|  |  |  |  |
| --- | --- | --- | --- |
|  | 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 13th MEETING**

**Budapest, Hungary**

**Hungarian Academy of Sciences KFKI**

**Atomic Energy Research Institute AEKI**

**March 5-7, 2008**

Meeting Location: Conference room of the hotel “Budapest”

|  |
| --- |
| 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 |

|  |
| --- |
|  |

Final minutes, September 9, 2008 CEG-SAM / M-13

|  |
| --- |
| Subject: 13th Meeting of the ISTC  “Contact Expert Group on Severe Accident Management” (CEG-SAM)  Place: Conference room hotel „Budapest“, Budapest, Hungary  Date: March 5-7, 2008  Participants: 39 participants of 27 organizations from 11 countries:  Mr. E.Altstadt FZD, Dresden-Rossendorf  Mr. D.Bottomley EC, DG JRC / ITU, Karlsruhe  Mr. B.Clement IRSN, Cadarache  Mr. G.Ducros CEA, Cadarache  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. G.Pretzsch GRS, Berlin  Mr. J.Stuckert FZK, Karlsruhe  Mr. K.Trambauer GRS, Garching  Mr. W.Tromm FZK, Karlsruhe  Mr. A.Vimi AEKI, Budapest  Mr. H.Willschütz E.ON, Hannover  Mr. V.Baty ISTC NPPP, Chernobyl  Mr. S.Bechta RIT-NITI, Sosnovy Bor  Mr. V.Bezlepkin SPAEP, St.Petersburg  Mr. A.Goryachev RIAR, FRD, Dimitrovgrad  Mr. Y.Gorbachev SPB SPU, St.Petersburg  Mr. A.Ignatyev SPAEP, St.Petersburg  Mr. A.Kisselev IBRAE, DNS, Moscow  Mr. S.Krasnukha NAEK Energoatom, Kiev  Mr. L.Lebedev SPAEP, St.Petersburg  Mr. M.Lebedev NPO CKTI, St.Petersburg  Mr. V.Nalivaev NPO LUCH, Podolsk  Mr. V.Ozrin IBRAE RAS, Moscow  Mr. V.Protsak UIAR of NAU, Kiev  Mr. V.Stepanenko STCU, Kiev  Mr. O.Tarasov IBRAE RAS, 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: Ms. Z.Stancic DG-RTD  (Shortened version Ms. M.Minch DG-RTD / D  of the minutes) Mr R.Burmanjer DG-RTD / D.3  Mr. J.Sanders DG-RTD / D.3  Mr. O.Quintana Trias DG-RTD / J  Mr. A.Perez Sainz DG-RTD / J.1  Mr. S.Webster DG-RTD / J.2  Mr. M.Deffrennes DG-RTD / J.2  Mr. P.Manolatos DG-RTD / J.2  Mr. G.Van Gothem 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. S.Vorobiev ISTC, Moscow  Mr. W.Gudowski ISTC, Moscow  Mr. A.Gozal 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 Atomic Energy Research Institute (AEKI) of the Hungarian Academy of Sciences (KFKI) organized the 13th CEG-SAM meeting in Budapest on March 5-7, 2008. The meeting location was the Conference room of the hotel Budapest “Körszallo” in Budapest.

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 chairmen M.Hugon and L.Tocheny welcomed the CEG-SAM members

**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 13th CEG-SAM meeting of the Contact Expert Group on Severe Accident Management (CEG-SAM) of the International Science and Technology Centre (ISTC).

He used the opportunity to express his thanks to Z.Hozer from AEKI who kindly offered to organize and host the 13th CEG-SAM meeting in Budapest. This meeting was the first one in the new EC Member States. It was also the first CEG-SAM meeting in which scientists of the Ukraine participated.

**Topic #2:** Adoption of the agenda of the 13th CEG-SAM meeting

One additional presentation by K.Trambauer (topic #19) as well as some comments by L.Tocheny (topic #5) and Ch.Journeau (topic #25b) were announced. With these changes, the appended agenda (see Annex 1) was accepted.

**Topic #3:** Approval of the minutes of the previous 12th CEG-SAM meeting in St.Petersburg, September 11-13, 2008.

The secretary took into account the comments received on the draft minutes by G.Cenerino, G.Ducros, Ch.Journeau and A.Miassoedov as well as those by S.Bechta and M.Veshchunov in the revised minutes dated November 30, 2008. The revised minutes were then approved by the CEG-SAM members without any additional changes at the CEG-SAM meeting in Budapest, March 5, 2008.

**Topic #4:** Discussion of the “Specific action list” of the 12th CEG-SAM meeting in St.Petersburg

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).

*L.Tocheny mentioned that ISTC has a new director S.Vorobiev.*

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 successfully completed.*

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

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

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.

*A project proposal on VERONIKA was prepared and send to the ministry for approval in February 2008. Due to organizational problems within ROSATOM no action was taken. L.Tocheny mentioned that a new commission will be formed in the near future. B.Clement & D. Bottomley were asked to prepare an advice on VERONIKA (action #13/8).*

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.

*The initial extensive project proposal included experiments with UO2. As a result of the new export control regulations in Russia it was proposed to delete all activities with UO2 containing material. However, the current structure of the proposal should be left. Right now only a demonstrative MCCI test without UO2 should be envisaged; estimated costs about 100k€. L.Tocheny mentioned that A.Kondrashenko was not being able to attend the CEG-SAM meeting since the project is not yet officially approved. Ch.Journeau (CEA) will send to A. Kondrashenko his presentation concerning the composition of the concrete (topic #25b) that should be examined in the frame of the ISTC project #3831 (MCCI, first phase).*

Action 12/7: L.Tocheny (ISTC) will ask 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 (i.e. the Japanese and US organisations). *The non-EU foreign collaborators were not removed (see topic #5).*

Action 12/8: The location of the 14th CEG-SAM meeting in September 2008 should be decided by the Russian partners. *See topic #34.*

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

M.Hugon gave a presentation on ISTC project 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. 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 2008 about 15 M€ and in 2009 about 8 M€, while it was in 2007 about 25 M€.

M.Hugon stressed once more that future ISTC/STCU project proposals should be in line with the SARNET priorities.

At the 11th CEG-SAM meeting in Dresden the CEG-SAM decided the following ranking of the various project proposals: 1. ISTC #3813, CORPHAD-P (now called PRECOS); 2. VERONIKA; 3. Large-scale MCCI; 4. ISTC #3702: CHESS-2; 4.STCU #4207: Chernobyl shelter; 6. ISTC #3690: PARAMETER (funded); 7. ISTC #3635: Structural integrity of RP vessel under creep in severe accidents (funded).

The ranking at the 12th CEG-SAM meeting in St.Petersburg was different since only officially registered project proposals could be considered. The ranking resulted in the following order: 1. ISTC #3813: PRECOS (funded); 2. ISTC #3609: EXPULS; 3. ISTC #3702: CHESS-2; 3.STCU #4207: Chernobyl shelter.

A ranking procedure by e-mail prior to the 13th CEG-SAM meeting in Budapest resulted in the following order: 1. ISTC #3831: Large scale MCCI (medium-scale experiment with simulated materials, no UO2); 2. ISTC #3609: EXPULS; 3. ISTC #3702: CHESS-2; 3. STCU #4207: Chernobyl shelter. Therefore, M.Hugon sent an e-mail to J.Sanders to propose him that he should present at the next ISTC GB Meeting in April the project ISTC #3831 (MCCI phase 1).

In 2007 altogether three ISTC projects were funded: ISTC #3635: RPV behaviour in Severe Accidents (429 k€); ISTC #3690: PARAMETER (447 k€) and ISTC #3813: PRECOS (996 k$).

L.Tocheny mentioned that as a result 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 financially more 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) have to be considered as Russian co-funding of current ISTC projects.

L.Tocheny presented the status of on-going and new project proposals and described the latest decisions on non-disclosure agreement, on programmatic approach and on export control problems.

Regarding the non-disclosure agreement the following text is proposed: *The ISTC Governing Board has decided that, under any justified circumstances, and at the appropriate time, foreign collaborators and project participants should sign confidentiality and non-disclosure agreements.*

Concerning the programmatic approach the new procedures and topics were described.

With respect to the export control problems there is an official provision on export and import of nuclear materials, equipment, special non-nuclear materials and related technologies. The term "nuclear export" means export from nuclear materials, equipment, special non-nuclear materials and related technologies.

Nuclear export into the non-nuclear weapon countries may be realized only after receiving **the affirmations of the State competent organs** of these countries that have nuclear export objects, and also produced as a result of its use nuclear and special non-nuclear materials, installations and equipment, that these will not be used for production of nuclear weapons and other nuclear explosive devices, or for any other military purposes. Project proposals have to be sent to Brussels where all 27 Member States have to agree.

Usually the Recipient Institute(s) has/have to add at least 50% of the project cost as additional indirect project cost. It means that ISTC projects may be considered as examples of really joint collaborative-type work, and not as donation.

Finally L.Tocheny described the financial difficulties concerning the ISTC project #3635 which are caused as a result of the increase of prices for RPV steel and the increase of manufacturing costs for the vessel mock-ups. Currently one is looking within the Russian Federation for additional money sources for both the vessel mock-ups manufacturing and for an alternative manufacturing plant.

**Topic #6**: 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). In the new structure of the webpage all documents (project proposals, advices, work plans, progress reports) 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. 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 project 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 recommended the participation of Russian organizations in FP7 without EURATOM funding. With respect to joint calls there is no concern regarding export control as long as the receiver institution is known.

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

The presentation was shifted to topic #11.

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

The new ISTC project proposals will be presented under topics #28 to #31. There was only limited time to discuss them in detail. Nevertheless, a new ranking of the available officially registered project proposals has been required. The new ISTC project proposal THOMAS (topic #28) is not yet registered but it will get an ISTC number very soon. For this reason it was also considered. The STCU proposed project #3511 (topic #33) is not SAM related and was therefore not considered.

Concerning the terminated ISTC project #3345 EVAN no following up project was proposed. Possible contents of a 2nd phase EVAN project should be presented at the next CEG-SAM meeting.

Regarding the project #3690 PARAMETER, the CEG-SAM recommendations were not all considered in the test matrix up to now.

# Extended session

**Topic #10**: Welcome of the Russian, Kazakh and Ukrainian colleagues; approval of the shortened minutes of the 12th CEG-SAM meeting in St.Petersburg; adoption of the agenda

M.Hugon opened the extended session of the meeting and welcomed the Russian, Kazakh and Ukrainian participants and expressed his thanks to Z.Hozer and his co-workers from the Atomic Energy Research Institute (AEKI) in Budapest who kindly offered to organize and host the 13th CEG-SAM meeting.

L.Tocheny delivered additional greetings to the participants from ISTC, especially to the Ukrainian participants who attended for the first time the CEG-SAM meeting.

V.Stepanenko (STCU) expressed his thanks to be able to participate at a CEG-SAM meeting for the first time.

The revised shortened minutes of the 12th CEG-SAM meeting, distributed to the Russian participants in November 2007, were accepted without any additional changes.

Two additional presentations, one by K.Trambauer (topic #19) and the other one by Ch.Journeau (topic #25b), were announced. The planned presentations from V.Loktionov (topic #23) and A.Kondrashenko (topic #25a) could not be given since they were not able to attend the meeting. The agenda was then approved and adopted with these changes.

**Topic #11:** 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 framework of SARNET.

The latest ISTC proposals were presented and discussed during SARNET annual review meeting (21-25 January 2008 in Bled, Slovenia).The SARNET opinion is consistent with final ranking by CEG-SAM members.

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.

B. Clement described the on-going work on Severe Accident Research Priorities within SARNET. 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: 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 4 issues remaining with **medium priority** are:Research activities on hydrogen generation during reflood, on corium coolability, 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 the impact of core reflooding on source term.

**Topic #12**: Presentation on the preparation of SARNET-2

W.Tromm (FZK) presented and discussed the 8 work packages of SARNET-2. Only EC’s grant will be considered as a bonus to be used to adapt the national R&D programmes into SARNET-2.

The content of the proposal will be: 1. A direct choice of experimental topics (or WPs) to be backed by the grant from the beginning of “SARNET-2”, 2. To concentrate the planned work on topics directly related to high priority pending research issues, 3. To demonstrate that the EC grant is really used for a better integration of experimental national programmes, 4. The definition of a roadmap for the distribution of the grants.

**Topic #13**: Status of the official ISTC CEG-SAM webpage

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

**On-going project presentations**

**Topic #14:** Final report on the experimental part of the ISTC project # 1648.2 “Examination of VVER fuel behaviour under severe accident conditions, Quench state” (VVER-QUENCH)

The project consists of three stages. Stage A: Study of the behaviour of irradiated fuel rod segments 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 (see topic #15). Stage C: Development of models and codes to describe VVER core behaviour under severe accident re-flood conditions (quench stage) on the basis of the results of stages A and B (see topic #16).

A.Goryachev (RIAR) presented the final results of stage A. Altogether 14 quench tests with un-irradiated and 21 quench tests with irradiated fuel rod segments (re-fabricated from VVER fuel rods with burn-ups of 50 and 60 MWd/kgU) were carried out under the test conditions of 1400, 1600 and 1700°C without and with cladding pre-oxidation (about 100 and 300 µm, respectively). The re-flood initiation was conducted by immersion of the oxidized specimens into the water reservoir with a speed of 20mm/s. The tests provided data on hydrogen generation, volatile fission product 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 due to a more extensive cladding oxidation and different mechanism of brittle cladding failure (formation of longitudinal cracks). As a result, more hydrogen was produced during quenching due to oxidation of the newly-formed metallic crack surfaces. The observed phenomena may be explained by the disappearance of the initial fuel/cladding gap in the irradiated fuel rod segments at higher burn-ups and oxygen pick-up by the cladding from the oxide fuel resulting in a more brittle behaviour. The gaseous fission product release increases with increase of the pre-oxidation time and the maximal temperature at quenching. In addition the Cs isotope release into the quench water was determined.

**Topic #15:** Final report on the stage B of the ISTC project # 1648.2. Results of the integral re-flood test QUENCH-12 with a VVER bundle

J.Stuckert (FZK) presented the final results of stage B. The bundle test QUENCH-12 was successfully conducted at FZK in September 2006. The experiment investigated the effects of VVER materials (Zr+1%Nb) and VVER bundle geometry under core re-flood conditions, in comparison with test QUENCH-06 (ISP-45) with Western type PWR cladding (Zry-4) and 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 re-flood 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 –beside the different cladding materials- an extensive damaging of the cladding surfaces due to the breakaway oxidation and local melt formation with subsequent melt oxidation.

At FZK and RIAR comprehensive metallographic post-test examinations were performed at fuel rod bundle cross sections from several bundle elevations together with measurements of the extent of cladding oxidation. These examinations show the strong tendency of the Russian cladding alloy Zr+1%Nb (E110) to breakaway oxidation under the applied test conditions. In competition with the cladding oxidation the formation and relocation of molten cladding material under the formation of small melt pools (via “necking” mechanism) have been observed within the bundle region. Some melt pools have been supplied by molten material from the non-instrumented massive corner rods. The thick-walled shroud was also partially molten which resulted in a relocation of the molten material into lower bundle regions.

**Topic #16:** Final report on the analytical part of the ISTC project # 1648.2 “Examination of VVER fuel behaviour under severe accident conditions, Quench state” (VVER-QUENCH)

M.Veshchunov (IBRAE) presented the final results of stage C of the project, i.e. the development of models and codes to describe the VVER material behaviour in the quench tests. For this reason the SVECHA/QUENCH (S/Q) and MFPR codes were adapted to describe the thermo-mechanical behaviour and failure of the VVER fuel rod simulators in the RIAR quench tests. The modified S/Q code predicts the temperature evolution well 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 rod segments, demonstrating similarity with results of the FZK quench tests (with Zry-4 cladding).

The S/Q code was extended for simulation of the RIAR quench tests with irradiated fuel rods:

Calculations of the S/Q code confirm the test observations of complete disappearance of the gap between fuel pellets and cladding at high burn-ups resulting in the formation of an internal α-Zr(O) layer and embrittlement of the cladding. Thus, the fuel rod cladding embrittlement can take place even lacking external oxidation. However, the additional external cladding oxidation considerably enhances the cladding embrittlement. Thermo-mechanical consideration of the S/Q code confirms this conclusion and demonstrates formation of through-wall cracks in fuel rods during quenching.

The MFPR code, coupled with the S/Q code, predicts reasonably well the Cs and Kr fission product release in the RIAR quench tests with irradiated fuel rod segments. The release from fuel pellets is associated mainly with the high-temperature annealing stage rather than with the short-term quenching stage. In accident scenarios with a strong temperature escalation during quenching (observed in some FZK QUENCH bundle tests) it is expected an enhanced fission product release from fuel pellets into the pellet-cladding gap during heat-up stage and further release outside cladding after cladding failure during quenching.

The SVECHA/QUENCH code was also applied to simulate the bundle test QUENCH-12. 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. . This discrepancies indicate on the strong influence of the oxide spalling (so called “break-away effect”) on the oxide growth and hydrogen generation rates, observed in the tests, but not modeled in the code (foreseen in the future code development).

## Topic #17: Part 1: Status of the ISTC project #3690 on the “Fuel assemblies behaviour under severe accident top quenching conditions in the PARAMETER-SF test series (PARAMETER-SF3 and -SF4 experiments); Part 2: Destructive post-test examination results of fuel bundle PARAMETER-SF2

Part 1: V.Nalivaev (FSUE SRI SIA “LUCH”) presented the current status of the project PARAMETER that includes the conduct of VVER-1000 bundle experiments with UO2 pellets and Zr+1%Nb cladding under severe reactor accident conditions (18 heated rods and 1 unheated rod). For the test PARAMETER-SF3 the following test conditions are planned. Coolant flow rates: argon 2g/s and steam 3.5g/s. The pre-oxidation of the bundle will be carried out at about 1470K for 3000s. Then the bundle will be heated up with 0.5 K/s to 1870K and then flooded with water 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) are fixed on the basis of SVECHA code predictions by IBRAE.

Part 2: V.Nalivaev described briefly the results of the destructive post-test examinations of the bundle PARAMETER-SF2. Five bundle cross sections were examined in detail. UO2 fuel relocation was not observed. A pronounced Zr+1%Nb cladding oxidation took place at the bundle elevations between 1000 and 1300mm. Beside the formation of compact ZrO2 on the outer cladding surface, in addition localized spalling of thin ZrO2 multi layers took place. The crack surfaces in the metallic part of the cladding (through wall cracks) were not oxidized. The final report will be issued in November 2008.

## Topic #18: PARAMETER-SF3 test scenario and results of SF3 pre-test numerical modeling,

Specification for numerical simulation of PARAMETER facility; Tests SF3 and SF4

T.Yudina (IBRAE RAS) described the results of pre-test calculations of test PARAMETER-SF3. Various code systems have been used: RATEG/SVECHA (SOCRAT), RELAP, PARAM TG and ICARE/CATHARE. The results on cladding temperatures, oxide layer thicknesses and hydrogen production were presented. The test conduct is planned for September 2008; test conditions see topic #17, part 1.

Concerning the test PARAMETER-SF4 (air ingression test) it was decided that the foreign collaborators of the project should propose a test scenario (action #13/3).

**Topic #19**: Preliminary results of PARAMETER-SF2 post-test calculation with ATHLET-CD

K.Trambauer (GRS) presented the results of the post-test calculations of the test PARAMETER-SF2 with the code system ATHLET-CD. The special aim of this experiment was to study the efficiency of combined top and bottom flooding for the VVER-1000 assembly overheated to 1500 °C and to obtain valuable information for code verification. With the help of the experimental data especially the modelling of flooding and oxidation processes should be checked.

For the post test calculation of SF2 with ATHLET-CD an input data deck was derived from the post-test calculation of the SF1, which was adjusted to the special initial and boundary conditions of test SF2 and also to the changed geometry. A first calculation showed good agreement of the calculated temperatures until start of cool-down, but the used Sokolov correlation for the simulation of Zirconium oxidation led to an underestimated hydrogen production. With the oxidation rates calculated by the Leistikow/Prater-Courtright kinetic data the calculated hydrogen generation agrees well with the measured data.

After the start of top-flooding the injected liquid dropped too fast down to the bottom of the bundle with the effect that the pre-cooling of the rods up to a bundle elevation of about 700mm was too strong. The cooling-fronts derived from measured temperatures and the calculated quench-fronts are in good agreement; so this calculation simulates very well the average behaviour of the cool down of the bundle. An additional calculation with increased interfacial friction for annular-mist flows shows even a better cool-down behaviour also at the lower bundle elevations.

**Topic #20**: Progress report on 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), 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.

Due to further delay of the delivery of necessary materials and equipment only three tests could be performed with the available materials using single plasmatrons dipped into prototypic corium without preliminary melting.

Post-tests examinations of test TOP-1 showed that main part of protective coating on the graphite electrode kept its integrity. Chemical analysis of the corium composition showed the presence of both solid solution of uranium and zirconium oxides and corresponding oxy-carbides.

The test TOP-2 was prepared and conducted using 12 kg of corium mass during 2 hours holding period. The applied power of plasmatrons was about 16.5 kW. The maximum temperature on the outer corium boundary was about 900°C. Post-test examination showed that main energy release in plasmatrons was in the bottom direction. The solidified corium ingot was about 30 mm thick. The protective coating on the graphite surface showed its reliability against corium attack. The main phase of the corium ingot is a solid solution of uranium and zirconium oxides.

The test conditions of test TOP-3 were similar to test TOP-2 but the gas gap between inner and outer vessel in the lateral wall was increased to obtain a higher thermal insulating effect. Additionally, an increased nitrogen content in the pressure vessel atmosphere was created to study the influence of nitrogen on plasma burning and corium composition. The power of the plasmatrons was not higher than 16 kW; the duration of the test was 2 hour. The maximum temperature on the outer corium boundary was about 850 degree C. The resulting corium ingot appeared similar to the TOP-2 test result but the material was very fragile. Phase analysis showed a relatively high content of uranium and zirconium nitrides (S.Bechta mentioned that nitrogen gas should not be used).

The main positive results of the TOP tests are: the electric arc burning is stable during 2 hours of operating conditions; plasmatrons power is almost steady during the tests; the inner electrode erosion depth can allow the test duration to be prolonged for more than 2 hours; the quality of the protective Zr-coating is reliable against chemical corium attack at temperatures higher than 2500 degree C; the use of a thermal insulation on the outer surface of RPV model could enable physico- chemical interactions to be observed between corium and carbon vessel steel.

The test TOP-4 will be performed in the case of successful increase of the plasmatrons power.

**Topic #21**: Final report on the ISTC project #3345 “Ex-vessel source term analysis” (EVAN), phase 1

V.Bezlepkin (SPAEP) presented the final report 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, 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. The project consisted of 7 tasks.

Task 1 included analysis of radioactive releases involved in beyond-design-basis severe accidents (SLOCA and LLOCA). Mechanisms of fission product release and transport were scrutinized.A severe accident scenario was examined involving reactor coolant escape to the secondary coolant circuit.

Task 2 included experiments targeted at the determination of fission product (SrO, BaO, La2O3, CeO2, Ru, and Mo) release rates versus melt temperature and degree of its oxidation.

Task 3 included developments and program realization of “equilibrium” and “nonequilibrium” models describing release of fission products from the corium melt.

Task 4 included experiments with precipitation of liquid aerosol AT 1, as well as precipitation and entrainment of solid aerosol (ammonium chloride) AT 2. Test data have been obtained for finely-dispersed and coarse-dispersed liquid aerosol precipitation in a tube at various air flow velocity values. Also, test data have been obtained for solid aerosol precipitation at different air flow velocities.

Task 5 included pre-test and post-test analyses of aerosol transport and precipitation, to be used in Task 4 experiments. The results of experiments concerning aerosol precipitation on tube walls satisfactorily agree with theoretical model and numerical calculations results. Within the framework of Task 5 a model of particle precipitation/entrainment was developed.

Task 6 included experiments involving irradiation of media in stainless steel ampoule, and experiments with media in fluoroplastic pressure bomb not exposed to radiation. The media were analyzed before and after the tests. As a result, experimental data were yielded that describe the iodine volatility as a function of iron sludge concentration.

Task 7 included the development of iodine module for a severe-accident code, which encompassed the following blocks: water inventory block; рН block; block of water phase surfaces; atmospheric block; block of atmosphere-exposed coatings; and common memory block. The computer code was developed for this version of the module; pre-test calculations were carried out; mathematical model adequacy was demonstrated; the code was verified against the results of experiments first carried out within the framework of this project; and post-test calculations were carried out.

The conclusions of the EVAN project are: The developed mathematical models have been brought up-to-date and verified. As a result, part of the uncertainties in the evaluation of fission product release into the containment and the environment during a severe accident in NPP, have been partially eliminated.

The CEG members agreed that all tasks of the ISTC project #3345 are fulfilled completely, and agreed in general with content of the report.

**Topic #22**: Progress report on the ISTC project #3592 (METCOR-P) "Corium Melt Interaction with Reactor Vessel Steel”

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 at vertically positioned interfaces, peculiarities of interaction with European vessel steel, and corium melt oxidation transients. Two tests have been performed up to now.

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); the presence of a compact metallic inclusion in the corium ingot; differences in the interaction zone structure and composition, and a lower temperature at the final position of the interaction zone/specimen boundary.

The MCP-2 test on the interaction of vessel steel with the UO2+x-ZrO2 corium in air has been performed as an additional (concluding) test of the METCOR project. The analysis of МСР-2 data in combination with all experimental results of METCOR has enabled: to extract correlations for the VVER vessel steel corrosion as a function of the corium composition, interface temperature and corium-steel heat flux; to determine a relationship between the intensified corrosion of fusible corium and liquid-phase diffusion in the corium crust on the steel surface, within a predetermined temperature range; and to identify the practical stability of the apparent activation energy value at variable conditions of steel corrosion in oxidizing atmospheres.

The MCP-3 test is currently under preparation. It is proposed to change the sequence of tests. Before the next test with a vertically-positioned interface a test with oxidation of the interaction zone will be made.

The METCOR-P results will be documented by four publications, which have different degrees of preparedness. The preparation of reports (МСР-1, МСР-2) and further experimental activities will be possible only after ROSATOM (problems of non-proliferation; export control approval needed) and ISTC agree about additional conditions stipulating further project implementation. The project is therefore suspended until ROSATOM and ISTC decisions are available.

For the obtained results an export licensing is required. A partner recipient of the project results should be nominated. Information confidentiality and non-proliferation should be confirmed. Possible solution: The funding party (EC) will authorize one of its research centers as the recipient of the results (see topic #5, comments of L.Tocheny), but spreading of results to other European partners is not yet solved.

**Topic #23:** Progress report on the ISTC project #3635 “Experimental investigation of the thermal and structural integrity of the VVER pressure vessel Lower Head in severe accidents”

The paper was not presented due to absence of V.Loktionov (MPEI) and the difficulties described by L.Tocheny under topic #5.

The CEG-SAM recommended that V.Loktionov should contact the three non-paying collaborators (Department of Engineering Physics, College of Engineering, University of Wisconsin; Division of Nuclear Power Safety, Department of Physics, Royal Institute of Technology, Sweden; Japanese Institute of Nuclear Technology, Institute of Nuclear Safety System) for funding.

**New or updated project proposals**

**Topic #24**: Status of the ISTC project #3813 “Phase diagrams for NPP severe accident studies (CORPHAD-P called now PRECOS)”

S.Bechta (RIT/NITI) described the ISTC project proposal: **CORPHAD-P (now called PRECOS). 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 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, 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. 2) Metal-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.

PRECOS has been funded by 44th ISTC GB in December 2007. PRECOS Work plan has been prepared and sent for ROSATOM export control in January 08. The work plan will be distributed after its approval by the export control. The PRECOS kick-off meeting will be held in July 2008 in St Petersburg.

**Topic #25a**: Status of the ISTC project #3831 “Development and experiments at large-scale installation for heating and retention of corium”

The paper of A.Kondrashenko (VNIIEF) was not presented. The chemical composition of the concrete proposed by A.Kondrashenko should be modified (see topic # 25b).

**Topic #25b:** Remarks on the composition of the concrete to be examined

Ch.Journeau (CEA) presented the result of a joint proposal of the CEG-SAM members. For the medium-scale pre-test, limestone-common sand concrete should be used since this type of concrete is linked to isotropic ablation and any artefact in the heat flux distribution will be detected, whereas for siliceous concrete it must be verified that the observed ablation anisotropy is not an artefact due to the size or heating system of the experiment.

**Topic #26:** Status of the ISTC project #3609 “Experimental investigation of flow pulsation effects on burnout in RPV external cooling system (EXPULS)”

S.Bechta (RIT/NITI) presented the status of the project on behalf of Y.A.Migrov (NITI). The objective of the project is to enhance the safety of water-cooled 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 (IVR). The project objectives are:to obtain experimental data on Departure of Nucleate Boiling (DNB) processes at the external surface of reactor pressure vessel (RPV) under coolant flow oscillation conditions and to verify the computer codes which describe the mentioned processes.

To retain the core melt within the RPV is one of the possible ways to confine a severe accident. This approach is adopted in several VVER, PWR, and BWR NPP designs. The main condition for in-vessel core melt retention is the prevention of DNB on the outer reactor wall cooled by external water. Critical Heat Flux (CHF) experiments were performed in a number of test facilities and their results were generalized and used in numerical analyses. The critical heat flux depends on the coolant flow stability/instability. Significant flow oscillations can reduce the 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.

To study the effect of flow oscillations on CHF level an experimental program has been developed. 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). DNB is simulated using the “hot spot” method in two test areas inclined at 30o and 90o to the horizontal, respectively.

Preliminary calculations will give the variation range for the parameter values determining the flow oscillation rates. The experimental data obtained will be analyzed and generalized to arrive at correlations between the flow oscillation rate and CHF level. These data will be also used for the verification of RELAP5-MOD3.2 and KORSAR version 1.1 and other computer codes.

The CEG-SAM recommendations from Z.Hozer should be considered in the test programme.

**Topic #27:** Status of the ISTC project proposal on “Study of fission products release and behaviour of VVER fuel with high burn-up under severe accident conditions (VERONIKA)”

A.Goryachev (RIIAR) presented the status of the project proposal 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 samples will be subjected to an additional short-term irradiation at low temperatures to generate short-lived FPs in solid solution in the uranium dioxide matrix. The experimental FP release data will allow the verification of code models from diffusion of individual atoms to their release through a network of porosity both formed as a result of the base irradiation and developing as a result of heating up the test specimens to temperatures which are characteristic for SA scenarios.

Because of the essential influence of structure modifications (formation of open and closed porosity in the UO2, and inclusions influencing the movement of gas bubbles) on the FP release an extensive program of post-test examination of the uranium dioxide structure is planned.

Due to the re-organization within RIIAR and new official restrictions the project will be delayed. The issue of export control has been raised that plays an important role for this project. The CEG-SAM stressed that it must be solved before the start of the project.

**Topic #28**: Thermo hydraulics of U-Zr-O molten pool under oxidising conditions in multi-scale approach (crucible- bundle -reactor scales); THOMAS project

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.

Oxidation kinetics of Zr-containing melts can be significantly higher in comparison with that of solid materials, therefore, it strongly determines high heat generation and hydrogen source term during severe accidents, as unambiguously shown, i.e., in the QUENCH tests. On the other hand, the oxidation kinetics strongly depends on thermal hydraulic behaviour of oxidised melt. Therefore, investigation of in-vessel molten pool behaviour under oxidation conditions is still an important issue with respect to core degradation and reactor pressure vessel coolability and failure analysis.

The proposed project aims at the tight coupling of the two advanced tools developed within the previous Project #2936: the SVECHA physico-chemical (molten pool oxidation) model and the thermo-hydraulic code CONV. This will allow a realistic mechanistic description of a (U-Zr-O) molten pool behaviour in oxidising conditions and will extend the thermal hydraulic consideration of oxidised melt from small-scale (crucible tests) up to a large-scale (reactor pressure vessel), including an intermediate scale corresponding to molten pools in the bundle tests. Moreover, improved interpretation of Phebus FP test observations of corium melt oxidation, as well as transposition of thermal hydraulic consideration from the experiments (i.e. MASCA, RASPLAV) to reactor case, are foreseen.

There will be no export control difficulties within this project proposal since ROSATOM does not give its agreement but the Russian Academy of Sciences (to which IBRAE belongs) instead. The developed code system will be available to CEG-SAM members on a bilateral basis.

**Topic #29**: Overview of the SAM STCU list of projects and current state

V.Stepanenko (STCU) presented an overview on SAM related projects of STCU and a short characterization of the Ukrainian institutes and universities involved in the SAM and related activities as: NAS of Ukraine, NSC KIPT, Kyiv Inst. of Nuclear Research, Ukrainian Institute of Agricultural Radiology, Institute for safety problems of nuclear power plants in Chernobyl and the Institute for Scintillation Materials. Ukraine is the second largest country of the former Soviet Union with about 40 million inhabitants. About 50 % of the electricity in Ukraine is produced by 15 nuclear power plants of the type WWER, which are operated by NAEC “ENERGOATOM” at 4 different regions of the Ukraine. The Ministry of Emergency of Ukraine coordinates all activities at the Chernobyl NPP and the adjacent “Exclusion Zone”.

STCU was created in 1994. ISTC and STCU are sister organizations having slightly different administrative arrangements and are working with distinct recipient countries: Armenia, Belarus, Georgia, Kazakhstan, Kyrgyzstan Tajikistan and Russian Federation for ISTC and Azerbaijan, Georgia, Moldova, Ukraine and Uzbekistan for STCU.

In the 1st part of the overview a list of active (running) projects that are funded through STCU were briefly described. STCU project #3511 “Development of the setting and measurement methods of angular gamma-radiation distributions under hard radiation conditions” (see topic #33), STCU project P170 “Experimental Platform in Chernobyl (EPIC)” and STCU project P304 “Organisation of the manufacture of radiation detectors from CdTe (CdZnTe)”.

In the 2nd part STCU project proposals under review were presented: STCU project # 4207 “Long-term prognosis of behaviour of the fuel dust in Chernobyl shelter” (see topic #30), STCU project #4452 “Robot-technical complex for ChNPP on the base of robots of Ukraine and USA” submitted by KPI and the Institute for safety problems of nuclear power plants in Chernobyl , and STCU project #4298 “Developing of large area plastic scintillators for high energy physics and systems for nuclear safety” submitted by Institute for Scintillation Materials, Kharkiv.

In the 3rd part some pre-proposals before reviewing were overviewed: on the lava analysis, on the optimisation scheme of radioactive waste conditioning and on the methods of radio-ecology monitoring of contaminated soil.

## Topic #30: Status of the STCU project proposal #4207 “Long-term prognosis of behaviour of the fuel dust in Chernobyl Shelter”

V.Protsak (UIAR of NAU) presented the current status of the project proposal STCU #4207. The Chernobyl shelter of the RBMK-1000 Chernobyl NPP unit 4 is a source of radioactive particles formed during the accident (now present inside the construction in the form of dust) and in the following 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 Shelter (500 to 2000 kg according to the various estimates) 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 transformation are still not clear.

The main objective of the project is to use these data from the previous tasks to create a model predicting the long-term (50-100 years) behaviour of the radioactive dust in the shelter. The model will describe both transformation of the existing fuel dust and the processes of the dust formation from the main types of FCM under the current and future shelter conditions. The project work will include the following 5 main tasks: 1. Study of the mechanisms of formation of the Chernobyl hot particles (HP) and their classification according to the physical-chemical characteristics. 2. Study of the characteristics and behaviour of RA and water in the shelter. 3. Experimental study of the fuel particle (FP) destruction rate and its dependence on the matrix characteristics (oxidization degree of uranium) and media properties. The results of these studies will form the basis for the long-term prognosis of the FP behaviour in the shelter. 4. Creation of a model to describe the long-term transformation of the fuel dust under the shelter conditions. 5. The long-term prognosis of the shelter radioactive dust behaviour on the basis of the obtained results and data by the Kurchatov Institute (KI, Russia) on the fate of the Shelter FCM during the transformation of the shelter into an ecologically safe system.

The realization of the project will enable for the first time the long-term prognosis of the fuel dust transformation in the shelter. The project results will be very important for development of the strategy for handling the FCM in the shelter. Specific results will also be used for solution of particular tasks arising in future works for the transformation of the shelter into an ecologically safe system.

Taking into account that the two projects ISTC #3702 and STCU #4207 are related by common tasks and research methods, UIAR of NAU intends to continue and to extend its collaboration with KI by means of coordination of the detailed working plans at their preparation phase; exchanging the current information, calculation results and experimental data during the projects realization; coordination of the presentations and published materials; organizing twice a year the joint scientific meetings and invitation of the representative managers of the ISTC, STCU and interested institutions and publishing joint conclusions after completion of the projects.

**Topic #31:** STCU project proposal on Chernobyl lava analysis “Numerical and experimental analysis of buried fuel-containing aggregations at 4-th unit of Chernobyl NPP”

V.Baty (ISF NPP) presented the project proposal since V.Krasnov (ISF NPP) was not able to attend the meeting.

As result of the active stage of nuclear accident at ChNPP Unit 4 with RBMK-1000 reactor lava-like fuel containing materials (LTCM) produced, which originated in premises 305/2 and spread along unit premises with forming clusters of diverse configuration and with diverse uranium content. A part of them is in an open state and is sufficiently well studied. Considerable LTCM part is hidden under destroyed unit debris and 1986 year concrete is practically inaccessible and not sufficiently studied.

Such hidden FCM clusters are located also in south-east part of the sub-reactor premises 305/2 of the «Shelter» object. They are located in cavities produced as result of concrete melting by fuel meltdown, which penetrated on the sub-reactor plate. At this location hidden FCM clusters with high nuclear fuel content are anticipated. This is testified by results of core analyses from boreholes drilled into the assumed area of hidden fuel clusters; by measurements of temperature fields and neutron flux changes.

Due to preliminary estimates, nuclear fuel concentration in these clusters can reach 40% and more. Criticality of such clusters is probable only under the presence of water as moderator. Today the penetration of water into clusters can lead to optimal wetting and the probable occurrence of a nuclear incident. Therefore, estimated and experimental examinations to characterize hidden nuclearly hazardous clusters, as well as to define the ways for preventive sub-criticality suppression are an urgent task for the conversion of the «Shelter» object into an ecologically safe system.

The characterization of hidden nuclearly hazardous clusters is an important task, which should be solved before a new confinement is erected. In the case of inaccessibility to clusters, the main research methods will be search and research works in boreholes drilled into area of clusters in premises 305/2, as well as modeling of clusters media and processes occurring under influence of external factors (humidity, temperature, medium geometry change et al.). Besides, continuation of researches of this topic will allow unique data to be obtained on the processes of interaction of fuel meltdown with structural materials and will permit developing proposals to localize out-of-project accidents at NPPs.

**Topic #32**: Problems of Severe Accident Analysis in Ukraine

S.Krasnukha (STC NAEK “Energoatom”) presented the overview on SA activities in the Ukraine. Currently, Safety Analyses Reports (SAR) have been already performed for 5 pilot nuclear power units. All reports include sections of PSA-2 and BDBA (Beyond Design Basis Accident) analysis on the basis of MELCOR code calculations. However, the analyses do not sufficiently investigate possible personnel actions to mitigate the consequences of the accident after core melt. The maximum contributions to the risk are categories of the radioactive release connected with leaks from primary to secondary side. Most significant will be hydrogen explosion, so it is necessary to realize at power units hydrogen control and re-burning systems. All calculations are fulfilled until onset of core melting, i.e. only those actions which should prevent core damage were investigated.

The RELAPSCDAPSIM Mod 3.4 code was determined as a beneficial tool for severe accident investigations and SAMGs activities, because it is possible to use the input deck, already developed in the frame of BDBA. The MELCOR code is the second code which could be used for containment and radioactive release investigations taking into account an existence of good MELCOR input deck, developed in frame of PSA-2.

SU NPP have planned to obtain Severe Accident Management Guidelines from Czech republic (RZEZ) in order to use them as a basis to develop and validate their own SAMG. Regulatory requirements, which demand SAMG to be developed, are absent (only BDBA analysis is requested). There are weaknesses concerning scientific supporting organizations in the Ukraine due to different reasons. The experimental basis for such investigation in Ukraine is not sufficient.

**Topic #33**: Status of the STCU project #3511 on “Development of device and method for gamma-radiation angular distributions measurement under hard radiation conditions”

V.Baty (ISF NPP) presented the project proposal since V.Krasnov (ISF NPP) was not able to attend the meeting.

Under hard radiation conditions it is important to estimate angular distributions of gamma-radiation intensity in order to determine main radiation sources and to organize radiation protection of the personnel. This problem is especially important for ensuring radiation safety during the liquidation of the accident consequences at the Chernobyl NPP Unit-4, for decommissioning of the other three Units of this site, for the investigation of radwaste storages at other Ukrainian NPPs and at other radioactive hazard objects, including military ones.

At present the multi-detector device SD-1 is used for these purposes at ChNPP. By using SD-1 new data about gamma-radiation angular distributions at “Shelter” object conditions were obtained. But, measurements showed several disadvantages of SD-1, which essentially limit the possibilities of its use. In order to remove above-mentioned disadvantages a new device was developed on the basis of CdZnTe detectors. The new detectors will provide the possibility of distance control measurements, automatic data accumulation and measurements at any point near radiation-dangerous objects.

The Institute for safety problems of NPPs presented a proposal on the *"Estimated experimental research to characterize hidden nuclear hazardous clusters of fuel-containing materials in the destroyed Chernobyl NPP Unit 4"*. It is proposed to drill boreholes in direction to the reactor room 305/2 and to conduct heat measurements, as well as modelling. The aim is to determine the mass and geometry of the clusters, as well as their physicochemical properties. One of the direct safety outcomes would be to assess the criticality risks and preventive measures. It would also be a complement to the data collected thanks to the CHESS-1 project, so that it will also have a generic impact on corium knowledge.

**Topic #34**: Next CEG-SAM meeting, September 2008

V.Stepanenko (STCU) kindly offered to host the 14th CEG-SAM meeting in Kiev, Ukraine, September 9-11, 2008.

M.Hugon thanked once more Z.Hozer (AEKI) and his co-workers for the organisation of the 13th CEG-SAM meeting, and V.Stepanenko (STCU) for his offer to organize the 14th CEG-SAM meeting and all participants for their engagement.

**Restricted session** (continued)

**Topic #35:** SARNET and CEG-SAM comments on ISTC & STCU proposals

Concerning the selection of an ISTC/STCU project proposal the chairmen clarified that only officially registered proposals (with a number) can be chosen by the CEG-SAM and proposed for consideration at the next GB meeting in April 2008. For this reason the ISTC project proposals VERONIKA (topic #27) and THOMAS (topic #28) cannot be considered since they do not yet have an official number. For both projects, advices should be prepared (actions #13/7 and #13/8) to take them into account at the GB meeting in June 2008.

For the registered projects the following ranking was decided that is in the interest of the SAM community and it is in line with the priorities of the SARNET Network of Excellence: 1) ISTC #3831 MCCI; 2) ISTC #3609 EXPULS (the status should be changed from [3] to [2] in order to be reconsidered by the GB); 3) ISTC #3702 CHESS-2; and 4) STCU #4207 CHERNOBYL SHELTER. M.Hugon mentioned that, if the status of EXPULS cannot be changed from [3] to [2], CHESS-2 and CHERNOBYL SHELTER should be submitted via J. Sanders to the GB. The new STCU project proposal from V.Krasnov (topic #31) should be considered in the future although the chemical composition of the examined Chernobyl corium is not prototypic for Western type NPPs, whereas the proposal STCU #3511 (topic #33) is out-of scope of the CEG-SAM activities.

It was decided to prepare a new ranking of the ISTC/STCU project proposals after the GB meeting in April 2008.

The big problem concerning the “export control” by ROSATOM was once more briefly discussed. Theoretical activities will be more easily approved than experimental ones. M.Hugon will contact J.Sanders in this matter and propose that JRC-ITU will become recipient of the results of projects (for example METCOR-P), which are subject of “export control” permissions.

L.Tocheny proposed to prepare a joint paper that could be presented at an international conference. S.Bechta and M.Veshchunov are considered to write a summary paper on ISTC related projects. He recommended that Russian and Ukrainian scientists should participate in training courses for young scientists within SARNET. Financial support for Russian participants will be given by ISTC.

**Topic #36:** Detailed discussion of presented ISTC & STCU project proposals and preparation of specific CEG-SAM advices

See topic #35 and list of actions (Annex #3).

**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 KFKI/AEKI 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. Updated final agenda of the 13th CEG-SAM meeting
2. List of participants at the 13th CEG-SAM meeting
3. Specific action list (appended below)

Annex #3:

**Specific Action List**

13th CEG-SAM meeting; Budapest, Hungary, March 5-7, 2008

**Action 13/1:** L.Tocheny (ISTC) will contact all managers of on-going ISTC projects to inform them that they should provide information (name and e-mail address) to A. Miassoedov (FZK) and K.Trambauer (GRS) to be included in the CEG-SAM website users list. After that they will have full access permissions for their projects web-pages and will be exclusively responsible for updating the project documentation/deliverables and the upload of presentations from project progress meetings.

**Action 13/2:** L.Tocheny (ISTC) will initiate working meeting (or/and phone/e-mail conferences) of the # 3635 Project Manager (PM) and the project EU collaborators (CEA-Saclay, JRC-ITU, FZK, FZR, RIT). The goals are: to get information on current status and further perspective of the project implementation and to agree possible actions and corrections (if any) of the project Work Plan accordingly to available budget. The CEG SAM members will be informed on the results of the meeting. L.Tocheny (ISTC) will ask the US and Japanese foreign collaborators to contribute to the funding of ISTC project # 3635, which is underfunded due to increase of costs in the Russian Federation. The manager of this project is looking for additional financial means in Russia.

**Action 13/3:** S.Güntay (PSI) will define together with the other foreign collaborators of the ISTC project #3690 a test scenario for the planned test PARAMETER-SF4 by August 2008 at the latest.

**Action 13/4:** Ch.Journeau (CEA) will send to A. Kondrashenko (VNIIEF) his presentation concerning the composition of the concrete that should be examined in the frame of the ISTC project #3831 (MCCI, first phase).

**Action 13/5:** M.Hugon (EC) should inform J.Sanders that the CEG-SAM members have a strong interest in the ISTC project #3609 (EXPULS). In order to consider this project by the ISTC GB once more its status should be changed from [3] (accepted without funding) to[2] (submitted to parties for board decision).

**Action 13/6:** The recommendations of Advice A-17 on ISTC project #3609 (EXPULS) should be taken into account by its manager, Dr. Migrov.

**Action 13/7:** A.Miassoedov (FZK), D.Bottomley (JRC-ITU) and Ch.Journeau (CEA) will prepare a joint advice for the planned ISTC project THOMAS.

**Action 13/8:** B.Clement (IRSN) and D. Bottomley (JRC-ITU) will prepare an advice for the ISTC project VERONIKA.

**Action 13/9:** M.Hugon (EC) will investigate the possibility for the EC to authorize one of the JRC's institutes to become recipient of the results of ISTC project # 3592 (METCOR-P) to overcome the problem of export license control.