NKS-R STATUS REPORT

Karoliina Ekström
NKS-R Programme Manager
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TABLE OF CONTENTS

1 Status summary

This report gives a short overview and summary of the current status of the NKS-R programme.

1.1 Seminars

One seminar is announced for this year, the *NKS-R Nordic-Gen4* seminar, which will be held in Risø 29 - 31 October 2012.

1.2 Young scientist travel support

No claims have been received this year.

1.3 Published reports

The following reports have been published since the last board meeting:

NKS-260	Prediction and validation of pool fire development in enclosures by means of CFD (Poolfire) Report – Year 1	POOLFIRE	01 Febr 2012
NKS-261	Guidelines for reliability analysis of digital systems in PSA context	DIGREL	01 Febr 2012
NKS-262	Intermediate report of MoReMO. Modelling Resilience for Maintenance and Outage	MoReMo	01 Febr 2012
NKS-263	Organizational factors in design and implementation of technological and organizational solutions in the nuclear industry.	SADE	01 Febr 2012
NKS-264	Modeling of interaction of multiple vent pipes in a pressure suppression pool	ENPOOL	30 Apr 2012

2 Activities initiated in 2011

Eight activities were initiated in 2011. Seven of these were initiated according to the normal schedule in January. Activity RASTEP was started later, in June 2011. DIGREL is a continuing activity, whereas the others are new activities. Six activities have delivered final reports, one report is promised 31.5 and the RASTEP final report isn't due before end of June.

All earlier activities than 2011 are finished.

Table 1 gives an overview of the status of 2011 activities.

Table 1. 2011 activities.

Activity	Description	First invoice	Report	Second invoice
AIAS	Ad-/absorption and desorption/revaporisation behaviour of iodine aerosols on containment surface	x	31.5	-

	materials			
DIGREL	Guidelines for reliability analysis of digital systems in PSA context	x	x	-
ENPOOL	Experimental and numerical studies on suppression pool issues	x	x	-
MoReMO	Modelling resilience for maintenance and outage	x	x	-
NOMAGE4	Nordic Nuclear Materials Forum for Generation IV Reactors	x	x	x
POOLFIRE	Predictive analysis of pool fires in enclosures by means of CFD models for risk assessment of nuclear power plants	-	x	-
SADE	Safety culture in design and implementation of technological and organisational solution - improving resilience of the sociotechnical system through the life-cycle	x	x	x
RASTEP (cross-over activity R/B)	Using bayesian belief network modelling for rapid source term prediction after a severe accident	x	30.6	-

3 Activities initiated in 2012

Nine activities were started in 2012. Seven are continuing activities and two are new. Contracts have been signed with all of these. First invoices are missing from six activities.

Table 2 gives an overview of the status of 2012 activities.

Table 2. 2012 activities.

Activity	Description	Funding
AIAS	Ad-/absorption and desorption/revaporisation behaviour of iodine aerosols on containment surface materials	500
DECOSE	Debris coolability and steam explosion	500
DIGREL	Guidelines for reliability analysis of digital systems in PSA context	300
ENPOOL	Experimental and numerical studies on suppression pool issues	590
MoReMO	Modelling resilience for maintenance and outage	500
Nordic-Gen4	Nordic nuclear forum for generation IV reactors	250
POOLFIRE	Predictive analysis of pool fires in enclosures by means of CFD models for risk assessment of nuclear power plants	360
SADE	Safety culture in design and implementation of technological and organisational solution - improving resilience of the sociotechnical system through the life-cycle	500
RASTEP (cross-over activity R/B)	Using bayesian belief network modelling for rapid source term prediction after a severe accident	400

3.1 AIAS

The goal of the project is to investigate the ad-/absorption and desorption/revaporisation behaviour of different iodine aerosols, IOx and CsI, in the containment. The project focuses on their interactions with dominating containment materials in light water reactors, such as epoxy paint films (Teknopox Aqua VA) and various reactive metal surfaces (Cu, Al, Zn, SS, Pt, Pd).

The production of both IOx and CsI aerosols and exposure to the studied surfaces is performed at VTT. For the production of IOx aerosols within AIAS-1 a modified version of the existing EXCI CONT facility had been build within AIAS-1 and will be reused within AIAS-2 in 2012. For the production of CsI aerosols another facility, the EXCI PC (EXperimental Study on Iodine Chemistry in Primary Circuit) has been build up at VTT in spring 2012.

Metal samples have been ordered and started to be prepared for exposure. Paint samples are currently prepared at Chalmers. Paint films of different age, exposed to heat, humidity and pre-irradiated ones (gamma radiation, dose rate = 14 kGy/h) are prepared using Teknopox Aqua VA epoxy paint. The samples will be exposed to the aerosols during late summer/autumn 2012 and transported by plane to Göteborg, Sweden. The samples will be analysed during autumn and winter 2012. Characterisations of the sample surfaces before and after exposure with the iodine species will be mainly performed at VTT, while desorption studies under different conditions (heat, gamma irradiation, humidity: FOMICAG facility) will be exclusively performed at Chalmers. Until now the analysis of the data gained from the analysis of the samples within AIAS-1 is still going on and the results are used for the planning of the conditions used in the desorption studies for the 2012 samples.

3.2 DECOSE

See attachment A1 for a detailed status report.

3.3 ENPOOL

See attachment A2 for a detailed status report.

3.4 MoReMO

Dissemination seminar and project planning meeting
A dissemination seminar with practitioners was held at Ringhals NPP in February to discuss preliminary findings and the organizational core task definition of maintenance during outage. The research group also performed joint analyses and discussions of the interview data and agreed on plans for the 2012 activities.
Submission of conference paper to ECCE 2012
A paper on “Understanding maintenance activities in a macrocognitive work system” has been submitted to the European Conference of Cognitive Ergonomics (ECCE) 2012.
Internal workshop
An internal 3 days’ workshop was held at VTT in April to identify and describe the “Working practices” associated to the core task demands of maintenance organization. A preliminary set of practices was identified. The core task model for a maintenance organization was also revised and updated. It is an on-going discussion in the research group on the methodological limitations and added-values of the FRAM for identifying resilience practices in maintenance activities

Interviews with process operators
The modeling of resilience for outage include a study of process operators, their perceived constraints (e.g., knowledge, technical systems, work practices, time, workload) and possible changes of work processes to improve safety and efficiency. Recently, we discussed these topics with ten process operators in two group interviews. The preliminary results show that over the years, the process operators have experienced increased task load, especially during outages. Meanwhile, the level of experience among process operators has decreased due to changes in the education and staff turnover. They emphasized that the transfer of plant knowledge and understanding from experienced workers to newcomers has decreased. The interviews also provided examples of trade-offs between efficiency and thoroughness during outage, and between concentrating and distributing activities at the plant. The process operators suggested an integrated, handheld device for procedures, work orders, communication and data links as a major safety and efficiency improvement. The interviews will be complemented with field observations during an outage in August 2012.

3.5 Nordic-Gen4

A kick-off meeting has been held in Gardermoen (airport Oslo) on 22 March 2012. The aim of this kick-off meeting was to plan the activity of the network for 2012 (and especially the next seminar in Risø), to get updated on the latest Gen-IV activities by the different participants and to discuss the future of the network.
The preparations of the next Nordic-Gen4 seminar are well under way. A local organizing committee has been established, consisting of Bent Lauritzen (DTU Nutech), Erik Nonbøl (DTU Nutech), Dorte Juul Jensen (DTU Wind Energy), Søren Fæster (DTU Wind Energy), Morten Mostgaard Eldrup (DTU Energy conversion), Peter Kjær Willendrup (DTU Physics), Pia Elhauge (DTU Elhauge, DTU Nutech –secretary). The first announcement was sent out on the 4th of April. Detailed information and registration information can be accessed through the updated website www.Nordic-Gen4.org (which is maintained by IFE/Halden).
Several invited speakers have already confirmed their participation, such as Concetta Fazio (Nuclear Materials research in Europe), Christian Linsmeier from Garching (Advanced fusion materials characterization: The FEMaS project), Janne Wallenius, KTH (ELECTRA - a European Lead Cooled Reactor), Ferenc Mezei, ESS, (ESS target design approach: common challenges).
At the kick-off meeting, Rudi Van Nieuwenhove, Sami Penttilä, Bent Lauritzen, Natalia Luzginova, Marketa Zychova, and Radek Novotny gave an overview of the Gen-IV activities within their organizations. At IFE/Halden, work is ongoing on instrument development (for Gen-IV) and the testing of protective coatings. Testing of some of these coatings under supercritical water is being performed by VTT.
During this meeting, it was learned that Studsvik will no longer participate in the network, since Studsvik has no longer activities in this field.
It was discussed how the network could be made sustainable in the future, assuming that the funding from NKS will not last indefinitely. One possibility is to introduce a small membership fee for all the members of the network. This is now under investigation. For universities, it seems however to be very difficult to pay even a small membership fee. Therefore, it is at present unclear whether such an approach could work.
Further, it is interesting to mention that VTT has become a full member in the EERA (European Energy Research Alliance) Nuclear Materials Program (which was launched in November 2010).

On 5 March 2012, IFE has been accepted as associate partner to VTT and participated for the first time in the EERA annual congress in Brussels 2-3 May 2012.

3.6 POOLFIRE

The following achievements can be reported between December 2011 and May 2012.

The first year report was delivered at the end of January [1].

Further work was performed on the new evaporation model for pool fires. VTT has been investigating the simulation of heat transfer in and to the liquid pool. Inside the pool liquid layer, they have studied if the buoyancy current models can improve the heat transfer. Considering the heat flux to the pool, they are studying the absorption of radiation inside the fuel vapour layer.

Lund has performed successfully the first set of validation simulations using the data from the OECD PRISME project [2]. They relate to test data where a pool fire is placed in room configurations with mechanical ventilation. The work will now be imported in the automatic generation tool developed by VTT (see report December 2011)[3]. More work needed to be done to obtain the correct information of the ventilation system from the fire tests in Cadarache, France

Together with Haugesund, Lund University conducted a first set of tests in their firelab with a small methanol pool fire using a PIV set-up for measuring the velocities in flames. The work was done as part of a joined effort where a MSc student from Haugesund College is validating a new combustion model in FDS. As part of the effort, PIV measurements were performed in a methanol pool fire and a propane sandbox burner. The PIV measurements in the methanol pool fire were successfully and first data will be available before the summer. They will form the basis for a second campaign with other fuels. Major challenges with the technique are the distribution of the particles for the PIV measurements and the filtration of the radiation from the soot. A second campaign will be planned later.

Another test campaign is planned in June where a number of different square pool fires will be performed with new build containers, which are adapted to incorporate thermocouples. Tests on methanol, heptane and transformer oil are planned and the data will be able to be used as validation data for the pyrolysis model. The final test set-up will be discussed with VTT at the end of May.

Another important step is that Ringhals and OKG visited early in 2012 their colleagues in Heysham (England) and obtained real scale data from pool fires, which will also be input for the validation of the model in a real-case set-up. As such the project has access to international data. The project is running as planned and no delays occurred.

References

1. Patrick van Hees, Jonathan Wahlqvist, Simo Hostikka1, Topi Sikanen1, Bjarne Husted2, Tommy Magnusson3, Fredrik Jörud4, Prediction and validation of pool fire development in enclosures by means of CFD(Pool fire)Report–Year1, LTH Report 3163, Lund2012.
2. Patrick van Hees, Board report December 2011.
3. http://www.nea.fr/jointproj/prisme.html (downloaded 2011-12-15)

3.7 RASTEP

The main sub-activities and indicative time plan for the activity are presented below:

Sub-activities		Start	End
A.	Initial activities	July 2011	August 2011
B.	In-depth treatment of specific issues	December 2011	June 2012
C.	Signal validation	April 2012	June 2012
D.	Dissemination of results	July 2011	June 2012
E.	Project seminar	April 2012	June 2012
F.	Project report	May 2012	June 2012

Please note that most of these activities will also be carried on into the next project phase (2012-2013).

On-going activities

Initial activities
Initial activities, mainly dealing with initial work planning, have been finalised according to plan.

In-depth treatment of specific issues
This is the most important part of the NKS project, as it addresses a number of research challenges in the practical application of BBN techniques. This part of the project is partly carried out through three M.Sc. thesis works:

- *Definition and evaluation of a dynamic source term module for use within RASTEP*
- *Uncertainty analysis, sensitivity analysis, and optimisation of a Bayesian Belief Network for analysis of severe nuclear accidents*
- *Development of a systematic method for determination of conditional probabilities in a Bayesian Belief Network*

Thesis projects are to be carried out in 2012 and 2013. The first of these projects started in January 2012 and will be finalised during June or July. Further students are evaluated, and one more of these M.Sc. Thesis projects is planned to be initiated during the autumn of 2012.

Status of MSc Thesis work "Definition and evaluation of a dynamic source term module for use within RASTEP: A feasability study"
The aim of the work is to identify methods that can introduce more of a dynamic approach into the source term module of RASTEP and to investigate how/if they can be implemented in the tool (feasibility). Four different methods have been identified of which two have been selected as the most feasible. The methods are listed below with the ones considered most feasible underlined.

- Linking RASTEP to a fast-running deterministic code
- Adjusting the existing source terms (stored in the spread-sheet)
- Using DPSA methods

– Extending the Bayesian Network to a Dynamic Bayesian Network

Mapping of all the methods have been performed. Identification of ways of applying the two selected methods has been started. Documentation and discussion of the "other" methods will also be included since they concern interesting aspects of nuclear safety analysis as well as Bayesian network theory. Remaining work includes continuation of work with application of the two methods considered most feasible, as well as report writing.

Signal Validation
A start-up meeting with IFE Halden was held in mid-April, and initiation of this work, which is planned for June 2012; the work will mainly be performed during the second project phase.

Dissemination of Results
The following dissemination of results is planned during 2011-2012:

Already done
- Conference paper and presentation at the Nordic PSA Conference *Castle Meeting 2011*; Stockholm, Sweden; September 2011

Planned
- Conference paper and presentation at PSAM 11 *Probabilistic Safety Assessment and Management*; Helsinki, Finland; June 2012
- NKS report for phase 1 of the project.
- Presentation at NKS-R/B mini seminar (if held during the year)

In addition, the project is presented to various organisations when suitable occasions arise. As an example, RASTEP was presented to the IAEA (Nuclear Safety Division) in early 2011.

Project seminar
A project seminar will be held during the spring or early autumn of 2012.

Finalisation of project report
The NKS project report is planned to be released in a draft version during June 2012; finalization will follow within a month or two.

3.8 SADE

The main objective of SADE project is to identify the organizational challenges associated with design and implementation activities and contribute toward better evaluation of the risks linked to new designs and their implementation.

The following activities were planned for the year 2012:

1. In-depth analysis of the interviews conducted in 2011
2. Workshops with the power companies and the regulators in Finland and Sweden
3. Additional data gathering concerning the interface and collaboration between design organizations and end users / operators
4. Preliminary model of human and organizational factors affecting the design process.

5. Internal workshops with the research parties
6. Final report of the second phase of the SADE project

During the first reporting period of 2012 the following activities were performed:

1. In-depth analysis of the interviews conducted in 2011 is currently on-going. The analysis is focused on the identification of the factors affecting the design process and in particular on the factors emerging from the interactions of different actors involved in the design process.

2. Additional data gathering took place in the beginning of the year 2012. At the present time data were collected through:

- One workshop organised in Sweden with four representatives from a vendor.
- Two interviews conducted in Sweden with representatives from a power plant.
- One interview conducted with representative from the Swedish regulator

3. Internal workshops with the research parties have been planned and will take place in the month of May and June 2012

4. The development of the preliminary model has started and will continue during the internal workshops

5. The planning of workshops with power companies and regulators in Finland and Sweden has been discussed in the research group. The actual organisation of the workshops will take place in the late spring 2012. Workshops are conceived for discussing the preliminary model with stakeholders, and it will serve both the scope of further data gathering for the research project and as preliminary validation of the model itself.

Potential difficulties and delays

Potential difficulties and/or delays in achieving the project's objectives are:

- Delay in conducting workshops with power companies and regulators due to availability of representatives of those organisations.

Envisaged solution: planning the workshops with representative should start as soon as possible.

- Difficulties in the identification of the factors emerging from the interactions of different actors involved in the design process due to sensitive of data and willingness of the stakeholders to discuss the topic.

Envisaged solution: in the case available data are not sufficient to identify the emerging factors, research will also make use of information of available literature.

Attachments

A1. Status report DECOSE

STATUS REPORT OF DECOSE-NKS
May 11, 2012

Work at Royal Institute of Technology (KTH), Division of Nuclear Power Safety DECOSE-NKS and APRI-8

Pavel Kudinov, Simone Basso, Alexander Konovalenko, Sachin Thakre, Liangxing Li, Weimin Ma, Aram Karbojian.

Deliverables of KTH in 2012:

Deliverable 1: The effect of the heaters geometry on the DHF. Comparison of data from POMECO-HT and COOLOCE. POMECO-FL tests for effective particle diameter.
The goals of the tests are (i) to provide comparison of DHF data with the same particles in COOLOCE and POMECO-HT which use different test sections and heater geometries, and (ii) provide measurements of pressure drop and effective particle size in POMECO-FL facility. POMECO-HT and POMECO-FL facilities have been prepared for the tests. The experiments will be started as soon as the particles will be delivered to KTH lab.
Task completion: 15 %

Deliverable 2: DECOSIM code development and validation against the experimental results produced in COOLOCE and POMECO-HT facilities.
Validation of the DECOSIM code has been started against existing COOLOCE data. Results show reasonably good agreement between experiment and prediction. Validation will be continued when new data will become available from POMECO-HT and POMECO-FL facilities.
Task completion: 30 %

Deliverable 3: Investigation of particulate debris spreading and possible effect of heaters in COOLOCE facility (Task 4).
New PDS-C facility (which stands for particulate debris spreading – closures) has been commissioned. Exploratory tests with stainless steel particles have been performed. A mock-up of the COOLOCE heaters is under design. The tests will start as the particles will be delivered to KTH lab.
Task completion: 20 %

Deliverable 4: DEFOR-A confirmatory series of tests with melt simulant material (Task 2).
Two confirmatory DEFOR-A tests have been performed with new corium simulant material ZrO_2-WO_3. The effects of jet free fall height and melt superheat were investigated. We found similar dependencies for the melt agglomeration fractions as function of water pool depth as in the previous DEFOR-A tests with another simulant material. The effect of the jet free fall height seems insignificant with respect to the particle size distribution.
Task completion: 40 %

Deliverable 5: Application of MC3D to analysis of steam explosion in a BWR containment (Task 8).
Molten fuel-coolant interaction (FCI) scenarios are considered for a Nordic BWR conditions with different jet diameters, initial melt mass and fragmentation models in order to assess the effect on the pressure rise in the containment, impulse on walls and the amount of fragmented mass. The comparison of results shows that the rate of pressure rise in the cavity is higher for larger jet diameters.
Task completion: 10 %

Deliverable 6: Reporting of the POMECO-FL, POMECO-HT and PDS experiments.
Reporting of PDS and DEFOR-A tests have been started.
Task completion: 20 %

Deliverable 7: Delivery of relevant experimental data to the simulation partners.
The task has not been started.
Task completion: 0 %

Work at VTT
DECOSE-NKS and SAFIR2014

Eveliina Takasuo, Ville Hovi, Niina Könönen, Mikko Ilvonen, Ilona Lindholm, Stefan Holmström, Tuomo Kinnunen

Deliverables of VTT in 2012:

Deliverable 1: The effect of the heater geometry on the DHF. Comparison of data from STYX with COOLOCE.
A sieve analysis has been performed for the alumina gravel used in the STYX experiments in order to achieve a particle size distribution that corresponds to the original one. The central heaters of the cylindrical test bed which were in poor condition have been replaced with new heaters. Other maintenance work has been done in order to prepare for the experiments.
Task completion: 20 %

Deliverable 2: Experiment with cylindrical geometry with water ingress through the sidewall.

The inner cylinder of the test bed has been sent to an engineering workshop for modifications in which removable sidewalls will be installed.
Task completion: 10 %

Deliverable 3: Experiment on the effect of initial pool subcooling with cylindrical debris bed geometry.

No activities yet. This experiment presumably requires no significant modifications to the test facility.
Task completion: 0 %

Deliverable 4: PORFLO code development and validation calculations against the experiments.

A 3D unstructured grid model of the cylindrical test bed has been generated by ICEM CFD. The model can be read into Fluent and PORFLO (in .cgns format). The debris bed friction models have been partially implemented into the latest PORFLO version.
Task completion: 20 %

Deliverable 5: Application of MC3D to analysis of steam explosion in a BWR containment.

No activities yet. A new research scientist has started to study steam explosion phenomenology but calculations have not yet been initiated.
Task completion: 0 %

Deliverable 6: Feasibility study for advanced instrumentation.

Discussion of the possibility of a double-tip conductivity needle probe has been on-going with Dresden-Rossendorf research center. Basic technical issues concerning the installation and positioning of the probe in the test vessel have to be resolved before reliable cost estimation can be done.
Task completion: 15 %

Deliverable 7: Reporting of the COOLOCE experiments.

Reporting will be started as soon as the there is enough data available.
Task completion: 0 %

Deliverable 8: Delivery of relevant experimental data to the simulation partners.

Reports of the experiments will be distributed after their completion. Reports and detailed specifications of the previous experiments are available.
Task completion: 0 %

A2. Status report ENPOOL

STATUS REPORT OF ENPOOL-NKS and NORTHNET RM3 April 19, 2012

Work at Lappeenranta University of Technology (LUT)
ENPOOL-NKS, NORTHNET RM3 and SAFIR2014/EXCOP

Markku Puustinen, LUT

Deliverable 1: Execution of the experiment series on DCC.

Behavior at the blowdown pipe outlet during air/steam discharge needs to be investigated experimentally in more detail in order to improve simulation models. To achieve this goal sophisticated measuring devices (for example a Particle Image Velocimetry system and a modern high speed camera) have been installed to the PPOOLEX test facility in 2011.

Direct contact condensation (DCC) at the blowdown pipe outlet with improved instrumentation for tracking the flow fields and the level of turbulence will be studied experimentally in the PPOOLEX facility. The overall goal of the experiments is to produce CFD grade measurement data of rapid steam condensation processes to be used in the development of simulation tools by VTT and KTH.

Task completion: 10 %

Deliverable 2: Reporting of the DCC experiments.

Task completion: 0 %

Deliverable 3: Execution of the experiment series on the dynamics of free water surface in the blowdown pipe.

PPOOLEX experiments in 2012 will also provide necessary data for the development of the effective momentum source (EMS) model at KTH. Dynamics and movement of the free water surface in the blowdown pipe will be detected with a fine net of measurements. Six experiments with different steam flow rates and transient times will be carried out according to the test plan written by KTH. The experiments will focus on the development of thermal stratification during a low mass flow rate period and on complete mixing due to chugging regime. These data are needed for the systematic validation of the GOTHIC models.

Possibilities to track the movement of the steam/water interface in the blowdown pipe with level and void fraction probes have been studied. The price of this kind of systems with the needed electronics and software is in the range of 20k$ to 25k$. This is considered to be too high and therefore the movement of the water level will be tracked with thermocouples.

Task completion: 20 %

Deliverable 4: Reporting of the free water surface experiments.

Task completion: 0 %

Deliverable 5: Delivery of relevant experiment data to the simulation partners.

Task completion: 0 %

Work at VTT
ENPOOL-NKS and SAFIR2014/NUMPOOL

Timo Pättikangas, Jarto Niemi, Antti Timperi and Michael Chauhan, VTT

Deliverable 1: CFD simulation of chugging in a PPOOLEX experiment.

The CFD model for chugging is further developed. The models for heat transfer and the interfacial area of liquid water and vapor are improved. In CFD modeling, the goal is to obtain correct collapse speeds of vapor bubbles and correct penetration of liquid water in the vent pipes. The PIV measurements are used for detailed comparison of the calculations to the experiments, when they become available. Simulations of the chugging phase of a PPOOLEX experiment are performed with a fine mesh and a short time step in order to achieve improved resolution in the simulations.

Modifications of the direct-contact condensation model have been started. The present condensation model is compared to Japanese observations on the heat transfer coefficients in the liquid and vapor phases. The condensation model is modified to obtain higher condensation rates at the outlets of the vent pipes and to obtain lower frequency of the chugging oscillations. Test simulations are being performed.

Task completion: 20 %

Deliverable 2: FSI calculation of collapsing vapor bubble in a PPOOLEX experiment.

Modeling of the rapid bubble collapse is refined by taking into account the effect of the finite condensation rate. This is done by fitting the calculated collapse time and pressure load with the experiments. Proper approximations for the condensation rate are searched by co-operation with the CFD part of the project. The simulations are compared to the high-speed video images and pressure measurements from the experiments. The scaling of the pressure load amplitude and duration from the laboratory experiment to the BWR are also studied.

A short Fortran program has been written, which solves the one-dimensional dynamics of a spherical, collapsing steam bubble. The code was first validated against earlier analytical and numerical calculations for the simplified case of infinite steam condensation rate. So far, constant condensation rates have also been tested. The condensation rate has been adjusted so that the bubble collapse time observed in PPOOLEX experiment COL-01 results. The aim is to test different approximations for the condensation rate and to compare the collapse times and pressure loads near the bubble with the experiments.

Task completion: 10 %

Deliverable 3: FSI calculation of chugging with a BWR model with multiple vent pipes.

The loads in a BWR are considered with an acoustic model of half or full containment, i.e., 8 or 16 vent pipes. Stochastic analysis of the loads originating from multiple vent pipes is used to analyze the loads in the chugging phase. The pressure source statistics, such as load amplitude and delay between the vent pipes, is determined from experiments and data available in literature. Simulation of the loads and structural response in the BWR geometry is performed.

Modeling the phenomenon by using modal superposition technique is studied. Modal superposition procedure is less time consuming than direct time integration, and utilizing the method would enable the examination of the response of the structure with varying loads, resulting from the variation in the desynchronization time of chugging.

The work on this subtask will be started in October.
Task completion: 0 %

Deliverable 4: Report on the CFD and FEM calculations.

A report on the CFD and FEM calculations will be written.
Task completion: 0 %

Work at Royal Institute of Technology (KTH), Division of Nuclear Power Safety ENPOOL-NKS and NORTHNET-RM3

Hua Li, Walter Villanueva, and Pavel Kudinov, KTH

Deliverable 1: Development of the new Effective Heat Source and Effective Momentum Source models.

Development of the Effective Heat Source (EHS) and Effective Momentum Source (EMS) models is on-going. Different approaches to the implementation of the EHS model have been proposed, which take into account the dynamics of steam condensation inside a blowdown pipe and pool conditions. Examples of simple approaches include uniform heat fluxes on the walls of the blowdown pipe and heat fluxes at the pipe's outlet. These approaches can result in different thermal stratification behavior in the pool.

The EMS model has been developed further by taking into account the varying nature of the steam mass flux (with respect to time) from the steam source. It has also been established that if the steam mass flux varies significantly in time, variable effective momentum can provide more accurate prediction of the time scales for mixing of the pool. The model is improved by varying the effective momentum for different time windows. Calculation of the effective momentum can also be improved significantly given an accurate water level measurements inside the blowdown pipe which is expected to be implemented with the new series of PPOOLEX tests.

Task completion: 20 %

Deliverable 2: Validation of the current version and modified GOTHIC code models against latest available data.

The EHS model has been validated against PPOOLEX STR-03 and STR-04 tests that exhibited thermal stratification. Further analysis and improvement of the EHS model to predict more accurately the thermal stratification in the experiment is being conducted. In addition, the effect of the clearing phase in these tests on the general thermal behavior of the pool is currently being investigated.

Validation of the combined EHS and EMS models against STR-09 and STR-10 tests are being done. These tests exhibit both thermal stratification and mixing. A variable effective momentum is implemented along with a modified EHS model. Validation of the EHS/EMS models against other STR tests, namely STR-05, 06, 07, 08, and 11, will also be performed.

Task completion: 15 %

Deliverable 3: Pre- and post- test simulations of the new series PPOOLEX tests.

Pre- and post- test simulations will commence in May 2012.

Task completion: 0 %

Deliverable 4: Report on the model development and validation.

A report on the model development and validation will be written.

Task completion: 0 %