R2CA Newsletter

Issue 2

24/08/2021

What's new in R2CA

The project is now in its second period. After the first year, the consortium members were brought together in a webinar to discuss the main achievements, the work plan for the future and identify potential issues. **Despite the health crisis, most of the work has been carried out on time.**

The first-period work was focused on reactor calculations of accidental scenarios and their associated release evaluations. The numerous results obtained should be presented outside the consortium next year at a dedicated open workshop.

Some of the project advances can be summarized as follows:

- **About 48 accidental scenarios** (both LOCA and SGTR) **were calculated on different kinds of reactor designs** (VVERs, PWRs, EPR and BWR), covering both DBA and DEC-A conditions, a simplified radiological evaluation tool was built ;
- **22 tests related to Zr-4 and E110 Hydrogen uptake in representative conditions of SGTR transients** (300-400°C) **were carried out** for clad hydration model upgrading ;
- **24 sets of reactor measurements of the iodine activity increase in primary circuit during power transients were provided** for iodine-spiking model improvement ;
- **1409 were selected from the collected burst test results**, for the future development of a new burst criterion based on clad stress ;
- **9 related publications were produced**.

In parallel, the R&D in support of the model improvement was initiated. First reports, to be published in August, should already contain interesting information concerning clad burst failure, secondary hydriding, fission product releases from defective rods, iodine partitioning in damaged steam generators, behavior of high BU fuel zone during transients.

Nathalie Girault, IRSN

SCIANTIX Course

On October 16, 2020, we held the first online SCIANTIX Training Course. SCIANTIX is an opensource code devoted to the simulation of inert gas behaviour within nuclear fuel, designed for inclusion in fuel performance codes. **In the frame of R2CA, SCIANTIX is being extended to also model the production and transport of fission products within the fuel pellet**.

The training included a general introduction to physics-based modelling of inert gas behaviour and proposed hands-on case studies for the participants to directly use SCIANTIX. The 30+ participants to the training came from both institutions within and outside the consortium of R2CA. **The material used in the Training** (slides, case studies with related documentation) **is publicly available, together with the source code of the SCIANTIX version used**. The recording of the Training is also available, divided in six videos covering all the topics presented. We take the occasion to thank all the participants to this first online training and look forward to organizing other activities!

L. Luzzi, POLIMI

News from Task 2

The main objective of Task 2.3 of the R2CA project is the simulation of the LOCA and SGTR accident. These simulations will serve as a reference point for Task 2.5 in which several improvements to the codes/models will be evaluated. Prior to this task several reactor cases were selected by the R2CA Senior Expert Group. It was decided to give at the different organizations as much liberty as possible with their choice of reactor cases to simplify the calculations for them.

This task includes a total of 13 organizations, with LEI as leading organization. The organizations provided a LOCA and/or SGTR simulation for DBA and/or DEC-A conditions for Light Water Reactors (PWR, EPR, VVER, BWR). In the following table you can find the list of partners with the reactor-type analyzed and the performed accident simulation and accident conditions.

Organization	Type of reactor	LOCA		SGTR	
		DBA	DEC-A	DBA	DEC-A
ARB	VVER-440	✓	✓	✓	✓
	VVER-1000	✓	✓	✓	✓
Bel V	PWR-1000			✓	✓
BOKU	PWR-1400			✓	✓
	VVER-1000			✓	✓
CIEMAT	PWR-1000			✓	✓
ENEA	PWR-900	✓	✓		
HZDR	PWR-Konvoi	✓	✓		
IRSN	PWR-900	✓	✓	✓	✓
LEI	BWR-4		✓		
EK	VVER-440	✓		✓	
SSTC-NRS	VVER-1000	✓	✓	✓	✓
TRACTEBEL	PWR-1000			✓	✓
UJV-NRI	VVER-1000	✓		✓	
VTT	EPR-1600	✓			
	VVER-1000	✓			

For every simulation/analysis a separate report containing detailed information is drawn up in accordance with a prescribed table of contents. In this way, **37 individual reports have been provided by the different participants**. The deliverable linked to this task (Deliverable 2.5) will contain a summary and a complete overview of all different analysis. For example, information on the main thermal hydraulic, thermo-mechanics, core degradation and fission product behavior results will be included in this report. In the framework of task 2.3 several future improvements were already foreseen to be implemented in task 2.5 (Deliverable 2.7).

Initially, the deliverable 2.5 was planned to be finished by the end of February 2021. However, due to several problems COVID-19 related (i.e., working from home, problems connect to calculation clusters and other related workload reasons) some calculations were postponed. Consequently, **the deliverable report is planned to be finished by the end of summer of 2021**.

P. Bradt, TRACTEBEL-ENGIE

News from WP3 Group

WP3 is dedicated to a better evaluation of the radiological consequences of Loss-Of-Coolant Accidents in PWRs and BWRs by improving both simulation tools/models and calculation methodologies. Involved partners started their work related to fuel structure modelling, fuel rod cladding burst, core modelling approach and LOCA calculation methodology for failed rod evaluation, fission products releases from fuel and their behavior in the containment vessel.

Regarding fission product behavior, the activity started with an analysis of existing data for FP behavior (especially iodine in containment and more particularly with the use of experimental measurements issued from the ***B***ehaviour of ***I***odine ***P***roject (BIP, OECD) for iodine paint adsorption model refinement in COCOSYS code for Ameron Amerlock coatings used in VVERs. A bibliographic review of the fission product and structural material release models, developed in ASTEC for severe accidents, was also performed.

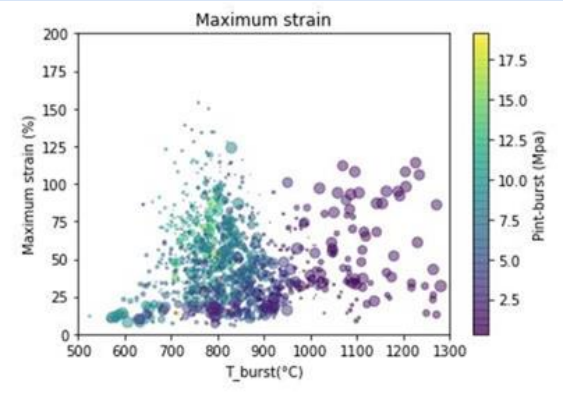


Figure 1: Reassessment of Burst test database

An IRSN existing Zy-4 burst database has been extended with recent data provided by R2CA partners or from international programs and contains about 1450 burst test results in various conditions. A review of the clad failure models embedded in some codes (i.e. ASTEC, DRACCAR) has also been initiated.

A historical outlined methodology for LOCA analyses built from TRANSURANUS studies and currently used for German PWRs safety evaluation was provided. It includes models suitable for performing detailed clad thermo-mechanical simulations including ballooning and burst, high-temperature oxidation and hydrogen pick up occurring during a LOCA.

Progress has been made for coupling of the TRANSURANUS code to mesoscale simulations (MFPR-F and SCIANTIX) via point models. More precisely, the current coupling with MFPR-F now allows for simulating LOCA cases with pre-irradiated fuel (from the IAEA–FUMAC project). Regarding the open-source code SCIANTIX, work has begun for enhancing the High burnup structure (HBS) model. Starting from the current description of the HBS formation, the model is expected to also simulate the fuel porosity evolution as a function of burn-up.

In the meantime, work on calculation chains also started. Kraken, the newly developed reactor simulation framework used by VTT, was thus updated by changing the Xs library generation tool to facilitate the anticipated future use of new software in the chain. In the statistical system, the software also has been replaced by an in-house sampling tool more easily usable and modifiable.

V. Busser, IRSN

News from WP4 Group

WP4 is dedicated to the evaluation of the radiological consequences of steam generator tube rupture. The partners started important activities related to fission product (FP) release and transport simulation and analyses of secondary hydriding phenomena in defective fuel rods (FR).

The input model for the VVER-1000/V320 was revised and updated to suit the FP transport calculation with ATHLET-CD. Improvements have been made in the source code of MAAP (EDF version) to model more precisely the releases for different groups of fission products and to evaluate the release of radioactive FP from water flow from the SGs. The available information on existing models for iodine spiking, experimental data and databases on spiking phenomena and related regulatory requirements have been collected and evaluated.

The quantification of the impact on the rod failure on the fuel temperatures and hence microstructural changes and fission product release was started using the TRANSURANUS code for VVER-1000 scenarios. An improved FP release model has been developed for the SCIANTIX code focusing on a physics-based treatment of the FP behaviour at the grain boundaries, and on the use of an implicit spectral solver to handle the time evolution of FP concentrations. The implementation of the ANS5.4 model into the latest version of the TRANSURANUS code started.

New NPP measurements were evaluated for the improvement of iodine spiking model in the RING code considering the change of PP, reactor power and coolant boric acid concentration. Bibliographic review on secondary degradation of defective FR in normal operating condition were performed. The physical mechanisms involved in the secondary hydriding phenomena were identified and the scenario assumptions made in the literature were analysed. Exploratory studies on the effect of hydrogen precipitation on secondary hydriding were carried out and the first version of the model describing the diffusive mixing of the gases under the cladding of the fuel rod was prepared as a standalone module with plans to couple it with the TRANSURANUS code. A new model for hydrogen uptake under transient conditions was tested.

Experimental series with hydrogen charging of Zircaloy-4 and E110 alloys were successfully completed. The tests covered the temperature range of 300-400 °C and experimental data showed the increase of hydrogen uptake with the increase of temperature.

Z. Hòzer, ELKH

Upcoming events of interest for the R2CA community

- NUGENIA-TA2, SNETP, ENEA, UNIPI, "*Short Course on Severe Accident Phenomenology*", Bologna, October 25-29, 2021.
- On July 2021, the *EURATOM Research and Training Work Programme* 2021-2022 has been published. Details on Call for proposals are available on the Commission Funding portal.

Dissemination activities currently on-going

[1] R. Calabrese, A. Schubert, et alt., "*M5 cladding material: reviews of models relevant for LOCA simulation"*, International Conference Nuclear Energy for New Europe NENE2021, Bled (Slovenia) September 6 - 9, 2021.

[2] I. Zamakhaeva, A. Kecek, "*Adsorption of iodine on painted surfaces in Nuclear Power Plants containment buildings"*, International Conference Nuclear Energy for New Europe NENE2021, Bled (Slovenia) September 6 - 9, 2021.

[3] F. Feria, C. Aguado, et alt., "*Effect of hydrogen precipitation on in-clad hydrides distribution in irradiated fuel rods"*, Annual Meet. of the Spanish Nuclear Society 2021, Granada (Spain), 2021

[4] R. Iglesias, L. E. Herranz, et alt., "*Modeling SGTR DEC-A sequences with the MELCOR Code"*, Annual Meeting of the Spanish Nuclear Society 2021, Granada (Spain), 2021.

[5] Z. Soti, P.V. Uffelen, et alt., *"Extending the application of TRANSURANUS to coupled code calculations and statistical analysis"*, TOPFUEL 2021, Santander (Spain) 24-28 October 2021.

[6] Z. Hózer, P. Szabó, et al., "*Review of experimental databases for SGTR and LOCA analyses"*, TOPFUEL 2021, Santander (Spain) 24 - 28 October 2021.

[7] F. Feria, L.E. Herranz, "*Scoping calculations of in-clad hydrides distribution under secondary hydriding in defective fuel rods"*, TOPFUEL 2021, Santander (Spain) 24 - 28 October 2021.

[8] G. Zullo, D. Pizzocri, et alt., "*Coupling of SCIANTIX and TRANSURANUS: Release of radioactive fission products",* International Workshop for TRANSURANUS Users and Developers 2021.

[9] G. Zullo, D. Pizzocri, et alt., "*On the use of spectral algorithms for the prediction of volatile fission product release: Methodology for bounding numerical error"*, Journal of Nuclear Engineering and Technology, 2021.

[10] R. Zimmerl, L. Anzengruber, et alt., "*Code to experiment comparison of a steam generator hot header break at PSB-VVER test facility with RELAP5/SCDAP 4.1 thermal hydraulic system code*", International Topic meeting on Nuclear Reactor Thermal Hydraulics, NURETH19, Brussels (Belgium), 6-11 March, 2022.

R2CA Members

17 Organizations (11 Countries)

Duration

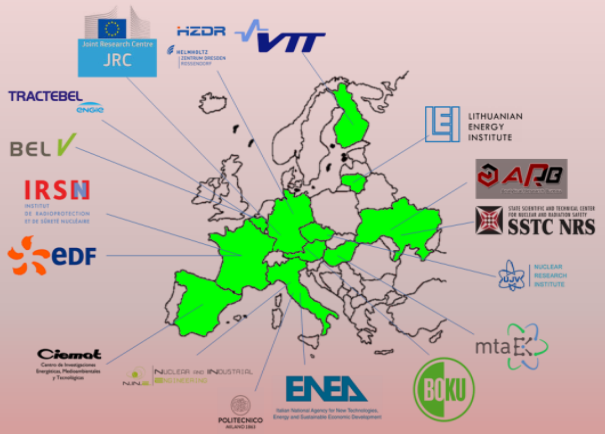
01.09.2019 – 31.08.2023

Commitment

522 person/months

Overall Budget

€ 4.2 M€ (~ ¾ funded by EU)



THE CONSORTIUM

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