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|  | EUROPEAN COMMISSIONDIRECTORATE-GENERAL ‘RESEARCH’ | INTERNATIONALSCIENCE ANDTECHNOLOGYCENTRE |  |  |

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## NON PROLIFERATION THROUGH SCIENCE AND CO-OPERATION

**CONTACT EXPERT GROUP**

**on**

**SEVERE ACCIDENT MANAGEMENT**

**(CEG-SAM)**

**MINUTES OF THE 17th MEETING**

**Centro de Investigaciones Energéticas Medioambientales y Tecnológicas (CIEMAT)**

Unit of Nuclear Safety Research; Division of Nuclear Fission

**Madrid, Spain**

**March 29-31, 2010**

Meeting Location: Conference room “B” of CIEMAT

Avda. Complutense 22

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| Dissemination level: REPU: publicRE: restricted to EC and a group specified by the CEG-SAM membersCO: confidential, only for EC and CEG-SAM members |

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Final minutes, September 28, 2010 CEG-SAM / M-17

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| Subject: 17th Meeting of the ISTC/STCU “Contact Expert Group on Severe Accident Management” (CEG-SAM)Place: Conference room B of CIEMAT, Madrid, SpainDate: March 29-31, 2010Participants: 34 participants of 25 organizations from 10 countries: Mr. D.Bottomley EC, JRC - ITU, Karlsruhe 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.2, Brussels (**chairman**) Mr. Ch.Journeau CEA/DTN, Cadarache Mr. M.Koch RUB, Bochum Mr. M.Krause AECL, Chalk River, Canada Mr. W.Luther GRS, München Mr. A.Miassoedov KIT, Karlsruhe Ms. L.Nicolas CEA, Saclay Mr. F.Oriolo University, Pisa Mr. G.Pretzsch GRS, Berlin Mr. A.Schumm EdF, Clamart Mr. M.Sonnenkalb GRS, Köln Mr. J.Stuckert KIT, Karlsruhe Mr. W.Tromm KIT, Karlsruhe Mr. S.Bechta RIT-NITI, Sosnovy Bor Mr. A.Gontar LUCH, Podolsk Mr. A.Gozal ISTC, Moscow Mr. D.Ignatiev LUCH, Podolsk Mr. A.Klyuchnikov ISF NPP, Kiev Ms. V.Kornyeyeva NSC KIPT, Kharkov Mr. V.Krasnov ISP NPP, Kiev Mr. V.Loktionov MPEI, Moscow Mr. V.Pazhetnov EDO “GIDROPRESS”, Podolsk Mr. V.Protsak UIAR of NUBIP, Kiev Mr. V.Stepanenko STCU, Kharkiv **(co-chairman**) Mr. L.Tocheny ISTC, Moscow **(co-chairman**) Mr. M.Veshchunov IBRAE-RAS, Moscow Mr. V.Zhdanov IAE NNC RK, Kurchatov-CityDistribution list: (Shortened version of the minutes) Mr. J.Sanders DG-RTD / D3 Mr. O.Quintana Trias DG-RTD / J Mr. A.Perez Sainz DG-RTD / J.1 Mr. A. Zurita DG-RTD / J.1 Mr. S.Webster DG-RTD / J.2 Mr. P.Manolatos DG-RTD / J.2 Mr. G.Van Goethem DG-RTD / J.2 Mr. R.Schenkel DG-JRC Mr. D. Haas DG-JRC / 2 Mr. J. P. Joulia DG-AIDCO/A.4 Mr. S.Popa DG-AIDCO/A.4 Intranet of Unit J.2 Mr. L.Tocheny ISTC, Moscow Mr. S.Vorobiev ISTC, Moscow Mr. W.Gudowski ISTC, Moscow Mr. A.Gozal ISTC, Moscow Mr. V. Stepanenko STCU, Kyiv EU CEG-SAM membersContact 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 Department of Energy within the Unit of Nuclear Safety Research and Division of Nuclear Fission of CIEMAT organized the 17th CEG-SAM meeting in Madrid, Spain, on March 29-31, 2010. The meeting location was the conference “B” room of CIEMAT.

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/STCU projects. The extended sessions are dedicated to presentations of the progress of on-going ISTC/STCU projects and of new or revised ISTC/STCU proposals by scientists from the Russian Federation, the Republic of Kazakhstan, and the Ukraine.

The co-chairman L. Tocheny (ISTC) welcomed the CEG-SAM members, the Russian, Kazakh, and Ukrainian participants of the meeting. He expressed his thanks to L.E.Herranz (CIEMAT) who organized and hosted the meeting in Madrid. The chairman M. Hugon (EC) arrived later at the meeting.

In the morning, the visit of three different laboratories of CIEMAT was planned. L.E.Herranz described briefly the tasks of the laboratories before the guided tours took place.

1) Visit of the FUSION facilities: The aim of the Laboratorio Nacional de Fusión is to contribute to the scientific exploitation of the TJ-II Stellarator to the European Fusion Program. At present, the laboratory is taking part in a number of international projects: JET (Joint European Torus), IFMIF (International Fusion Materials Irradiation Facility), or ITER (International Thermonuclear Experimental Reactor) among others. The Stellarator TJ-II began its operation in 1998. Since then, a number of improvements in diagnostics, heating systems and operation have been done. Besides the TJ-II operation, the Laboratorio Nacional de Fusión carries out a wide program on fusion materials development and characterization. The laboratory has become a reference in this field.

2) Visit of the MATERIALS laboratories: This division analyzes the evolution of structural materials during the operation of fission and fusion reactors and actinide transmutation equipment to assess their evolution over time and their safety. It also transfers technology to conventional thermal power plants. The objective of the various test procedures is to understand the structural material behaviour under realistic environmental conditions and to increase the overall safety levels and useful lifetime of the facilities. In addition, some post-test examination equipment such as SEM/EDX & XPS were shown.

3) Visit of the Laboratory for Analysis of Safety Systems (LASS): The three facilities that comprise it examine 1) decontamination of gaseous systems by sprays (GIRS, Gas Iodine Removal by Sprays), 2) catalytic recombination of hydrogen and oxygen system efficiency (RECA, Recombination Efficiency of Catalytic systems), and 3) particle retention systems (PECA, Plant for Experiments on Collection of Aerosols) The objective of this unit is to contribute to the improvement of safety in current and future nuclear facilities, through the assimilation, development and validation of risk evaluation methodologies and the reduction of existing uncertainties in hypothetical accident situations.

**Restricted session**

**Topic #1:** Welcome of the CEG-SAM members by the Head of the Nuclear Fission Division

The L. Tocheny opened the first part of the restricted session and welcomed the EU participants of the 17th meeting of the Contact Expert Group on Severe Accident Management (CEG-SAM) of the International Science and Technology Centre (ISTC) and of the Science & Technology Centre in the Ukraine (STCU).

He expressed his thanks once more to L.E. Herranz (CIEMAT) who kindly offered to organize and host the 17th CEG-SAM meeting in Madrid.

L.E.Herranz introduced the Head of the Nuclear Fission Division E.Gonzales who presented a short overview on CIEMAT and his division.

CIEMAT is an organization of the Ministry of Education and Science; it is a Public Research Agency for excellence in energy and environment, as well as in many vanguard technologies and in various areas of fundamental research. Since its creation in 1951 it has been carrying out research and technological development projects, serving as a reference for technical representation of Spain in international forums, and advising government on matters within its scope. CIEMAT is technically and geographically diversifying to better care for the R&D needs of Spain in general and its Autonomous Regions in particular. CIEMAT activities are organized around research projects that span the bridge between R&D and the interests of society. The CIEMAT team is made up of approximately 1200 people, of whom 47% are university graduates.

The objective of the Nuclear Fission Division is to contribute to the improvement of safety in current and future nuclear facilities, through the assimilation, development and validation of risk evaluation methodologies and the reduction of existing uncertainties in hypothetical accident situations.

**Topic #2:** Welcome of the CEG-SAM members and opening remarks

L.Tocheny (ISTC) described the current situation at ISTC. At the 15th anniversary of ISTC all Funding Parties confirmed the great value of ISTC as useful tool for international collaboration. The parties proposed the upgrade of some rules. There is some information that the Russian authorities are considering future activities of ISTC. Rosatom will not support ISTC; however, Russian organizations are in favour of prolonging ISTC activities. The EC has decided to fund ISTC/STCU activities in 2010 and 2011, but at a significantly reduced level. At the same time Euratom and Rosatom are considering a bilateral approach as an acceptable basis for the future. That means, each side has to fund its own part of activities.

V.Stepanenko (STCU) mentioned that contrary to Russia (ISTC) the STCU activities are strongly supported by the scientific community within the Ukraine and other ex-soviet countries joined in STCU, as well as generally in the social life. There exists consensus between different political parties (except extreme and marginal ones), government, parliament etc. in sense of support of STCU activities. As example, new jointly funded calls for proposals (on the 50:50 basis) between STCU and the National Academy of Science of Ukraine (and accordingly STCU - Azerbaijan, Georgia and Moldova) have been defined. The main concern on the STCU future is connected with decreased support of funding by Western parties, especially from the USA. One way to escape problems - joint (50:50 funding scheme) calls for proposals, another attraction of commercial companies through partner projects. However, in the future we need to correct status of STCU in order to widen the spectrum of activities within the Ukraine (as number of former weapon scientists is decreasing rapidly).

**Topic #3:** Adoption of the agenda of the 17th CEG-SAM meeting in Madrid

A.Schumm (EdF) will give a short presentation on “PARAMETER-SF4 post-test calculation with MAAP 4.07” (topic #18). With these changes, the appended agenda (see Annex 1) was accepted by the group members.

**Topic #4:** Approval of the minutes of the 16th CEG-SAM meeting in Moscow, Russia, September 8-9, 2009

The secretary took into account the comments received on the draft minutes by the participants in the revised minutes. The revised minutes were then approved by the CEG-SAM members without any additional changes at the 17th CEG-SAM meeting in Madrid, March 29, 2010.

**Topic #5:** Discussion of the “Action List” of the 16th CEG-SAM meeting in Moscow

**Action 16/1**: All ISTC/STCU project coordinators / collaborators should make a list of their joint open publications with the collaborators published in peer-reviewed international journals and/or conferences and send it to the CEG-SAM secretary, A. Miassoedov and J. Stuckert. The publications should be stored in the ISTC/CEG-SAM webpage by a link to the corresponding projects. *The list of joint publications has not yet been completed. After completion it should be stored in the CEG-SAM webpage and continuously updated.*

**Action 16/2**: D. Bottomley (JRC-ITU), Ch. Journeau (CEA), M.Krause (AECL) and G. Pretzsch (GRS) should prepare an advice for the STCU project proposal #4758 on “Natural and calculation-experimental research of processes of fuel melt interaction with construction materials for severe radiation accidents on nuclear power plants”. *Action completed.*

**Action 16/3**: P. Hofmann will add the advice #20 for the ISTC project # 3936 on “Study of fuel assemblies with boron carbide absorber rods under severe accident conditions in the PARAMETER-SF tests series; SF-5/SF-6” to the official advice list of the CEG-SAM. *Action completed. However, the project received the status #3 by the ISTC GB. What could be done to reactivate this project? The new administration of LUCH is ready to add some additional money. According to ISTC experiments are most valuable for CEG-SAM.*

**Action 16/4**: D. Bottomley (JRC-ITU), Ch. Journeau (CEA) and M. Krause (AECL) will contact V. Kornyeyeva (NFC KIPT) to explore the possibility of the execution of specific material interaction experiments at high temperatures in the Ukraine. *Some tests have been proposed, but up to now there was no direct feedback on these tests instead Ms. Kornyeyeva had proposed a project on innovative fuels and their interactions with structural materials this had already been examined by ITU & KIT (see topic #28 for further details).*

**Action 16/5**: J. Stuckert (KIT) will prepare a list of publications on chemical interaction experiments with core materials at high temperatures performed within the European research community. The list should be sent to V. Kornyeyeva (NFC KIPT) for her information and to the secretary. *Action completed*.

**Action 16/6**: Ch. Journeau (CEA) will discuss possible activities in the research area of the ISTC project proposal # 1411 on “Experimental and numerical study of liquid metal boiling as simulation of accidents in fast reactor core” with interested colleagues within CEA. The outcome should be presented at the 17th CEG-SAM meeting. *IPPE did not indicate any interest for reviving this old proposal. So, the action has been halted.*

**Action 16/7**: V. Loktionov (MPEI), coordinator of ISTC project #3635 “Scale experimental investigation of the thermal and structural integrity of the VVER pressure vessel Lower Head in severe accidents”, will discuss the remaining research activities of his project with L.Nicolas (CEA). *Action has been partially performed, however, exchange of information with MPEI is toilsome due to limited feedback.*

**Topic #6**: Reports by the secretariats

See topic #2. In addition A.Gozal (ISTC) mentioned that partnership projects (co-funding by end-users) have to be considered in the future. If the CEG-SAM is interested in a project proposal which received the status #3 (accepted without funding) by the ISTC-GB it should send a request to ISTC to explain the importance of the project for the group and ask them to re-consider the project by the GB.

**Topic #7**: Preliminary discussion of updated and/or new ISTC/STCU project proposals

The new and updated ISTC/STCU project proposals will be discussed under the topic #32.

**Topic #8**: Outcomes of the ISTC project progress meeting #3831 in Nizhny Novgorod on “MCCI Experiments at Large-Scale Installation for Heating and Retention of Corium” in Sarov, Russia

Ch.Journeau (CEA) reported on the Steering Committee Meeting of the ISTC project #3831 “Large Scale MCCI experiments–development grant” which took place at the VNIIEF Offices in Nizhny Novgorod, Russia, on January 10, 2010. Five collaborators were present along with a representative from the ISTC while there were 5 experts from VNIIEF, Sarov, led by A.Kondrashenko (VNIIEF). The aim of the Large Scale MCCI Project was to perform three 1000 kg tests of a UO2 –ZrO2 corium and study its interaction with concrete. A nine month project development grant (from 1st May 2009 to 31st Jan 2010 of 98k$ or 10%) was offered to develop the technique and perform three MCCI tests of a medium scale 60 to 100 kg of corium melt and using a ZrO2-FeO melt to avoid export control problems. There had been an early preparatory meeting followed by a meeting after the first test to refine the technique. This meeting discussed the remaining and most important tests. These had been successful: the expected temperatures and durations had been achieved. The pyrometric and other temperature measuring techniques had given interesting results; there was a considerable discussion of the results and their interpretation, including the heat flux rates and the form of the concrete ablation. The presentation will give a summary of the preliminary results from this project as the final values and reports will not be available until April/May 2010.

D. Bottomley (JRC-ITU) presented in more detail the obtained intermediate MCCI test results. At the meeting in Russia it was not possible to receive the test results in an electronic form by A.Kondrashenko.

The CEG-SAM expressed its main interest in the conduct of MCCI tests with UO2. It has to be clarified if VNIIEF can perform the tests with UO2. L.Tocheny (ISTC) will write a letter to the boss of A.Kondrashenko to clarify this question (action 17/1).

# Extended session

**Topic #9**: Welcome of the participants by the host of the meeting

L.E.Herranz (CIEMAT) welcomed the participants of the 17th CEG-SAM meeting and wished them interesting discussions.

**Topic #10**: Welcome of the Russian, Kazakh and Ukrainian colleagues; approval of the shortened minutes of the 16th CEG-SAM meeting in Moscow; adoption of the agenda of the 17th CEG-SAM meeting in Madrid

M.Hugon opened the extended session of the meeting and welcomed the Russian, Kazakh and Ukrainian participants and expressed his thanks to L.E.Herranz (CIEMAT) for organizing and hosting the 17th CEG-SAM meeting.

The shortened minutes of the 16th CEG-SAM meeting were distributed to the Russian, Kazakh and Ukrainian participants by the secretary. The obtained comments had been considered in the revised shortened minutes. This version of the minutes was accepted at the meeting without any additional changes.

A.Schumm (EdF) will give a short presentation on “PARAMETER-SF4 post-test calculation with MAAP 4.07” (topic #18). The planned presentations topic #26 and #27 by V.Krasnov (ISP NPP) will be summarized in one presentation. With these changes the appended agenda (see Annex 1) was accepted.

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

The ISTC CEG-SAM webpage is hosted by GRS (Garching, Germany) and is now fully operational (<http://cegsam.grs.de>) and will be updated steadily. In the new structure of the webpage all documents (project proposals, advice notes, work plans, progress reports, and joint publications) are collected under the ISTC project number. There will be a unique user name and password for each user and different read/write permissions for the different users. The Russian, Kazakh and Ukrainian project managers 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 the agendas, list of participants and minutes (restricted and open sessions), and all other stored documents (presentations). There will be special access rights for non-European members for the project in which they participate.

**Topic #12**: Future of the CEG-SAM

M.Hugon gave a presentation on the status of the ISTC contact expert group CEG-SAM. It has been quite successful since its launching in April 2002. Up to now, 15 ISTC/STCU projects were selected for funding, 9 of them being completed and 6 others are on going. The interaction between the CEG-SAM and SARNET2 is excellent. Results of SARNET2 activities are periodically presented to CEG-SAM members and ISTC/STCU proposals and project reports related to SAM are transmitted to the SARNET2 topical co-ordinators.

At present, there are two STCU project proposals of potential interest for the CEG-SAM: 1) STCU project proposal #5243 on ”Interaction studies of improved VVER structural materials at severe accident conditions”; 2) STCU project proposal #4758 on “Experimental research of hidden nuclearly hazardous clusters of fuel-containing materials in the ruined Chernobyl NPP Unit 4” has been replaced by the STCU project proposal #5244 on “Nuclear fuel interaction products with structural materials under heavy nuclear-radiation accidents”.

The ISTC/STCU funding from EC was about 7.4M€ in 2009 and will be the same in 2010, but the basic annual costs of ISTC and STCU is about 6M€; therefore, the funding for proposed projects in 2009 and 2010 is limited to about 1.5M€ per year.

The Deputy Director-General of ROSATOM sent a letter to the Director of Energy (Euratom) of DG Research in December 2009 to give its assurance that ROSATOM will finance the Russian part of the projects selected for funding following the third call on nuclear fission and radiation protection in FP7. This applies in particular to the ERCOSAM project. Both European and Russian projects will be linked by a coordinating agreement.

The future of the CEG-SAM could be as follows: 1) continue its previous tasks with ISTC/STCU projects and interaction with SARNET2; 2) include in CEG-SAM the ERCOSAM project funded by Euratom and ROSATOM; 3) investigate the possibility of establishing a structured dialogue between Euratom and Ukraine (a second technical meeting on Euratom-Ukraine cooperation in nuclear fission research was held in Brussels on 16 February 2010).

**Topic #13**: Update on SARNET2

B.Clément (IRSN) presented the SARNET2 (**S**evere **A**ccident **R**esearch **NET**work of excellence) update. SARNET2 started on April1, 2009; altogether 21 countries with 41 organizations are participating in the programme that will last 4 years. The total effort is about 10M€ per year with about 1.5M€ per year of EC funding. The main objectives of SARNET2 are to tackle the fragmentation that exists between the different R&D organisations, notably in defining common research programmes and developing computer tools; in particular the continuation of ASTEC assessment and its extension to cover BWRs and CANDU reactors.

B.Clement described briefly the work on Severe Accident Research Priorities within SARNET2. Six issues remain open with high priority, four issues with medium priority, and five issues remain open with low priority and could be closed after finalizing the related research activities. The 6 issues with **high priority** are research on 1) core coolability during reflood and debris cooling in lower head; 2) ex-vessel melt pool configuration during MCCI and ex-vessel corium coolability by top flooding; 3) corium melt relocation into water and ex-vessel fuel coolant interaction; 4) hydrogen mixing and combustion in the containment; flame acceleration; 5) the impact of oxidising conditions on source term; 6) iodine chemistry in the RCS and in the containment. The tasks of SARNET2 will be executed by 8 work-packages on management, spreading of excellence (courses, conferences), information systems, ASTEC, corium and debris coolability, MCCI, steam explosion and hydrogen combustion in containment and oxidising impact on source term.

Up to now the interaction between CEG-SAM and SARNET2 works well and the SARNET2 recommendations were considered in the final work programmes of the various ISTC/STCU project proposals. The results of ISTC/STCU projects are used by foreign collaborators in the framework of SARNET2. The interaction between SARNET2 and CEG-SAM brings mutual benefits and further assures a critical mass of expertise for ISTC/STCU 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.

B.Clement described the progress in the last 6 months. The next main milestones of SARNET2 are joint workshops, conferences, and education courses. The 4th ERMSAR conference will take place in Bologna, May 10 to 11, 2010. The SARNET Book on Severe Accidents is currently under review and the planned publication will be by the end of 2010. The 1st Education & Training course is planned in January 2011 on “Generation III NPP SA Phenomenology”, jointly organised by the Univ. of Pisa and CEA in Pisa (Italy).

**Topic #14:** EU-ROSATOM Project ERCOSAM: “Containment thermal-hydraulics of current and future LWRs for severe accident management”

S.Guentay (PSI) presented the status of the project ERCOSAM that is addressing better understanding margins for hydrogen management possibilities in the containment. The presence of a stratification in a NPP containment is a source of concern, as pockets of hydrogen in high concentration could lead to a deflagration or detonation risk, which might challenge several equipment necessary for safety functions and even the containment structural integrity.

The objectives of ERCOSAM is: 1) Establish whether in a test sequence representative of a severe accident in a LWR, well chosen from existing plant calculations, a hydrogen (helium) stratification can be established during part of the transient starting from the initiation of the loss of coolant accident (LOCA) blow-down until the end of bulk hydrogen release from the reactor vessel into the containment. 2) How this stratification can be broken down by the operation of Severe Accident Management systems (SAMs): sprays, coolers and Passive Autocatalytic Re-combiners (PARs).

A two-tier approach is planned: Experiments in four containment simulators with very small to very large scales under conditions corresponding to scaled down prototypical accident conditions in real plants, and pre- and post-test calculations using 3D, CFD and lumped parameter codes to gain improved confidence in the codes for future plant safety analyses (PSA L2, plant behaviour, assessment and design of SAM measures for hydrogen management). The duration of the project will be 4 years.

**On-going project presentations**

**Topic #15:** Status of the ISTC project #3690 on the “Fuel assembly behaviour under severe accident top quenching conditions in the PARAMETER-SF test series (PARAMETER-SF3 and PARAMETER-SF4 experiments)

D.Ignatiev (FSUE SRI LUCH) presented the final results on the ISTC Project # 3690 on “The behaviour of fuel rod assemblies under severe accident top quenching conditions in the PARAMETER-SF test series”. The project was executed jointly by three organizations: FSUE SRI SIA “Luch”, IBRAE RAS, OKB “GIDROPRESS” with participation of the leading specialists from JSC “VNIINM”, RRC “Kurchatov Institute”, A.I. Leipunsky SRC RF - IPPE and methodical support by foreign collaborators (KIT, GRS, JRC-ITU, PSI, EdF, CEA, AEKI, and IRSN).

Within the framework of the Project two experiments of PARAMETER-SF series (SF3 and SF4) were conducted with 19-rod fuel rod assembly simulators (18 heated rods and 1 unheated rod) of a VVER-1000. The simulators were manufactured with the standard reactor structural materials (UO2 pellets and Zr+1%Nb cladding tubes) similar to the PARAMETER-SF2 experiment (ISTC project #3194).

The PARAMETER-SF3 experiment was conducted under the following test conditions. Coolant flow rates: argon 2g/s (670K) and steam 3.5g/s (770K). The pre-oxidation of the bundle was carried out at cladding temperatures of about 1470K for 4000s. Then the bundle was heated up with 0.2 - 0.3 K/s to a maximum bundle temperature of 1870K. At this temperature, top flooding of the bundle with water (40 g/s) was initiated. 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. The cladding temperatures of the bundle were presented as function of time for different bundle elevations during the pre-oxidation and transient heat-up and quench stages. The total mass of hydrogen generated during the test was about 34g. Post-test destructive examinations of the fuel bundle have been performed to determine the extent of cladding and shroud oxidation.

The PARAMETER-SF4 experiment was conducted in an air environment with bottom quenching under the following test conditions. Coolant flow rates: argon 2g/s (670K), steam 3.5g/s (770K) and air 0.5g/s. The pre-oxidation of the bundle was carried out at cladding temperatures of about 1470K for about 6000s. Then the bundle power was decreased to reduce the temperature to about 1200K and switch the flow from steam to air before it was heated up to a maximum bundle temperature of about 2000K. At this temperature bottom flooding of the bundle with water (80 g/s) was initiated. The bundle cool-down took approximately 1000s. 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 different code predictions. The measured cladding temperatures of the bundle were presented as function of time for different bundle elevations during the pre-oxidation and transient heat-up and quench stages. The total mass of hydrogen generated during the test was 110g maximum. The amount of hydrogen measured during the pre-oxidation of the bundle has not exceeded 21g. Post-test destructive examinations of the fuel bundle were performed to determine the extent of cladding and shroud oxidation for comparison with code predictions.

**Topic #16**: PARAMETER-SF4 preliminary post-test calculation

S.Guentay (PSI) presented preliminary results of post-test calculations on the experiment PARAMETER SF-4. The objectives of the experiment have been: 1) Achieve air oxidation, but limited to enable a significant period of oxygen starvation. 2) Achieve reflood successfully without significant excursion and without melting/degradation. Among the goals are to realize a transient analogous to the experiment QUENCH-10, including a period of complete oxygen consumption (in order to investigate nitriding by air), and to avoid an oxidation excursion during reflood in order, as far as possible, to preserve the bundle in its post-air-ingress state.

The test was successfully conducted on July 21, 2009, with clear indications that the target conditions were met.

First post-test calculations have been performed using the PSI version(s) of SCDAP/RELAP5/irs that was used in pre-test analysis. The input is based on pre-test model and reported experiment conduct. The pre-oxidation transient is in fair agreement with the experiment. The extent of oxidation and temperatures are overestimated with the Cathcart-Pawel correlation (premature excursion, results not shown). A better agreement is obtained using the Sokolov oxidation correlation. The used “Air” model predicts an earlier oxygen starvation than observed in the experiment. The starvation front propagates to bundle mid-elevation (discrepancy in oxygen exit flow not yet resolved ). Moderate reflood temperature excursion with temperatures up to 2600 K in the experiment (effect of air flow continuing ca. 1 min during water injection (in calculation). Some UO2 liquefaction and candling takes place.

**Topic #17**: Preliminary PARAMETER-SF4 post-test calculation with ATHLET-CD

W. Luther (GRS) presented the preliminary post-test calculation results with ATHLET-CD of the test PARAMETER-SF4. The input model and the options for the ATHLET-CD post-test calculation were described. The results were discussed and figures of the temperatures, the quench fronts and the hydrogen generation rate were shown. ATHLET-CD calculates with good agreement the maximal temperatures within the pre-oxidation phase for the given time function & power input. The air injection with a rate of 0.5 g/s leads to a oxygen starvation at the axial bundle elevations above about 600 mm after a time period of 1300 s (at ~17300s, start of air injection at 16000s). Therefore, the elevation of the maximum bundle temperature moves to lower elevations in agreement with the test data (no nitride formation is considered up to now). The temperature increase calculated during the air oxidation phase is in good agreement with test data using the option IOXAIR=6 in the ATHLET-CD model. The temperature increase after start of reflood (steam oxidation) seems to be underestimated in the simulation (max. temperature = 1984°C = 2257°K). The comparison with measured data is difficult due to the failure of many thermocouples. The time needed for bottom quenching is about 400 s (slightly shorter compared to test data). The total hydrogen generation is 34 g and so much lower than the measured one (107 g).

**Topic #18**: PARAMETER-SF4 post-test calculation with MAAP 4.07

A. Schumm (EdF) carried out a first simulation calculation of the test PARAMETER-SF4 with a customized version of MAAP 4.07, including specific extensions for Zr oxidation in air and material properties of the heater element materials. The simulation covers the time from t=1500s (start of second ramp) to t=16000 (just before bottom reflood). The usual Cathcart/Urbanic correlation was used for steam pre-oxidation; the air oxidation was described by a NUREG correlation.

The results show reasonable agreement for the thermal behaviour, although it was more precise for the inner rods. The hydrogen production was well predicted during the pre-oxidation phase. The reflooding was not covered by this preliminary simulation. The simulation does not predict oxygen starvation, as opposed to other models and experimental results. A possible explanation could be the under-estimation of temperatures during air ingress, due to a parabolic correlation for the post-break away regime. The results require an additional detailed evaluation.

**Topic #19**: Visit of the José Cabrera NPP in Almonacid de Zorita

A technical tour to Almonacid de Zorita took place to visit the shut down JoseCabrera (Zorita) NPP, which is located about 70km east of Madrid in the Guadalajara province of Spain. The NPP is a single loop Westinghouse Pressurized Water Reactor design (about 160 MWe) cooled by the waters of the River Tajo. The plant was synchronized to the grid in 1968 and was permanently shutdown on April 30, 2006. UNION FENOSA Generacion has been the owner and operator of the plant.

The decommissioning activities are carried out by Empresa Nacional de Residuous Radiactivos (ENRESA). Details of the different planned activities were described. The first step in decommissioning a nuclear power plant is the removal of used nuclear fuel from the reactor. This work has already been carried out, and the 175 tonnes of used fuel is now kept within 12 dry storage modules in a section of the plant site. All the rest of the plant buildings are to be cleared away in a job that was put at €135 million in 2006. An estimated 104,000 tonnes of material must be dealt with, the vast majority of which is concrete. Some 4700 tonnes of steel is expected to be recycled. Only about 4% of the material will be radioactive, and this will be packed up for permanent disposal at El Cabril. The reactor's internal components make up about 43 tonnes of this. The main parts of the reactor's primary coolant loop will be remotely dismantled to minimise radiation exposure to workers.

The temporary storage facility at José Cabrera nuclear power plant is located on the plant site and has been designed to house all the spent fuel unloaded from the reactor under dry storage conditions. It consists of a reinforced concrete slab, which will support 12 storage modules and is surrounded by a single outer radiological protection fence (outside which the conditions are those of a free access zone) and a double inner security fence cordonning off the storage area.

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

S.Bechta (RIT-NITI) described the objectives of METCOR-P project: Qualification and quantification of physico-chemical phenomena of corium melt interactions with reactor vessel steel with particular interest to interaction characteristics i) at vertically-positioned interfaces, ii) peculiarities of interaction with European vessel steel, and iii) corium melt oxidation effects.

The results of the conducted test MCP-4 were presented. The corrosion rate of European reactor vessel steel (20MnMoNi5-5) due to interactions with molten corium should be determined in the test under oxidizing conditions and compared with the corrosion rate of Russian vessel steel (15Kh2NMFA). During the first stage of the test a corium mixture of 71 mass% UO2 and 29 % ZrO2 was used. Three almost steady state temperature regimes were realized with temperatures at the corium/steel interface between 1000 and 1200°C. After that Fe was added into the UO2/ZrO2 melt and oxidized to form a molten pool of (UO2+x-ZrO2-FeOy). The completion of the corium oxidation was determined by measurements of the oxygen concentration in the off gas. The corium composition (UO2+x-ZrO2-FeOy) was used in the second stage of the test when three almost steady state temperature regimes between 900 and 1250°C at the interaction interface were established. Preliminary results of the test show that the corrosion rate of the European vessel steel is comparable with that of the Russian vessel steel. Similar to the VVER steel, an intensification of the European steel corrosion occurs at the interface vessel steel/molten corium if the interface temperature exceeds some limiting value. The obtained data base is not sufficient for final conclusions.

The test МСР-5 has been recently performed to compare the corrosion rates and depths of European and Russian vessel steel at its interaction with molten sub-oxidized corium. The melt composition and steel specimen surface temperature in this test were similar to those in МС6 with Russian steel: Сn≈30%; Ts≈1400ºC. First results of the experiment show that the incubation period, which precedes the stage of steel corrosion, is longer than the one observed in МС6, but the temperature of the final boundary of the interaction zone is comparable with МС6. At present the posttest analysis of this experiment is in progress.

**Topic #21**: Progress report on the ISTC project #3813 “Phase relations in corium systems” (PRECOS)”

S.Bechta (RIT-NITI) described the objectives of the project **PRECOS. The** subject of the project is the experimental investigation of phase diagrams of oxidic and metallic-oxidic corium systems that form as the result of core meltdown and interactions of melt with construction and structural materials of the reactor core, concrete shaft, and core catcher.

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, and ZrO2-FeO-CaO) that contain components of concrete and sacrificial materials, i.e., of importance for modeling the interaction of corium with materials of the concrete shaft and core catcher. The SiO2–containing systems should be specially mentioned, as their high viscosity and low conductivity make their experimental investigation problematic. These systems are very important for modeling the ex-vessel corium behaviour. 2) Metallic-oxidic systems U-Zr-Fe-O with different concentrations of components, especially in the miscibility gap. 3) Multi-component mixtures representing prototypic ex-vessel corium.

Results of experiments in the SiO2-UO2 system, to define the monotectic temperature and the shape of the miscibility gap cupola, and in the systems UO2-CaO and UO2-SiO2-FeO were presented and described in detail. Experiments on the ZrO2-FeOy system are delayed due to the transfer of the experimental installations to an other building. In the SiO2-UO2 system a large amount of new experimental data has enabled the improvement of the phase diagram. In the system CaO-UO2 the liquidus temperatures at high CaO content and the melting point of CaO have been determined (previously there had been a substantial difference between published data). Test results on the determination of the solidus temperature in the system ZrO2-FeOy and the composition of the solid solution ZrO2(FeOy) at the eutectic temperature were presented and discussed. The eutectic temperature in the system ZrO2-FeOy was defined more exactly.

**Topic #22:** Progress report on the ISTC project #3876 on “Thermo-hydraulics of U-Zr-O molten pool under oxidising conditions in multi-scale approach (THOMAS)”; part #1

M.Veshchunov (IBRAE-RAS) described the objectives and work plan of the project THOMAS and its status (Task 1 and 2). Non-destructive and destructive post-test examinations of bundles in various tests showed the formation of molten pools of different scales at various stages of core degradation. Small local pools were observed at different elevations in bundles in the early stage of core degradation in CORA and QUENCH tests. Results of the PHEBUS -FP tests confirmed that a significant part of the fuel bundle was liquefied and that the amount of fuel damage was close to TMI-2 with an extended molten pool located in a central zone of the bundle underneath a cavity. In the late stage of a severe accident, the formed melt can relocate into the lower head of the reactor pressure vessel and form a large molten pool interacting with cooled walls.

Task 1: “Development and implementation of a 1-D numerical model for U-Zr-O corium melt / steel oxidation into the 2-D thermo-hydraulic code”

The 2-D stand-alone code developed to simulate (in the simplified geometry of the tests) simultaneous UO2 fuel dissolution, U-Zr-O corium melt oxidation accompanied with the bulk ceramic precipitates formation and oxidation of the steel wall of a vessel in contact with corium, was transformed into the 1-D corium melt/steel oxidation module, in order to describe local interactions at the corium-steel interface (in the geometry of the pressure vessel). This excludes a simplified description of the heat and mass exchange between the U-Zr-O corium melt and peripheral crusts in the code, and enables the use (in future) of the detailed thermo-hydraulic approach of the CONV code. The resulting new 1-D oxidation numerical module simulates evolution of the solid phase layers ((Zr,U)O2-x crust, FeO corrosion layer and steel), temperature distributions in the layers and U, Zr, O molar fluxes into the melt. Two types of multilayer structure geometry are considered: cylindrical and plane. The interface program unit for coupling of the melt/steel oxidation 1-D module with the corium melt 2-D thermo-hydraulic code is developed. 1-D oxidation module is currently under implementation into the 2-D thermo-hydraulic code and will be completed during the 7-8th quarters.

Task 2: “Development and improvement of the unified thermal hydraulic technique (CONV code) for simulation of the multiphase processes in complex domains of convectively stirred melts”

For improving of turbulence modelling at extremely high Rayleigh numbers, a large eddy simulation (LES) approach was included in the CONV code. The modelling of a large-scale turbulence is based on a turbulence filtration and in essence, this method is more universal, since the immediate restriction on magnitude of Reynolds number does not superimpose. The results of choice set of commutative filters for LES approach were presented. Results of verification of the modified version of the CONV code against Backward-facing step flow tests and T-junction thermal mixing tests were discussed. The method of a large-scale turbulence modelling is applied to testing semi-empirical models.

**Topic #23:** 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 results of the performed INVECOR experiments. The objective of the in-vessel corium retention experiments (INVECOR), i.e. 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 project started on May 1, 2006 and will be finished on April 30, 2010, and consisted of 4 tasks.

Task 1: Development of technologies to produce protective coatings on the internal surface of the graphite crucible and on the outer surface of the graphite nozzles of the plasmatrons. Various modes of corium melting and discharging into the experimental section have been tested. The design and operating modes of the plasmatrons to simulate the decay heat in corium was developed. The experimental sections and details of the experimental facility were designed and fabricated. Numerous calibration experiments have been executed for the plasmatrons and the experimental test section including experiments with individual plasmatrons, dipped into a mixture of corium components. First tests with plasmatron devices for the simulation of the decay heat were conducted in a RPV model. A prototypic corium С-30 melt of 60kg was produced in the induction electric melting furnace.

Task 2: Modeling of the corium pool in the RPV model and definition of the efficiency of heating, distribution of thermal fluxes and temperatures on an internal surface of the RPV model; calculation and optimization of the external cooling system of the RPV model; calculation of the temperature and deformed condition of the RPV model (pre-test and post-test calculations).

Task 3: Four large-scale experiments have been performed with maintenance of energy release in the corium pool that was contained in the RPV model. In the tests oxidic corium С-30 and oxidic-metallic corium С-30+10 wt.% of steel were used.

Task 4: Conduct of post-test analysis of the solidified corium melt and RPV steel samples by XRD; optical metallographic and specific element analysis of the specimens.

The performance of the main task (#3) has been the conduct of integral large-scale experiments. In the tests up to 60kg of corium melt С-30 was discharged from the electric melting furnace from a height of 1,7m into the RPV model with the plamsatrons in place for the simulation of the decay heat. The duration of the experiment on corium retention in the vessel has lasted 1 to 2 hours. The specific capacity of energy release into the corium varied between 4 and 8 W/cm3. The maximum temperature of a RPV model wall was 1300°C that was reached due to thermal insulation of the external surface of RPV model and by regulation of the cooling water flow rate. The steel addition in corium was carried out by imitation of plating of an internal surface of the RPV by stainless steel (in one experiment) and steel sheet dropping on a corium pool surface (in other experiment). In two experiments up to 10kg of oxidic corium С-90 has been located preliminary in RPV model in addition to 60kg of the melt discharged from the electric melting furnace. In the fourth experiment efficiency of a thermal insulation on an external surface of RPV model was increased and the additional thermal screen over the molten corium was established. Post-test examinations showed that solidified corium was both in the form of a continuous ingot and in the form of small fragments located over the ingot. Insignificant erosion of the internal surface of the steel wall of the RPV model took place.

On the basis of the performed experiments the following preliminary conclusions can be drawn:

1) In the course of experiments low thermal fluxes from corium through the wall of the RPV model were obtained that can be explained by the presence of a thermal insulation on the outer surface of the RPV model which leads to a redistribution of the thermal fluxes to the wall and along a wall to the massive flange of RPV model. In addition, an incomplete dissolution of uranium dioxide took place in the molten zirconium contained in the electric melting furnace and continuation of the endothermic dissolution of urania. A gap formation between the corium crust and the RPV wall was caused by thermal expansion of RPV model and the layered character of the lower corium crust that leads to decrease of effective heat conductivity of a crust.

2) The observed steady-state phenomena during IVR substantially depend on the previous transient processes connected with the formation of the corium pool in the reactor core, on time of existence of this pool in a specific elevation of the core and on the character and speed of the melt dropping into the lower head.

The final report by results of work on the project will be placed on a CEG web-page after finishing of the project, in May-June, 2010.

The question was raised of the impact of atmosphere on the test results. An informal specialist meeting has been organized asides from the main CEG-SAM meeting to discuss the obtained experimental results.

**Topic #24:** Status of the ISTC project #3635 on “Scale experimental investigation of the thermal and structural integrity of the VVER pressure vessel Lower Head in severe accidents”

V.Loktionov (MPEI) presented the status of the project. The overall objective of this project is the experimental and numerical study of VVER-440 lower head (LH) reactor vessel models under thermal and overpressure loadings corresponding to realistic SA scenarios. The different tasks are the manufacturing of the VVER LH reactor vessel scale models (1:5), the conduct of the scale experiments with VVER vessel models at high temperatures as well as separate-effect tests on the creep behaviour of the VVER vessel steel and numerical pre- and post-test analyses of the scale experiments.

The expected results will be experimental data on the creep behaviour, heat-up and failure of the VVER-440 vessel material. The data will be used for verification of thermo-mechanical codes that are used in safety assessment in SA management strategy for NPPs.

For the calculations and analytical analysis the power Unit 1 of Kola NPP (VVER-440/V-230) has been chosen as reference reactor plant. The goal of the calculations was to estimate the decay heat power level in the lower plenum. Parametric calculations were carried out using the codes SOKRAT and NARAL assuming different masses of debris relocating into the lower plenum after core disruption. Depending on the relocated mass (7-40t that corresponds to 1.2-12MW decay heat) the time of vessel failure varied between 4 and 25 h. At about 1MW decay heat the melt may be kept in the vessel without effective cooling.

The project efforts are focused on the following tasks:

Task À: Pre-test simulations will be carried out by means of the numerical codes to determine the behaviour of the vessel models during the scale experiments for the chosen SA scenarios.

Task B: Development and manufacturing of the experimental test facility and supporting systems for the VVER-440 scale vessel models testing (a geometrical scale ~1:5). The material and thermal treatment of the vessel steel have to correspond to the same conditions as for a regular VVER vessel.

Task C: Examination of the VVER-440 vessel behaviour under SA conditions by experimental and numerical investigations (thermal and structural analyses). The mathematical treatment and analysis of scale experiments will be done with the domestic code ATM-VVR and with commercial codes MSC-Marc, MELCOR, RELAP/SCDAP for validation of the physical models implemented in these codes.

Task D: Determination of the creep characteristics and mechanical properties of the vessel steel 15Kh2NMFA in the temperature range from 750 to 1200 C and times up to 50 hours. The execution of short-term tensile and material creep tests experiments with samples from the VVER vessel steel have been conducted to obtain data for refinement of the mechanical characteristics of this steel.

One of the problems during the scale tests has been the oxidation of the outer vessel surface. The reason for the separate-effects tests in air was questioned. A meeting with the foreign collaborators should be organized. First test: June-September 2010.

Prolongation of the project without additional funding requested and confirmed for up to one year.

**Topic #25:** Status of the STCU project #4207 “Long-term prognosis of the behaviour of the fuel dust in the Chernobyl Shelter”

V.Protsak (UIAR) presented the project progress. The Chernobyl shelter of the RBMK-1000 Chernobyl NPP unit 4 is a source of radioactive particles that formed during the accident (now present inside the construction in the form of dust) and in the subsequent period due to physical-chemical destruction of the fuel containing material (FCM). In view of the planned transformation of the “Shelter” into an ecologically safe system, the presence of the fuel dust in the shelter (about 30000kg) will become a serious problem. In spite of the numerous data on the characteristics, composition and localization of the fuel dust in the shelter, the mechanisms of its formation and, especially, the prognosis of its further physical/chemical transformation are still not clear.

V.Protsak described the physical-chemical characteristics of the Chernobyl fuel particles and mechanisms of their formation. The project studies will be focused on the fuel particles and main types of the fuel-containing materials (FCM) in the shelter, as well as on the mechanisms governing their destruction. Experimental data show that the FCM destruction in the present time occurs due to internal and external influences. It results in the FCM transformation into the highly-mobile and highly-radioactive dust. Therefore, it is very important to carry out experimental and theoretical studies within the framework of the project, which will enable the formulation of a model of the long-term behaviour (50-100 years) of the fuel dust under the shelter conditions. The model must describe both the transformation of the existing fuel particles and the processes of their formation from the main types of the FCM.

During the reported period the criteria of modernization of the existing database on “Hot particles” (HP) have been determined aimed in its extension (updating with the new information) and improving the interface for formulation of various correlations between the HP parameters which will be used for modeling the HP behaviour under shelter conditions. According to the most optimistic prognoses, the radiation destruction of LFCM will be possible only in millions of years, while the pessimistic assessments predict such a dangerous scenario in the near future. Analysis of the literature data shows the urgency and complexity of the investigations planned within the framework of the project.

The obtained information is treated and stored in the created database. The main input data are: the room’s number, description of the room, presence and type of the FCM, the FCM parameters, presence of the fuel dust, presence of the water flow and its parameters, presence of the air flow, and the FCM destruction model. The final version of the database will be organized in the manner enabling not only the information storage and update, but also the assessment of the FCM destruction using the relevant models and, therefore, calculation of the quantity and characteristics of the fuel dust in the Shelter. According to the observations, almost each water volume in the Shelter is characterized by its own radionuclide activity ratios. In the Shelter’s waters the 244Сm and 241Am fractions of the total TUE activity are 5-10 times higher than in the FCM

The main idea of measurements of radio-nuclides in the water volumes of the Shelter is to establish the links between these volumes and certain aggregations of the FCM for estimation of the radio-nuclides fluxes from the FCM. The destruction rates of the main types of the FCM in water have been estimated for black and brown LFCM and for fuel fragments. For the estimation of the FCM surfaces in the Shelter’s rooms the mathematical and computer processing of the photo and video images has been applied. By the data of the FCM surfaces an assessment of the parameters of the radioactive aerosols generation can be determined.

**Updated and new project proposals**

**Topic #26:** Status of STCU Project #5244 on “Research of objects - nuclear fuel interaction products with structural materials under heavy nuclear-radiation accidents

V.Krasnov (ISP NPP) presented the status of the STCU project #5244. When erecting a “New Safe Confinement” (NSC) for the ChNPP, temperature growth and moisture decrease can entail in some areas with a high probability of occurrence of a self-sustaining chain reaction. In this connection the concept of the “Shelter” Object should be revised in terms of preventive criticality suppression in critical mass risk areas. The objective will be to obtain information on neutron-physical processes occurring in clusters under impact of external factors.

The expected results will be visual observation data; information obtained when drilling research boreholes; results of sampled lava-like fuel-containing materials (LFCM) analysis; instrumental measurement data; mechanisms of LFCM cluster production with high uranium content. Considering the above data, as well as neutron and heat estimates, new instrumental measurement data and research results of physico-chemical properties of newly taken samples from cluster area, the following will be defined: structure, geometry, and LFCM physicochemical properties in two critical mass risk areas, in south-west quadrant of sub-reactor room 305/2 ChNPP Unit 4 («Shelter» object). Examinations of neutron-physical processes occurring in clusters under impact of external factors will also be conducted.

The Project #5244 will cover researches and estimate-experimental works aimed at definition of structure, content, neutron-physical and physicochemical characteristics of corium in hidden LFCM clusters, as well as development of measures to control sub-criticality of such clusters.

**Topic #27:** Status of the STCU project proposal #4758 on “Estimate - experimental research of hidden nuclearly -hazardous clusters of fuel-containing materials in the ruined Ch-NPP Unit 4”

V.Krasnov (ISP NPP) presented the status of the STCU project although its financing is not yet settled. At the 15th and 16th CEG-SAM meeting the group concluded to update the scope of some work branches and to change the name of the project. D.Bottomley (JRC-ITU) and G.Pretzsch (GRS) have sent their remarks and recommendations of the revised project proposal to V.Krasnov. The STCU project #4758 activities were a kind of initiation and qualitative evaluation of hidden nuclearly hazardous clusters. ISP NPP has registered in the meantime a new project proposal at STCU with the number #5244. The new title is “Research of objects - nuclear fuel interaction products with structural materials under heavy nuclear-radiation accidents” (see topic #26) which will be a continuation of the examinations und studies conducted in the frame of the STCU project #4758.

**Topic #28:** Status of STCU Project #5243 on “Interaction studies of improved VVER structural materials at severe accident conditions”

V.Kornyeyeva (NFC KIPT) presented the STCU project proposal #5243. Measures must be developed to manage beyond design-basis accidents, which result in severe damage of core components, melt formation and its variation with time. Of special interest is to know the behaviour of the fuel and absorber elements during a severe accident; the processes and kinetics of the material interactions of all core components with each other and with the environment under melt formation conditions. The determination of melt parameters such as viscosity, fluidity, and chemical activity during the interaction with other solid-state materials is also important. It has been indicated that KIPT had previously determined the thermo-physical properties of prototypes of Chernobyl corium (FCM).

The project is designed to obtain data on interaction parameters of materials in WER improved core structural components; to obtain data on melt formation of fuel and neutron absorbers with the structural materials; to identify the phase compositions of the resulting melts in the solid state; to determine physical parameters of viscosity and fluidity of the melts of WER core components.

The project intends to upgrade and prepare technological equipment and devices for the investigations; to develop designs and technological procedures to manufacture fuel element and absorber samples for the investigations; to develop procedures for experiments and investigations of the core material structures and compositions before and after their interaction (in the solid state and after melting); to obtain melts of standard WER fuel and absorber element materials, namely, a combination of UO2+Gd2O3 with the alloy Zr1%Nb (E110), stainless steel with boron carbide; to study the effect of fuel and absorber element designs on the interaction of material combinations as UO2–Zr and stainless steel–B4C; and to obtain temperature parameters for the beginning of melt formation versus the material state; investigation of melt formation processes of materials such as stainless steel+B4C, stainless steel + (Dy2O3•TiO2), and stainless steel + (B4C+Hf) and interaction of these components with the melt of UO2+Zr fuel materials; to study the phase composition of the resulting melts; to evaluate melt viscosity and fluidity depending on phase composition. The obtained melt parameters will allow the prediction of accident meltdown processes and carry out more detailed experiments on interaction of melts with sacrificial material of traps.

**Topic #29**: ISTC project proposal on “Study of fuel assemblies with boron carbide absorber rods under severe accident quenching conditions in the PARAMETER-SF test series”

A.Gontar (FSUE SRI “LUCH”) presented the objectives of the ISTC project proposal on the continuation of the PARAMETER-SF test series. The objective of the project is to study the behaviour of two VVER-1000 fuel rod assembly simulators with 18 heated fuel rods and 1 central B4C absorber rod under severe accident conditions with quenching from the top. The maximal temperature of claddings should be for PARAMETER-SF5 about 1520К and for PARAMETER-SF6 about 1720К, respectively. Quenching from the top should be conducted with a water flow rate of about 40g/s.

The following information will be obtained within the framework of the project: 1) the physico-chemical behaviour of model fuel assemblies (FA) with boron carbide absorber rods (AR) under the initial stage of a severe reactor accident with top flooding. 2) The degree of cladding oxidation and of melting of the cladding, guide tubes, and AR materials will be studied depending on temperature. 3) Chemical composition and structure of the solidified and relocated melts be obtained. 4) The database for the verification of severe accident codes will be broadened. The obtained results can be used for the improvement of SA computer codes used (SOCRAT/B1, ATHLET, ICARE-CATHARE, etc.) and for justification of critical limits of NPP design and operation.

A similar project proposal (ISTC #3936) has been considered at the15th CEG-SAM Meeting in Villigen, Switzerland, in March 2009 and at the 16th CEG-SAM meeting in Moscow in September 2009. The project received the status “3” (accepted without funding) by the ISTC GB. “LUCH” will contribute financially to the estimated project cost of about 600000 USD if it will also be financially supported by the expected foreign collaborators.

**Topic #30:** Next CEG-SAM meeting, September 2010 in St.Petersburg, Russian Federation

The 18th CEG-SAM meeting will take place in St.Petersburg, September 28-30, 2010. S.Bechta (RIT-NITI) kindly offered to host the meeting and to organise a visit of the installations in Sosnovy Bor.

M.Hugon thanked once more L.E. Herranz (CIEMAT) for the organization of the 17th CEG-SAM meeting in Madrid. He also expressed his thanks to all speakers and participants for their engagement at the meeting.

**Restricted session** (continued)

**Topic #31:** SARNET and CEG-SAM comments on ISTC & STCU proposals

D.Bottomley (JRC-ITU) and G.Pretzsch (GRS) reviewed critically the STCU project proposal #4758 and sent their comments to V.Krasnov (ISP NPP) to revise it. V. Krasnov prepared a new STCU #5244 proposal. D.Bottomley (JRC-ITU), Ch.Journeau (CEA), M.Krause (AECL) and G.Pretzsch (GRS) were asked to prepare a new advice for the STCU project proposal #5244 (action 17/2). The subject of possible re-criticality of fuel-containing material accumulations in the Chernobyl NPP Unit4 is of generic interest. Further research in this area is important and therefore necessary to obtain as many results as possible for code validation purposes.

Concerning the STCU project proposal #5243 some concern was expressed on the experimental results that have to be expected. Therefore, V.Kornyeyeva (NFC KIPT) should provide more detailed information on the selected materials to be examined. The material examinations should be done with materials that are of interest for the group. V.Stepanenko (STCU) will request the paper from V.Kornyeyeva to be distributed to the CEG-SAM (action 17/3).

The ISTC project proposal on PARAMETER-SF5 +-SF6 with boron carbide absorber rods is of interest for the CEG-SAM. However, it corresponds to the initial ISTC project proposal # 3936 that received the status “3”, accepted without funding, from the ISTC GB some time ago. It is very unlikely that this proposal can be revitalized, although LUCH could possibly cover a part of the planned costs (600 000USD).

The ISTC project #3635 from V.Loktionov (MPEI) should be prolonged by 1 year without additional funding. A.Miassoedov (KIT) will prepare a letter to request the prolongation and send it to the foreign collaborators and to L.Tocheny (ISTC) (action 17/4). The CEG-SAM will decide on the test procedure that V.Loktionov should send to the collaborators by June 2010.

A.Kondrashenko (VNIIEF) will send the prepared report on the conducted tests to the collaborators of the ISTC project #3831 at the latest by June 2010. Ch.Journeau (CEA) suggested organizing a meeting with A.Kondrashenko and the foreign collaborators at the ERMSAR conference in Bologna in May 2010 although A. Kondrashenko may not travel to Italy. It is requested that A. Kondrashenko will attend the next CEG-SAM meeting in Russia to favour direct discussions. A.Miassoedov (KIT) mentioned that only MCCI tests with UO2 are of great interest for the CEG-SAM. However, in the framework of the current project only feasibility tests have been performed, which did not require UO2.

**Topic #32:** Detailed discussion of presented ISTC and STCU project proposals and preparations of specific CEG-SAM advices

Once more, a general discussion took place on future funding models for ISTC projects since the funding will be limited. One possibility could be co-funding of projects by several sources, for example, Russian partner(s) institutions, EU institutions, and ISTC. Projects without ISTC financial support will cause fewer problems with export control measures, intellectual property rights and non proliferation.

L.Tocheny (ISTC) mentioned that in Russia a programme on new test reactors and fast breeders has been launched. IBRAE will be responsible for the development of new codes that should couple the material behaviour and neutronics. Concerning the funding of future ISTC projects, L.Tocheny mentioned that the foreign collaborators should contribute to the expenses of ISTC projects.

Another possibility is the submission of joint Euratom-ROSATOM proposals (such as ERCOSAM) to nuclear fission calls. In these cooperative actions, Euratom will fund solely the EU partners, while ROSATOM will support the efforts of Russian partners. In each cooperative action, the Russian contribution is expected to be equivalent to that of Euratom.

**Topic #33:** Discussion of various actions

See specific action list (Annex #3).

**Topic #34:** Other matters; Final remarks

The chairman M.Hugon thanked once more CIEMAT for hosting the meeting and for all its 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)

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**Annexes:**

1. Updated final agenda of the 17th CEG-SAM meeting
2. List of participants at the 17th CEG-SAM meeting
3. Specific action list (appended below)

**Annex #3:**

**Action List**

17th CEG-SAM meeting; Madrid, Spain, March 29-31, 2010

**Action 17/1**: L.Tocheny (ISTC) will write a letter to the director of A.Kondrashenko to clarify if VNIIEF can conduct future MCCI tests with UO2; see topic #8

**Action 17/2**: D.Bottomley (JRC-ITU), Ch.Journeau (CEA), M.Krause (AECL), and G.Pretzsch (GRS) will prepare a new advice for the STCU project proposal #5244 (for this purpose the earlier advice for the STCU project #4758 can be modified). The new advice should be sent to M.Hugon (EC) and to the SAC chairman; see topic #31.

**Action 17/3**: V.Stepanenko (STCU) will request the paper from V.Kornyeyeva (NFC KIPT) that should provide more detailed information on the selected materials to be examined in the framework of the STCU project #5243. The paper should be distributed to the CEG-SAM members; see topic #31.

**Action 17/4**: A.Miassoedov (KIT) will prepare a letter to request the prolongation of the project #3635 of V.Loktionov (MPEI) and send it first to the foreign collaborators and then to L.Tocheny (ISTC); see topic #31.

**Action 17/5**: M. Hugon (EC), D.Bottomley (JRC-ITU), B.Clement (IRSN), Ch.Journeau (CEA), S. Güntay (PSI) and W.Tromm (KIT) should prepare a paper on the future of the CEG-SAM and how to improve the collaboration with the Russian Federation and the Ukraine. The paper should be distributed to the CEG-SAM members before the next meeting and discussed at 18th CEG-SAM meeting in St.Petersburg.

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