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

## NON PROLIFERATION THROUGH SCIENCE AND CO-OPERATION

**CONTACT EXPERT GROUP**

**on**

**SEVERE ACCIDENT MANAGEMENT**

**(CEG-SAM)**

**MINUTES OF THE 11th MEETING**

**Dresden, Germany**

**Forschungszentrum Dresden-Rossendorf (FZD)**

**Institute of Safety Research**

**March 7-9, 2007**

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

|  |
| --- |
|  |

Final minutes, September 11, 2007 CEG-SAM / M-11

|  |
| --- |
| Subject: 11th Meeting of the ISTC “Contact Expert Group on Severe Accident Management” (CEG-SAM)Place: Forschungszentrum Dresden-Rossendorf, Dresden, GermanyDate: March 7-9, 2007Participants: 35 participants of 21 organizations from 7 countries: Mr. E.Altstadt FZD, Dresden-Rossendorf Mr. G.Azarian AREVA NP, Paris Mr. D.Bottomley EC, DG JRC / ITU, Karlsruhe Mr. G.Cenerino IRSN, Fontenay aux Roses Mr. B.Clement IRSN, Cadarache Mr. G. Ducros CEA, Cadarache Mr. Y. Dutheillet EdF, Clamart 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. Ch. Journeau CEA/DTN, Cadarache Mr. M. Koch RUB, Bochum Mr. M. Krause AECL, Chalk River, Canada Mr. A. Miassoedov FZK, Karlsruhe Mr. M.Nie AREVA NP, Erlangen Mr. J. Stuckert FZK, Karlsruhe Mr. K.Trambauer GRS, Garching Mr. W.Tromm FZK, Karlsruhe Mr. H.G.Willschütz FZD, Dresden-Rossendorf  Mr. S.Bechta RIT-NITI, Sosnovy Bor Mr. V.Bezlepkin SPAEP, St.Petersburg Mr. S. Bogatov RRC KI, Moscow Mr. V. Chudanov IBRAE, Moscow Mr. A. Goryachev RIIAR, FRD, Dimitrovgrad Mr. A.Kisselev IBRAE, DNS, Moscow Mr. V.Nalivaev NPO LUCH, Podolsk Mr. A.Palagin JRC / ITU, Karlsruhe Mr. V.Semishkin OKB GIDROPRESS, Podolsk Mr. V. Strizhov IBRAE, Moscow Mr. L. Tocheny ISTC, Moscow (**co-chairman**) Mr. M.Veshchunov IBRAE, Moscow Ms. T. Yudina IBRAE, Moscow Mr. V.Zhdanov IAE NNC, Kurchatov-City, RK Ms. V.Zhdanova IAE NNC, Kurchatov-City, RKDistribution list: Mr. J.M.Silva Rodríguez DG-RTD(Shortened version Mr. Z. Stancic DG-RTDof the minutes) Mr R. Burmanjer DG-RTD / D.3 Mr. J.Sanders DG-RTD / D.3 Mr. P. Fernández Ruiz DG-RTD / J Mr. A. Perez Sainz DG-RTD / J.1 Ms. I. Tome DG-RTD / J.1 Mr. S. Webster DG-RTD / J.2 Mr. R.Schenkel DG-JRC Mr. P. Frigola DG-JRC / 2 Mr. G. Sadler DG-JRC / 2 Intranet of Unit J.2 Mr. N. Jousten ISTC, Moscow Mr. W. Gudowski ISTC, Moscow EU CEG-SAM 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 11th CEG-SAM meeting was organised and hosted by the Institute of Safety Research of the Forschungszentrum (Research Centre) Dresden-Rossendorf in Rossendorf (FZD), Germany on March 7-9, 2007.

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

The chairman M.Hugon opened the meeting and welcomed the participants of the 11th meeting of the Contact Expert Group on Severe Accident Management (CEG-SAM) of the International Science and Technology Centre (ISTC) as well as the participants from Russia and Kazakhstan. He expressed his thanks to E.Altstadt and H.G.Willschütz from the Research Centre of Dresden-Rossendorf who kindly offered to organize and host the 11th CEG-SAM meeting in Dresden.

Of additional interest of the meeting participants was the visit of the research facilities ROCOM (Rossendorf Coolant Mixing Model) and TOPFLOW (Transient Two Phase Flow Test Facility) at the FZD in Rossendorf on March 7, 2007.

ROCOM is a 1:5 test facility for the investigation of coolant mixing in a wide range of flow conditions inside the pressure vessel of pressurized water reactors. ROCOM is equipped with four loops in which nearly any desired combination of flow rates in the single loops can be realized.

TOPFLOW is a multi purpose thermal fluid dynamic test facility to study the transient phenomena in gas-liquid flows in the power and chemical/physical process industry. The objectives are to improve the fluid dynamic modelling at nuclear and chemical plants, but also to enhance their safety and efficiency.

**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 11th CEG-SAM meeting. For the first time G.Cenerino from IRSN participated in the meeting and he was welcomed by M.Hugon and the group members.

L.Tocheny mentioned that the new Deputy Director of ISTC for Europe, W.Gudowski, will take care of the activities of the CEG-SAM. His predecessor, U.Meyer, changed to the German embassy.

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

M.Hugon mentioned that J.Sanders was not able to attend the meeting and for this reason he would take over topic #5 of the agenda. Additional general topics #6, #7, #8 and presentations topics #32 and #33 were added.

With these changes, the appended agenda (see Annex 1) was accepted.

**Topic #3:** Approval of the minutes of the previous 10th CEG-SAM meeting in Kurchatov-City, Republic of Kazakhstan, September 5 to 8, 2006.

The secretary took into account the comments received on the draft minutes by G.Ducros, S.Bechta and A.Vurim in the revised minutes dated November 30, 2006. The revised minutes were then approved by the CEG-SAM members without any additional changes at the CEG-SAM meeting in Dresden, March 7, 2007.

**Topic #4:** Discussion of the “Specific action list” of the 10th CEG-SAM meeting in Kuchatov-City, Republic of Kazakhstan

Action 10/1: General procedure for “Letters of Support” (LoS).

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

Actions 10/2: The general situation concerning the ISTC CEG-SAM webpage did not improve. The CD prepared by A. Miassoedov containing a mock-up of the updated CEG-SAM webpage, which was sent to L. Tocheny last spring, has still not been downloaded on the ISTC webpage by the ISTC Secretariat. M.Hugon will therefore discuss this matter with L.Tocheny in September in Brussels to find a satisfactory solution. If there is no satisfactory solution, K. Trambauer will investigate with SARNET the possibility to host the CEG-SAM website on the SARNET ACT. *Not yet done by ISTC; see topic #9.*

Action 10/3: D.Bottomley, A.Miassoedov and W.Tromm will prepare a short paper describing the tasks and scope of a possible Russian SAM coordinator by beginning of October, 2006. The description should be then sent to L.Tocheny for further consideration. *Action done by the three people on October 2007 but they received no response by L.Tocheny and M.Hugon. Therefore, the paper was not distributed to the CEG-SAM members but briefly explained at the meeting. A discussion took place on the neutrality of the Russian co-ordinator and who could take over this task. IBRAE is considered to have the experience to co-ordinate the severe accident research in Russia.*

Action 10/4: K.Trambauer will discuss within GRS its possible interest in an ISTC project proposal on RBMK reactors and severe accident analysis (in- and ex-vessel) by beginning of October 2006. *K.Trambauer could not find someone at GRS interested in this subject; action completed.*

Action 10/5: A.Miassoedov will contact the members of the CEG-SAM interested in the large-scale MCCI tests to define with them the test conditions and the chemical composition of the concrete by the end of September and send this information to V. Kondrashenko by beginning of October 2006. A.Miassoedov should then inform V. Kondrashenko and L.Tocheny that a Project Development Grant should be prepared and sent to ISTC Secretariat and P. Hofmann. *A.Miassoedov defined the composition of the concrete in co-operation with the interested CEG-SAM members. The data were sent to V. Kondrashenko but no response was received by him up to today. The SAROV institute should also prepare a proposal for a Project Development Grant; letters of support were sent by the collaborators to L.Tocheny but he had not been able to get in contact with V. Kondrashenko. If no advance is reported at the next CEG-SAM meeting in September 2007, then the action will be dropped. Thanks to a CEA-ROSATOM meeting in April 2007, it has been heard from Dr Kondrashenko that this delay was due to export control problem. The proposal for a Project Development Grant without UO2 is being processed to ISTC.*

Action 10/6: The collaborators (Ch. Journeau) of the ISTC project #2916 (CHESS) should prepare a joint e-mail requesting from A.Borovoi the promised data sets for phase 2 of the Chernobyl accident and the ISTC project proposal on the long term behaviour of Chernobyl lava. *The CHESS data set on Chernobyl had been received by Ch. Journeau.*

Action 10/7: M.Hugon will ask L.Tocheny if he received the promised data set on Chernobyl data (see action 10/6) on a CD from A. Borovoi. G.Ducros received an e-mail from A. Borovoi saying that the CD should be transmitted at the 10th CEG-SAM with the help of L.Tocheny. *Action successfully completed.*

Action 10/8: The collaborators of VERONIKA, who are CEG-SAM members, should discuss with T.Haste, the responsible EC-SARNET topical coordinator for SOURCE TERM issues, the test matrix so that it includes tests in steam in the first stage of the ISTC project proposal. After the discussion the new test matrix should be discussed with A.Goryachev (action of B.Clement) to prepare a revised VERONIKA project proposal. The revised proposal should be sent to ISTC and the secretary of CEG-SAM. *B. Clement reported that he had been in contact with A.Goryachev and that he had adopted the re-revised test matrix as a result of the discussions with SARNET.*

Action 10/9: K.Trambauer will inform G. Yadigaroglu (ETH) that there exists a possibility to conduct LOCA and SA in-pile tests in the IGR reactor with fresh fuel rod segments but probably not with pre-irradiated fuel rods. M. Hugon will discuss with F. Serres (CEA), the co-ordinator of the MTR+I3 project on material test reactors in FP6, the possibilities to link the IGR reactor to this project. *There exists no interest in experiments with only fresh fuel rods; tests with highly irradiated fuel rods are not possible. To link the IGR with the MTR+I3 project is not of interest for the MTR+I3 community.*

Action 10/10: K.Trambauer will interact with V.Nalivaev to propose needed modifications to perform the second bundle test in the frame of the ISTC project #3194 (PARAMETER test facility) and additional measurements (outflow of water, temperature measurements). *K.Trambauer had been in discussion with A.Kisselev and V.Nalivaev to adapt the PARAMETER test conditions so that more complete data sets could be achieved with improved instrumentations and measurements.*

Action 10/11: M.Hugon will contact the chairman of the CEG on transmutation regarding the presentation on “Risk assessment of thermal reactor with maximal reproduction of fissile material” and send him the paper. *Action not completed.*

Action 10/12: P.Hofmann will send the "Corium Melt Interaction with Reactor Vessel Steel" ISTC project proposal METCOR-P (# 3592) to J.M.Bonnet, the responsible EC-SARNET topical coordinator for CORIUM issues, for comments within two months. *Done, comments had been obtained.*

Action 10/13: D.Bottomley and W.Tromm will prepare an advice for the "Corium Melt Interaction with Reactor Vessel Steel" ISTC project proposal METCOR-P (# 3592) by the end of September, 2006. The proposal should be submitted for funding to the next ISTC GB meeting in December 2006. *This had been done and the proposal was approved at the last GB meeting.*

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

M.Hugon gave the report on the future of the ISTC on behalf of J. Sanders who was unable to come. It is expected that the ISTC funding will be constant for this year, but that from 2008 the funding will only be about 50 % (12.5 M€ /yr) and will probably slightly decrease in the years after that. The budget lines appear to have been completely changed. However Russian partners are permitted to participate directly in the FP7 programme and it is hoped to find some other means of collaboration with the Russians so that they can bring their own financing when participating in FP7.

He pointed out that the PLIM (Plant Life Management Group) contact expert group had just recently recommended an ISTC project proposal of reactor steel creep testing for severe accident conditions “Scale experimental investigation of the thermal and structural integrity of the VVER pressure vessel lower head in severe accidents” (ISTC #3635). This proposal is also relevant for the CEG-SAM. The CEG-PLIM had also proposed that the CEG-SAM should review the proposal but there was only time to circulate the copies at the meeting and discuss it briefly.

**Topic #6**: Relationship of ISTC and the Ukrainian STCU (Science and Technology Centre of Ukraine)

The relationship between the ISTC and STCU (Science and Technology Center of Ukraine) was described by L.Tocheny. He stated that it is possible to have parallel projects (with separate ISTC and STCU funding) and to hold joint ISTC/STCU project meetings. There have been instances of such arrangements for projects from the Transmutation, PLIM and Fusion CEG's. Thus, it would be no problem to have CHESS-2 and STCU Chernobyl project meetings.

**Topic #7**: Rosatom / Euratom Seminar on “Research and Training Programmes of Mutual Interest in Nuclear Fission” in Moscow, April 2007

M.Hugon mentioned that there would be a DG RTD Euratom/Rosatom seminar on “Research and training programmes of mutual interest in nuclear fission” in April 26 and 27, 2007, to encourage collaborations in certain topics (reactor safety, plant life extension management, fuel cycle development and advanced reactor systems, radiation protection). The seminar will take place over two days. Overall presentations of the respective Russian and Euratom Research Programmes will be given. At the end of the seminar, an action plan should be agreed, indicating practical ways for co-operation and leading to the selection of pilot examples for co-operation in the next years.

The goal of the seminar is to define technical areas where scientific or technological co-operation might be beneficial for both sides and select possible ways forward in terms of organization and financing of this co-operation.

**Topic #8**: Large-scale MCCI experiments

The CEG-SAM expressed its interest in large-scale MCCI experiments to study the radial versus the axial concrete ablation. The SAROV institute had been asked to prepare a proposal for a Project Development Grant (see topic #4 action 10/5).

**Topic #9**: Status of the official ISTC CEG-SAM webpage

A.Miassoedov developed a new structure for the ISTC CEG-SAM webpage where all documents (project proposal, advice, work plan, progress reports) are collected under the ISTC project number. But, the still existing problem is that A.Miassoedov has no direct access to the ISTC CEG-SAM webpage to deposit documents. For this reason the possibility of an other CEG-SAM webpage was considered and discussed.

GRS (Garching, Germany) has agreed to host the webpage within the SARNET portal. Therefore, A.Miassoedov transferred the data set to GRS. The CEG-SAM webpage structure will be similar to the SARNET portal. There will be a unique account for each user. It will have different read /write permissions for the different users. Russian project managers have full access, upload/modify permissions for their projects, and will be responsible for updating the project documentation. CEG-SAM members will have full access to minutes (restricted and open sessions) and 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 #10**: Report by the secretariat; update of the list of collaborators and new members

The secretariat briefly reported that Hungary and Slovakia are now members of the CEG's for Transmutation and Plant Life Management (PLIM). There may be some interest of the members of the EU to join the current CEG’s.

Korea wishes to be a collaborator for the METCOR-P project but it was not clear what they would contribute, since they are not funding this project.

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

B. Clément (IRSN) gave 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 Information exchange between SARNET and the CEG-SAM is very open and has been in evidence for the comments for the VERONIKA test matrix (which was revised twice) and the METCOR-P project. The severe accident research priorities (SARP) had been just revised and it is recognized that the ISTC projects can be very valuable in filling in the gaps in the knowledge. PARAMETER, VVER-QUENCH and large-scale MCCI facility are some examples of such valuable contributions. The fruitful co-operation between SARNET and the CEG-SAM should be integrated in a possible future co-ordination of the severe accident research in Russia. M.Hugon and L.Tocheny asked if a copy of the defined SARP priorities could be sent to the ISTC authorities in Moscow.

**Topic #12**: SARNET source term comments on the ISTC project proposal METCOR-P

D.Bottomley briefly reviewed the positive comments by SARNET to the METCOR–P project. The ISTC Governing Board has approved the project for funding in full in December 2006. The main objective of the project proposal METCOR-P is the NNP reactor safety enhancement in case of a severe accident with core degradation and meltdown. The specific subject of the project is the experimental study of physico-chemical phenomena occurring at the interaction between a molten corium pool and reactor vessel steel.

**Topic #13**: Preliminary discussion of new ISTC project proposals

The new ISTC project proposals will be presented under topics #27 to #33. There was no time to discuss the proposals in detail.

# Extended session

**Topic #14**: Welcome of the Russian colleagues; approval of the shortened minutes of the 10th CEG-SAM meeting in Kurchatov-City; adoption of the agenda

M.Hugon opened the extended session of the meeting and welcomed the Russian and Kazakh participants. He expressed once more his thanks to E.Altstadt for organising and hosting the 11th CEG-SAM meeting in Dresden-Rossendorf.

The shortened minutes of the 10th CEG-SAM meeting, distributed to the Russian participants in November 2006, were accepted without any changes. The agenda with the additional presentations (topics #32 and #33) was approved and adopted.

**Topic #15:** Welcome of the participants by the host of the meeting. Short overview on the main research activities at the “Research Centre Dresden-Rossendorf (FZD)”

E.Altstadt welcomed all members to the FZD. He then gave a presentation on the facilities at Rossendorf: As part of the Science Associations of Gottfried Leibnitz, FZD is also one of the Centers for Eastern Competence. It has 650 employees with a budget of 65 M€ in 2006. It is composed of six institutes including Ion Beam Physics Material Research, Radiation Physics, Radio Pharmacy, Safety Research (E.Altstadt's Institute) and High Magnetic Field Research. Examples were given such as 1) nano clusters research in high packing density computer memory and 2) research into the uranium ore sites in Thüringen and Saxony. Moreover, the High Magnetic Field Laboratory had achieved the highest magnetic field so far and was intended to reach 100Tesla soon.

The Institute for Safety Research had the objective of assessment and improvement of reactor safety. Amongst others they have a 3-D core neutron model (DYN3D) that models the neutron kinetics and the thermal hydraulics in the core. They have a large experimental thermal-hydraulic facility (TOPFLOW) to provide data. They have also modeled scenarios concerning In-Vessel Retention (IVR) in support of the METCOR project.

**Topic #16:** Status of the information exchange and interaction between ISTC CEG-SAM and EC-SARNET

The interaction between EC-SARNET and CEG-SAM will bring mutual benefits and will further assure 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. Clément (IRSN) gave 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 Information exchange between SARNET and the CEG-SAM is very open and has been in evidence for the comments for the VERONIKA test matrix (which was revised twice) and the METCOR-P project. The severe accident research priorities (SARP) had been just revised and it is recognized that the ISTC projects can be very valuable in filling in the gaps in the knowledge. PARAMETER, VVER-QUENCH and Large-scale MCCI Facility are some examples of such valuable contributions. The fruitful co-operation between SARNET and the CEG-SAM should be integrated in a possible future co-ordination of the severe accident research in Russia.

For future review processes EC-SARNET recommended the CEG-SAM to send them the first drafts of ISTC project proposals to interact at earlier stage. The CEG-SAM considers the SARNET advice as a valuable input to prepare recommendations for project revisions to be discussed with the Russian or Kazakh project coordinators at the following CEG-SAM meeting.

The latest definitions of priorities of EC-SARNET in terms of R&D needs should be presented to the CEG-SAM members and Russian organisations. The list will be updated periodically within EC-SARNET. A feedback of the Russian and Kazakh scientists on the information exchange is desired.

**On-going project presentations**

**Topic #17:** Progress report on the ISTC project # 1648.2 “Examination of VVER fuel behaviour under severe accident conditions, Quench state” (VVER-QUENCH)

Part 1: A.Goryachev (RIIAR) presented the status of the project that consists of three stages. Stage A: Study of the irradiated fuel rod segment behaviour under re-flood conditions to determine the hydrogen generation and fission product release, stage B: conduct of one integral quench experiment with 31 VVER fuel element simulators, and stage C: development of models and codes to describe VVER core behaviour under severe accident re-flood conditions (quench stage) on the base of the results of stages A and B. The objectives are to obtain an extension of the available experimental data base for the irradiated fuel behaviour during re-flood and the modelling of the observed phenomena,

Altogether 18 quench tests with irradiated fuel rod simulators were planned at temperatures of 1400, 1600 and 1700oC under hot-cell conditions (cladding oxidation in steam). In addition, eleven tests with un-irradiated simulators were conducted to create a data set for comparison with the irradiated fuel rod simulator tests. Only five tests with irradiated fuel rods were performed up to now. However, at the fourth test the heater of the furnace failed which will result in a delay of the test series of about half a year.

The tests with irradiated fuel rod segments, re-fabricated from VVER fuel rods at burn-ups of 54 and 65 MWd/kgU, reveal some differences compared with the un-irradiated fuel rod simulator test results. The differences are: a) the enlarged hydrogen generation during the test and b) an intensive α-Zr(O) layer formation on the cladding inner surface due to tight fuel cladding contact that lead to the enhanced cladding embrittlement in comparison with the un-irradiated simulators tested under similar conditions. Typically, the irradiated rods show a hydrogen generation only at the final quench stage because of the existing thick oxide scale while the non-irradiated fuel rod segments oxidize during the first quench stage.

Part 2: M.Veshchunov (IBRAE) presented the development of models and codes to describe the material behaviour in the quench tests. The modeling of the oxidation by the SVECHA/QUENCH codes of IBRAE was then given: it had been necessary to make adaptations to the heat exchange and the cladding oxidation since the FZK bundle tests and the RIAR single rod test used different heating methods (resistance wire versus induction coil). The high temperature oxidation kinetics of non-irradiated Zr-1%Nb is similar to that of Zircaloy-4. One of the main differences is the breakaway oxidation at 900 to 1000°C.

The oxidation profiles of the rods were modeled but initial attempts underestimated the thickness. This was because there was probably no steam starvation in the transition phase as had been supposed. The network of through-wall cracking appearing in the thicker oxides is probably due to the ZrO2 tetragonal to monoclinic transition. However, the H2 generation predicted is too low; this could be due to discrepancies in the temperature or steam flow measurements. Fission product releases had been calculated by the MFPR code with good results for all irradiated tests.

The stage B Fuel Assembly tests were reported. These reached 2000-2200°C at 900-1050mm bundle height during the re-flood phase. Considerable spalled oxide was observed at the bottom of the bundle from both the shroud and the cladding materials. Neutron measurement showed considerable dissolved H2 in the inner, residual metallic Zircaloy cladding of the rods. Quench 12 produced 24g H2 - 6 times more H2 compared with Quench 6 (as standard test).

**Topic #18:** Progress report on the stage B of the ISTC project # 1648.2. First results of the integral re-flood test QUENCH-12 with a VVER bundle

J.Stuckert (FZK) presented results of the test QUENCH-12 which was successfully conducted at FZK in September 2007. The experiment investigated the effects of VVER materials and VVER bundle geometry under core re-flood conditions, in comparison with test QUENCH-06 (ISP-45) with Western type PWR geometry. While the PWR bundle simulator is made of a single unheated rod, 20 heated rods, and 4 corner rods arranged on a square lattice, the VVER bundle uses 13 unheated rods, 18 heated rods and 6 corner rods, arranged on a hexagonal lattice. The test was conducted under the same test conditions as QUENCH-06. This involved pre-oxidation at a temperature of about 1200 °C to a maximum oxide layer thickness of about 200 µm on the cladding, followed by a power ramp until a temperature of 1800 °C was reached, then re-flood with water at room temperature from the bottom was initiated. The electrical power was reduced to 4 kW during the re-flood phase, thus simulating the decay heat. During re-flood a shroud failure was detected while the heated and unheated rods failed simultaneously towards the end of the transient phase.

Preliminary results for hydrogen production are 34 g in the pre-oxidation and transient phases and about 24 g in the quench phase; the amount released in the quench phase is six times higher than in QUENCH-06. This may be attributed partly to the longer excursion time in QUENCH-12 and partly to an extensive damaging of the cladding surfaces.

**Topic #19:** Progress report on the ISTC project # 2936 “Modelling of reactor core behaviour under severe accident conditions. Melt formation, relocation and evolution of molten pool” (Reactor Core Melting)

Part 1 by M.Veshchunov (IBRAE): The main objective of the project is a detailed analysis of available and new experimental data, to update, improve and verify models on reactor core molten materials behaviour at consecutive stages of a severe accident from the early stage when melt formation and progression during core degradation occur (SVECHA/MELT code), to the late stage, when the core is completely degraded and a molten pool is formed in lower head of the PRV (CONV code), and to prepare them for benchmarking of simplified models and for implementation in the existing SA system codes.

In order to describe melt behaviour during initial stage of the SA, the following set of mechanistic models were revised and/or developed 1) model for simultaneous dissolution of UO2 and ZrO2 cladding shell by molten Zry; 2) model for breach formation in oxidised cladding; 3) model for release of U-Zr-O mixture from the cladding breach and a candling model for melt slumping in the form of droplets and rivulets; and 4) a model for oxidation of corium molten pool (MP). The models were thoroughly validated against available separate-effect tests and implemented in the single-rod code SVECHA/MELT (S/M).

The S/M code was applied to interpretation of observations of melt behaviour in various bundle tests (CORA, QUENCH, and PHEBUS FP) and used for further validation of the newly developed models. Some important conclusions concerning molten pool oxidation and relocation (slug) were deduced. The Phebus FPT1 bundle has been analysed and it suggests that the corium pool formed in a metallic state and then later oxidized.

Part 2 by V.Chudanov (IBRAE): The final stage is the 3D thermal hydraulic modeling of the molten corium pool. In order to describe the melt behaviour the code CONV was developed including the heat generation/distribution and convection. Heat generating fluids, which generate temperature stratification, were modeled as were fluid without internal heat sources. The latter were validated with the LIVE test results where it is bottom-heated. The final stage will be to include modeling with crust formation and with turbulent mixing (high Rayleigh numbers) with a Large Eddy Simulation (LES) approach.

**Topic #20**: Experimental results of complex starting-up and adjustment actions on preparation of the PARAMETER-SF2 Experiment. Status of Project # 3194 “Fuel Assembly Tests under Severe Accident Conditions, PARAMETER facility”

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

The first test PARAMETER-SF1 was conducted on April 2006 and the results were presented at the last CEG-SAM meeting. The second test PARAMETER-SF2 with bottom and top flooding will be conducted on March 2007.

For the performance of the experiment PARAMETER-SF2 a new test section has been fabricated in FSUE SRI SIA “Luch”. In the design of the new test section some unexpected effects have been eliminated that were revealed in the detailed analysis of the PARAMETER- SF1 experiment: 1) the possibility of bypassing of steam and water in the top flooding test; 2) the loss of the thermal insulation integrity under thermal expansion and thermal shock conditions; and 3) the uncontrolled condensation of steam in the lower part of the test section.

**Topic #21**: Computational assessment (pre- or post-test) of fuel assembly tests in frame of the project # 3194

A.Kisselev (IBRAE) presented the completed post-test computational assessment of the experiment PARAMETER-SF1. The assessment should evaluate the reliability and self-consistency of the results of the PARAMETER-SF1 experiment as well as the effect of uncertainties of parameters and variation of the facility itself (heat conduction of thermo-insulation, coolant bypassing the assembly, cladding temperatures reached at the elevation with incomplete indications of thermocouples, etc.) on the results of calculations by the computer codes RATEG/SVECHA and ICARE/CATHARE. The results of the numerical modeling confirm the self-consistency of the PARAMETER-SF1 measured data and the fact that this data represent valuable information for severe accident computer codes verification.

For the experiment PARAMETER-SF2 new nodalization schemes have been developed to perform pre-test calculations with the computer codes RATEG/SVECHA, RELAP/SCDAPSIM and ICARE2. Based on the new schemes a few assessment calculations have been performed in order to define the PARAMETER-SF2 test conditions (electric power, flow rate of coolant, gas, quench water injection and so on).

**Topic #22**: Progress report on the ISTC project #1950.2 “Phase diagrams for multi-component systems containing corium and products of its interaction with NPP materials” (CORPHAD-2)

The project CORPHAD-2 had a duration of 50 months and finished last November 2006.The project concentrated on the determination of key sections of the phase diagrams of major corium systems. It progressed systematically from binary to ternary, to quarternay and finally to a complex corium prototypical for an accident. Tie lines and concentration curves of solidus and liquidus temperatures in the various systems were determined by visual examination, high-temperature microscopy thermo-gravimetry, differential thermal analysis, and differential scanning calorimetry. Typical results were the finding that the miscibility gap in the UO2-SiO2 is bigger than was thought and also the considerable influence of the pO2 on the SiO2-Fe2O3/Fe3O4 system was demonstrated. The U-Zr-O system was investigated and compared with other collaborator's work. Joint publications have been made and the data has been put in the NUCLEA database of IRSN, France The collaborators are interested in a further project to clarify other poorly characterised systems in this field.

Concerning the further ISTC project proposal: **CORPHAD-P (now called PRECOS),** which was described in detail at the last CEG-SAM meeting, S.Bechta mentioned that it will be sent to ROSATOM for export control and government support in May 2007. The proposal is expected to be sent to ISTC and to have the number in advance to the next CEG SAM.

**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 once more briefly the objective of the in-vessel corium retention experiments (INVECOR), e.g. the improvement of the safety assessment of LWR corium in-vessel retention (IVR) and the modelling of the thermal and physico-chemical processes of the prototypical corium pool and its retention in the water-cooled RPV lower head. This project is looking at the 3-D behaviour of the molten corium in the reactor vessel. This will use results from the METCOR project to examine conditions where vessel wall failure is most likely to occur. In order to stay within budget, considerable changes to the experimental facility have had to be made, as well as doing preparatory work in their small-scale facility. They have examined the performance of porous graphite (25%) as opposed to dense graphite (<10%); the dense graphite has substantially better resistance for the electrode's operation in the melt. Various designs of the Plasmatron (heating electrodes for the corium) have been tested and their performance checked during the lifetime (gradually, the electrode tip is less effective in heating). Three experiments on Zr-coating application on available crucibles made from GMZ graphite are performed in large-scale facility.

The Zirconium coating technique has been tested and has shown deep penetration of molten Zirconium into the graphite wall of high porosity graphite but reliable results for a crucible of dense graphite.

A system of reactor vessel insulation has been fabricated and checked to achieve the necessary temperature of 1230°C on the inside to ensure tests will reach the conditions of RPV failure and optimize the results from the test series. The tests have shown that the application of thermal insulation made from glass fiber thickness of 0,25 mm on the external surface of RPV allows a temperature on the cooled surface of the steel wall of approximately 380°С to be achieved. The increase of temperature up to about 650°C is possible via application of thicker glass fibers or using multilayer thermal insulation.

**Topic #24:** Progress report on the ISTC project #2916 “Nuclear fuel behaviour during the Chernobyl accident (CHESS-1)”: Part 1: Input data and general approaches to modeling;

Part 2: Current abilities of modeling and the results obtained

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

S.Bogatov (RRC KI) presented the first part of the project: Creation of a data base on origin and penetration of lava-like fuel containing materials in Unit-4 of the Chernobyl NPP after the accident. The acquisition and analysis of information on fuel and Zirconium in the metal that had been melted during active phase of the accident and the adaptation of initial data for modelling of the accident.

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

The database is to enable the codes to predict the lava formation, flow and distribution; it will be sent to collaborators in electronic or (if required) in paper form. The lava is very inhomogeneous. The neutron “spike” in 1990 after heavy rain was probably the result of water seeping down to a zone of high concentration Uranium (black and brown lava is 4wt% and 8wt% U, respectively, but zones of up to 30-40wt% U would be necessary to cause such re-criticality). However, there is sufficient fuel in the reactor for this to be possible. The lava-like fuel containing material (LFCM) contains in addition to U and Zr in ceramic form, small metallic particles: these are mostly constructional materials (Fe, Cr, Ni).

V.Strizhov (NSI RAS) presented part 2 of the project. The modelling of the lava spreading and lava interaction with concrete has been described. This includes erosion/decomposition depth of the concrete during the spread for both horizontal and vertical directions (and wall breach criterion). They use transition and decomposition temperatures. Parametric dependences were obtained to define lava spreading time for thin lava layer at different initial temperature and experimental values of viscosity. They also model the viscosity of the FCM over the solidus/liquidus temperature range and above allowing for the heat generation. Examples were given for the modelled lava flows to some of the major FCM masses in the rooms under the reactor. Typically, the concrete degradation depth could reach 0.8m.and the biggest masses could be up to 2.5m thick. One mass is estimated to have an average concentration of 16wt% U. In this case, the degradation could have lasted for days. The model agrees with most of the values deduced from the sampling from the outer lava masses. The raw sample data also has been assessed. Unfortunately, no samples have been retrieved from the interior of the reactor.

The time of cooling of 0.5m thick layer of the melt down to 1300K, at which the process of spreading virtually terminates, makes up about 20 hours. Crust of a rather large thickness (0.1m) is generated during 5 to 6 hours. For a 0.5m-thick layer the depth of concrete de-structuring is 10–15cm. For 1m thick layer and 4% of U the depth of erosion was about 0.1m. The concrete de-structuring was 0.3– 0.4m. These data are in a good qualitative agreement with the observed values.

Fission products are distributed according to the fuel distribution and its concentration is very low in metallic melts.

RRC KI and IBRAE agreed to hold a topical meeting in the summer 2007 to present these results in detail.

**Topic #25:** Status of the ISTC project #3345 “Ex-vessel source term analysis” (EVAN), phase 1

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

As the initial step of work, the earlier LWR severe accident calculations for VVER-640 and VVER-1000 were analyzed. The parameter ranges within the reactor plant and containment, core melt parameters, fission product aerosol characteristics, surface boundary conditions at structures and equipment, chemical content of containment sump solution were recovered as result of this review. The test specifications for Tasks 2, 4, and 6 were identified using these data.

The analysis of the existing models for fission products release from core melt was made; the recommendations for choosing a calculating model were formulated. The mechanisms of the behavior of fission products in core melt of VVER type reactor were considered. The mathematical method of fission products release from core melt was proposed.

Experimental conditions and test procedure for study of low-volatile FPs such as Ba, Sr, La, Ce; platinum group element (Ru) and Mo during corium melt oxidation transient have been proposed for EVAN-FP1 test. Modifications of induction furnace for corium melt preparation, of gas/aerosol system for oxidant supply and aerosol collection have been prepared. Results of pretest calculation confirmed efficiency of technical solutions and provided necessary data for preliminary design of installation.

Runs of pre-test calculations the FP aerosol transport was simulated inside experimental tube (task 5). The gas pressure and velocity, the boundary temperatures on the surface of wall, on entrance and exit of tube, tube position were specified. The one group of the FP includes the partially volatile elements at the reactor temperature. Another group of FP includes elements with rather low volatility at the temperature up to fuel melting point.

As control parameters, the following ones were chosen: distribution of the aerosol concentration on the basis of dimensional groups; the mass concentration of each FP class in different conditions; the FP class mass leaving the tube. Pre-test calculations were conducted for two regimes of gas flow inside the tube for the purpose of gas dynamic simulation. The air movement was varied from free to mixed convection. The boundary heat condition was varied.

Autoclave for research of iodine water/gas partition are prepared (task 6). They have available active equipment for determination of inorganic and organic volatile radioiodine species and intend to correlate the iodine trapping efficiency with various sorbents and filtering materials. Pretest calculations goal – volatile iodine forms (I2, I) concentration in gas phase will be determinated in experimental conditions taking into account the iodine forms adsorption on ferric hydroxide (or oxide) in aqueous phase. The experimental conditions are taken from test matrix on Task 6. The calculations have shown rate of influence of iodide-ion concentrations in water solutions and pH on adsorption of iodine on ferric hydroxide.

**Topic #26:** Main results of the finished ISTC project #833.2. “Study of corium melt interaction with NPP reactor vessel steel” (METCOR-2) and status of the ISTC project #3592 (METCOR-P)

The work carried out within the ISTC METCOR-2 project is aimed at studying physico-chemical phenomena taking place during the interaction of molten corium with reactor vessel steel in the case of in-vessel melt retention (IVR).

The ISTC #833.2 METCOR-2 project has been completed in the 2nd quarter of 2006. Final report has been issued in the 3rd quarter of 2006. In the frame of this project steel interaction with UO2-ZrO2 and UO2-ZrO2-Zr-(SS) corium in the neutral atmosphere; also with UO2+x-ZrO2 and UO2+x-ZrO2-FeOy melt in steam has been examined at different temperatures of the steel specimen surface. Experimental data on steel corrosion kinetics and final depth have been produced. Correlations for corrosion calculation have been proposed. The presentation contains a short review of the main experimental results of the project. This project looked at interactions in air atmospheres in part1 while in part 2 it looked at interactions in steam and Ar. The behaviour was monitored using a camera and a pyrometer. The vessel steel interaction was examined and analysed electron-optically. The rate of corrosion was dependent on the Fe diffusion through the oxide layer towards the melt (and dependent on the melt oxidation state). The diffusion of U and Zr towards the steel then created a U-Zr-Fe oxide that had a low temperature eutectic. Teut was determined to be about 1090°C by DTA. Once this liquid phase formed, then the corrosion accelerated.

Further experimentation of the more reactive sub-oxidised melt chemistry with tests of dual metallic/oxidic corium was proposed for ISTC #3592 METCOR-P project, which had just been accepted for funding. The contract agreement between NITI and ISTC is expected to be signed in May 2007.

This will look at three specific situations: 1) the interaction kinetics in a vertical orientation of the interaction interface, 2) the effect of changeover from reducing to oxidizing conditions in the corium, 3) a test using a West European vessel steel.

**New project proposals**

**Topic #27:** SARNET and CEG-SAM comments on the draft ISTC proposal VERONIKA

B.Clément (IRSN) presented the SARNET Source Term (ST) comments on the draft ISTC project proposal VERONIKA. The Source Term group provided comments in May 2006 on the initial VERONIKA proposal concerning fission product release from VVER fuel at high temperatures. One concern of the ST group was that the series should include some with an air atmosphere, which would be relevant to Ruthenium studies being performed in Work Package 14. In response to this the Russian colleagues provided a revised proposal in which tests involving an air atmosphere replaced those with steam. At the CEG-SAM meeting in September 2006 it was felt that this revised matrix went too far in the direction of an air atmosphere, so that some tests with steam should be re-introduced to improve the balance of the proposal. Detailed comments and recommendations were given on the test matrix, the temperatures, the atmospheres as well as pre- and post-test examinations. Finally a revised test matrix was proposed to be discussed at the 11th CEG-SAM meeting. The CEG-SAM was invited to consider these comments, and in particular the revisions to the test matrices to cover the conditions of temperature, oxidising potential, and presence or absence of cladding, in its discussions leading to the production of the final VERONIKA proposal to ISTC.

**Topic #28:** Study of fission product release and behaviour of VVER fuel with high burn-up under severe accident conditions (VERONIKA). Discussion of the revised test matrix

A.Goryachev (RIIAR) presented the revised 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 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.

In the revised test matrix, the SARNET recommendations were taken into account. To meet the comments by SARNET some changes and improvements were and will be additionally made in the proposal regarding experiments to be conducted in air, the fuel characterization and the cladding oxidation, and the re-irradiation history. The revised test matrix is divided into halves with each 10 tests taking 36 months (777400$) and 30 months (494000$) respectively. The 20cm long samples will be re-fabricated from the fuel rods (including its genuine cladding) before re-irradiation. The re-irradiation will be with a centerline temperature of 800°C and a cladding temperature of about 80°C to avoid loss of the volatile fission product inventory and will have maximum of 30 days cooling time. Samples will be either cladded fuel segments or bare fuel pellets. The de-cladding will use an induction furnace to cause ballooning away and rupturing of the cladding and then the pellets (or pellet pieces) can be collected. The samples size is limited by the capacity of the iodine filters in the RIAR Dimitrovgrad Hot Cells. The original test matrix did not include air atmosphere; after two revisions, it had a better balance of atmospheres. The test will take about 1 month/test and 18 months for a whole programme of 10 tests. The testing will include full pre-test and post-test examination of the samples. One important aim is for the bare fuel to provide fission product release data to validate the MFPR mechanistic diffusion code being developed at IBRAE.

**Topic #29:** Study of fuel assemblies under severe accident top quenching conditions in the PARAMETER-SF test series. (PARAMETER-SF3 and -SF4 experiments, ISTC project proposal #3690)

V.Nalivaev (LUCH) presented the project proposal of additional quench tests with 19 rod fuel assemblies. The scope of activities within 24 months includes the preparation and conduct of two ex-reactor experiments (PARAMETER-SF test series) in the PARAMETER test facility in FSUE SRI SIA “LUCH”. The planned tests with WWER-1000 type fuel rod simulators under combined top and bottom quenching conditions expected from the ECCS (emergency core cooling system) will be a continuation of the experiments PARAMETER-SF1 and SF2 performed in the frame of the ISTC project #3194. This would particularly look at the central blockage and the degradation mechanism of the bundle. The tests PARAMETER-SF3 with 18 heated rods and -SF4 with 16 heated rods would be carried out with quenching from 1874K and 2074K, respectively, after a pre-oxidation phase at 770 -1470K. The proposal would include the post-test examination of both tests and would start by post-test examination of SF2 to refine the test procedure.

Some CEG-SAM members were surprised that the post-test examination of PARAMETER-SF2 was not included in the existing PARAMETER programme. In reply to EdF's question, the post-test examination of SF2 was worth approximately 100k€. The total cost was 600k$.

**Topic #30:** ISTC proposal on “Long-term behaviour of corium after the accident (using the data of the Chernobyl NPP accident)”; CHESS-2, ISTC #3702

This project proposal, presented by S.Bogatov (RRC KI), would run in parallel with the Ukrainian STCU project #4207 on “Long-term prognosis of transformation of the fuel containing materials (FCM) in the Chernobyl shelter”.

The objective of the ISTC project proposal #3702 is to develop a model of the long-term behavior of “lava” under the “Shelter” conditions (10 days to 100 years taking account of works on the “Shelter” transformation compared to CHESS-1: 0.5h to 10h) and to issue general recommendations on increasing safety of corium storage and removal. The main tasks of the project are as follows: Task 1: Acquisition of the data on main macro - and micro-properties of Chernobyl “lavas”. Task 2: Study of external and internal factors influencing on long-term conditions for different types of “lava”. Task 3: Analysis of direct experimental studies of the long-term behaviour of different types of “lava”. Task 4: Existing analogues of Chernobyl “lava” and results of their variations for long-term storage. Task 5: Model of the long-term behaviour of corium. The cost would be 345k$ for a duration of 30 months.

S.Bogotov presented also the STCU project proposal #4207 on behalf of Prof. Kashparov of the Institute of Safety Problems in Kiev on “Long-term behaviour of the Chernobyl hot particles (HPs)”. Objective of second project is a more detailed description of the forms of fuel containing materials (FCM) in the Sarcophagus that is radioactive dust. 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 Shelter conditions. The aim is to create a model predicting the long-term behaviour of the radioactive dust in the shelter, its transformation and the processes of dust formation from FCM types in the Shelter (here it overlaps with the ISTC project which will deal with larger lumps of FCM).

Main tasks of the project are as follows: Task 1: Study of the mechanisms of formation of the Chernobyl hot particles (HP) and their classification according to their physical and chemical characteristics. Update of the database. Task 2: Study of the characteristics and behaviour of radioactive aerosols and water in the shelter. Task 3: Experimental study of the fuel particles destruction rate and its dependence on the matrix characteristics (oxidation degree of uranium) and media properties. Task 4: Creation of model of the fuel particles transformation under shelter conditions. Task 5: The long-term prognosis of the Shelter radioactive dust behaviour based on the results and data obtained by Kurchatov Institute in Russia and the fate of the Shelter FCM during the transformation of shelter into an ecologically safe system.

The combined aim of the two projects is to create a model to describe the formation of dust from all sources both larger masses and finer particles. This will enable proper risk assessment especially for any work inside the shelter involving disassembly or removal of material. The project will be 30 months long and will cost 300k$. It is intended that the STCU and the ISTC projects should run in parallel and will have joint meetings where possible.

**Topic #31**: Thermo hydraulics of U-Zr-O molten pool under oxidising conditions in multi-scale approach (crucible - bundle - reactor scales)

M.Veshchunov presented this project proposal. This project intends to extend upon the ISTC project #2936 “Reactor Core Modelling”, in which an effort was done for development of a numerical physico-chemical model for U-Zr-O melt oxidation. Being developed on the base of the crucible tests, the new model was extended to a larger scale and allowed quantitative interpretation of observations of CORA, QUENCH and Phebus tests.

However, the main deficiency of the SVECHA approach was oversimplification of the thermal hydraulic description of the convectively stirred melt. Similarly to modelling of crucible tests, in this approach the main thermal hydraulic characteristics of the convectively stirred melt were taken into consideration using simple correlations for the mass transfer coefficients at the oxide/melt interface.

On the other hand, within the same ISTC Project #2936, the 3D unified thermal hydraulic technique for multi-dimensional simulation of multiphase processes in complex domains of convectively stirred melt were strongly advanced in the CONV code. Initially designed in the frameworks of RASPLAV and MASCA Projects, the code was further developed and validated in the ISTC Project using experimental data, including experiments with a heat generating fluid such as LIVE, COPO, SIMECO.

M.Veshchunov presented this project proposal. This project intends to extend upon the ISTC project #2936 “Reactor Core Modelling”. It will particularly concentrate on the thermo hydraulic modelling of the corium pool using the 3D CFD thermo hydraulic code CONV, with the aim of improved interpretation of the Phebus FP tests. This will also use the CORA tests and the small-scale melt tests (Zr dissolution of UO2 crucibles) done at FZK.

The SVECHA code can describe the heat transfer and crust formation in the pool on the basis of the small tests but it is oversimplified and should be extended to cover other conditions. Stirring and convection in the pools is not considered. Convection is already advanced in CONV thus a coupling of these codes would enable this to be modelling. Further modelling could broaden its capabilities to include the lower head geometry and chemical interactions with structural materials (Fe) and density effects. They would also examine (as in the MASCA & RASPLAV projects) the high temperature liquid properties of structural materials. Density measurements and surface tension measurements of selected coria (different oxidation states) could be performed. This data would be incorporated into the model to improve its accuracy.

In the new ISTC project it is proposed, in order to develop a mechanistic description of U-Zr-O molten pool behaviour in oxidising conditions, to carry out a tight coupling of the two advanced tools developed within the previous Project #2936: the SVECHA physico-chemical (molten pool oxidation) model and the 3D thermo-hydraulic code CONV. The project duration will be 36 months, the estimated total costs 200k$.

**Topic #32**: ISTC project proposal on “Study of Corium transient behaviour; Corium properties measurements”

V.Strizhov (IBRAE RAS) presented the project proposal. The objectives are to develop an accident management strategy at the stage of the melt pool formation in the lower head, to determine the boundary conditions for the success of the strategy and to study the material interactions and their influence on the success of the IVR concept. The RASPLAV/MASCA Project results provided new insights on the behavior of the corium and structural materials and their interactions and cover PWR, VVER, BWR, and CANDU parameters. The success of the long term in-vessel retention strategy depends on the corium oxidation degree and amount of steel in the lower head.

The understanding of the melt pool transient behavior is one of the issues determining the success of the in-vessel retention strategy: the stability of layered configuration, the debris behavior and the formation of a melt pool, the extension of the material properties database as well as molten ZrO2 and corium properties. The goal of the project is to study formation and behavior of the debris in the reactor pressure vessel.

**Topic #33**: Proposal on continuation of ISTC #1648.2 VVER QUENCH; (J.Stuckert-FZK, A.Goryachev,RIAR)

There was also a discussion to extend this proposal to do quenching with re-irradiated fuel. G. Ducros stated that this was an interesting project for CEA for the FP release during re-flooding and potential formation of fuel debris. However one should also try to measure some of the short–lived isotopes such as Xe-133. K.Trambauer noted that FP release under quench conditions is a priority for SARNET. A further remark was that the current VVER QUENCH needed more results (only 5/18 tests) before the problem could be properly discussed. L.Tocheny again mentioned that the SARNET list of research priorities (SARP) would be very helpful to the Russian and Kazakh collaborators in order to guide their proposals.

**Topic #34**: Next CEG-SAM meeting in St. Petersburg, September 2007

V.Bezlepkin (SPAEP) and S.Bechta (RIT-NITI) offered to host the 12th CEG-SAM meeting in St.Petersburg, September 11-13, 2007. Passport data must be sent at least 2.5 months earlier to ensure visas and access to SPAEP.

M.Hugon thanked once more E.Altstadt (FZD) for the organisation of the 11th CEG-SAM meeting and the participants for their engagement.

The following project progress meetings for #1648.2 (VVER QUENCH), #2936 (Reactor Core Modelling), #3194 (PARAMETER), #3345 (EVAN) are proposed for 3 days in the 1st week in July in Moscow (2-6th July '07). This brought the open session to a close.

**Restricted session** (continued)

**Topic #35:** Detailed discussion of presented ISTC project proposals and preparation of specific CEG-SAM advices

Due to a lack of time no discussion of the various ISTC project proposals by the Russian scientists was possible. Therefore a ranking of the proposals was executed by the CEG-SAM members. The averaged ranking was:

1. CORPHAD-P;

2. VERONIKA and Large scale MCCI;

4. CHESS-2;

5. PARAMETER;

6. Structural integrity of vessel under creep in severe accidents (ISTC proposal #3635).

As the project proposal #3635 had not been examined by the CEG-SAM, it was requested that the members look at the proposal and give their opinion.

Because of the lack of time, it was proposed that the CEG-SAM meetings should last 2 and half days in the future.

**Topic #36**: Discussion of various actions

See specific action list (Annex #3).

**Topic #37:** Other matters

No specific comments.

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

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

**Annexes:**

1. Revised final agenda of the 11th CEG-SAM meeting
2. List of participants at the CEG-SAM meeting
3. Specific action list (appended below)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Annex #3:

**Specific Action List**: 11th CEG-SAM meeting; Dresden, Germany, March 7-9, 2007

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

Action 11/2: E.Altstadt and S.Güntay will write the CEG-SAM opinion on the ISTC project proposal #3635, while Ch.Journeau will send it to SARNET WP10.2 for an official advice. **Deadline:** **March 23, 2007**.

Action 11/3: Y.Dutheillet and K.Trambauer will write the draft opinion on the PARAMETER project proposal (# 3690).

Action 11/4: L.Tocheny will contact Sarov to investigate the status of the grant on MCCI.

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

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

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

L.Tocheny put together some documents that describe the practical steps preparing a LoS and the role of the collaborators (see attached file “Various documents concerning the role of foreign ISTC collaborators…..”).

Action 11/7: GRS will host the CEG-SAM web page (see Topic #9).

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

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_