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

**CONTACT EXPERT GROUP on CORIUM MANAGEMENT**

**(CEG-CM)**

**MINUTES OF THE 2nd MEETING**

**Forschungszentrum Karlsruhe, Germany**

**October 1-2, 2002**

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

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January 2003 CEG-CM / M-02

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| Subject: Second Meeting of the ISTC  ‘Contact Expert Group on Corium Management’ (CEG-CM)  Place: Forschungszentrum Karlsruhe, Germany  Date: October 1-2, 2002  Participants: 23 participants of 17 organisations from 6 countries:  Mr. B.Adroguer IRSN, Cadarache  Mr. E.Altstadt FZR, Rossendorf  Mr. G.Azarian Framatome ANP, Paris  Mr. G.Cognet CEA/DEN/DSNI, Saclay  Mr. M.Fischer Framatome ANP, Erlangen  Mr. P.Hofmann Consultant, Karlsruhe (secretary)  Mr. O.Kymäläinen FORTUM, Vantaa  Mr. S.Marguet EDF, Clamart  Mr. A.Miassoedov FZK, Karlsruhe  Mr. F.Oriolo University, Pisa  Mr. J.Stuckert FZK, Karlsruhe  Mr. L.Tocheny ISTC, Moscow (co-chairman)  Mr. W.Tromm FZK, Karlsruhe  Mr. H.Unger RUB, Bochum  Mr. S.Bechta RIT / NITI, Sosnovy Bor  Mr. A.Goryachev SSC-RIAR, Dimitrovgrad  Mr. V.Khabensky RIT / NITI, Sosnovy Bor  Mr. V.Melikhov EREC, Moscow  Mr. S.Chouvalov VIR / FR, St.Petersburg  Mr. V.Smirnov SSC-RIAR, Dimitrovgrad  Mr. M.Veshchunov IBRAE, Moscow  Mr. P.Bottomley JRC / ITU  Mr. A.Zurita DG-Research / J.4 (chairman)  Distribution list: Mr. A.Mitsos DG-Research  Mr. P.Fernández Ruiz DG-Research / J  Mr. H.Forsström DG-Research / J.4  Mr. L.Bellemin DG-Research / 05  Mr. D.Gambier DG-Research / 05  Mr. D.Taylor DG-TREN / C.4  Mr. R.Schenkel DG-JRC  Intranet of Unit J.4  Mr. L.Tocheny ISTC, Moscow (co-chairman)  EU participants  Contact person: Mr. A.Zurita Tel. : 58365 – MO75, 5/30 |

Agenda of the meeting see annex 1.

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

The chairman A.Zurita opened the meeting and welcomed the participants of the 2nd meeting of the International Science and Technology Centre (ISTC) – Contact Expert Group on Corium Management (CEG-CM). For the first time, 7 Russian scientists attended the meeting to present their project proposals to the CEG-CM.

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

The topic #12 was cancelled since A.Borovoi from the Kurchatov Institute was not able to attend the meeting. The topic should be presented at the next meeting. Instead it was agreed that S.Bechta should present details of the ISTC project 1950.2 (CORPHAD). With these changes the agenda of the meeting was adopted.

**Topic #3:** Approval of the minutes of the 1st CEG-CM meeting

The statement in topic #2 (CEG-CM guidelines) in the minutes of the 1st meeting “The ISTC projects are financially covered by the TACIS budget” has to be clarified until the next meeting. It will be therefore cancelled in the minutes.

The remaining parts of the minutes were accepted without changes. Furthermore, an aspect completing the description of the scope of the group activities was agreed, and consequently the guidelines of CEG-CM will be accordingly updated.

**Topic #4:** CEG-CM membership

The chairman raised the question if the CEG-CM group would accept organisations of non-EU countries associated to the Euratom Framework Programme (Hungary, Czech Republic, Switzerland, etc.) as observers at their meetings*. There were no negative reactions from organisation members.*

The concern of ISTC (L. Tocheny) for non-EU organisations to attend CEG-CM meetings will possibly be intellectual property rights and the ownership of project results. All obtained information and documents are open to all EU member countries and financing parties but may be partially or fully restricted to other non-EU organisations.

After some discussion the chairman recommended to postpone any decision. He will discuss this subject within the EC and report on the outcome at the next meeting.

**Topic #5:** Report by the secretariat

One of the main tasks of the group is to elaborate advice and priorities ISTC project proposals for the ISTC Board delegates of the financing party EU. The co-chairman L.Tocheny was asked to provide a draft official ISTC document in which the important role of the CEG-CM will be clearly defined. This text will be used to prepare a constitutive CEG-CM document that could also be used in any descriptions of the EC activities. This would help the CEG-CM in its work if its activities were better known within the EC or the relevant scientific fields.

In this connection the chairman reported on the positive impact of the CEG-CM advice on the ISTC project #833.2 (Investigation of corium melt interaction with NPP reactor vessel steel - METCOR). The status of the project #833.2 was improved from 3 (approved without funding) to 5 (approved for funding). L.Tocheny (ISTC) confirmed the important influence of the group on the ISTC decision concerning the project #833.2.

Furthermore, the status of the project #2219 (Steam explosion in the Corium-water system) was passed from 1 (registered, processed by secretariat) to 2 (submitted to parties for board decision); see annex 2.

**Topic #6:** Preliminary discussion of individual project evaluation forms

# ISTC project #833.2: Investigation of corium melt interaction with NPP reactor vessel steel; METCOR

At the first meeting in Brussels (April 2002), this project was discussed as being a worthwhile proposal, which should be approved. During the meeting a major comment was that the OECD / MASCA project had given an unusual result in which a metallic layer that sits normally on top of a stratified corium pool had sunk to the bottom. This melt inversion had major consequences for in-vessel retention and thus this problem should be further investigated in that project.

D.Bottomley and W.Tromm revised the program together with S.Bechta and V.Khabensky to take into account among other things suboxidized metallic/oxidic coria and circulated this to the group members to collect and consider all comments before handing it to A.Zurita and the ISTC by early June 2002. D.Bottomley and W.Tromm are supporting the METCOR phase 2 project with its current work programme.

The opinion of some other group members was to organise a meeting (seminar) with the Russian colleagues to discuss details of equipment, specimen arrangement, instrumentation, test conduct and access to data base of the experiments. In this connection the role of foreign collaborators (see annex 3) and the distribution of data and reports was discussed. Non-EU partners of the OECD / MASCA project should not have access to the data.

# ISTC project #1648: Examination of VVER fuel behaviour under severe accident conditions, Quench stage

For the evaluation of the project proposal only the work plan was available for the CEG-CM members; the information on technical schedule, personnel commitments and estimated expenditures were distributed at the meeting.

The project proposal, which comprises 3 different stages, was modified in April 2002.

Stage 1: Spent ROD-QUENCH, stage 2: Fresh FA-QUENCH, stage 3: FA QUENCH Model.

Several questions came up, especially concerning project stage 1, which should be discussed with the Russian colleagues (see topic #10). The main concern have been some of the low-temperature (1200°C) tests for the quench initiation of the spent fuel rod segments since they may not result in the requested information for severe accident considerations. Of great importance are on-line measurements of the generated hydrogen and the released gaseous fission products during quenching. *It was suggested to add in the tests matrix, for comparison purposes, few tests with fresh fuel rod segments . Among other comments from partners, the main point was that too many tests are planned at low temperatures (1200°C°).*

The project #1648 has been also intensively discussed by European experts involved in the COLOSS and ENTHALPY projects and has been considered of strong interest. However, the tests should be mainly focused on processes with the largest uncertainties.

**ISTC project #2219:** Steam explosion in the corium-water system

For the evaluation of this project only a short summary has been available. Therefore only preliminary judgements on the expected scientific and technical merit were possible.

The following general recommendations are made to improve the project proposal: the experiments should be conducted with chemical corium compositions of interest but different to that which will be used in other national programs as TROI and KROTOS and the project #2219 should be complementary to those programs. Of great interest is the visualisation of melt dispersion by the mentioned X-ray impulse method*. More information has to be provided on this visualisation system.* A detailed work plan is needed.

**Topic #7:** National programmes

Short summaries on national programmes were presented by H.Unger, E.Altstadt and S.Marguet:

H.E. Unger gave a brief summary on the severe accident R&D-activities in Germany. Most of them are performed at the research centers Jülich (FZJ), Karlsruhe (FZK) and Rossendorf (FZR), the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) Köln, Becker Technologies (BT) Eschborn, Framatome ANP, Erlangen and several universities, e.g. Aachen, Bochum, Karlsruhe, Saarbrücken, Stuttgart (IKE and MPA) and more or less affiliated engineering and consulting institutions. Most of the research is sponsored or supported by the German government. The general aim of these in- and ex-vessel activities is an improved understanding and modelling of severe accident sequences in order to gain more knowledge and control about possible accidents with respect to their assessment and management, including fuel-coolant interactions. For in-vessel activities the thermo- and fluid-dynamic code system ATHLET-CD (Core Degradation) is being improved at the GRS and the IKE and validated by several institutions, CD standing for core heat-up, degradation, meltdown and debris bed formation modules. Investigations to avoid primary vessel failure even in cases of extended core melt formation, pressure and thermal shock attacks are performed at several institutions also. Ex-vessel activities are addressed to improve knowledge and evaluate possibilities for an effective management aiming at containment protection and source term retention in case of beyond base accident events. To support this, the comprehensive containment code system COCOSYS is being developed also at the GRS; for its validation the THAI-containment mock-up facility is operated at BT. The code and related activities cover items like convection, heat transfer, aerosols formation and behaviour, melt ejection and propagation, concrete interaction as well as melt control and retention. Hydrogen combustion, deflagration resp. detonation and controlled catalytic recombination are also R&D-activities; furthermore the assessment of transient pressure loads on the containment. The program is accompanied by Level 1 and Level 2 probabilistic safety analyses.

A workshop on such progress in severe accident reactor safety is planned by the Reactor Safety Division of the German Nuclear Society for October 2003 at the FZK.

E. Altstadt gave a brief overview about the Institute of Safety Research of the Forschungszentrum Rossendorf (FZR). The institute consists of the 5 departments Accident Analysis, Experimental Thermofluid Dynamics, Materials and Components Safety, Particle and Radiation Transport and Magneto Hydrodynamics. The main activity of the FZR in the field of severe accidents is modelling of in-vessel retention. This work is sponsored by the German Ministry of Economics (BMWi). The project title is "Modelling of in-vessel retention after relocation of corium into the lower plenum: evaluation of the temperature field and of the visco-plastic deformation of the vessel wall", which finally aims at the determination of the vessel failure time and of the failure mode. Outside corium management FZR is involved in the ISTC-project #1606 (Experimental study of molten salt technology for safe, low-waste and proliferation resistant treatment of radioactive waste and plutonium in accelerator-driven and critical systems) as collaborator.

S.Marguet mentioned that the primary tasks at EdF are studies on molten pool/reactor pressure vessel interactions, hydrogen generation during fast cooldown (quenching) of an overheated core by water injection and the thermochemistry of high burnup and Pu-containing fuel. With respect to code application reasonable confidence exists mainly concerning the prediction of the generated hydrogen during quenching.

**Topic #8:** Welcome of the Russian colleagues

A.Zurita opened the extended session of the meeting, welcomed the Russian participants and described briefly the objective of the meeting to present the ISTC project proposals #833.2, #1648 and #2219 to the group for detailed technical discussion.

**Topic #9:** Presentation, justification and discussion of ISTC project #833.2; METCOR

S.Bechta (RIT/NITI) presented the project “Corium interaction with NPP reactor vessel steel; phase 2” in detail. A handout was distributed in which the experimental approach to obtain the requested information on the physico-chemical phenomena of corium/steel interaction for long-term in-vessel conditions are described. The results of METCOR phase 1 showed that the key parameters affecting the vessel steel corrosion are the oxygen potential of the system, the steel surface temperature and the melt/steel heat flux density. METCOR phase 2 should mainly focus on steel interaction with suboxidised corium melts, with U-Zr-Fe metallic melts and influence of U and Zr partitioning and metal/oxide layers inversion on the interaction.

In the subsequent discussion the following specific points were considered: 1) The chemical composition of the corium melts, 2) crust formation between melt and steel crucible and its physico-chemical behaviour, 3) tests in air and/or under inert gas conditions, 4) surface temperature of steel, 5) test conduct, control of heating power, measurement techniques and measured data for code validation, 6) destructive post-test examination and specimen chacterization methods, and 7) test matrix and modelling efforts. Various recommendations were made by individual CEG-CM members.

The group has approved the modified work plan. In this regard, a meeting can be organized in conjunction with the celebration of the Eurocourse on Corium (Aix-en-Provence, January, 27-31, 2003) to discuss all these details once more with Russian experts.

In phase 2 of the project METCOR probably the same organisations will act as foreign collaborators as in phase 1 (FZK, FORTUM, JRC-ITU) *along with two new collaborators (CEA and FANP). IRSN could also be candidate, this proposal being to be confirmed soon.* The continuation of the University of Santa Barbara (USB) acting as collaborator in project #833.2 phase 2 will be clarified by L.Tocheny. According to distributed information on project collaborators, the latter may apply to the financing party for a partial or total transfer of IPR *(Intellectual Property Rights).*

**Topic #10:** Presentation, justification and discussion of ISTC project #1648

A.Goryachev (SCC/RIAR) presented the project “Examination of VVER fuel behaviour under severe accident conditions, Quench stage”. In the distributed handout the 3 different project tasks and their objectives are described.

Stage 1 “Spent ROD-QUENCH separate-effects tests”: evaluation of failure of pre-oxidised spent VVER fuel rod segments (50-60 MWd/kgU) during quenching, determination of hydrogen generation and gaseous fission product release and modification of the SVECHA code developed for “fresh” PWR fuel rods to describe the examined VVER materials.

Stage 2 “Fresh FUEL ASSEMBLY QUENCH”: Assessment of fast cooling (quenching) on VVER fuel element bundle degradation and hydrogen generation. The bundle test with 31 fuel rod simulators of about 1m length will be conducted at the FZK QUENCH test facility.

Stage 3 “FUEL ASSEMBLY QUENCH MODEL”. Analytical support of the tests and modelling of core degradation phenomena during reflooding of VVER fuel rods under severe accident conditions. The extension and validation of the IBRAE/SVECHA code is planned.

The general opinion of the group has been that the planned activities and the expected results of the ISTC project will be valuable and result in new findings. However, the planned separate-effects tests with spent fuel rod segments (stage 1) should be shifted from 1200°C, at onset of quenching, to much higher temperatures. The test matrix should be therefore revised and the test temperatures should be increased from 1200-1600°C to 1400-1700°C. SCC / RIAR will check if even higher temperatures will be possible. Also the planned 3 different initial oxide layer thickness values on the outer cladding surface should be reconsidered. In addition, for comparison reasons, a limited number of tests with unirradiated fuel rod segments are necessary. The number of tests with irradiated fuel should be fixed to the initially planned tests of altogether 18.

**Topic #11:** Presentation, justification and discussion of ISTC project #2219

The project “Steam explosion in the corium-water system” was presented by V.Melikhov (EREC); a handout was *distributed but there was no copy of the proposal available. T*he objective of the project is to investigate the interaction of corium melts with water and to determine conditions in which steam explosions may occur. Both in-vessel and ex-vessel fuel-coolant interaction (FCI) studies are planned. The database of FCI experiments with realistic corium is insufficient and inconsistent for modeling and code (VAPEX) verifications.

The group did not completely agree with all of the presented conclusions. Although investigations on steam explosion have been performed for a long time many phenomena are not yet fully understood. For example, why Al2O3 can cause energetic steam explosion but no such explosion could be detected up to now with corium or oxide fuel *(except in the recent TROI Korean programme in which test conditions are unclear).* Recommendations were made by the group, i.e. firstly with respect to the state of the art report on FCI, the available OECD SOAR on FCI should be considered as basis and updated, secondly the tests should be connected to specific accident scenarios, and thirdly the test design and test data measurements *need more information (in particular H2 and particle size, the latter by X-ray analysis)* should be further discussed with experts (mainly experimentalists) to eliminate possible earlier drawbacks. *In addition, pouring conditions from the crucible have to be clarified in order to have a very “clean corium jet “ as initial conditions.*

The ISTC project #2219 is a continuation of the finished ISTC project #408. L.Tocheny will send the final report of the project #408 to A.Zurita and P.Hofmann. It should be then distributed to the CEG-CM members. Russian technical experts should be invited to the next meeting of the group to discuss further and clarify the remaining questions.

**Topic #12:** ISTC project #1950.2; Phase diagrams for multicomponent systems containing corium and products of its interaction with NPP materials (CORPHAD)

The planned presentation “Conclusions from Chernobyl corium” by A: Borovoi could not be given since he was not able to come to the meeting. It will be shifted to the next meeting.

Instead, S.Bechta presented the ISTC project #1950 phase 2 (CORPHAD). The group strongly supported the execution of this project, mainly aimed at experimental studies to develop and further investigate phase diagrams of realistic corium systems and structural reactor materials mixtures. It should contribute to optimise and complete the still limited corium related thermodynamic databases for high temperature application and consequently to improve chemical corium interaction models needed for reactor severe accident reactor application.

A project development grant was already given to this project. The continuation of ANL acting as collaborator in #1950.2 phase 2 will be clarified by L.Tocheny. According to distributed information on project collaborators, the latter may apply to the financing party for a partial or total transfer of IPR.

**Topic #13:** Detailed discussion and preparation of the CEG-CM reports

After the presentation of the various ISTC project proposals by the Russian scientists the restricted session of the meeting continued with detailed discussion by the CEG-CM members in order to elaborate advice and priorities of the presented Russian proposals. The results are summarised in a table (see annex 4) also supported by the specific advice A-02 to A-04.

The projects #1648 and #1950.2 (CORPHAD) were considered worth funding. Higher priority was given to the project #1648.

The project #2219 was not considered worth funding right now but of potential interest for CEG-CM. Further discussion is needed. Project development grant for preparation of a detailed work plan was recommended. JRC/ITU (D.Bottomley) will act as project collaborator.

The group has approved the modified work plan of the project #833.2 (METCOR). Two new foreign collaborators were announced, i.e. FANP and CEA.

**Topic #14:** Discussion of “Promising research abstracts (PRAs)” and list of ISTC CEG-CM related projects

L.Tocheny mentioned that PRAs are a collection of information on possible research activities in a first step in order to prepare future project proposals.

**Topic #15:** Other issues

The role of foreign collaborators was discussed and appropriate information was distributed to the CEG-CM members. New collaborating organisations to specific projects should communicate their intention to act as collaborators to the EC

(Mr. D.Gambier, DG RTD 05, SDME 01/137, B-1049 Brussels; e-mail: Didier.Gambier@cec.eu.int).

It should be guaranteed for the next meetings that the group always has the latest proposals and documents on corium-related projects. L.Tocheny will check and provide A.Zurita and P.Hofmann the latest developments of new and listed projects (annex 2) in order to assure their inclusion into coming CEG-CM agendas, as well as their distribution to CEG-CM members. Moreover, the CEG-CM members were also recalled to react on time to draft documents sent for comments by the CEG-CM secretariat.

**Topic #16:** Next meeting

The next meeting of the ISTC CEG-CM will take place in St. Petersburg from 10 to 12 February, 2003.

The future meetings should always take place about 6 weeks before the ISTC Board meetings (early February and early September) to have sufficient time to prepare recommendations on ISTC project proposals for the ISTC Board delegates of the financing party EU.

A. Zurita (Chairman) P.Hofmann (Secretary)

**Annexes:**

1. Agenda of the meeting
2. ISTC CEG-CM related projects (updated: 30-09-02)
3. Role of foreign collaborators (distributed at the meeting)
4. Summary of ISTC projects’ discussion at the ISTC 2nd CEG-CM meeting
5. Specific action list (see below)

Annex 5: **Specific Action List**

Further to the normal CEG-CM operation, the specific actions agreed during the meeting were recalled:

2/1 - Topic 3: Clarification of EU financing to ISTC (A.Zurita)

2/2 - Topic 3: Agreed completion of the CEG-CM guidelines (A.Zurita)

2/3 - Topic 4: Issue of possible observers in the CEG-CM meetings (A.Zurita)

2/4 - Topic 5: Drafting text for a constitutive CEG-CM document (L.Tocheny)

2/5 - Topic 9: Checking of possible USB collaboration in project #833.2 (L.Tocheny)

2/6 - Topic 12: Checking of possible ANL collaboration in project #1950.2

(L.Tocheny)

2/7 - Topic 16: Logistic organisation of the 3rd CEG-CM meeting with hosting

organisation (L.Tocheny)