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

## NON PROLIFERATION THROUGH SCIENCE AND CO-OPERATION

**CONTACT EXPERT GROUP on**

**SEVERE ACCIDENT MANAGEMENT**

**(CEG-SAM)**

**MINUTES OF THE 7th MEETING**

**Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)**

**Cologne, Germany**

**February 28 – March 1, 2005**

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

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Revised minutes, April 24, 2005 CEG-SAM / M-07

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| Subject: Seventh Meeting of the ISTC  “Contact Expert Group on Severe Accident Management” (CEG-SAM)  Place: Gesellschaft für Anlagen- und Reaktorsicherheit (GRS)  Date: February 28 – March 1, 2005  Participants: 35 participants of 21 organizations from 6 countries:  Mr. B.Adroguer IRSN, Cadarache  Mr. H.J.Allelein GRS, Cologne  Mr. E.Altstadt FZR, Rossendorf  Mr. G.Azarian Framatom ANP SAS, Paris  Mr. J.Birchley PSI, Villigen, Switzerland  Mr. D.Bottomley DG-JRC / ITU, Karlsruhe  Mr. P.Hofmann Consultant, Karlsruhe (**secretary**)  Mr. M.Hugon DG-RTD / J4, Brussels (**chairman**)  Mr. Ch.Journeau CEA/NT, Cadarache  Mr. M.Koch RUB, Bochum  Mr. M.Krause AECL, Chalk River, Canada  Mr. S.Marguet EdF, Clamart  Mr. F.Oriolo Pisa University, Pisa  Mr. N.Reinke GRS, Cologne  Mrs. B.Rhode D6 RTD, Brussels  Mr. J.Stuckert FZK, Karlsruhe  Mr. W.Tromm FZK, Karlsruhe  Mr. S.Bechta RIT / NITI, Sosnovy Bor  Mr. V.Chudanov IBRAE, Moscow  Mr. A.Egorov RFNA, Minatom, Moscow  Mr. S.Gavrilov RRC KI, Moscow  Mr. A.Goryachev RIAR, FRD, Dimitrovgrad  Mr. A.Kisselev IBRAE, DNS, Moscow  Mr. V.Nalivaev LUCH, Podolsk  Mr. N.Parshin LUCH, SIA, Podolsk  Mr. V.Semishkin Gidropress, Podolsk  Mr. L.Tocheny ISTC, Moscow (**co-chairman**)  Mr. Yu.Vassiliev NNC, Kurchatov, R. Kazakhstan  Mr. M.Veshchunov IBRAE, Moscow  Mr. V.Zhdanov NNC, Kurchatov, R. Kazakhstan  Distribution list: Mr. A.Mitsos DG-RTD  (Shortened version Mr. Z. Stancic DG-RTD  of the minutes) Mr. A. Siegler DG-RTD / N  Mrs. B.Rhode DG-RTD / N.3  Mr. L. Samaniego Moffre DG-RTD / N.3  Mr. P.Fernández Ruiz DG-RTD / J  Mr. M.Poireau DG-RTD / J.1  Mr. V. Bhatnagar DG-RTD / J.4  Mr. R.Schenkel DG-JRC  Mr. P. Frigola DG-JRC / 2  Intranet of Unit J.4  Mr. N. Jousten ISTC, Moscow  Mr. L.Tocheny ISTC, Moscow  EU CEG-SAM members  Contact person: Mr. M. Hugon Tel.: +32 2 296 5719 – DG-RTD / J.4 |

Agenda of the meeting see annex 1, list of participants see annex 2.

The 7th CEG-SAM Meeting was conducted after the SARNET (Severe Accident Research Network) meetings. Both meetings took place at GRS (Gesellschaft für Anlagen- und Reaktorsicherheit) in Cologne. Since CEG-SAM and SARNET cover the same technical field, e.g. research on severe nuclear reactor accidents, and all EU experts of the CEG-SAM belong to organizations/institutions members of SARNET, a strong interaction between the activities of both groups was envisaged (see topic #7).

The meeting is divided into open and restricted sessions. The restricted sessions are to discuss internal matters and the status of current ISTC projects. The open sessions are mainly for the presentations of new or revised ISTC project proposals by Russian scientists.

**Restricted session**

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

The chairman M.Hugon opened the first part of the restricted session and welcomed the participants of the 7th meeting of the International Science and Technology Centre (ISTC) – Contact Expert Group on Severe Accident Management (CEG-SAM). He expressed his thanks to H.J. Allelein from GRS to host the meeting. H.J. Allelein welcomed the members of the CEG-SAM on behalf of GRS.

For the first time M.Krause from AECL, foreign collaborator of the ISTC project #2916 (CHESS), participated in the meeting. It was regretted that Hee-Dong Kim from KAERI, foreign collaborator of the ISTC project #2936, was not able to attend the meeting.

**Topic #2:** Adoption of the agenda

The sequence of presentations in the extended session was slightly changed. The presentation under topic #14 by S.Marguet on flooding of a reactor from the top was added. One planned presentation by B.Rhode (EC) was cancelled. With these changes, the attached agenda (see annex 1) was accepted.

**Topic #3:** Approval of the minutes of the previous 6th CEG-CM meeting in Dimitrovgrad, Russia, September 14-17, 2004

The secretary took into account the various comments on the draft minutes received by the group members in the revised minutes, dated November 10, 2004. These were approved without changes at the meeting in Cologne.

**Topic #4:** Discussion of the “Specific action list” of the 6th CEG-SAM meeting in Dimitrovgrad

Action 6/1: L.Tocheny will ask A.Borovoi to prepare a work plan on the ISTC project # 2916 CHESS, which is then to be sent to the collaborators of the project for comments. Prof. A.Borovoi will eventually hold a seminar on this project at the Kurchatov Institute. *>L.Tocheny informed the CEG-SAM that the work plan of ISTC project #2916 on “Nuclear fuel behaviour during Chernobyl accident” was accepted by the ISTC Secretariat and started at February 1, 2005. AECL (Canada) will act as additional foreign collaborator. A.Borovoi will organize a kick-off meeting on CHESS in connection with the next CEG-SAM meeting at the Kurchatov Institute in Moscow, September 12 - 13, 2005.*

Action 6/2: A small working group composed of CEA, FZK and IRSN should collect more information and define the interest of the CEG-SAM on the project proposal “Development of methods for elimination of consequences of severe nuclear accidents”. *>The planned working group was not yet active since no information on the revised proposal was available. In a letter A.V.Kondrashenko (VNIIEF, Sarov) informed L.Tocheny on the current status of the project proposal #1974. The new project proposal is divided in three tasks. In the frame of the first task the experimental technology will be developed and experiments with small and large corium masses of several hundred kilograms are planned. The second task comprises experiments with large corium melt masses up to 1 ton. Within the third task a backup series of experiments could be executed in case the first and second tasks were not successful. The duration of each task (subproject) will be 18 months. For any further decision on the project proposal a detailed work program is needed by the end of April 2005 at the latest.*

Action 6/3: D.Bottomley to maintain contact with Dr. Leontiev at SPAEP. The revised EVAN proposal from Dr. Leontiev can be circulated to the working group (incl. H-J Allelein) and further comments by the working group should be incorporated. At a later stage -if necessary- a working visit by Dr. Leontiev and some experts from experiments to the working group partners can be made to finalise the work packages making up the proposal in preparation for presentation at a CEG meeting. *>The action has been fulfilled. Some days before the CEG-SAM meeting an expert group meeting took place in Cologne with three Russian EVAN scientists (the visit of the Russian experts was sponsored by the specific ISTC Travel Support Program). The work plan of the project proposal EVAN was revised and a modified version will be submitted. Details of the meeting of the working group with Yu.Leontiev (SPAEP) and his colleagues will be given by D.Bottomley under topic #12.*

Action 6/4: D.Bottomley to send memo to A. Lukianov requesting him to take contact with Kurchatov Institute & IBRAE in preparation for CHESS Phase 2 project so that IPPE can include the 3-D DINCOR modelling of the FCM melt flows in Phase 2. *>No decision was made since there was no feedback from A.Lukianov. Action still pending on DB*

Action 6/5: B.Adroguer to collect revised '“Determination of parameters of fission product release from VVER irradiated fuel under beyond design basis accident conditions” proposal from Dr. Lukianov incorporating the working groups' remarks. This can be circulated to the working group for final comment before presentation at a CEG meeting. *>Since there is a great interest of the group on this subject A.Lukianov was asked at the last CEG-SAM meeting to consider the request and recommendations of the group in a revised project proposal. But there was no feedback from him by the date of the 7th CEG-SAM meeting. There may be due to difficulties in organising the delivery of irradiated fuel from RIAR to IPPE. RIAR, expected partner of the IPPE project will also be contacted*

Action 6/6: A letter of support should be prepared by the working group on the project proposal on “Fuel assembly tests under severe accidents conditions” (PARAMETER facility) and should be sent to L.Tocheny. *>Action executed. Several organizations send a letter of support and/or a statement to act as collaborator to ISTC. The project proposal has been officially registered (#3194).*

Action 6/7: Ch.Journeau will prepare a short report after his visit of the test facilities in the Republic of Kazakhstan. *>The report was distributed to the group members and technical details are given by Ch.Journeau under topic #8.*

Action 6/8: A working group should formulate a letter of interest on the lower head and MCCI experiments and send it to L.Tocheny and collect major questions for Ch.Journeau to pose during the visit to the facilities in Kazakhstan. *>The project proposal of NNC on INVECOR will comprise only in-vessel corium retention experiments. No MCCI experiments are currently planned.*

Action 6/9: A working group, lead by H.-J.Allelein, will prepare a letter of support and elaborate –together with the Kurchatov Institute- a detailed work plan for the project proposal ASAC. *>Action still open since there is no new information available and there was no response from the Kurchatov Institute. B. Adroguer mentioned that the delay is mainly due to administrative problems at the level of Kurchatov InstituteI which have been solved recently. The project is maintained and will be submitted to the CEG-SAM at the next meeting.*

Action 6/10: L.Tocheny will contact Russian organisations involved in safety-related research on RBMK to stimulate them for ISTC project proposals. *>No progress has been made in this matter. L.Tocheny proposed that the CEG-SAM group should first define its interest. H.J.Allelein (GRS) is the responsible contact person in this matter.*

Action 6/11: The next CEG-SAM meeting should take place in connection with the 2nd EC-SARNET meeting in Cologne. It will be kindly organised by H.-J.Allelein (GRS). He will inform the CEG-SAM members on the possible dates of the next meeting as soon as the date of the SARNET meeting will be fixed. >Action executed.

**The group members expressed again their concern that most of the requested documents from ISTC regarding selected project proposals were not made available to them in sufficient time before the CEG-SAM meetings. A better organisation in this matter is highly desirable to establish a fruitful exchange of information and successful co-operation between ISTC and the CEG-SAM.**

**Topic #5**: Status and content list of the official ISTC CEG-SAM webpage

The password-protected website of the EG-SAM group within the official ISTC webpage has been setup by Alex Miassoedov (FZK) in co-operation with Olga Myznikova (ISTC) and is now operational providing an access to the CEG-SAM related documents. The website can be accessed at <http://ceg-sam.istc.ru> (the login and password was send to the group members by separate mail).

The CEG-SAM group thanked A.Miassoedov (FZK) and O.Myznikova (ISTC) for their work and proposed a few modifications of the website. The colour of the banner is such that the stored titles of the stored documents are nearly illegible and should therefore be changed. For the title where the progress reports are stored “Progress and final reports” should be written instead of “Project reports”. Further recommendations were to add the title of the project proposals and work programs to the listed numbers of the various documents. The list of advices should be added to the CEG-SAM website. It was also proposed to regroup all documentation by project (work plan, progress & final reports, etc.) to clarify the web page.

It was further decided that each project co-ordinator should also send their progress reports to L.Tocheny (ISTC) and A.Miassoedov (FZK) to be stored on the website.

**Topic #6**: Report by the secretariat; update of the list of collaborators

M.Hugon welcomed once more the new members of the CEG-SAM M.Krause from AECL Canada (foreign collaborator of ISTC project #2916, CHESS) and J.Birchley from PSI Switzerland.

L.Tocheny proposed to create a “Nuclear technology coordination program” to coordinate the ISTC projects on SAM which were submitted to the ISTC Governing Board since 2002. The objectives of the program are to optimise the management of on-going and future ISTC projects in the field of nuclear technology, to avoid duplication of work through coordination of the work plans and technical programs with foreign collaborators. The CEG-SAM considers the proposal of such an ISTC coordination program as very interesting since a closer research co-operation with Russian organisations in the SAM area would be formalised, which would lead to a better interaction with SARNET. L.Tocheny will give further information at the next CEG meeting.

**Topic #7**: Possible information exchange and interaction between ISTC CEG-SAM and SARNET activities

J.C.Micaelli (IRSN) and M.Hugon (EC) prepared a paper on “Possible interaction of SARNET and CEG-SAM activities” that was sent to the group members before the meeting for comments. The background, objectives, and consequences and feedback of the planned interaction between both independent organisations were presented by B.Adroguer (IRSN).

SARNET and CEG-SAM cover the same technical field: research on nuclear reactor severe accident management and have consistent objectives and activities in terms of project recommendations, definition of R&D priorities and dissemination of knowledge. All EU experts of CEG-SAM belong to organisation members of SARNET. SARNET activities are co-sponsored by the EC and most of ISTC projects (monitored by CEG-SAM) are financed by EC. The planned interaction will guarantee the coherence between CEG-SAM and SARNET activities.

The main aspects of the proposal are that CEG-SAM and SARNET keep unchanged their respective objectives and structure. ISTC project proposals will be transmitted to SARNET topical coordinators in charge of the concerned research field for additional expertise. Concerned SARNET topical coordinators will then organise a consultation among SARNET members and prepare a technical advice for the CEG-SAM to be considered as input to prepare its recommendations for ISTC. SARNET will propose nomination of its members to become foreign collaborators to the ISTC projects it recommends for funding to the CEG-SAM. When a project funded by ISTC is considered of interest by the SARNET consortium, the experimental results of the project will be integrated in DATANET (SARNET database network) and used for the development of knowledge, e.g. interpretation and modelling tasks.

After the presentation of B.Adroguer and additional comments by M.Hugon an extended discussion took place. The following recommendations were made: 1) for each ISTC project one responsible person should be nominated that will establish contact with SARNET topical coordinator of the considered research area, 2) the intellectual property rights have to be clarified, for example for the SARNET ASTEC code system, 3) the access to information on SARNET projects for foreign collaborators such as Canada and Korea has to be defined; in the case of Canada, there exists the EURATOM-Canada co-operation agreement.

Ms B.Rhode, Head of Unit on Multilateral Cooperation Activities in DG RTD of the EC, proposed that Ukrainian teams financed through STCU (Science and Technology Centre of Ukraine) should be incorporated in the planned cooperation and activities.

The revised paper of J.C.Micaelli and M.Hugon was adopted at the 7th CEG-SAM meeting. It will be presented for approval at the next Governing Board meeting of SARNET on 18 March 2005 in Paris. The final version will be added as an annex to the CEG-SAM guidelines.

*Note from the Secretariat:* The SARNET Governing Board approved the document entitled “Possible interaction of SARNET and CEG-SAM activities” at its meeting on 18 March 2005.

**Topic #8**: Report on the “Evaluation of the capabilities of the LAVA-B facility in Kazakhstan (INVECOR)

Ch.Journeau (CEA) visited various “Corium” facilities at the National Nuclear Centre (NNC) of the Republic of Kazakhstan to explore possibilities of conducting large-scale melt experiments with corium mixtures. In a short travel report, which was sent to the CEG-SAM group members before the meeting, he described the LAVA-B facility and its possible use for high-temperature corium melt experiments. The corium facility has been developed and used within several severe accident programs. Altogether 44 large-scale tests have been conducted successfully at temperatures up to 3200K. The corium melts consisted of mixtures of UO2-ZrO2 and UO2-ZrO2-Zr with masses up to 60kg.

The LAVA-B facility is located in a containment, which can be pressurized up to 40 bars. The melt is contained in a graphite crucible which is inductively heated. The graphite crucible causes some compatibility problems with the molten corium, especially in the case where the melt contains metallic Zr. For this reason NNC developed various coating techniques to reduce the chemical interactions between the graphite crucible and the corium melt.

The test facility is of interest to conduct in-vessel melt retention experiments. A Japanese-sponsored program was performed in which the test section (lower head model of a RPV) was made of stainless steel (304L). Some of the mock-up had a penetration in the lower part of the vessel head. Sustained heating is provided by a set of graphite electrodes which are inserted into the melt. Also in this case an appropriate coating of the electrodes has to be developed to prevent a contamination of the corium melt with carbon.

NNC will prepare an ISTC proposal to conduct three in-vessel melt retention (IVR) experiments (INVECOR); see topic #20. The expected results are new experimental data on the final structure of the corium pool and the ablation of the lower head for various melt compositions (C30, C70, C30+steel) and thermal loadings. The tests with real corium would supplement the LIVE program at FZK with corium simulate materials. MCCI experiments would be possible but are currently not planned.

**Topic #9**: Preliminary discussion/checking of individual ISTC project proposals: EVAN, DINCOR, PARAMETER, ASAC, and INVECOR

Comments on the revised ISTC proposal on “Ex-vessel source term analysis” (EVAN):

The ISTC project proposal “Ex-vessel Source Term Analysis” includes theoretical and experimental research of the physico-chemical processes affecting the late phase fission product release into the PWR containment atmosphere. This stage is characterised by corium relocation outside the reactor pressure vessel connected with fission product release into the containment atmosphere and thus made available for possible release to the environment.

The initial EVAN project proposal presented at the last CEG-SAM meetings contained a long list of research topics, including experiments. However, concerning the experiments iodine chemistry and fission product release from molten pools and aerosol behaviour in primary circuit the information was too limited. Additional information was needed on these experimental possibilities to evaluate their interest to the CEG-SAM. The opinion has been that only a small number of selected well-defined tests on fission product release and source term should be performed.

A revised project proposal was prepared by Yu.Leontiev (Design and Research Institute of St.Petersburg, SPAEP) which was discussed in a specific expert group meeting with specialists of the EU in Cologne on February 16, 2005, which took place in parallel to the SARNET meeting. The outcome and recommendations of this meeting will be presented by D.Bottomley (JRC-ITU) under topic #12.

Comments on the proposal “3-D calculation codes for two-fluid flow” (DINCOR):

The CEG-SAM requested more information on a possible use of the DINCOR code (3-D modelling) for describing the corium melts behaviour in the frame of the CHESS project phase 2. Up to now the CEG-SAM received no further information.

Comments on the proposal “Fuel assembly tests under severe accident conditions” (PARAMETER):

The project proposal and work plan were revised. A letter of support was sent to ISTC. See action 6/6. An extension of the test matrix from two to three bundle tests was discussed. The decision was to perform two bundle tests in a first phase and possibly a third bundle test in a second phase.

Comments on the proposal “Adaptation of severe accident ICARE/CATHARE and ASTEC codes to VVER” (ASAC):

No further information is available; see action 6/9.

Comments on the proposal INVECOR:

See topic #8. See also topic #20, the presentation by V.Zhdanov.

# Extended session

**Topic #10**: Welcome of the Russian colleagues; discussion of the shortened minutes of the 6th CEG-SAM meeting in Dimitrovgrad; adoption of the agenda

M.Hugon opened the extended session of the meeting and welcomed the Russian participants. The change in the sequence of presentations was discussed and accepted. The shortened minutes of the 6th CEG-SAM meeting, distributed to the Russian participants, were accepted without any changes.

13 Russian scientists attended the 7th CEG-SAM meeting. 6 of them gave presentations on the status of ongoing ISTC projects, project proposals or ideas, which could be considered as candidates for future project proposals, or other type of research works related to the technical scope of the CEG-SAM group.

**Topic #11:** Status of the possible information exchange and interaction between ISTC CEG-CEG-SAM and SARNET. Future scope and activities of the ISTC CEG-SAM

M.Hugon presented a short summary of the paper entitled “Possible interaction of SARNET and CEG-SAM activities” and the subsequent discussion and small changes recommended by the CEG-SAM (see Topic # 7). There were no specific comments on this topic by the Russian participants. The final text will be sent also to the Russian participants together with the shortened minutes.

The revised paper was adopted at the 7th CEG-SAM meeting. It will be presented for approval at the next Governing Board meeting of SARNET on 18 March 2005 in Paris. The final version will be added as an annex to the CEG-SAM guidelines.

*Note from the Secretariat:* The SARNET Governing Board approved the document entitled “Possible interaction of SARNET and CEG-SAM activities” at its meeting on 18 March 2005.

Concerning severe accident management (SAM), SARNET activities are co-sponsored by the EC and most of ISTC projects (monitored by CEG-SAM) are financed by EC. Therefore, an integration will bring mutual benefits and the interaction between SARNET and CEG-SAM would further assure a critical mass of expertise for ISTC proposals addressing specific issues in the SAM area. Furthermore, a closer research co-operation with Russian organisations in the SAM area would be formalised. The possibilities of success in this co-operation would be higher if an equivalent Russian programme on SAM is launched by ISTC.

Results of SARNET related to the priority definition in terms of R&D needs will be periodically presented to the CEG-SAM members and Russian organisations. This list should be prioritized and updated continuously within SARNET

L.Tocheny mentioned that ISTC is developing a coordination program on “Severe Nuclear Accident Management”. The objectives are to i) optimise management of on-going ISTC projects in the field of nuclear technology, avoiding duplication through timely coordination of the work plans and current technical programs with foreign collaborators, ii) to direct the efforts of the project participants toward further sustainability and commercialisation of the project results, and iii) to provide coordination of the ISTC projects with relevant international and national nuclear programs and to avoid overlapping.

**Topic #12:** Current status of the revised “Ex-vessel source term analysis” (EVAN) project proposal

D.Bottomley (JRC-ITU) summarised the outcome of the expert group meeting in Cologne that was necessary to review the various experimental and modelling matrices in order to prioritise and finalise the initial test matrix for submission to the ISTC. The EVAN proposal consists of 4 tasks: 1) Analysis of reference accident sequences, 2) Experiments on fission product release from corium molten pool, 3) Aerosol transport processes in the primary circuit equipment: experimental testing and numerical modelling, and 4) Containment parameters & their impact on volatile iodine species behaviour.

Two project options were discussed; the preferred result was to have a “two-phase approach” rather than a “parallel approach”. The two phase approach would have a first initial testing phase of 1 year. In the first phase equipment is setup and initial testing and analysis performed, followed by a review of the results. This would provide input to the second phase. In the second phase, there would be a more detailed testing of the priorities selected in phase 1. It was also advised to make phase 2 of two years duration and to revise the overall budget for three years (instead of two years as previously). It was also strongly recommended to split task 1 into two parts as follows: 1.1) Analysis of earlier results of severe accident scenario calculations (boundary conditions), and 1.2) Modelling and analytical support of experiments (tasks 2, 3, and 4). VTT & CEA now also wished to become collaborators in addition to GRS, IRSN & ITU.

**Topic #13:** Revised ISTC project proposal # 3194 on “Fuel assembly tests under severe accident conditions” (PARAMETER Facility)

A.Kisselev (IBRAE) presented the revised proposal of V.Nalivaev (LUCH) on fuel element bundle tests in the PARAMETER facility, located at the LUCH factory in Podolsk. Details of the facility and test conditions were described in the minutes of the 6th CEG-SAM meeting (topic #20). The revised work plan contains 2 out-of-pile tests with 19 rod fuel assemblies of VVER type reactor (Zr+1%Nb cladding; UO2 pellets). In the first test the experiment will be terminated by quenching of the overheated bundle from the top with a low flooding rate. In the second test top and bottom flooding with high water injection rates will be applied. The test results will provide new data for the development and/or verification of physico-chemical models for implementation into code systems predicting the behaviour of VVER fuel elements under severe accident conditions.

Some collaborators of the project (EdF, FZK, and IRSN) will prepare an advice for the ISTC Governing Board, which will meet on April 11, 2005.

Considering that no European codes are going to be used in this project, an extended discussion took place on which SA code system should be used for the pre- and post-test calculations. The conclusion was that for the pre-test calculations the leading institutions (LUCH, IBRAE, GIDROPRESS) can use their own code systems, partially of Russian origin. For the post-test calculations primarily European code systems such as ASTEC, ATHLET and ICARE/CATHARE should be used in the framework of SARNET. But, post-test calculations are not part of the ISTC project proposal.

**Topic #14**: EdF participation in Corium topics; Top quenching in PWRs

S.Marguet (EdF) presented a short paper concerning top quenching of an overheated reactor core. Most experimental and numerical investigations are mainly related to bottom quenching. Little is known about top quenching, which is probably not the most efficient way to cool down the core but this phenomenon has a high probability to arise in reactor quenching during a severe reactor accident. For this reason the development of a generic top quenching model is needed to be implemented in code systems as for example in ASTEC. Some recommendations were given concerning flooding rates to be applied in the experiment.

**Topic #15:** Presentation of the work plan of the project # 2916 “Analysis of fuel-containing mass (FCM) behaviour during the active phase of the Chernobyl accident / Chernobyl lessons” (CHESS)

L.Gavrilov (RRC KI) described briefly the tasks of the project and presented the work plan. The objective of the project is to fit energy (heat), chemical and mechanical models that would be able to describe correctly the processes that resulted in the damaged Chernobyl NPP (4th unit) during the active phase of the accident. There exist several models and scenarios to describe the accident, but all of them have the disadvantage that they do not agree with the final state of the damaged reactor.

The work plan of the ISTC project #2916 consists of 5 tasks. Task1: Collection, verification and analysis of initial data on nuclear fuel behaviour, formation and spread of corium at various stages of the active phase of the accident and the nuclear fuel status immediately before the accident. Task 2: Creation of a data base for modelling the accident scenario. Task 3: Determination of the uranium and zirconium concentrations in metallic melts in the compartments below the reactor. Experimental investigations on uranium and zirconium concentrations and where possible also the carbon content of the molten relocated materials. Task 4: Application of the existing code systems to describe the accident and the relocated fuel containing masses. Task 5: Preparation of the final report of the project.

The kick-off meeting of this project is planned in connection with the next CEG-SAM meeting in Moscow in September 2005.

**Topic #16:** Progress report on the project # 833.2 “Investigation of corium melt interaction with NPP reactor vessel steel” (METCOR-2)

S.Bechta (RIT-NITI) described the progress of the project since the last meeting in Dimitrovgrad. The main task was the conduct of the experiment MC 9. The objective of MC 9 was to study the interaction of a sub-oxidised corium melt (C 30 + steel) with steel of a reactor pressure vessel (RPV). The maximum melt temperature was about 2600°C. The outcome of the test was a very rapid inversion of the stainless steel and corium melts after steel introduction into the molten corium which resulted (after a short incubation period of 10 minutes) in interactions of the metallic Fe-U-Zr-O melt with the RPV steel specimen. The final ablation depth of the RPV steel was reached after 12h at 1080°C. This compared with a long incubation period of 2-5 hours for an oxidic melt.

Future experiments will consider RPV steel ablation at temperatures which cause melting of the steel surface. In addition the influence of sulphur, chrome and manganese content of the steel specimen and the presence of boron in the melt on the steel ablation will be examined.

**Topic #17:** Progress report on the project #1950.2 “Phase diagrams for multi-component systems containing corium and products of its interaction with NPP materials” (CORPHAD-2)

The CORPHAD-2 project focuses on experimental studies of phase diagrams of corium/NPP material mixtures to obtain information on liquidus and solidus temperatures, on temperature-concentration regions of miscibility gaps and on solubility limits. The reactor application of the results is used based on the thermodynamic NUCLEA database optimisation. Applications are expected regarding corium behaviour modelling.

S.Bechta (RIT-NITI) reported on studies of the UO2-ZrO2-FeO and Zr-Fe-O systems. The objectives were to specify the ternary eutectic temperature and composition under inert conditions and to determine the solubility of components in the formed solid solutions for the UO2-ZrO2-FeO system and the liquidus temperature and miscibility gap for the systems Zr-Fe-O and U-Fe-O.

He mentioned a close collaboration with foreign collaborators (IRSN and FRAMATOME-ANP-GmbH) who contributed to the definition of the various mixture compositions for experiments as well as to the use of results in NUCLEA.

**Topic #18:** Work plan and status on the project # 1648.2 “Examination of VVER fuel behaviour under severe accident conditions, Quench state”

A.Goryachev from RIAR Dimitrovgrad described the different stages and tasks of the project, including the test procedures. Stage A comprises the study of spent fuel rod segments under reflood conditions to determine the hydrogen generation and fission product release. Stage B covers the conduct of one integral quench experiment with fuel element simulators that consist of 18 electrically heated and 13 unheated fuel rods. Stage C contains the development of a quench model, which can be used in code systems to predict the VVER core behaviour during reflood conditions.

The current status is as follows: the installation for the single rod test facility in a hot cell at RIAR is completed. First tests with pre-oxidized un-irradiated specimens have been conducted which have shown that the axial temperature distribution of the irradiated fuel rod specimens has to be improved, probably by better insulation of the furnace tube.

Concerning the bundle quench experiment the various components have been prepared by RIAR and are ready for transportation to Karlsruhe (FZK) as soon as the necessary official papers to export the materials are available. The VVER 1000 bundle quench test with 31 fuel rod simulators will be conducted in the QUENCH facility at FZK, the currently planned date for the test is April 2006.

With respect to the modelling activities the following requirements to the SVECHA code models (mainly concerning the material properties) were elaborated in order to be able to describe VVER reactor fuel element behaviour under severe accident conditions. The preliminary stage of the adaptation of the models of high temperature oxidation and mechanical behaviour of VVER cladding tubes was performed. First results on adaptation of models of high temperature cladding oxidation and mechanical behaviour show a rather good agreement of calculated and experimental parameters

**Topic #19:** Work plan and status on the ISTC project # 2936 “Modelling of reactor core behaviour under severe accident conditions. Melt formation, relocation and evolution of molten pool”

M.Veshchunov (IBRAE) presented the objectives, work plan and status of the project #2936. On the basis of detailed analysis of available experimental data to update, to improve and to verify models on reactor core molten materials behaviour at consecutive stages of a severe accident (melt formation, onset of melt relocation, molten pool formation in the lower RPV head) and to prepare them for benchmarking of simplified models and for implementation in existing severe accident system codes.

The work plan is divided in 8 tasks starting with modelling of melt formation and relocation up to a thermo-hydraulic model for the molten corium pool behaviour in the reactor pressure vessel including the crust formation. Results of the modelling activities on simultaneous dissolution of UO2 and ZrO2 by molten Zr, of a cladding oxide shell failure criteria, the release of the molten U-Zr-O mixture from the cladding breach and of a U-Zr-O molten pool oxidation model were presented. In addition the thermal-hydraulic model with a variable density was developed and implemented in the three-dimensional CONV code (the CONV code is under adaptation to the LIVE facility at FZK). Task 1 “Modelling of melt formation and relocation” and task 6 “Development of the 3-D CFD code and adaptation to the LIVE project” have been finished.

**Topic #20:** Experimental study of the processes of corium-melt retention in the reactor pressure vessel (INVECOR)

V.Zhdanov (NNC RK) presented the key questions of research at in-vessel stage of severe accidents: 1) Structure of a stratified molten pool and its time dependent variation. 2) Distribution of the melt components between liquid layers and between molten and solidified material. 3) Physico-chemical aspects and kinetics of the corium interactions with RPV material. 4) Thermal-hydrodynamics of molten pool, conditions of heat transfer both on internal and external RPV surfaces and between the stratified layers, including the crust presence between liquid layers and on boundary surfaces. 5) Stress-deformed condition of the RPV under simultaneous thermal, chemical and mechanical loadings. 6) the character of not 'outside cooled' RPV damage and the conditions for molten corium penetration into the reactor containment.

The objective of the IN-VEssel COrium Retention (INVECOR) experiments is the improvement of the safety assessment of LWR corium in-vessel retention (IVR) under severe accident conditions and the experimental modelling of the thermal and physico-chemical processes of the prototypical corium pool and its retention in the water-cooled RPV lower head. The project proposal is divided into 4 tasks. Task 1: Modernization of the available facilities and optimization of melting technology and simulation of decay heat, development of crucible surface protection technology including experiments on coating application for large-scale crucible tests. Task 2: Pre- and post-test calculations of the tests and development of a molten pool model. Task 3: Conduct of large-scale experiments with maintenance of the energy release into the molten pool. Task 4: Post-test analysis of the corium samples and the RPV steel. The main parameters of the various test facilities, including the accompanying small-scale tests, the instrumentation and the planned post-test examinations were described in detail. Experts from NITI, St. Petersburg will also be assisting in the project proposal.

The main results of the project proposal will be new experimental data on the final structure of corium pools, RPV lower head ablation for various corium melt compositions, and the thermal loadings on the RPV wall in a 2-D configuration with a real RPV lower head curvature.

The above experiments are of interest of the CEG-SAM group (see also topic #8). Therefore, an official ISTC project will be prepared by V.Zhdanov after the Kazakhstan ministry has approved the proposal. CEA, FZK, FZR, GRS and ITU are interested to act as collaborators for the project.

**Topic #21:** Overview of AECL’s reactor safety research program, Canada

M.Krause (AECL) presented a short overview of the reactor safety research program at Canada. AECL’s Reactor Safety R&D Objectives are to address generic safety issues for CANDU power plants, e.g. to improve plant operations and margins, improved safety analysis methodologies, technology to improve margins (e.g. fuel improvements), and development of simpler, less costly, more reliable safety systems. The various extensive research activities (programs), test facilities (thermo hydraulics, hydrogen combustion, containment behaviour, moderator, fuel channel) and developed safety analysis computer codes were described and the essential results presented.

In summary, AECL has the capabilities and facilities required to respond to emerging issues in the areas of reactor safety for CANDU nuclear power plants. The fundamental understanding gained through AECL’s Safety R&D program is used to develop and qualify computer programs used to license and operate CANDU reactors, to support directly licensing and operation, and to assess and mitigate the consequences of off-normal operation and fission product releases.

**Topic #22**: Next meeting

V.Nalivaev offered on behalf of “LUCH” to organize the next CEG-SAM meeting in Podolsk near Moscow. The planned date for the meeting is September 14 -16, 2005. In connection with the CEG-SAM meeting an ISTC meeting on the project “CHESS” is planned on September 12 and 13, 2005. A.Borovoi will organize the kick-off meeting on “CHESS”. It will take place at the Kurchatov Institute in Moscow.

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**V.Nalivaev pointed out that it is important for them to receive the list of participants and the preliminary agenda of the 8th CEG-SAM meeting at the latest by the beginning of June 2005 (at least 90 days before the meeting!).**

**Restricted session** (continued)

**Topic #23:** Detailed discussion of presented ISTC project proposals and preparation of CEG-SAM recommendations.

After the presentation of the various ISTC project proposals by the Russian scientists, the restricted session of the meeting continued with detailed discussion on the presented activities to elaborate recommendations and priorities of the proposals.

The joint paper of J.C.Micaelli and M.Hugon on the interaction between SARNET and CEG-SAM was once more briefly discussed and the changes in the text agreed. The further procedure is described under topic #7.

The CEG-SAM group members performed a critical judgement and ranking of the 3 ISTC project proposals EVAN, INVECOR and PARAMETER presented at the meeting. The outcome of the extended discussion on their scientific/technical merits was as follows: the proposal EVAN got the highest rating and was followed by the proposal PARAMETER and then by INVECOR.

However, only the ISTC proposal PARAMETER (#3194) has been officially registered, processed by the ISTC Secretariat and submitted to the parties for Board decision. The proposals EVAN and INVECOR have been submitted to the CEG-SAM, but have not yet been registered by the ISTC Secretariat. To be eligible for funding, a project must be registered and distributed to the Board 3 months before the meeting. For these reasons, the CEG-SAM will only prepare the recommendation for EU funding of the proposal PARAMETER to the ISTC Governing Board, which will meet on 9-11 April 2005.

The project proposal EVAN was already discussed several times in previous CEG-SAM meetings and in an expert group meeting and the initially extensive program was reduced to an appropriate level (see topics #8 and #9). A “two-phase approach” with a first initial testing phase of 1 year and a second phase of experimental and analytical investigations with a duration of 2 years was decided.

INVECOR was also considered as a valuable project proposal.

It is the intention of the CEG-SAM group to recommend for EU funding the EVAN and INVECOR project proposals in that order for the following meetings of the ISTC Governing Board, once they have been officially submitted and registered by the ISTC.

In the subsequent discussion, it was proposed to allocate the EU funding as follows: for PARAMETER 400k€ and for the first phase of EVAN 350k€ and for the second phase 450k€. For INVECOR, the budget estimate was not discussed.

It was recalled that the participation of AECL to the projects under preparation is depending on its funding contribution.

**Topic #24:** Other issues

W.Tromm (FZK) suggested inviting Zoltan Hozer from Hungary (AEKI) to become a member of the CEG-SAM. The group members agreed to this proposal (action # 7/7).

The chairman M.Hugon thanked once more GRS to host the meeting, the group members for their efficient work and contributions, and he reminded the members to fulfil on time the various actions decided during the meeting. He left and P. Hofmann closed afterwards the meeting.

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

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**Annexes:**

1. Revised final agenda of the 7th CEG-SAM meeting
2. List of participants
3. List of ISTC CEG-SAM related projects (updated March 2005)
4. Specific action list (see below)
5. Example of a letter of support from GRS (see action 7/1)

Annex #4:

**Specific Action List:** 7th CEG-SAM meeting, Cologne, February 28-March 1, 2005

Action 7/1: **For all CEG-SAM members.**

In future, the collaborators should send the letter of support and/or advice by airmail 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 and Mrs. Barbara Rhode (EC). See appended example of a letter of support from GRS.

**In the future, progress meetings of the new ISTC projects underway (#833.2, #1648.2, #2916 and #2936) should also take place. When the project proposal #3194 is accepted for funding by the ISTC Governing Board a project meeting should also be considered. The meetings should be organized by the Russian project leaders together with the foreign collaborators and should take place in connection with the fall meeting of the CEG-SAM in Russia. The outcome of the project progress meetings should be presented to the CEG-SAM.**

Action 7/2 (see topic #20): L.Tocheny will contact V.Zhdanov to prepare an official ISTC project proposal on INVECOR to be decided at the next CEG-SAM meeting. Possible MCCI tests should be included.

Action 7/3: L.Tocheny should contact Yu.Zvonarev (RRC KI) to prepare a revised work plan on the project proposal on ASAC (Adaptation of SA ICARE/CATHARE and ASTEC codes to VVER). A small working group, lead by H.J Allelein, will define its interest and send it to L.Tocheny.

Action 7/4: L.Tocheny will contact Russian organisations involved in safety-related research on RBMK (RRC KI, NIKIET) to stimulate them to propose an ISTC project. L.Tocheny proposed that the group should first define its interest to proceed in this matter. HJ Allelein stated he would make inquiries about this with the Berlin office of GRS.

Action 7/5: The electronic versions of available progress reports of ongoing ISTC projects should be send by the responsible EU collaborators to L.Tocheny and A.Miassoedov to include them in the ISTC CEG-SAM webpage.

Action 7/6: The recommendations of the CEG-SAM to the ISTC Governing Board for funding project proposals should be sent by the Secretary to the Chairman, who will forward them to B.Rhode, L.Samaniego and L.Tocheny.

The recommendation for the project proposal PARAMETER will be prepared by B.Adroguer and S.Marguet. (Done on 10 March 2005)

Action 7/7: The recommendations for EVAN will be prepared by H.J.Allelein and D.Bottomley and that for INVECOR by Ch. Journeaux and W.Tromm, once they have been officially registered at the ISTC Secretariat (done for INVECOR begin of April).

Action 7/8: M.Hugon will officially invite Zoltan Hozer, [Hozer@sunserv.kfki.hu](mailto:Hozer@sunserv.kfki.hu), (KFKI Atomic Energy Research Institute, AEKI, Hungary) to participate at the next CEG-SAM meeting in Podolsk and offer him membership of the group.

Action 7/9: L. Tocheny will contact VNIIEF, Sarov, concerning the follow-up of project proposal # 1974 on MCCI (see Action 6/2 of the 6th CEG-SAM meeting).