Overview of progress in the Corium area

Jean-Michel Bonnet

CEA – DEN/DTN, Cadarache, France

SARNET contact: FI6O-CT-2004-509065

SUMMARY

Within SARNET, Corium topic covers all the behaviour of corium from early phase of core degradation up to in or ex-vessel corium recovery issues with the exception of corium interaction with water, direct containment heating and fission product release. During EURSAFE European PIRT exercise, 311 phenomena had been identified for corium area and 54 were selected for additional needed research according to their importance from safety point of view.

The Corium topic regroups in three work packages the critical mass of competence to improve significantly the corium behaviour knowledge. The spirit of the SARNET networking is to share the knowledge, the facilities and the simulation tools to reach a better efficiency and to rationalise the R&D effort at European level. At mid term, all the knowledge will be accumulated in ASTEC safety code through physical model improvements and extension of validation database.

This paper summarizes the progresses that have been achieved in the frame of the networking activities and underlines also the orientation of the corium work packages tasks for the next period.

A. DESCRIPTION OF THE CORIUM TOPIC ORGANIZATION

A.1 Corium topic structure

Due to the extension of corium topic, subdivision in 8 sub-topics regrouped in three work packages has been necessary for the coordination around small expert groups sharing the same activity. Sub topics have been defined according mainly to the conclusions of EC EURSAFE PIRT project [1] where the remaining important safety issues and the main related physical phenomena have been identified:

Early phase of core degradation (WP9 EARLY)
- WP9-1: Hydrogen generation during Core reflooding
- WP9-2: Early core degradation and B_4C effects
- WP9-3: Zircaloy oxidation by air and steam-air mixture

Late phase core degradation (WP10 LATVES)
- WP10-1: Late-phase core degradation and corium behaviour in lower head
- WP10-2: Vessel failure and corium release into cavity

Ex-vessel corium recovery (WP11 EXCORE)
- WP11-1: Core and debris coolability during reflooding
- WP11-2: Molten corium concrete or ceramic interaction
- WP11-3: Ex-vessel corium coolability

A last subtopic devoted to the development of SARNET thermodynamic and material properties databases is distributed in the three work packages to promote exchanges with other corium topic partners and plays a real transverse role.

A total of twenty organisations from nine countries are involved in corium topics.

A.2 Work-package tasks

For the three corium topic work-packages, networking activity and exchange with other SARNET groups have been arranged around the same four tasks:

- Task 1: Joint review of experiments which contributes to the synthesis progress report of the CORIUM topic on review of experiments whereas available experimental data will be stored in the STRESA data base. Experimental results are the input data for the second task.
- Task 2: Joint interpretation which contributes to the synthesis progress report of the CORIUM topic on joint interpretation of experiments. Interpretations of phenomena observed during experiment are inputs for modelling activity and feed the task 3.
- Task 3: Proposal of models for ASTEC is based on existing models data base and on task 2 outputs. It contributes to the synthesis progress report of the CORIUM topic on proposals of models for ASTEC.
- Task 4: Synthesis of plant application. This task ,in connection with the Severe Accident Research Priority (SARP) work package, contributes to the definition of the next joint R&D program of activity for the Corium topic through the evaluation of the progress made faced to the remaining uncertainties and their acceptability from the safety point of view.

B. SUMMARY OF THE TECHNICAL ACTIVITY

This section resumes the progresses that have been performed from technical point of view after one year and a half of SARNET networking corium topic activities. It gives only a general overview. More detailed technical presentations are provided in the ERMSAR session 2 papers [2, 3, 4, 5, 6] for several experimental, interpretation and modelling activities.

B.1 Status of the early phase of core degradation work-package

The objective of the EARLY work-package is to improve our knowledge of the early phase of core degradation. Selected during the EURSAFE PIRT exercise, the research item n°1.1, concerns the improvement of the magnitude of hydrogen generation knowledge and more especially during the rapid generation of hydrogen which may not be accommodated by re-combiners associated with the risk of early containment failure.

The conclusions of the COLOSS 5th FWP project [7] and the preparation of PHEBUS FPT3 test, have also shown the improvement needs for understanding and modelling for B_4C or fuel burn-up impact on core degradation.

For oxidation and hydrogen production in a damaged core, oxidation by air has been stressed during EURSAFE PIRT exercise. Ranked at low level for core degradation, there is nevertheless a strong impact of oxidizing environment on the fuel and on the fission products release, especially for Ruthenium. Initially addressed in source term topic, as initial conditions for fuels rods behaviour and fission product release, the Zircaloy oxidation by air or by steam-air mixtures issue has been identified as a separate subtopic within EARLY work-package.

To progress in the understanding of physical phenomena, this work package relies on both small and bundle scale facilities. During a technical meeting in January 2005 on oxidation and degradation, IRSN and FzK test results were presented and based on interpretation activity the need for models improvement on oxidation by air/steam mixture and on B_4C degradation were stressed. The decision to share jointly test matrixes for oxidation and degradation separate effect tests between IRSN and FzK was taken. This effort in term of rationalization of the use of European experimental facilities and existing results, will support modelling activity and contribute also for B_4C aspect to the interpretation of PHEBUS FPT3 experiment that was successfully performed in November 2004.

FzK has performed in July 2004 the QUENCH-10 experiment to study the impact of air ingress on core degradation. The results of this experiment, designed in the frame of EC LACOMERA platform access, are open to all SARNET partners. PSI, in close collaboration with FzK, has performed pre-test and post-test calculations with MELCOR and SCDAP/RELAP5. Separate effect tests on the oxidation of Zircaloy in mixed steam-air atmospheres have been extended to temperatures up to 1500 °C at FZK and a diploma thesis work has been started on the sequential oxidation of steam pre- oxidized Zircaloy in air and nitrogen (simulating oxygen starvation conditions). Results of the separate effect tests are being used by PSI for the development of a new air oxidation model.

Regarding the oxidation of Zircaloy by air ingress, forty fresh Zircaloy-4 oxidation tests under air in the range 600/1000°C have been performed by IRSN and analysed. Now pre-oxidizedZircaloy-4 tests are starting and pre-hydrided Zircaloy-4 and M5 samples are under preparation. Zircaloy oxidation by air or air-steam mixture model has been developed in ICARE/CATHARE code to simulate Zircaloy oxidation of intact or degraded geometries and the ZrN layer formation.

The boil-off bundle test QUENCH-11 will be conducted in October (pre-test) and November (main test) 2005. This test simulation Station Blackout out the boundary between DBA and BDBA will be the second of two QUENCH tests within the EC LACOMERA program.

EDF is developing a top-flooding model that will be integrated in ASTEC at the horizon end of 2006. In the frame of ISTC programs, this top-flooding model will be qualified by PARAMETER tests at the Russian Research Center LUCH.

For JRC-ITU, additional irradiated fuel dissolution experiments, to extend the test matrix performed during COLOSS project with medium burn-up level, have been done. First results on melting temperature have been reported as the preparation of sample collected from irradiated fuel/cladding dissolution experiment.
IRSN has developed an UZrO (liquid and solid) mixture oxidation model in ICARE/CATHARE code and tested it on reactor applications.

Regarding the early phase degradation and B_4C effects, the B_4C oxidation kinetic is still under improvement based on the latest VERDI experiments (May-July 2005). The coupling between ICARE/CATHARE and the GEMINI2 codes, taking into account gaseous convective transports has been achieved. It allows the computation of the B_4C off-gas composition. Unfortunately, numerical results are not satisfactory and a further development is foreseen replacing thermal-equilibrium reactions by chemical kinetic relations. The calculation with the code ICARE2 of the FPT3 test and the interpretation of results, focusing on the B_4C behaviour under oxidizing conditions in bundle geometry, have been performed. Concerning oxidation tests of B_4C-steel mixtures, a test matrix has been published to support FPT3 interpretation. Preliminary tests on Fe-B mixtures have been started with encouraging results. These tests together with Fe-B_4C mixtures tests will be achieved by the end of 2005. The fuel dissolution model of ICARE/CATHARE has been improved and now it must be validated.

B.2 Status of the late phase core degradation and vessel behaviour work package

The objectives of the LATVES work-package are to improve our knowledge of the late phase of core degradation, i.e. the corium behaviour after the core relocation in the lower head, derive from EURSAFE PIRT selections. It concerns the research item n°1.3, selected to improve predictability of the thermal loadings on RPV lower head (or corium catcher devices) to maintain their integrity but also the external vessel cooling and RPV integrity, research item n°1.4, including mode and location of RPV failure to characterise the corium release into the containment, research item n°1.6, if in vessel recovery is not successful. A part of the research item n°3.1 “Melt relocation into water and particulate formation” is considered within this work package whereas fuel coolant interaction aspects are addressed within FCI containment topic work package.

Based on EURSAFE individual phenomena investigation and ranking, a more complete understanding is needed on the following physical processes. For coolability of a molten corium pool in the lower plenum or in an external core-catcher, it concerns, in case of dry cavity, initial corium characteristics from the core region when relocating to the lower plenum and behaviour of molten pool in the lower plenum (segregation/stratification, heat transfers to boundaries…). In case of external vessel cooling, it concerns critical heat flux and external cooling conditions in order to evaluate and design accident management strategies for in-vessel melt retention. For vessel integrity and corium release to cavity, it concerns, in conditions of dry cavity, vessel mechanical failure (mode, instant, location) due to thermal and mechanical loadings, breach opening processes and characteristics of corium release to the cavity.

Concerning core degradation, University of Bochum and IKE report calculation and interpretation of TMI-2 and PHEBUS FPT4 with ATHLET-CD. Improvement with the use of MESOCO degradation module is stressed even if there are still computational difficulties.
IKE performed also simulation of corium relocation to the lower head with IKEMIX and study subsequently the corium debris bed formation, coolability or re-melting with MEWA module.

Several activities have been reported about corium pool behaviour in the lower head. CEA, in the frame of EC PLINIUS platform access, achieved the COLIMA post-tested analysis and complete test report to document experiment that have been performed in 2003 to study, with a Bulgarian team, fission product release from a corium pool for VVER composition. In the frame of EC LACOMERA platform access, the first LIVE test in collaboration with a Bulgarian team to study corium pool behaviour in 3D geometry have been delayed by FzK by the end of 2005 due to technological problems. In order to assess new relocation models, IRSN with the support of CEA defined a second LIVE test also through the opportunity offered by FzK in the frame of LACOMERA platform access.
GRS focussed its contribution to the network on the improvement of AIDA-3D code by adding simulation rules to describe in simplified way the upper unstable layer in corium pool induced by top cooling (Rayleigh Bénard convection). CEA, taking into account the specific needs for low power experimental reactor, improves ASTEC models to describe corium transfer from core to lower head, to simulate more realistic pool configurations according to OECD MASCA program feedback and to simulate external cooling device. Interpretations of SIMECO 3 layer experiments in connection with MASCA issues have been reported by KTH.

Regarding vessel integrity, in order to develop a new failure criterion (which will be used in numerical modelling) that can take into account the effect of the steel vessel chemical composition on the failure characteristics (brittle or ductile behaviour at high temperature), a joint analysis and experimental program between IRSN, CEA and INSA de Lyon has been undertaken.

The most recently developed numerical models will be used to study the propagation of vessel failure and to estimate its final size.

Up to now, five 16MND5 steel families have been chosen to reflect different chemical compositions (in particular contents of sulphur, aluminium, manganese...) for metallurgical studies and for analytical tests. The metallurgical study has been already performed for three of the steel families. Initial tests on compact tension (CT) specimens have just been performed and should lead to knowledge of tear strength of the five different types of steel. Several tests have been performed on plate specimens in order to develop a method to determine rupture propagation velocity at high temperature. The method will be adapted for tube geometry experiments. The experimental program is envisaged to last until the beginning of 2007.

At FZR an integral axisymmetric finite element model has been developed for simulating the late phase of core melt down scenarios in a RPV. The model allows for the calculation of the failure time and the failure mode of a vessel with a heated melt pool. In the thermal sub model the transient temperature field of the melt and of the vessel wall is evaluated. This can be done either with a CFD model or with the Effective Conduction Convection Model (ECCM). Within the mechanical sub model the visco-plastic deformation of the vessel wall is simulated. By use of the material damage the failure time and position can be determined. An additional mechanical sub model is used to evaluate the melt pool deformation. The thermal and the mechanical sub models are recursively and sequentially coupled.

The coupled model for vessel failure was for pre- and post-test calculations of the FOREVER experiments performed at the KTH Stockholm. In general, a good agreement of the calculation and the experimental results could be achieved. The FE model can be considered as validated for medium scaled vessel tests. The main results can be summarized as follows. The creeping process is caused by the simultaneous presence of high temperature (>600 °C) and pressure (>1 MPa). At low pressure and high temperatures only a reversible expansion can be observed since the loads by the weight of vessel and melt are negligible. The hot focus region is the most endangered zone exhibiting the highest creep strain rates. The creep deformation leads to a wall thickness reduction, which accelerates the creep process. The exact level of temperature and pressure has an influence on the vessel failure time but not on the failure position. The failure time can be predicted with an uncertainty of 20 to 25%. This uncertainty is caused by the large scatter and the high temperature sensitivity of the visco-plastic properties of the RPV steel. The development of a gap between melt crust and vessel wall could not be proved.

First simulations of the prototypic scenario show that it seems to be possible to avoid a vessel failure if the reactor cavity is flooded.

EDF has been involved in this WP from the second year onwards. The final objective is to develop a mechanical approach of the vessel failure that is simplified enough to be integrated in global SA code but has proved its robustness. The use of FEM code (Code_Aster) aims at improving our understanding of the phenomenology involved and validates the models and behaviour law that have been developed in the past in e.g. Rupther and Revisa programs. This validation will be based on the FOREVER tests and the benchmark with Code_Aster will start in the early 2006. Meanwhile EDF has looked on the different laws that could be used to simulate the behaviour of the vessel under severe accident. The work has consisted in applying a loading directly given by the MAAP code (SA code used by EDF) and to determine the stresses and the rupture times. The thermal loading exhibits very steep gradient and thus the numerical convergence is not easy to obtain with models such as the Chaboche visco-plastic model with coupled damage.

Concerning reactor vessel external cooling, CEA and TECHNICATOME have defined a facility to validate the cooling device concept retained for CEA low power reactor. Scale 1:1 test on a 1:10 angular sector will be operated by CEA in 2006.

B.3 Status of the ex-vessel corium recovery work package

The objectives of the EXCORE work-package are to improve predictability of axial versus radial ablation up to late phase MCCI to determine basemat failure time and loss of containment integrity (EURSAFE research item n°2.1) but also to demonstrate the efficiency of specific corium catcher designs by improving the predictability of the corium interaction with corium catcher materials (EURSAFE research item n°2.3).

In case of water addition, the objective are to increase knowledge of cooling mechanisms by top flooding the ex-vessel corium pool to demonstrate termination of accident progression and maintenance of containment integrity (EURSAFE research item n°2.2) but also to demonstrate efficiency of water bottom injection to cool corium pool and its impact on containment pressurization (EURSAFE research item n°2.4).

Because of similar behaviour, the scope of the work-package is extended also to particulate debris coolability for in-vessel situation (EURSAFE research items n°1.2) to study the termination of the accident by re-flooding of the core while maintaining RCS integrity.

Based on EURSAFE individual phenomena investigation and ranking, a more complete understanding is needed on the following physical processes. For corium behaviour during interaction with concrete or ceramic, knowledge has to be improved for pool stratification and layer stability under gas sparging, heat transfer mechanism, power distribution and ablation homogeneity, fission product remaining in the pool and ceramic dissolution mechanisms. For ex-vessel pool corium coolability, knowledge has to be improved for cooling mechanisms with water on top of the melt (bulk cooling, water ingression or melt ejection), crust anchorage phenomena in reactor pit and consequence for melt ejection mechanism, porosity formation during cooling by bottom injection of water into the melt and consequences for water management and steam production. For core coolability, knowledge has to be improved to understand the behaviour of ex-vessel particulate debris beds in water present in the cavity, the thermal hydraulics of debris beds, without or with water injection, the coolability of debris beds (in- and ex-vessel), the coolability of the molten pool within the core, the fuel rod collapse and the molten pool crust failure for in vessel situation.

For debris coolability, VTT provided an experimental contribution with particles bed dry out heat flux tests in the STYX facility. Tests with irregular shapes and various diameter particles were done for different heights of debris bed. Results have been distributed to WP partners.
The thematic circle around STYX and DEBRIS (IKE) has been enlarged with POMECO (KTH) and SILPHIDE (EDF) to extend the database for model development and WABE (IKE) validation.
Major joint activities were related to the preparation of a special issue volume of Nuclear Engineering and Design (NED) on Particulate and Porous Debris Coolability. This includes exchange in the frame of reviewing of the contributions of the European partners about: -scenario evaluations, -formation of particulate debris from inflow of corium into water in the lower head or in ex-vessel water pools, -basic laws determining coolability in a particulate debris bed (friction and heat transfer), -comparisons of experiments and derived laws respectively model results (e.g. WABE and MC3D calculations on SILFIDE experiments), -applications of ATHLET-CD and CATHARE/ICARE modules on multidimensional coolability of particulate debris beds under reactor conditions, -ex-vessel debris coolability and MCCI with emphasis on porosity formation in spread layers under top and bottom flooding.

In the above frame, and especially the context of SARNET co-operation, editorial overview articles are currently written for the NED issue in joint work about the different sub-subjects. Especially, this concerns in one overview the different experimental and theoretical approaches on basic laws, the determination of dryout heat fluxes and their relevance for evaluating coolability under reactor conditions, the necessity of multi-dimensional models with appropriate basic laws and the extended coolability under realistic conditions of non-homogeneous particle beds. In another overview, the status on ex-vessel melt behaviour and coolability is addressed. Comparison calculations on quenching of particulate debris in the lower head have been performed between the ATHLET-CD module WABE and CATHARE/ICARE modules. Further comparison calculations with these codes demonstrate extended coolability due to 2D effects and cooling of dry regions in the steam flow. More detailed comparisons are envisaged in future work. In general, these overview and comparison works shall form the basis for more detailed elaborations in SARNET. New calculations on basic quenching experiments are e.g. presently performed at IKE on DEBRIS facility for comparison with calculations of IRSN.

In term of corium coolability during corium concrete interaction, additional data on water ingression mechanism have been obtained in the frame of MCCI-OECD program. The contribution of this mechanism to the coolability has been evaluated and SWICCS results have been analysed with CORCON by UPM. The efficiency of this mechanism is limited and decreases when the concrete fraction increases in the melt. CEA has focused its activity on melt ejection modelling with implementation of PERCOLA models in TOLBIAC-ICB code. If the efficiency of this second mechanism is better and directly related to particulates debris coolability, experimental validation in prototypic material stumbles over technological difficulties to avoid crust anchorage. Last separate effect melt ejection test in the frame of OECD program was unsuccessful and data about crust morphology (number of opening, size and diameter evolution related to freezing…) are still missing.
With new modelling work, IKE is developing an unified approach to treat both porosity formation by water injection from below or porosity formation by effect of sparging gas on melt ejection and debris formation in case of top flooding.

The VULCANO COMET experiment proposed by FZK has been selected in the frame of the CEA EC PLINIUS Transnational Access to Research Infrastructure FP5 project. The objective is to validate with prototypic oxidic corium the COMET-PCA concept that has been developed at FZK and previously tested on high temperature simulants (aluminium thermite). This test was successfully performed at CEA in October 2005. After IKE pre test calculations, post test analyses and post test calculations with WABE are planned jointly with IKE and FZK.

In the frame of MCCI studies, CEA has performed three VULCANO-CCI experiments (2004-2005) two with siliceous concrete and one with limestone concrete. Preliminary analysis of these three tests shows a faster radial ablation for both kinds of concrete, nevertheless more important for siliceous concrete. This trend seems contradictory with expected bubbling pool thermal hydraulic if boundary conditions are uniform. If dissymmetry is confirmed for siliceous concrete by the recent CCI-3 test performed in September 2005 by ANL, which reproduces on both sides the fast radial ablation behaviour observed during CCI-1 test on one side only, the profile ablation of CCI-2 test performed with limestone common sand concrete was homogenous.
On going material analysis and the continuation of VULCANO, as CCI (ANL), data analysis will contribute to explain the physical behaviour at boundaries which is a necessary step to improve existing simulation tool models and explain the difference observed.

First results of CEA ARTEMIS 1D program to address in simulant fluid the boundary condition issue for an interface releasing gas and the status of facility modifications to run 2D experiments were presented by CEA, during a Franco- German meeting in July 2005. From ARTEMIS 1D experiments, it is concluded, that for reactor conditions, solid crust is formed at interface with concrete with a boundary temperature close to the liquidus temperature of the melt. First ARTEMIS experiment in 2D has been successfully performed in September 2005. First observations show a faster radial ablation for homogeneous gas injection. This trend has to be confirmed by a detail analysis including material analyses.

In the frame of EC LACOMERA platform, FzK performed with IRSN a 2D corium concrete interaction test in stratified pool configuration, COMET-L1, using both metallic and alumina phases produced by thermitic reaction. The test duration was limited to 15 mn due to technological problem with sustain heating. The second test, COMET-L2, has been run with success, at the beginning of 2005, in homogeneous pool configuration (metallic pool). Results have been not fully distributed to offer the opportunity to perform a benchmark in blind calculation. A new test, COMET-L3, in stratified pool configuration is scheduled by the end of 2005.

Within this work-package, all countries contribute to the MCCI-OECD program. CEA, EDF, IRSN, FRA-ANP, GRS, UJV, KTH contribute directly to MCCI-OECD benchmark exercise organised by CEA around CCI tests first in blind conditions and then with a common set of parameters defined after the distribution of the results. If codes reproduce quite well the CCI-2 homogeneous behaviour, they are not able to reproduce the CCI-1 and CCI-3 dissymmetry without direct tuning. According to different solidification models used, with some time non consistent heat transfer models, large differences appear in pool temperature with nevertheless minor effect on power distribution and ablation rates.

Additional analyses and reactor evaluations have been performed by IRSN and CEA with MEDICIS and TOLBIAC-ICB codes to evaluate the sensitivity of remaining uncertainties. The most important parameters are pool configurations (homogeneous or stratified pool with oxydic and metallic layers) and heat transfer between oxide and metal. For homogenous pool the distribution of heat transfer coefficient as the boundary conditions are still important parameters.
The next step for the VULCANO facility is the preparation of a first stratified pool experiment (metal/oxide) scheduled at the beginning of 2006.

B.4 Status of the subtopic devoted to the development of SARNET thermodynamic and material properties databases

The objective of this subtopic is to maintain and develop the thermodynamic and material properties databases that are indispensable tools for reactor application but also for the design and the interpretation of experiments. The NUCLEA database (THERMODATA-INPG-CNRS) has been retained after the benchmark organised in the EC ENTHALPY Project as the reference for SARNET and for the construction of the ASTEC database.

A workshop between CEA, IRSN and THERMODATA for the NUCLEA maintenance is organized yearly at the beginning of autumn to define the priorities and the work for the next year.

The analysis of all experiment in prototypic corium and more especially the dedicated analytical experience as those performed by ITU or UJV within SARNET or by NITI in the CORPHAD project [8] performed in the frame of ISTC program contribute to the validation of NUCLEA database or to the supply of new data. Introduction of new measurements, or new models, in the database is the final step of a larger process. For example, during EC ENTHALPY project, some discrepancies were identified due to the too simplified modelling of the SiO_2-CaO-FeO-Fe_2O_3 oxide system in NUCLEA. The thermo chemical data of the this system has been reviewed and improved in 2005 by THERMODATA, with the support of IRSN. Now, the introduction of the Manara's measurements

(ITU) on the fuel at high temperatures in the hyper-stoichiometric region and of the new modelling of SiO_2-CaO-FeO-Fe_2O_3 system in the NUCLEA database has been decided.

A key issue, in severe accident understanding and modelling, concerns the coupling between thermal-hydraulic and physico-chemistry. Several corium topic partners develop different methodology to take into account the physico-chemistry within their thermal-hydraulic codes. For MCCI codes, FRA-ANP GmbH or CEA developed their own approach based on direct coupling with thermodynamic solver, within respectively COSACO and TOLBIAC codes. On a different way, IRSN develops an approach for ASTEC modules, or ICARE-CATHARE codes, based usually on tabulation of NUCLEA results for dedicated system.

For physical properties a survey will be organised by CEA among SARNET partners to collect properties and associated references to perform jointly an evaluation task and formulate additional recommendations for the material database of ASTEC, MDB.

C. CONCLUSION

Progresses about technical aspect are presented in section B but they concern also the way that networking activities are on going to rationalize R&D effort, to share the knowledge around corium behaviour and to accentuate technical exchanges among SARNET partners.

During the first year, the main objective was to initiate and make visible networking activities within a group where most of the partners use to collaborate in the frame of previous European projects or in the frame of international projects. In the frame of SARNET, Corium is a large topic dealing with more than half of the issues selected during EURSAFE PIRT exercise.

The networking activity has been promoted by the use of several tools available through the Advance Communication Tool: templates for facility, model or code description in order to collect comments, creation of discussion forums and the organisation of dedicated meeting taking also the opportunity of existing international meeting to exchange between European partners. First results are encouraging but there is yet some progress to make networking activity more visible: the contribution to discussion forums for example as to be emphasized keeping in mind that partners can exchange freely in their own name and not systematically in the name of their organisation. The coordination activity is now distributed at each subtopic level for a better efficiency and to promote exchange at the good technical level.

From technical point of view, the best results in term of jointly activities are observed around data that can be available for all corium topic partners or at least for a significant kernel. Joint activities have been reported in different fields and we can retain to illustrate this conclusion the following:

- Joint test matrix definition: in the frame of the definition of International Source Term program FzK and IRSN have decided to harmonize their test matrixes to study oxidation by air/Steam mixture and to study B_4C oxidation and degradation
- The ongoing joint publication in a special issue of Nuclear Engineering and Design about the debris bed coolability. The dissemination of new STYX results available for all partners.
- The contribution and the joint activities around MCCI-OECD program through test results interpretation, benchmarking activity and recommendation for the definition of new tests. First significant exchanges through ACT dedicated discussion forum.
- The existence of experiments performed in the frame of LACOMERA (QUENCH, COMET, LIVE) or PLINUS (COLIMA, VULCANO) platform transactional access to share more easily the

final results and to enhance the collaboration in the definition of the test parameters or through pre and pos-test calculations. By extension, the existence of ISTC programs promote similar activities among corium topic partners: top flooding models and ISTC PARAMETER, ISTC METCOR [8] and impact of conclusion on thermo-mechanical vessel behaviour, ISTC CORPHAD and NUCLEA database qualification and the proposal to perform a benchmark on MCCI phase of Tchernobyl accident with the data collected in the frame of ISTC CHESS project.

- Through technical exchanges between corium partners or between different SARNET topics, we can observe for the second period new contributions including specific requests to access experimental data or simulation tools: INR contribution to air oxidation experiments, IRSN then EDF express interest for FOREVER results, IVS to exchange with CEA on external cooling device modelling and simulation within ASTEC, CEA to have access to IKE simulation modules, proposal to provide BALI results to validate AIDA-3D simulation rules approach, CEA interest for future FRA-ANP GmbH simultaneous concrete and ceramic interaction with corium, joint proposal between different topics (corium and source term packages) to make some modification in the VULCANO or COLIMA facilities to study aerosol release through cracks in the concrete if appropriate and feasible.

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