core behaviour under severe accident re-flood conditions (quench stage) on the base of the results of stages A and B (see topic #13).

Altogether eleven quench tests with un-irradiated and ten quench tests with irradiated fuel rod segments (re-fabricated from VVER fuel rods at burn-ups of 54 and 65 MWd/kgU) were carried out under the planned test condition of 1400, 1600 and 1700°C without and with cladding pre-oxidation (about 100 µm). The tests provided data on hydrogen generation, volatile fission products release, as well as cesium release to the quench water. The tests with un-irradiated fuel rod segments have shown good agreement regarding the hydrogen generation compared with the results of earlier experiments with un-irradiated fuel rod segments at FZK.

In contrast, significant differences were obtained in the hydrogen generation in the tests with irradiated fuel rod segments compared to the tests with un-irradiated ones as a result of a more extensive cladding oxidation and embrittlement and different mechanism of cladding failure (fracture). As a result, more hydrogen was produced during quenching. The observed phenomena may be explained by the disappearance of the initial fuel/cladding gap in the irradiated fuel rod segments. The irradiated specimens show a pronounced hydrogen generation only at the final quench stage due to the existing thick oxide scale while the non-irradiated fuel rod segments oxidize stronger during the first quench stage.

The ISTC Project has been extended until the end of November 2007. It is assumed that all planned tests with irradiated fuel rod segments can then be executed in time.

Part 2: M.Veshchunov (IBRAE) presented the development of models and codes to describe the material behaviour in the quench tests. The modeling of the oxidation by the SVECHA/QUENCH codes resulted in the following conclusions: 1) SVECHA/QUENCH (S/Q) and MFPR codes were adapted to simulate behaviour of the VVER fuel rod simulators in the RIAR quenching tests. 2) The modified S/Q code predicts well the temperature evolution during quenching, the maximum extent of Zr-1%Nb cladding oxidation and the final mechanical state of the oxidized Zr-1%Nb cladding in the tests with fresh uranium fuel rods. 3) The S/Q code was extended for simulation of the RIAR quenching tests with irradiated fuel rods. Analysis and simulations of the tests show that the gap collapse and chemical interaction between the burned fuel pellets and the cladding due to swelling leads to additional embrittlement of the cladding. 4) The MFPR code reasonably predicts Cs release in the RIAR quenching tests with irradiated fuel rod segments.

**Topic #13:** Progress report on the stage B of the ISTC project # 1648.2. First results of the integral re-flood test QUENCH-12 with a VVER bundle

J.Stuckert (FZK) presented results of the test QUENCH-12 which was successfully conducted at FZK in September 2007. The experiment investigated the effects of VVER materials and VVER bundle geometry under core re-flood conditions, in comparison with test QUENCH-06 (ISP-45) with Western type PWR geometry. While the PWR bundle simulator is made of a single unheated rod, 20 heated rods, and 4 corner rods arranged on a square lattice, the VVER bundle uses 13 unheated rods, 18 heated rods and 6 corner rods, arranged on a hexagonal lattice. The test was conducted under the same test conditions as QUENCH-06. This involved a pre-oxidation phase of the cladding to a maximum oxide layer thickness of about 200 µm. Then a power ramp was launched until a bundle temperature of about 1800 °C was reached before re-flood of the bundle from the bottom with water at room temperature was initiated.

The total hydrogen generation was 58 g (for QUENCH-06: 36 g). During the reflood period of the bundle 24 g hydrogen was released (for QUENCH-06: 4 g). This may be attributed partly to the longer excursion time in QUENCH-12 compared to QUENCH-06. Other reasons for the increased hydrogen production may be an extensive damaging of the cladding surfaces due to the breakaway oxidation and local melt formation with subsequent melt oxidation.

The SVECHA/QUENCH code was applied to simulate the QUENCH-12 bundle test. The calculations adequately reproduce temperature evolution of the central rod at different elevations during the whole test duration including the quenching phase. The calculated oxide thickness at the end of the test was significantly underestimated. The details of the experimentally measured time dependence of the hydrogen production rate are well calculated during the pre-oxidation and transient phases. The calculations underestimate the hydrogen production rate at the end of the transient and quench phase of the test.

**Topic #14:** Final report on the ISTC project # 2936 “Modelling of reactor core behaviour under severe accident conditions. Melt formation, relocation and evolution of molten pool” (Reactor Core Melting)

M.Veshchunov (IBRAE) presented the essential results of the terminated ISTC project # 2936. The main objective of the Project has been to update and to improve and verify models on reactor core molten materials behaviour at consecutive stages of a severe accident on the base of detailed analysis of available and new experimental data from the early stage when melt formation and progression during core degradation occur (SVECHA/MELT code), to the late stage, when the core is completely degraded and a molten pool is formed in lower head of the RPV (CONV code), and to prepare them for benchmarking of simplified models and for implementation in the existing SA system codes. The project consisted of 2 parts and altogether 8 tasks that were described in detail.

Part 1: Melt behaviour in the early stage of core degradation (SVECHA/MELT code).

Task 1: Modelling of melt formation and onset of melt relocation. Improvement and implementation of the models for dissolution of ZrO2 and UO2 by molten Zircaloy, U-Zr-O melt oxidation and release from the cladding breach in the SVECHA code system. Task 2: Modelling of candling processes and implementation in the SVECHA code. Task 3: Modelling of slug relocation and implementation in the SVECHA code. Task 4: Verification of the newly developed SVECHA/MELT code against available experimental data. Preparation of the newly developed modules for the implementation in the system codes such as ICARE/CATHARE, MELCOR, or ASTEC. Task 5: Modelling of the U-Zr-O molten mixture behaviour. Analytical support for the ITU tests on irradiated and MOX fuel dissolution by molten Zr and U-Zr-O melting points determination.

Part 2: Melt behaviour in the late stage of core degradation (CONV code).

Task 6: Development of a three-dimensional thermal-hydraulic code and adaptation to the LIVE project conditions, implementation of the model in the CONV code. Task 7: Theoretical analysis and code validation. The numeric-theoretical analysis of the flows in a boundary layer adjacent to cooled boundaries. Validation of the developed flow models using experimental data including experiments with a heat generating fluid such as LIVE, COPO, SIMECO. Task 8: Development of a thermal-hydraulic model that accounts for crust formation. Development of models and code for numerical simulation of flows at high Rayleigh numbers under conditions of crust formation on a cooled surface. Test of the developed models and modules on experimental data with crust formation using, for example RASPLAV tests.

The models and codes developed within the Project will be implemented in the Russian severe accident code RATEG/SVECHA (SOCRAT) and will be prepared for implementation in the European code systems such as ICARE/CATHARE, MELCOR, or ASTEC. The work was carried out in tight connection with the SARNET project and with substantial support of the European collaborators, which are greatly acknowledged.

**Topic #15**: Status of Project # 3194 “Fuel Assembly Tests under Severe Accident Conditions, PARAMETER facility”

V.Nalivaev (FSUE SRI SIA “LUCH”) presented the current status of the project PARAMETER that includes the conduct of two VVER-1000 bundle experiments under severe reactor accident conditions, similar to the experimental conditions of the QUENCH-06 experiment conducted at FZK. In the first test the overheated bundle was flooded from the top (40 g/s) in the second test the bundle was flooded simultaneously from the bottom (130 g/s) and from the top (40 g/s). The test parameters for the bundle experiments (heat-up rate, steam flow rate, extent of pre-oxidation of the cladding, maximum cladding temperature before quenching, flooding rates) were fixed on the basis of SVECHA code predictions by IBRAE (see topic #16).

The first test PARAMETER-SF1 was conducted on April 2006 and the available results were presented at the last CEG-SAM meetings. The second test PARAMETER-SF2 with bottom and top flooding was conducted on March 2007. The test procedures and applied test parameters for both bundle tests were described in detail and the main results summarized and compared with the test QUENCH-06. The tests resulted in the following total amounts of hydrogen generated during the tests: PARAMETER-SF1 about 92g, -SF2 about 28g; QUENCH-06 about 36g hydrogen. For the PARAMETER-SF1 bundle experiment extensive post-test examinations have been carried out.

**Topic #16**: Computational assessment (pre- and post-test) of fuel assembly tests in the frame of the project # 3194

A.Kisselev (IBRAE) presented the completed post-test computational assessment of the experiments PARAMETER-SF1 and –SF2. The assessment should evaluate the reliability and self-consistency of the results of the PARAMETER experiments as well as the effect of uncertainties of parameters and variation of the facility itself (heat conduction of thermo-insulation, coolant bypassing the assembly, cladding temperatures reached at the elevation with incomplete indications of thermocouples, etc.) on the results of calculations by the computer codes RATEG/SVECHA (SOCRAT), RELAP, MELCOR 1.8.5, PARAM TG, ICARE/CATHARE, ATHLET and MAAP4 (SF1).

The results of the numerical modeling confirm the self-consistency of the PARAMETER-SF1 and -SF2 measured data and the fact that these data represent valuable information for severe accident computer codes verification. Main conclusions derived from numerical analysis of the PARAMETER-SF1 experiment are: the -SF1 experimental data are fully consistent (temperature, oxide scale thickness, UO2 dissolution, hydrogen release) and are generally well predicted by the codes. The SF1 test demonstrated that the top flooding of overheated fuel elements (>2000°C) leads to significant rod cladding degradation (up to 40%), to an increased total mass of generated hydrogen by a factor of 3 (about 30g before quenching was launched and about 92 g total mass).

For the experiment PARAMETER-SF2, new nodalization schemes have been developed to perform pre- and post-test calculations with the computer codes RATEG/SVECHA, RELAP/SCDAPSIM, and ICARE2. The tests PARAMETER-SF1 and –SF2 test provided valuable information for VVERs SAM procedures as well as for further model and code improvements and verification calculations.

**Topic #17**: Final report on the ISTC project #2916 “Nuclear fuel behaviour during the Chernobyl accident (CHESS-1)”

The general objective of the project has been the development of models describing the nuclear fuel behaviour during the active phase of the Chernobyl accident. The models should explain the current physical and chemical state as well as the spatial location of fuel containing materials (FCM) and radioactive substances inside the damaged reactor unit.

S.Bogatov (RRC KI) presented the first part of the project: Creation of a data base of lava-like fuel containing materials in Unit-4 of the Chernobyl NPP after the accident. The information on fuel and zirconium in the metal that was molten during the active phase of the accident was collected, analysed and adapted for modelling of the accident.

The data used were taken from publications, reports, survey certificates, and construction drawings, etc.; in addition available photo- and video-materials were studied. The total amount of information records used in the obtained database exceeds 6000. The database is divided into the following major sections: 1) fuel and construction materials of Unit 4 of the Chernobyl NPP before the accident; 2) status of the various materials half an hour after the accident (onset of the lava generation); 3) heat sources during the lava (corium) generation; physical and chemical processes during lava generation; and 4) lava spreading. The information is grouped into the following items: location of main accumulations of solidified metal, and results of chemical and radiochemical analyses.

The database will enable code systems to predict the lava formation, flow, and distribution. It will be sent to collaborators in electronic or (if required) in paper form. The lava is very inhomogeneous. The neutron “spike” that occurred in 1990 after heavy rain was probably the result of water seeping down to a zone of high concentration Uranium (black and brown lava is 4wt% and 8wt% U, respectively, but zones of up to 30-40wt% U would be necessary to cause such re-criticality.

Results obtained make it possible to predict LFCM location and structure in places where no direct observation or measurements are still possible. Proposals for future studies – long-term Lava-like Fuel-Containing Materials (LFCM) behaviour (“CHESS-2”) - would be a logical continuation of data acquisition on a real reactor accident.

V.Strizhov (NSI RAS) presented part 2 of the project. The presentation summarizes the results that were achieved during the execution of the project. Main objectives of the project were the systematization of a huge body of data on LFCM and the development of models describing lava generation and spreading during the early post-accident days***.***

Initial data involved in the data-base included condition of the fuel, materials and constructions of the Unit 4 before the accident, materials incorporated into the “lava”, heat sources and sequence of physical and chemical lava-generation processes adopted for further consideration.

The existence of FCM accumulations with high uranium concentration has been identified at two places under the reactor. The set of parameters necessary for lava spread modeling were determined and include lava viscosity, density, heat capacity, thermal conductivity, heat removal parameters etc. Results of 3D-simulation of the spreading phenomenon showed that the most probable melt temperature range varies between 1400 and 1450K. The spreading time for this temperature range varies between 1 to about 10 hours. Qualitative agreement between modeling results and observations was obtained. It was found that results are very sensitive to the dependence of viscosity on temperature. Other uncertainties such as corium flow rate through the break also significantly influence the modeling results.

The main outcomes achieved in the simulation of the lava spreading is a good and self-consistent agreement between visible and calculated lava characteristics and several results may be significant for future “Shelter” transformation activities, especially prediction of all lava-spreading boundaries for inaccessible rooms.

**Topic #18:** Status of the ISTC project # K-1265 “Study of the processes of corium-melt retention in the reactor pressure vessel” (INVECOR)

V.Zhdanov (IAE NNC RK) described briefly the objective of the in-vessel corium retention experiments (INVECOR), e.g. the improvement of the safety assessment of LWR corium in-vessel retention (IVR) and the modelling of the thermal and physico-chemical processes of the prototypical corium pool and its retention in the water-cooled RPV lower head.

The works on "Large-scale experiments" have been delayed due to procurement delays of necessary materials and parts of the equipment. Only one preliminary test was performed with a single plasmatron dipped into prototypic corium (C-32) without preliminary melting. The thickness of corium layer around the plasmatron was 30 mm at the bottom and sidewall of the vessel model. The total mass of the corium loading was about 9 kg. The power of the plasmatrons was 16 to 17 kW; the time of the test was about 1 hour. The maximum temperature on the outer vessel boundary was about 1100 °C.

In spite of the delay in the delivery of materials and equipment for the integral experiments, the activities of the project have been continued in order to obtain new useful data both for the performance of the INVECOR project and as supplement of the database on severe accident research. It should be noted, that all supporting experiments were accompanied by corresponding pre-test calculations.

**Topic #19:** Status of the ISTC project #3345 “Ex-vessel source term analysis” (EVAN), phase 1

V.Bezlepkin (SPAEP) presented the status of the project EVAN. The project includes theoretical and experimental research of the processes affecting the late phase fission product (FP) release into the containment atmosphere. This stage is characterised by corium melt release from the reactor pressure vessel into the containment compartment. At this stage, the fission products are released from the core melt into the containment atmosphere. The assessment of radiological consequences for severe accidents includes the determination of the time-dependent fission product release into the containment atmosphere and the physical-chemical composition of the environmental source term.

First of all the fission product (FP) composition inside fuel has been calculated for normal reactor operation conditions. The release of volatile FPs into the fuel cladding gap has been estimated for normal reactor operation and for accident conditions. The releases of low-volatile radioactive FP from fuel vary significantly when different codes are used.

The analysis of conditions of aerosols release from the primary circuit of WWER reactor-types during severe accidents has been carried out. The velocity ranges and Reynolds numbers for scenarios of severe accidents as well as large and small break LOCA, accompanied by blackout or failure of ECCS were obtained. For an accident with large break LOCA the behaviour of fission products in primary circuit is analyzed and the masses of the aerosols, which have left the break, are obtained. Conditions of aerosol formation and precipitation conditions above a corium melt have been carried out by numerical analysis of free convection by means of a 3-D code.

Development of the basic equations have been performed, criteria for their use defined, formulas for calculations of speeds of condensation, coagulation applied to determine the final aerosol characteristics in a containment atmosphere, and also the results of the calculations usíng an already-developed code are analysed.

A model of fission product release from the molten corium pool is presented. It is supposed that fission product vapor over molten corium is saturated and is blown off at finite rate, which determines the fission product release rate. Other kinetic effects are not taken into consideration. The model gives an upper estimate of fission product release into neutral atmosphere, which is confirmed by comparison of the model predictions with the results of the MASCA experiments. Molecular description of liquid and gas phases allows chemistry effects to be taken into account and to describe fission product release in oxygen-containing atmospheres.

The model for calculation of re-suspension in turbulent flow was described. The parameters characterizing particles, adsorbing surface and particle-surface interaction that should be obtained by systematic experiments are determined. The calculations of the turbulent gas flow in a tube were carried out. Based on their results the corresponding resuspension rates are calculated. Analysis of the results allows one to conclude that the effective resuspension takes place when the flow velocity exceeds 60 m/s. In addition, the surface roughness influences dramatically on the resuspension rate.

In the last topic of iodine behaviour in the containment test vessels looked at the gas/aqueous partitioning while autoclaves looked at the iodine chemistry under irradiation and the presence of sludge. At high temperatures with boric acid and CsI and under irradiation, iodine becomes volatile and the stainless steel surface corrodes. The ferrous sludge results in a small reduction of the iodine volatility. Modelling of the gas and aqueous phases has been compared with experiment and shows that the water phases are reasonably estimated but the gas phase estimates are an order of magnitude too low. Improvements will be made in the last quarter.

**Topic #20**: Progress report on the ISTC project #3592 (METCOR-P) "Corium Melt Interaction with Reactor Vessel Steel”

S.Bechta /NITI) described the objectives of METCOR-P project: Qualification and quantification of physicochemical phenomena of corium melt interactions with reactor vessel steel with particular interest to interaction characteristics at the vertically positioned interface, peculiarities of interaction with European vessel steel, and corium melt oxidation transients.

The MCP-1 test has been performed in the framework of Task 1. The conditions of MC6 (METCOR), i.e. C-30 corium, TS=1400°C and duration for 10 hours were repeated; the difference was in the vertical position of the interaction interface. A new furnace and steel specimen designs have been developed for this test. The results have shown differences compared to MC6 by: Incubation period shortening (or complete absence); presence of a compact metallic inclusion in the corium ingot; differences in the interaction zone structure and composition, and a lower temperature at final position of the interaction zone/specimen boundary.

The 1st METCOR-P Project Meeting has modified the experimental matrix. As a result, the MCP-2 test on the interaction of vessel steel with the UO2+x-ZrO2 corium was performed in air. Together with the test МС12 (UO2+x-ZrO2-FeOy corium), performed beyond the ISTC funding framework, the test MCP-2 has significantly broadened the temperature range under investigation. For the UO2+x-ZrO2-FeOy corium, the process of corrosion has been described as one determined by liquid phase diffusion of components through the corrosion layer and into the corium crust. It leads to an intensification of corrosion at TS>1050°C. A correlation generalizing experimental data has been proposed for the low-temperature UO2+x-ZrO2-FeOy corium. For the high-temperature UO2+x-ZrO2 corium, corrosion does not intensify until TS reaches 1370°C.

Posttest analyses are being finalized for the tests MCP-1 and MCP-2 and the reports should be expected in October and November 2007. The test MCP-3 has been scheduled for December 2007 (Task 1. Interaction of the sub-oxidized corium metallic melt with the vessel steel specimen at the interaction interface of vertical position).

**New or updated project proposals**

**Topic #21**: Development and experiments at large-scale installation for heating and retention of corium

A.Kondrashenko (VNIIEF) presented the planned experimental investigations on MCCI. In order to test experimentally the corium melt behaviour and melt interaction with concrete under severe accident conditions it is planned to develop a large-scale installation. It should heat and retain a corium melt, consisting of materials of a Western light water reactor core, and should have a complex diagnostic and measuring equipment. To obtain adequate results of the melt interaction with concrete, the installation should have the following characteristics: melt volume ~150 liter, melt mass ~1200-1300 kg, melt composition (30% UO2, 40 to 50% ZrO2, 30-40% Fe), melt temperature ~2500-3000 ˚C, heat fluxes towards walls and a bottom of a catcher ~100 kW/m2, melt retention time ~1-2 hours.

To test the technology of large-scale experiments, it will be a good solution to perform a medium-scale experiment at the first stage. The installation for this medium-scale experiment willhave the following characteristics: melt volume ~15-18 liters, melt mass ~100-120 kg, melt temperature ~2500-3000 0С, heat fluxes towards walls and a bottom of a catcher ~100 kW/m2, melt retention time 10-12 min. CEG-SAM members have proposed to use Limestone-Common Sand concrete for the preliminary test (since this type of concrete is linked to isotropic ablation, any artifact in the heat flux distribution will be detected) and siliceous concrete (for which it must be verified that the observed ablation anisotropy is not an artifact due to experiment size or heating system).

The CEG-SAM expressed its opinion that the planned large-scale experiments are only of interest if they are performed with UO2. There have been enough other experiments done with simulated materials. Simulant materials are acceptable for the technological test at medium scale but assurances that uranium melts can be studied at large scale in the second stage is necessary.

**Topic #22:** Study of fission product release and behaviour of VVER fuel with high burn-up under severe accident conditions (VERONIKA). Discussion of the revised test matrix

A.Goryachev (RIIAR) presented the general project proposal of VERONIKA (**V**VER **E**xperiments on **R**elease due to **O**ver-heating: **N**ormal**i**zation and **K**nowledge **A**ugmentation). This proposal will investigate fission product release from high burn-up fuel annealed under oxidizing and reducing conditions. The objective is to obtain experimental data on the release of fission products (Kr, Xe, I, Cs, Ru, Ce, Mo, Ba, Zr) from highly irradiated VVER fuel of 60 MWd/kgU in the temperature range between 1400 and 2300°C. The results will be used to develop, validate and improve physical models and numerical codes to describe the high burn-up fuel behaviour and fission product release under severe accident conditions (e.g. **M**odel for **F**ission **P**roducts **R**elease (MFPR)). In contrast to earlier similar tests (VERCORS), it is planned to perform comparative tests with and without cladding, as well as turning off the heating at intermediate temperature before fuel collapse, in order to analyze thoroughly the fuel microstructure and fission product distribution at each stage.

The various VERONIKA project proposals have been discussed several times at the last CEG-SAM meetings. To meet the advice from SARNET (25/09/2006) the recommendations and improvements were introduced in the re-revised test matrix presented at the meeting. the comments by SARNET had resulted in some changes and additional improvements will be made regarding experiments to be conducted in air, the fuel characterization, the cladding oxidation and the re-irradiation history. The project consists of two interconnected parts.

Part A: VVER FUEL-FPR. This part is intended for the solution of the next tasks: Experimental study of fuel behaviour and fission products release at temperatures and gas environments typical for severe accidents. Investigation of fission products release from fuel with burnup of 60 MWd/kgU in reducing and oxidizing environments in the temperature range of 1400 - 2300oC. Investigation of the release of a wide list of fission products including short lived isotopes: 85Kr, 133Xe, 131I, 137Cs, 134Cs, 106Ru, 103Ru, 144Ce, 99Mo, 140Ba, 95Zr and others. That will be made possible by additional low temperature irradiation of the specimens in the research reactor. The evolution of the high burn-up fuel microstructure under test conditions will be carefully determined by pre- and post-test microanalysis of the samples.

Part B: MFPR. This part of the Project is intended for the improvement of the theoretical models and MFPR code for description of fission products and highly irradiated VVER fuel behaviour under conditions of severe accidents on the basis of these new experimental results.

The issue of export control has been raised. The CEG-SAM stressed that it must be solved before the start of the project.

**Topic #23:** 23. ISTC proposal on “Long-term behaviour of corium after the accident (using the data of the Chernobyl NPP accident)”; CHESS-2, ISTC project proposal #3702

S.Bogatov (RRC KI) described the objectives of the “CHESS-2” project proposal and its details. It should have been a joint presentation together with V.Kashparov (UIAR, Ukraine) who was not able to participate at the meeting.

The “CHESS-2” project should answer many specific questions. After the end of the active Chernobyl NPP accident phase 20 years have elapsed. What types of physical and chemical processes have occurred in and with the “lava” during this time period? What processes will take place in the future until the removal and disposal of the “lava” for several more decades (up to 100 years) will take place? What physical and chemical processes and what external and internal mechanisms may have an effect on the “lava” degradation? What is the role of self-irradiation? Whether or not the “lava” will transform into fine fuel dust over the period in question? Whether or not soluble uranium compounds will be generated on its basis; and what will be the radiation hazard of such transformations? What countermeasures may be taken in case of hazards and what safety barriers may be recommended for use under the “Shelter” conditions? What general recommendations on safe protracted storage of corium could be proposed?

The project proposal is to develop a model for the long-term behaviour of “lava” under the “Shelter” conditions (10 days – 100 years taking account of the works on the “Shelter” transformation) and so make general recommendations to increase safety of corium storage and removal. While pursuing common objectives, the Projects “CHESS” and “CHESS–2” are solving different tasks through the use of quite different methods. The whole “CHESS” project database will be used in the “CHESS–2” project.

In addition, the database will be supplemented with new sections related to possible radiation and chemical causes of lava degradation. Examples are: data on microstructure of different “lava” types; data describing α-, β- and γ - radiation sources in the “lava” and the dynamics of buildup of absorbed dose from such sources; information on the most important chemical reactions leading to degradation of “lava” materials or, on the contrary, slowing down such degradation processes; investigations of causes and dynamics of degradation of vitrified waste –i.e. “lava” analogues. It is intended to continue the investigations of “lava” samples from the “Shelter” and monitoring of samples in special storage at several institutes. A model would be developed and verified from this extensive database. The final stage would be to combine this model with that from the parallel SCTU Chernobyl project and to make a combined model that would predict the distribution and condition of all radioactive material whether from fuel dust or FCM. This final stage would of course be carried out jointly and there would be combined project meetings throughout (but particularly in this final stage) to ensure that this occurs smoothly. The estimated costs for the project amount to 345000 USD, the duration of the project will be 30 months.

**Topic #24:** “Long-term prognosis of behaviour of the fuel dust in CHERNOBYL Shelter”, STCU project proposal #4207

The project proposal STCU #4207 was not presented since V.Kashparov from the Ukraine was not able to attend the meeting. Nevertheless the links of this SCTU (#4207) project on the 'Long term prognosis of behaviour of the fuel dust in Chernobyl shelter' with the ISTC project (#3702) on the 'Long term behaviour of corium after the Chernobyl accident' were clearly noted by Dr. Bogatov in the previous presentation. This project would also run for 30 months (in parallel with #3702) and would cost 300000 USD.

**Topic #25:** Study of fuel assemblies under severe accident top quenching conditions in the PARAMETER-SF test series. (PARAMETER-SF3 and -SF4 experiments), ISTC project proposal #3690, presentation of the work plan

V.Nalivaev (LUCH) presented the project proposal of additional quench tests with 19 rod fuel assemblies. The scope of activities within 24 months includes the preparation and conduct of two ex-reactor experiments (PARAMETER-SF test series) in the PARAMETER test facility in FSUE SRI SIA “LUCH”. The planned tests with WWER-1000 type fuel rod simulators under combined top and bottom quenching conditions expected from the ECCS (emergency core cooling system) will be a continuation of the experiments PARAMETER-SF1 and -SF2 performed in the frame of the ISTC project #3194. This would particularly look at the central blockage and the degradation mechanism of the bundle. The tests PARAMETER-SF3 with 18 heated rods and 1 central unheated rod and -SF4 with 16 heated and 3 central unheated rods would be carried out with top flooding quenching (40 g/s) from about 1600 °C and 1800 °C, respectively.

The obtained results will be used for safety justification of VVER (PWR) type reactors, as well as for the development of methods and means of control and protection systems, that would be capable of functioning under severe accident conditions. In addition, the database for the verification of severe accident codes (SOCRAT/B1, ATHLET, ICARE-CATHARE etc.) will be enlarged.

**Topic #26**: “Scale experimental investigation of the thermal and structural integrity of the VVER pressure vessel Lower Head in severe accidents”, Presentation of the work plan. ISTC project proposal #3635

V.Loktionov (MPEI) presented the work plan of the project proposal. The overall objective of this project is the experimental and numerical study of the VVER lower head (LH) reactor vessel models under thermal and overpressure loadings corresponding to realistic SA scenarios. 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 a SA in a VVER. The 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) The manufacturing of the VVER LH reactor vessel models. Material and thermal treatment have to correspond to the same conditions as for a regular VVER vessel.

3) The execution of the material creep test experiments with samples from the VVER vessel steel in the time range of 2-50 hours and a temperature range from 600 - 1200 °C to receive creep data for refinement of the constitutive creep model and extend the data on the mechanical characteristics of this steel.

4) The conduct of 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 the domestic code ATM-VVR and by commercial codes MSC.Marc, MELCOR, RELAP/SCDAP for validation of the mathematical models implemented in these codes.

In the ISTC project #3635 there are some non-European collaborators included without any financial contribution. For this reason, it was proposed to remove them from the project, except if they decide to contribute financially to the project.

**Topic #27**: “Experimental investigation of flow pulsation effects on burnout in RPV external cooling systems (EXPULS)”, ISTC project proposal # 3609

V.Granovski (NITI) presented the project proposal. The objective of the project is to enhance the safety of water-cooled water-moderated nuclear reactors under core-melt accident conditions by providing experimental and theoretical support to the capability of core melt retention within the reactor pressure vessel. The project tasks are:to obtain experimental data on burnout processes at the external surface of reactor pressure vessel (RPV) under coolant flow oscillation conditions and to verify the computer codes which model the mentioned processes.

To retain core melt within RPV is one of the possible ways to confine a severe accident. This approach is adopted in several VVER, PWR, and BWR NPP designs of power units up to 1400 MWe. The main condition for in-vessel core melt retention is the prevention of burnout on the outer reactor wall cooled by external water. Critical Heat Flux experiments were performed in a number of test facilities and their results were generalized and used in numerical analyses. All factors are equal: the critical heat flux (CHF) depends on the coolant flow stability/instability. Significant flow oscillations can reduce CHF. Though flow oscillations were observed in some of the experiments, the oscillation rates were apparently too low to reduce CHF. However, no separate analysis of this effect was carried out.

The highest possible natural convection flow rate in RPV external cooling system can be achieved by minimizing the hydraulic resistance in the cooling loop, especially, in its upward part. This condition is also most favourable for maintaining the two-phase flow stability. In some designs, however, minimization of hydraulic resistance is hard to realize. The steam-water flow instability may result from subcooling in the water pool (tank) from which the coolant flows to the downcomer part of the circulation loop. The water temperature in the pool depends on accident scenario. In fact, subcooling can still exist at the time of molten pool formation in RPV lower head. Obviously, the knowledge of the quantitative dependence of CHF on the parameters that determine the coolant flow oscillations or delineation of the region where CHF is unaffected by those oscillations would facilitate designing of RPV external cooling systems and/or improve the quality of theoretical support to in-vessel retention concept.

Where external cooling of RPV cannot be realized in natural circulation loop, the only possibility will be gravity water flow from a tank (further referred to as the “top tank”) installed at elevation with respect to RPV. This possible solution is being considered for modernization of VVER-440 plants. Though passive cooling here only be maintained for a limited time, this period should be long enough to prepare back-up systems for operation, namely, the coolant water feed or the top tank make-up. Gravity-driven flow is also provided for cooling the in-vessel core catcher in Korean advanced reactor APR1400 design.

The authors of the project have developed an experimental program for studying the effect of flow oscillations on CHF level. The experiments will be carried out in the KEDR test facility (NITI). The facility was already used to obtain experimental data on natural convection CHF. This data was then compared to CHF measurements made in the forced circulation test facility PETLYA (NITI). The KEDR test facility is a natural convection loop. The loop is nearly 7 m in height and incorporates an electrically heated 1:1 scale model of VVER-1000 RPV lower head (in slice geometry). Burnout is simulated using the “hot spot” method in two test areas inclined at 30o and 90o to the horizontal, respectively.

Gravity flow in experiments will be achieved by opening the loop seal. The experiments will be carried out with varied hydraulic resistance and water temperature (subcooling) in the top tank. Preliminary calculations will give the variation range for the parameter values determining the flow oscillation rates. Based on the first test results, the experiment matrix may be corrected. The experimental data obtained will be analyzed and generalized to arrive at correlations between the flow oscillation rate and CHF level. Also, this data will be used for verification of RELAP5-MOD3.2 and KORSAR Version 1.1 computer codes.

**Topic #28**: “Phase diagrams for NPP severe accident studies (CORPHAD-P called now PRECOS, ISTC project proposal #3813)”, Presentation of the work plan

S.Bechta (NITI) described the ISTC project proposal: **CORPHAD-P (now called PRECOS and presented the work plan and test matrix. The s**pecific subject of the project is the experimental investigation of phase diagrams of oxidic and metal-oxidic corium systems that form as the result of core meltdown and interactions of melt with construction and structural materials of the reactor, concrete shaft, and core catcher. The modern practice of justifying safety of reactor facilities in case of a severe accident is based on the coupled thermal hydraulic and thermodynamic modeling of high-temperature phenomena. Thermodynamic modeling of multicomponent melts employs specialized codes (e.g., GEMINI-2) and program-specific databases (e.g., NUCLEA-06) created on the basis of experimental data the volume of which is still insufficient for reliable reactor application.

The following systems will be studied in PRECOS:1) Binary and ternary oxidic systems (CaO-UO2, CaO-FeO, SiO2-UO2, UO2-FeO-SiO2, UO2-FeO-CaO, ZrO2-FeO-SiO2, ZrO2-FeO-CaO) containing components of concretes and sacrificial materials, i.e. of importance for modeling the interaction of corium with materials of the concrete shaft and core catcher at the ex-vessel stage of a severe accident development. The SiO2–containing systems should be specially mentioned, as their high viscosity and low conductivity make their experimental investigation problematic. Still, they are very important for modeling the ex-vessel corium from a series of power reactors, including such modern ones as EPR. 2) Metal-oxidic systems U-Zr-Fe-O with different concentrations of components, especially in the miscibility gap. 3) Multicomponent mixtures representing prototypic ex-vessel corium.

**Topic #29**: Next CEG-SAM meeting in Budapest, Hungary, March 2008

Z.Hozer (AEKI) offered to host the 13th CEG-SAM meeting in Budapest, March 5-7, 2008. The date and location for the fall meeting in Russia has still to be announced.

M.Hugon thanked once more V.Bezlepkin (SPAEP) and his co-workers for the organisation of the 12th CEG-SAM meeting and all participants for their engagement.

The location of the 14th CEG-SAM meeting in September 2008 should be decided by the Russian partners.

**Restricted session** (continued)

**Topic #30:** SARNET and CEG-SAM comments on ISTC proposals

Under this topic also the issues of the topics # 9, 31 and 32 were discussed.

Due to a lack of time no detailed discussion of the various presented ISTC project proposals was possible. Nevertheless, an extensive, partially controversial discussion on the ranking of the various projects took place. The following ranking of the proposals having been correctly registered by ISTC was executed by the CEG-SAM members. The final averaged ranking was:

1. Priority: ISTC proposal #3813: PRECOS: this proposal has been prepared in co-operation between Russian and European experts, who agreed on the experiments to be performed.

2. Priority: ISTC proposal # 3609: EXPULS: this proposal was presented at the meeting; it has the ISTC status [3]: accepted without funding.

3. Priority: ISTC proposal #3702: CHESS-2 and STCU proposal #4207: Chernobyl shelter, which are strongly linked.

This ranking is in the interest of the SAM community and it is in line with the priorities of the SARNET Network of Excellence.

The ranking of the VERONIKA and MCCI project proposals, which had no ISTC numbers, was left for the next CEG-SAM meeting. Both project proposals are considered of great interest for the CEG-SAM. In case the above listed ISTC project proposals PRECOS, EXPULS and CHESS-2 will not be considered at the GB meeting in December 2007 a new ranking of the projects should be conducted at the next CEG-SAM meeting.

**Topic #31:** Detailed discussion of presented ISTC project proposals and preparation of specific CEG-SAM advices

See topic #30.

**Topic #32:** Discussion of various actions

See specific action list (Annex #3).

**Topic #33:** Other matters; Final remarks

No specific comments.

The chairman M.Hugon thanked once more SPAEP for hosting the meeting and for all their related excellent efforts and he thanked also the participants for their efficient work and contributions and wished them a safe journey back home.

**M. Hugon** (chairman) **P.Hofmann** (secretary)

**Annexes:**

1. Revised final agenda of the 12th CEG-SAM meeting
2. List of participants at the 12th CEG-SAM meeting
3. Specific action list (appended below)

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Annex #3:

**Specific Action List**: 12th CEG-SAM meeting; St.Petersburg, Russian Federation, September 11-13, 2007

Action 12/1: General procedure for “Letters of Support” (LoS).

The collaborators should send the letter of support and/or advice by air mail to the Executive Director of ISTC, Norbert Jousten, with scanned copies by E-mail or by fax to the CEG-SAM chairmen M.Hugon (EC) and L.Tocheny (ISTC), the secretary P.Hofmann, and R. Burmanjer and J. Sanders (EC).

Action 12/2: A.Miassoedov (FZK) and D.Bottomley (JRC-ITU) will prepare the CEG-SAM advice for the ISTC project proposal PRECOS (# 3813).

Action 12/3: Z.Hozer (AEKI) and E.Altstadt (FZD) will prepare the CEG-SAM advice for the ISTC project proposal EXPULS (# 3609).

Action 12/4: K.Trambauer (GRS) and S.Lamy (EdF) will prepare the CEG-SAM advice for the ISTC project proposal PARAMETER (# 3690).

Action 12/5: B.Clement (IRSN) and D.Bottomley (JRC-ITU) will discuss with A.Goryachev (RIIAR) the revised final VERONIKA project proposal and prepare a CEG-SAM advice. The ISTC project proposal will be officially registered very soon.

Action 12/6: H.-J.Allelein (GRS) and Ch.Journeau (CEA) will discuss with A.Kondrashenko (RFNC-VNIIEF) details of the proposed large-scale MCCI experiments and will prepare a recommendation for a development grant.

Ch.Journeau proposed that A.Kondrashenko should prepare a new project proposal on the non-nuclear investigations on MCCI to avoid the described difficulties. M.Hugon mentioned that foreign collaborators could send a letter to ISTC to explain that the obtained nuclear results will only be used for non-military purposes.

Action 12/7: L.Tocheny (ISTC) will ask to V. Loktionov (MPEI, Moscow), co-ordinator of the ISTC project #3635 (RPV Behaviour in Severe Accidents) to remove from the list of foreign collaborators those which are not funding the project (e.g. the Japanese and US organisations).

Action 12/8: The location of the 14th CEG-SAM meeting in September 2008 should be decided by the Russian partners.

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