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

**CONTACT EXPERT GROUP on CORIUM MANAGEMENT**

**(CEG-CM)**

**MINUTES OF THE 3rd MEETING**

**Nuclear Safety Institute, IBRAE, Moscow**

**February 11-12, 2003**

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

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Reviewed minutes, May, 2003 CEG-CM / M-03

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| Subject: Third Meeting of the ISTC ‘Contact Expert Group on Corium Management’ (CEG-CM)Place: Nuclear Safety Institute, IBRAE, Moscow, Russian FederationDate: February 11-12, 2003Participants: 30 participants of 22 organisations from 4 countries: Mr. B.Adroguer IRSN, Cadarache Mr. E.Altstadt FZR, Rossendorf Mr. G.Azarian Framatome ANP, Paris Mr. D.Bottomley JRC / ITU, Karlsruhe Mr. G.Cognet CEA/DEN/DSNI, Saclay  Mr. P.Hofmann Consultant, Karlsruhe (secretary) Mr. J.Stuckert FZK, Karlsruhe Mr. W.Tromm FZK, Karlsruhe Mr. H.Unger RUB, Bochum  Mr. A.Zurita DG-Research / J.4, Brussels (chairman) Mr. S.Bechta RIT / NITI, Sosnovy Bor Mr. I.Belyakov RFNC-VNIIEF, Sarov Mr. L.Bolshov IBRAE, Moscow Mr. A.Borovoi RRC-KI, Moscow Mr. V.Boyarinov RRC-KI, Moscow Mr. S.Gavrilov RRC-KI, Moscow Mr. A.Grebennikov RFNC-VNIIEF, Sarov Mr. A.Goryachev SSC-RIAR, Dimitrovgrad Mr. L.Kabanov RMINSC-INSC, Moscow Mr. V.Khabensky RIT / NITI, Sosnovy Bor Mr. V.Kumayev IPPE, Obninsk Mr. Ju.Kuznetsov NIKIET, Moscow Mr. A.Luk’janov IPPE, Obninsk Mr. V.Mineev IVTAN-RAS, Moscow Mr. S.Orechov RRC-KI, Moscow Mr. V.Reshetov NIKIET, Moscow Mr. V.Strizhov IBRAE, Moscow Mrs. A.Swetlova ISTC, Moscow Mr. L.Tocheny ISTC, Moscow (co-chairman) Mr. M.Veshchunov IBRAE, MoscowDistribution list: Mr. A.Mitsos DG-Research Mr. L.Bellemin DG-Research / 05 Mr. D.Gambier DG-Research / 05 Mr. P.Fernández Ruiz DG-Research / J Mr. M.Poireau DG-Research / J.1 Mr. J.Poussielgue DG-Research / J.1 Mr. H.Forsström DG-Research / J.4 Mr. D.Taylor DG-TREN / C.4 Mr. R.Schenkel DG-JRC Intranet of Unit J.4 Mr. L.Tocheny ISTC, Moscow EU membersContact person: Mr. A.Zurita Tel.:+32-2-29.58365 – MO75, 5/30 |

Agenda of the meeting see annex 1.

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

The meeting was divided into open and restricted sessions. The chairman A.Zurita opened the restricted session and welcomed the EU participants of the 3rd meeting of the International Science and Technology Centre (ISTC) – Contact Expert Group on Corium Management (CEG-CM).

20 Russian scientists attended the meeting. 10 of them presented their project proposals or research works to the CEG-CM.

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

L.Tocheny modified the agenda one day before the meeting in co-ordination with the chairman A.Zurita, who met at the ISTC Headquarter. Additional presentations were given on various ISTC project proposals as well as corium-related activities of a few organisations, which may result in future ISTC proposals. The changes were discussed, however, it was not clear at the beginning of the meeting if all added presentations would be presented. Some of the invited Russian scientist may not have been able to attend the meeting. The presented agenda in annex 1 corresponds to the planned topics.

**Topic #3:** Approval of the minutes of the 2nd CEG-CM meeting in Karlsruhe

The minutes were accepted without changes. There was only one question concerning topic #11 in which it was mentioned that the ISTC project #2219 is a continuation of the completed ISTC project #408. The final report should have been distributed to the members of the group that was not the case. L.Tocheny was asked to send the final report to the chairman A.Zurita for further distribution.

**Topic #4:** Specific action list

Remarks to the action list of the last meeting.

Action 2/1: The EU contribution of the ISTC projects are financially covered by the TACIS budget. The EU,USA and Japan provide the main additional funding of ISTC projects. Other contributors are the Russian Federation, Norway and the Republic of Korea.

Action 2/2: Agreed updating of the CEG-CM guidelines (version 01.10.2002) by extension of the description of the scope of the group's activities including the corium interaction with structure materials (RPV, basemat and core catchers).

Action 2/3:The role of observers has still to be clarified by the EU *(still pending).*

Action 2/4: A drafting text for a constitutive CEG-CM document for general informative use should have been prepared by L.Tocheny in which the important role of the CEG-CM should be clearly defined. As well as the scope of the group. There was no final conclusion on this task and it will be reconsidered at the next meeting. According to L.Tocheny the available guidelines cover already the request.

Action 2/5+2/6: The possible USB collaboration in the ISTC project #833.2 and that of ANL in the project #1950.2 are discussed in topic #5 *(still pending).*

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

Discussion of the updated list of ISTC CEG-CM related projects (07.02.2003).

It was for the chairman surprising that the ISTC project #1648, that was highly recommended (priority 1) by the group, was not on the list of considered projects at the last ISTC board meeting. L.Tocheny explained that the project did not fulfil all ISTC requirements in time and was therefore not considered. It should be improved and once more submitted to ISTC.

The ISTC project #1950.2 that was highly recommended (priority 2) by the group, is under examination by a special committee in order to verify that there is no risk of proliferation.

The status of the ISTC project #2219 on steam explosion has been changed from 2 to 3 after satisfying all ISTC requirements. The proposed project development grant (PDG) for the project by the CEG-CM was not accepted by the ISTC governing board since a PDG will be given only in exceptional cases. However, if collaborators have still interest in this project it can again be submitted and eventually be promoted. At the 2nd CEG-CM meeting, this project was requested to be re-presented focusing more on experimental aspects. In spite of this, there was no additional presentation at the meeting.

At the ISTC project #833.2 four foreign organisations showed interest to act as collaborators. The status of the project has been changed from 5 to 6.

The status of the ISTC project #1950.2 has been changed from 2 to 5. The project agreement is under preparation.

ISTC project #1445 (1448) is new with status 1. The project co-ordinators are waiting for some collaborator response. The project activities are not within the scope of CEG-CM (see topic #24).

Concerning possible US collaborators in the ISTC projects #833.2 (USB) and #1950.2 (ANL) the following general statements were made. The prospective collaborator of a financing party sends a written agreement to the ISTC secretariat or funding party, which outlines the form and scope of collaboration and indicates acceptance of ISTC goals. A collaborator is not required to provide any direct project funding; its financing party does it indirectly. However, a collaborator may directly fund research projects. In the frame of CEG-CM activities any organisation interested to act as collaborator in an ISTC project should send its request (formal letter) to the ISTC secretariat, with copies to D.Gambier, A.Zurita and L.Tocheny [action 3/1]. No collaborator has the right to request the removal of another collaborator from an ISTC project.

Intellectual property rights (IPR) belong to the CIS institute and funding body. The collaborator may apply to the financing party for a partial or total transfer of IPR. The CIS institute shall grant to the financing party an exclusive licence for commercial purposes on that party’s territory.

Based on the fact that project collaborators may apply to the Financing Party for a partial or total transfer of IPR, a question was raised for the exceptional case of non-European organisations willing to collaborate in projects by the EU as unique financing party. The chairman recalled that in the cases of USB (University of Santa Barbara), that was collaborator of the project #833 (first phase), and ANL (Argonne National Laboratory), that was collaborator of the project #1950 (first phase), the actions 2/5 and 2/6 are still pending, i.e. to check whether those organisations would be interested to be collaborators in the second phases of those projects, which are financed only by the EU as unique financing party. Up to now, no communication has been received by those organisations.

Nevertheless, a discussion took place with encountered opinions on how to approach the potential IPR related issue concerning the case that those non-EU organisations would be interested to become collaborators.

**Topic #6:** Preliminary discussion/checking of individual ISTC projects

The ISTC project proposals #1648 and #1445 were considered. The earlier concern of the group on the project #1648 “Examination of VVER fuel behaviour under severe accident conditions; Quench stage” with respect to higher test temperatures at onset of quenching were taken into account in the modified proposal. A few recommended tests with fresh fuel rods for comparison reasons have been accepted but have not yet been included in the project proposal.

From the project #1445 “Reactivity accidents 3D modelling” the group did have only limited information that were available in the internet (2 pages). I.Belyakov has given more information in the presentation under topic #13.

**Topic #7:** Welcome of the Russian colleagues; discussion of the agenda

The chairman A.Zurita opened the extended session of the meeting and welcomed the Russian participants and expressed his thanks to IBRAE (M.Veshchunov and V.Strizhov) for preparing and hosting the 3rd CEG-CM meeting. The co-chairman L.Tocheny explained the Russian participants the task, scope and objectives of the group. The changes of the agenda with respect to the sequence of presentations by the Russian scientists were briefly discussed and agreed.

**Topic #8:** Research activities at IBRAE

The director of IBRAE Prof. L.Bolshov gave a short presentation on the various research activities. The Nuclear Safety Institute was founded in 1989 in the Academy of Sciences with the goal to extend fundamental researches on safety analysis of operating NPPs and those under construction, prediction of radiation accident consequences as well as their effect on the environment and humans. The main feature of the Institute activity is a complex safety analysis of nuclear power facilities using computer codes integrating the bases of theoretical, experimental and operating knowledge. Investigations into safety analysis of NPPs are one of the most important directions of IBRAE activity The institute carries out works on numerical-theoretical analysis and designing of computer codes to describe NPP at various stages of the accident and to verify the developed modules against the experimental data in the framework of national and international programs.

The institute staffs of about 400 people (310 scientists) are a combination of specialists in theoretical and applied physics, nuclear engineering, biophysics, radioecology and computational mathematics. At the moment the main research activities of IBRAE are focused on safety of NPPs, operator support systems and improving operational safety of NPPs, emergency response in radiation accidents and development of a concept of safe decommissioning of nuclear submarines in Russia.

A brochure was distributed in which the various activities of IBRAE are described in detail. In addition, a short tour of the institute was offered to the EU participants guided by M.Veshchunov after the first day meetings.

**Topic #9:** Research activities on corium within the EURATOM 5th and 6th Framework Programs

A.Zurita described the scope and objectives of past and future EURATOM Framework Programmes. The first EURATOM reinforced concerted action on reactor safety was carried out between 1990 and 1994 and was focused on accident progression analysis including core degradation, hydrogen behaviour, molten fuel/coolant interaction, PRV failure, molten corium/concrete interaction and source term, the behaviour and qualification of the containment system and accident management support. It was followed by different EURATOM Framework Programmes: the 4th FP from 1994 until 1998, the 5th FP from 1998 until 2002 and the new one will last from 2002 until 2006.

The 5th FP explored the operational safety of existing NPPs, plant life extension and evolutionary concepts. Additional topics were safety of the fuel cycle, safety and efficiency of future systems and radiation protection. The 6th FP will cover fusion energy research, management of radioactive waste, radiation protection, innovative concepts, safety of existing installations and education and training. Within the 6th FP a wider range of joint activities is planned by the formation of networks of excellence and integrated projects. The objectives are to facilitate needed rationalisation and consolidation in European research activities as well as to maintain critical mass and competence by more effective use of diminishing resources.

The various projects within the 5th FP and their specific tasks and objectives were described in detail. Additional information were given on the conduct of EUROCOURSES on reactor safety, on the international PHEBUS FP Programme, on the ISTC Contact Expert Group on Corium Management (CEG-CM) and on the FISA-2003 meeting, which will take place in Luxembourg, 10-13. November 2003.

**Topic #10:** The INCS activity on severe accident management and control for operating NPPs with VVER 1000/320 reactor

The presentation was given by Prof. L.Kabanov from the International Nuclear Safety Centre of Russian Minatom (RMINSC). RMINSC, founded in 1996, carries out R&D and expertise work to ensure safety of NPPs, research reactors, and other nuclear reactors for civil application. Scope of activity covers all aspects related to safety of nuclear facilities, including severe accident management, monitoring, diagnostics and structural mechanics.

Development of AMM procedures for NPPs of the type VVER-1000/320. Identification and evaluation of possible VVER-1000 modifications for severe accident management measures. Assessment of NPP instrumentation performance under SA conditions. Computer code analyses *(using the MELCOR code)* to check and confirm selected SAM strategies. A first version of generic severe accident management guidance for the VVER-1000 operating plants has been developed.

Various selected accident scenarios have been considered: SBLOCA, LBLOCA, LNHR (loss of normal heat removal), PRISE (primary to secondary circuit leak with failure to close affected steam line) and SBO. The results of calculations for the various accident scenarios were presented. For a LBLOCA the beginning of core meltdown occurs at 1660s and RPV would fail after 9350s; the maximum containment pressure was estimated to be 0.47 MPa.

The indicated open issues were the water supply to the reactor cavity concerning in-vessel core melt cooling and in case of lower head failure ex-vessel core melt cooling. Technical modifications of VVER-1000/320 will be needed to provide water supply to and steam removal from the reactor cavity. The phenomenological uncertainties involved are the potential for in-vessel core melt cooling and ex-vessel steam explosion. A possible future ISTC project on ex-vessel corium coolability is suggested.

**Topic #11**: Corium related investigations by KIAE/IBRAE.

Information of IBRAE activities on corium related investigations were given during a short tour to various research divisions of IBRAE by M.Veshchunov. The KIAE presentation was connected to the agenda topic #21.

**Topic #12:** Activity of Minatom Code Centre in modelling of severe accidents and corium studies (areas of further co-operation)

No presentation was given on this subject since S.Soloviev (Minatom, Moscow) was not able to attend the meeting.

**Topic #13:** Presentation of the ISTC project #1445 “Reactivity accidents 3D modelling”

The project was presented by Mr. I.Belyakov from RFNC-VNIIEF. The computer simulation of reactivity processes occurring in NPPs both at normal and accident conditions is an important task. The current available program system TENAR (developed within the ISTC project #0067) should be extended by improved mathematical models and numerical methods. Simulation activities require a complex study of complicated inter-related processes, primarily, neutron nuclear processes and thermo-hydro dynamical processes. In many cases capabilities of experimental studies of physical processes are limited. The processes should be computed in complex 3D NPP geometries taking into account specific design features of particular reactors as VVER-1000, RBMK-1000 and PWR.

The capabilities of such numerical simulation of processes have been limited due to insufficient computer performance. The current rapid development of new-generation parallel architecture base computers altered the capabilities in computer simulation of NPPs. The objective of this project is the development of a 3D program package for computing coupled problems of dynamics and analysing safety of reactors of the WWER, PWR, RBMK type based on simulation of neutron nuclear processes in a more complex, but, at the same time, considerably more accurate multi-group transport approximation. The coolant flow description will make use of 3D and 1D two-fluid and discrete-two-fluid models. It is anticipated that the program package to be developed should be used for precise computations whose results could be used to benchmark simpler models. In connection with the above described project the ISTC project proposal #1448 “3D simulation of coupled NPP safety problems on parallel computers with taking into account neutron transport processes in group transport approximation” may be of additional interest.

It was proposed to prepare an ISTC project proposal according to the current ISTC standards and to put the 2 projects (1445 and 1448) together as a single project in two parts. However, it was not clear which EU organisation may be interested in this program package (E.Altstadt showed some interest for the Forschungszentrum Rossendorf and H.Unger proposed GRS Munich).

It was commented that the reactivity accidents topic was not in the initial scope of the group. In addition, a more shaped project is suggested for further discussions. Information from these proposals should be transmitted to specialist in each company in order to evaluate their potential interest. Depending on this interest from western laboratories, L. Tocheny suggested to organize a specific seminar on this topic.

No information was given on the ISTC project proposal #2107 “Thermal properties of uranium dioxide”.

**Topic #14:** Presentation of the ISTC project #0243 “Models and codes for accident phenomena in NPPs”

The ISTC project presented by A.Luk’janov of IPPE was somewhat different from that ISTC project proposal #0243 documented in the internet which gives only a more general outline what could and should be done in this research area for VVER NPPs.

The planned code system (DINCOR) should be able to describe core degradation and melt relocation processes, fission product release and transport phenomena into the containment as well as the aerosol and hydrogen transport and behaviour to and within the containment. The purpose of the project is the development of: multidimensional theoretical models for physical-chemical and thermal-hydraulic phenomena in a reactor during a severe accident in a NPP; computer codes to evaluate different phenomena; and real technical approaches to the problem in the course of a core meltdown accident. In this connection a data bank on physical and physico-chemical properties of corium mixtures and of its components, which is required to execute the task, should be established.

The opinion of the group has been that this project is too broad and it would be better to propose a project, which should concentrate on some specific aspects. In this regard, the group would appreciate to receive description of capabilities and clear experimental and analytical objectives concerning the following three topics: fission product releases, corium dispersion and corium progression in porous medium. The chairman recommended providing a new project proposal to the CEG-CM and looking for EU organisations, which would like to act as collaborators.

**Topic #15:** Presentation of the ISTC project #0860 “Computer modelling of reactivity burst and initial phase of severe accident in VVER-type reactors”

The project was presented by Mr. V.Boyarinov from the Kurchatov Research Centre. The objective of the project is the elaboration of a best-estimate mathematical model for neutron-physical and thermal-hydrodynamic calculations of the nuclear reactor core under reactivity initiated accident (RIA) conditions. The investigations are based on a comprehensive approach to RIA after initiation of reflood of the core after a LOCA or in the cold reload state. The main attention is given to the development of mathematical models of the complex processes in the nuclear reactor, where the calculation accuracy is limited only by the uncertainty in knowledge of material properties data (in the absence of other uncertainties). The primary application of the created tool is the analysis of the most dangerous accidents connected with reactivity burst at reflood conditions of the core in VVER-type reactors. The created tool could be useful also for the more wide range of accident types and for the PWR-type reactors. A contact or collaboration with the CABRI programme might be useful.

**Topic #16:** Presentation and discussion of the revised ISTC project #1648 “Examination of VVER fuel behaviour under severe accident conditions; Quench stage”

A.Goryachev from RIAR-Dimitrovgrad presented the project, which was slightly modified, for the second time to the CEG-CM. The general purpose of the project is to find out possibilities to apply available databases to describe the VVER core behaviour under severe accident conditions focussing on the quench phase. For this reason it is necessary to carry out a limited number of experiments with VVER typical materials to find out possible differences in VVER and PWR type material properties under severe accident conditions. The primary task of the project is therefore to conduct a limited number of experiments to obtain data on the physico-chemical behaviour of VVER reactor core materials at high temperatures in order to develop physical models and codes applicable to VVER reactors. This task is assumed to be solved as complementary to the QUENCH project performed in FZK, Karlsruhe. The same methodical approach will allow a comparison of the behaviour of VVER and PWR materials. Within the frame of the ISTC project #1648 it is therefore planned to carry out several small-scale tests with irradiated short fuel rod segments and one large-scale integral experiment with an unirradiated fuel element bundle simulator both under quench conditions with VVER type materials to obtain the required specific database for the development and verification of quench models in code systems.

The recommended changes by the group at the 2nd CEG-CM meeting to conduct the quench tests with irradiated fuel rod segments at higher temperatures were taken into account in the modified project proposal. The maximum temperatures at onset of quenching will be shifted to 1700°C. Even higher temperatures would be of interest and could be performed but the obtained results would be difficult to correlate to the test conditions due to partial melting of still metallic parts of the cladding material. However, what should be considered additionally in the revised project proposal are a few tests with un-irradiated VVER fuel rod segments for comparison. There was no final decision concerning measurements of the release of specific fission products during quenching. Proposals from the group were that the Cs content in the quenching water be determined and also that the hydrogen generation - including any temporary absorption of hydrogen in cooler zones be monitored as closely as possible.Presently the RIAR facility is under design regarding the quench capacity and the heating mode of the furnace (either induction or resistance heating). This facility aimed at working in a hot cell has to ensure a good heating control avoiding any Zr melting.

The modified project #1648 fulfilling all ISTC requirements expressed during the 2nd CEG-CM meeting will be submitted to the ISTC Governing Board.

Two new foreign collaborators (EdF, CEA) are interested in this project in addition to IRSN and ITU already collaborators. According to the new ISTC regulations it was recalled how to become a foreign collaborator (see action 3/1).

**Topic #17:** Presentation of the ISTC projects #0939 “Catcher for the molten core” and #1974 “Brickwork materials for operational and new NPPs; Methods of severe accident”

The purpose of the project, which was presented by V.Mineev, is to develop advanced materials for brickwork elements of ex-vessel core catchers of existing and projected NPPs that can be used for the localization and retention of core melts escaping from the RPV under a severe accident conditions. The catcher should guarantee the localization, cooling and retention of the relocated molten material for an infinitely long time (1000 years) without serious damage to the containment structure and environmental effects.

Sacrificial and refractory materials will be developed within the framework of this project, whose properties compare well with those of the materials for the EPR catcher presently under development. In addition, the sacrificial materials should serve as immobilisers of radioactive materials.

Methods of preparing the protective and refractory layers of the catcher will also be developed, such as the concrete-pouring technology and the technology of brickwork and block masonry. Appropriate binders and cements will be developed for this purpose. The available experimental data indicate that such materials may be developed on the basis of ultra disperse zirconia powders. Sacrificial material based on titanate ceramics may be proposed for future investigations.

This was proposing titanate, ZrO2 and CaO fillers in cement that produce synroc-type minerals on fusing with corium melt so that they also effectively immobilise the radio nuclides (as with zirconalites formed from ZrO2 ). Determination of the liquidus temperatures of the materials was done by Xe-lamp heating. This had been a subject of an earlier grant. However there was mistrust in the committee about this as such core-catcher research had in the past supported the core catcher design of the VVER reactor sold by the Russians to China. Perhaps more fundamental study may be acceptable, but little interest was evident in the project as it was new. G. Cognet recommended to re-orientate the proposal on the measurement of physical properties at high temperatures.

Comment: The sacrificial material under investigation are known to be very expensive and the industrial application of such Ti-based materials is questionable.

**Topic #18:** ISTC project proposal “Development of an innovative conception on core melt localization facility for a high power nuclear reactor”

V.Reshetov from NIKIET described briefly a test facility (KLIMT) and a concept of a core catcher for NPPs. The presented ongoing research work and the possible application of the obtained results on a high power NPP will be the basis of a new ISTC proposal.

The final project (New proposal) was innovative concepts on core melt localization facility of a higher power nuclear reactor for design of BWR, and liquid metal reactors (Ju.Kuznetsov - NIKIET). They have a core localization facility that enables corium to be poured onto brickwork, that is cooled from outside by water. They also have low melting point facility of a vessel with a coolant 'jacket' that can control or measure heat fluxes from the corium melt surface, and could potentially examine various layered corium forms. They also have a liquid fuel circulation facility that can also use Pb-Bi coolant for testing of metallic melt properties of the liquid metal reactor; it can also use water for BWR circuits.

Here a remark was that a proposal on fundamental properties should be made since liquid metal reactor research will initially be advantageous for the US, as the EU has slight investments in this field.

**Topic #19:** Information on the status of the ISTC project #2219 “Steam Explosion in the corium-water system”

No presentation or information was given on this project since O.Melikhov (ENIC, Electrogorsk), the responsible project manager, did not attend the meeting.

**Topic #20:** Outcome of the METCOR discussion in Aix-en-Provence

W.Tromm reported briefly on the outcome of the METCOR phase 2 meeting that took place in Aix-en-Provence on January 29, 2003. The METCOR phase 2 project should have started in September 2002 but due to administrative delays at ISTC the contract was signed not before January 2003. During this time the RASPLAV facility (high temperature furnace for melting up to 2 kg of UO2-ZrO2 mixtures by a cold crucible technique) has been considerably upgraded with a new high frequency heating current generator and a new data acquisition system.

In the modified facility, now called RASPLAV-3, 2kg of corium can be handled in inert or oxidizing conditions. A pre-test was conducted with an 18/10CrNi austenitic stainless steel sample (new vessel material, steel surface temperature kept at about 1250°C) for the first time reaching maximum temperatures in the melt of 2600°C.

As seen in the course of the test (test duration several hours) the steel was badly pitted locally to a max. depth of 2.5 mm. This behaviour is in contrast to the low (Ni,Cr) alloy vessel steel of a VVER (2Cr-1.25Ni 0.5Mo), which shows uniform corrosion in the order of about 5 mm depth. The pitting corrosion of the austenitic stainless steel is only 2-3 times less than the low vessel steel uniform corrosion despite the considerably higher level of protective alloying elements (Ni,Cr) and it may not be corrosion-resistant under UO2-ZrO2 melt conditions.

The future test procedures were discussed in detail. D.Bottomley and W.Tromm suggested conducting tests with steel specimens applying a stepwise profile between 900°C and 1250°C in steps of 50°C. Under these test conditions the RPV steel corrosion rates were low enough (as seen by the phase 1 test results) to avoid any failure. It was also suggested to vary the heat fluxes at the max. steel surface temperature of 1250°C. NITI will circulate a test protocol to the steering committee members for comments and approval before carrying out the reference test with a fully oxidised UO2-ZrO2 melt up to 2600°C in an inert atmospheres. The next series of tests will be a sub-oxidised melt under inert test conditions while the final series of tests will be of a sub-oxidised melt under reducing test conditions. This programme should last 3 years (1 test series/year).

It was also suggested to add a point in the agenda of the next CEG-CM meeting giving a synthesis of results from METCOR-1

**Topic #21:** Conclusions from Chernobyl corium studies; formation scenario and physico-chemical properties. Development of the database “Nuclear fuel and radioactive waste in the shelter of Chernobyl NPP”

A.Borovoi presented the current status of the post-accident investigations concerning the core material behaviour and its physical, chemical as well as radiochemical state. The main source of information was the chemical examination of relocated solidified material that was extracted by drilling boreholes at various locations of the destroyed NPP.

In the accident, a power burst occurred blowing the top of the pressure vessel off in a steam explosion, and wrecking the reactor hall. The resulting air ingress ignited the graphite blocks and the flames threw approx. 5 MCi/day into the air for the next week as sand, boron, clay and water were dumped onto the burning reactor to quell the fire. Later a sarcophagus was constructed around it

During the accident a large amount of damaged and intact fragments of the core were released from the reactor. The investigations concentrated on different types of core materials: 1. Core fragments, 2. Fuel particles and 3. Lava-like fuel containing material. The core fragments were found in the reactor vault, once about 100 bore holes had been drilled into the reactor basement and periscope and video observation become possible. Two ways of fuel dispersion took place in the course of the accident. Firstly during an abrupt power increase “large” fuel particles were formed due to the release of gaseous fission products at fuel pellet grain boundaries. Their dimensions were dozens and hundreds of micrometers. Secondly, during the explosion and afterwards both fuel oxidation and “small” fuel particles of 3-4 micrometers generation occurred. Lava-like fuel-containing materials were found in many rooms under the reactor. They contained considerable amount of uranium as well as great quantities of radionuclides produced in the reactor. The lava-like fuel containing material was classified in different types: brown and black ceramics, slag or slag-like granulated material and “pumice” like material. In addition solidified once molten metallic material, which contained no fuel, was found. The estimated melting range of these ceramics was 1600-1700°C. About 95 % of the fuel is still in the reactor (190 tons). The location is known for 150 tons and 0.75 ton is buried deep, but the remaining 30 tons' location is not known. The accident was also modelled at IBRAE from '90-'96 with 3 modules: mechanical, physical and chemical processes and heat transfer, but the analysis effort could not be continued due to lack of finance. A large uncertainty is presently recognized on the timing of the corium progression (from 3 to 10 days) It was asked if IBRAE would be interested in continuing with such scenario modelling and submitting a proposal to the ISTC as apparently there are 6000 analyses of lava rocks. Collaboration with the Ukrainian SHELTER would be also being very advantageous. The CEG-CM showed great interest in the work and obtained results and suggested to submit a ISTC project proposal on the analysis of the corium progression.

A paper in which the above results are described in detail was given to the chairman.

**Topic # 22:** 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 on the presented activities to elaborate advice and priorities of the proposals.

The recommended changes in the ISTC project proposal #1648 “Examination of VVER fuel behaviour under severe accident conditions; Quench stage”, status #6, were taken into account (see topic #16). There is a large consensus on the interest of the project and it was therefore decided to prepare a new advice CEG-CM/A-05 (see annex #2). The submission of the modified advice may be too late for the Governing Board meeting in March but it could be considered in the July meeting. The dissemination level of the advice was changed from confidential to restricted. In future all advice should be restricted, that means, only available to EC, CEG-CM members, ISTC and CIS beneficiaries.

The project proposals #1445 “Reactivity accidents 3D modelling” and #1448 “3D simulation of coupled NPP safety problems on parallel computers with taking into account neutron transport processes in group transport approximation”, both status #1, (see topic #13) were considered to be outside the scope of the group which cannot give a technical advice on this RIA topic. However, some interest may exist in these research areas in the Forschungszentrum Rossendorf and in IRSN/Cadarache. The chairman recommended combining the two proposals in a new one. Any comments of foreign collaborators should be included in this new proposal. L. Tocheny recalled that a specific seminar could be funded by ISTC on this topic if justified.

A similar situation exist for the project proposal #0860 “Computer modelling of reactivity burst and initial phase of severe accident in VVER-type reactors”, status #3, (see topic #15) which is also outside the scope of the group. The Russian scientists should contact appropriate experts for technical advice , rewrite the proposal and look for foreign collaborators

In general the topics of the project proposal #0243 (from the Institute of Physics and Power Engineering, Obninsk) “Models and codes for accident phenomena in NPPs”, status #4, (see topic #14) could be of interest for the group. But up to now only a more general description what should be done was given. It would be therefore of great interest to get more precise information. For this reason the chairman recommended to prepare a new more focused proposal in which the models already available and those to be developed, the appropriate experimental data base which was or will be used for this purpose, and the used code system will be documented in detail. Of special interest will be the description of the in-vessel corium melts behaviour and progression in porous media, which is of great importance to predict the course of the late core degradation in a severe accident. Another point of interest if FP release experiments and models able to predict fission product release. The group recommend to get more information and would appreciate receiving a one page description of experimental and modelling activities regarding FP release, corium dispersion and corium progression in porous medium.

The project proposal #1974 “Brickwork materials for operational and new NPPs; Methods of severe accident”, status #3, (see topic #17) and the work presented under topic #18 “Development of an innovative conception on core melt localization facility for a high power NPP” showed results that reflect applied research that may result in some conflict concerning intellectual property rights. No interested collaborators were identified. However, more basic research activities in this area with respect to physical and physico-chemical properties of possible core catcher materials may be of greater interest and easier to be supported.

**Topic #23:** Discussion of list of ISTC CEG-CM related projects

The meeting resulted in only one clear advice concerning the ISTC project #1648 which obtained the highest priority (1) by the group concerning “Worth funding”.

The list of ISTC CEG-CM related projects will be updated after the meeting taking into account new project proposals presented at the meeting (see annex #3).

The CEG-CM defined minimum requirements concerning the future evaluation of official ISTC project proposals: The proposals should be made available to the group members latest 4 weeks before the meeting. It will not be the task of the group to check proposals, which have not yet submitted to the ISTC secretariat. However, the group may give some recommendations to planned proposals in advance and EU organisations may express their interest to become a foreign collaborator.

**Topic #24:** Other issues

Discussion if the CEG-CM should enlarge its scope of activities and document it in its guidelines. The discussion was based in view of the wider spectrum of severe accident phenomena included in different discussed topics and proposals. It was preliminary agreed that the technical scope of the group CEG-CM may be extended to include fission product release, behaviour and transport. For areas as LOCA and RIA assessments, there were different opinions among the members. This is still a pending discussion that should be confirmed and finished during the next meeting [action 3/2].

Modelling and code system development efforts should be on available experimental databases with optimisation of code systems.

Probably the expertise of the group with enlarged technical scope has to be extended by new members.

**Topic #25:** Next meeting

A general discussion was conducted how many meetings (one or two) per year are necessary for the CEG-CM to fulfil its task. The opinion of the group has been that 2 meetings are necessary.

The next meeting will take place in St. Petersburg in the third week of September 2003. It will be kindly organised and hosted by RIT/NITI (V.Khabensky) in connection with the METCOR and CORPHAD project meetings [action 3/3].

The preliminary agenda for the 4th CEG-CM meeting will be prepared and distributed in July 2003.

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

**Annexes:**

1. Agenda of the meeting
2. List of participants
3. ISTC CEG-CM related projects (updated: 07-02-03)
4. Summary of ISTC projects discussion at the ISTC 3rd CEG-CM meeting
5. Advice A-05 on ISTC project #1648 (February 2003)
6. Specific action list (see below)

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Annex 6: **Specific Action List**

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

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

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)

3/1 - Topic 5: Organisations interested to act as collaborator in an ISTC project should send its request (formal letter) to the ISTC secretariat in Moscow. Copies should be sent for information to D.Gambier, A.Zurita, L.Tocheny and P.Hofmann.

3/2 - Topic 24: Final discussion on the extension of the technical scope of the CEG-CM to include fission product release, behaviour and transport. Different opinions existed among the members concerning research areas as LOCA and RIA assessments.

3/3 – Topic 25: Logistic organisation of the the 4th CEG-CM meeting with hosting organisation in St. Petersburg (L.Tocheny, V.Khabensky)