NURESAFE NEWSLETTER

Issue # 1 / May 2014

IN THIS NEWSLETTER

1. INTRODUCTION

The NURESAFE project is in progress. The first year is over and the mid-term is approaching.

The **User Group** has been established with the following members:

- FORTUM
- TRACTEBEL
- KAERI
- Texas A&M University
- Penn State University

Two members of the NURISP User Group joined the NURESAFE consortium as full beneficiaries: ENEA and AREVA.

International contacts beyond Europe:

- Three UG members are non-European members.

Contacts have been established between NURESAFE and the US-DOE project CASL.

The Major European nuclear actors are involved in NURESAFE.

Four major European nuclear industrial companies (EDF, AREVA, TRACTEBEL, FORTUM) are now involved in NURESAFE.

Nine major European nuclear Research and Development Organisms (CEA, HZDR, KIT, PSI, VTT, KTH, KFKI, JSI, UJV, ENEA, NCBJ) are contributing to NURESAFE

Two major European Technical Support Organisations (IRSN, GRS) are contributing to NURESAFE.

Four European Universities (LUT, KTH, UPisa, UCL) and two US Universities (PSU, TAMU) are contributing to NURESAFE

ABOUT NURESAFE

The NURESAFE project addresses safety of light water reactors, which will represent the major part of fleets in the world along the whole 21st century.

The objectives of NURESAFE will be achieved through six sub-projects:

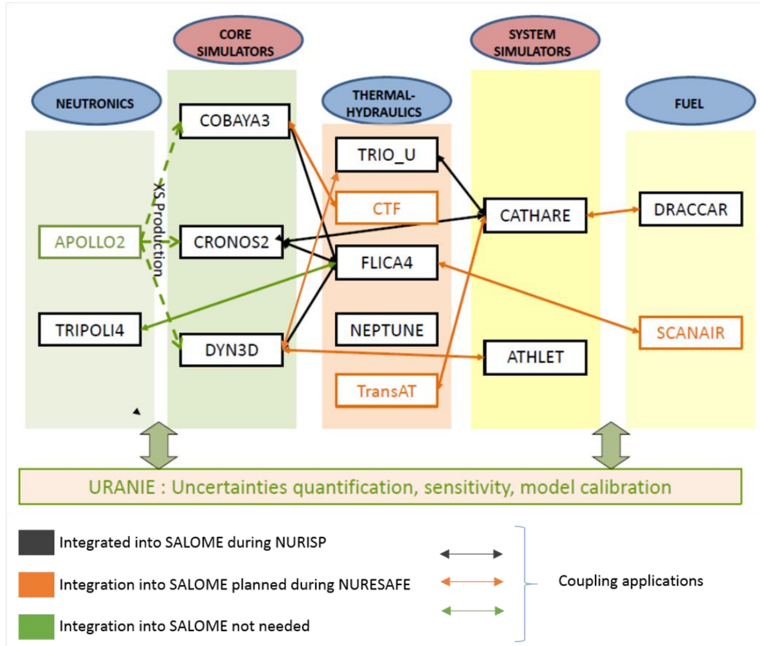
- *Sub-Project 0 (SP0): Networking*
- *RTD Sub-Project 1 (SP1): Multiphysics applications involving core physics - Coordinator: HZDR*
- *RTD Sub-Project 2 (SP2): Multiscale analysis of core thermal-hydraulics from DNS to subchannel modeling - Coordinator: ASCOMP*
- *RTD Sub-Project 3 (SP3): Multiscale and multiphysics applications of thermal-hydraulics - Coordinator: CEA*
- *RTD Sub-Project 4 (SP4): Platform - Coordinator: CEA*
- *RTD Sub-Project 5 (SP5): Education and training - Coordinator: KIT*

23 organisations participate in NURESAFE: AREVA, ASCOMP, CEA, EDF, ENEA, GRS, HZDR, ICL, INRNE, IRSN, JSI, KFKI, KIT, KTH, LGI, LUT, NCBJ, PSI, UCL, UJV, U-Pisa, UPM, and VTT.

They come from 14 European countries: Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Hungary, Italy, Poland, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

2. THE NURESIM MULTI-SCALE MULTI-PHYSICS PLATFORM

The multi-scale multi-physics platform is now assembling the following codes:



The last code versions were delivered to beneficiaries.

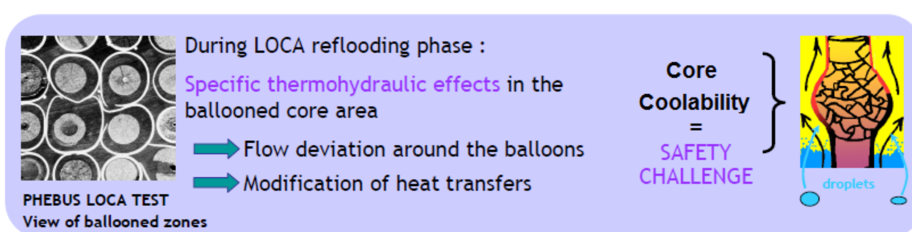
Training sessions were organised for SALOME, CATHARE, NEPTUNE-CFD, DRACCAR, TransaT, DYN3D.

HIGHLIGHTS

3. MULTI-SCALE SIMULATION OF FUEL THERMO-MECHANICS & THERMAL-HYDRAULICS

One important safety issue is the coolability of deformed fuel rods in a PWR during LOCAs.

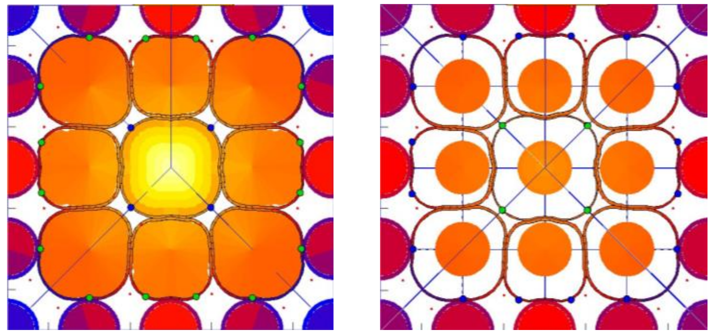
The challenging simulation of deformed fuel rods during LOCAs is now possible with the most advanced simulation tools for both thermal-hydraulics and fuel thermo-mechanics such as the DRACCAR code.



Use of the IRSN DRACCAR code for simulating ballooned rods under LOCA conditions.

SUBMITTED PAPERS BASED ON NURESAFE ACTIVITIES FOR PUBLICATION IN SCIENTIFIC JOURNALS OR (TO BE) PRESENTED IN CONFERENCES

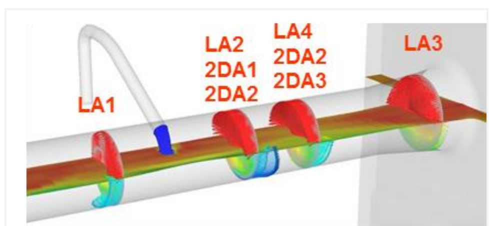
- P. Coste and N. Mérigoux, Two-phase CFD validation: TOPFLOW-PTS steady-state steam-water tests 3-16, 3-17, 3-18, 3-19 to be presented at CFD4NRS-5, Zurich, Sep. 2014
- P. Apanasevich, D. Lucas, M. Beyer, L. Szalinski, CFD based approach for modeling direct contact condensation heat transfer in two-phase turbulent stratified flows, presented at International Colloquium 150th Birthday of Richard Mollier, (Dresden, Germany)
- S. Bascou , O. De Luze, S. Ederli, G. Guillard, Development and validation of the multi-physics DRACCAR code, submitted to Annals of Nuclear Energy
- M. Tekavcic, B. Koncar, Analysis of Gas-Liquid Churn Flow in a Vertical Pipe, presented at Nuclear energy for New Europe, Ljubljana, 2013
- G. Patel, V. Tanskanen, R. Kyrki-Rajamaki, Numerical Modelling of Low-Reynolds Number Direct Contact Condensation in a Suppression Pool Test Facility , submitted to Annals of Nuclear Energy
- Y. Sato, " Computational fluid dynamic simulation of single bubble dynamics in convective boiling flows ", submitted to Multiphase Science and Technology
- Y. Bartosiewicz and J.M. Seynhaeve, Choked Flows Relevant to LOCA DEM model and implementation in system codes, presented at IMECE 2013
- A. Kovtonyuk et al., "Validation of the FFTBM-based methodology for evaluation of uncertainty of system code input parameters", to be presented at ICONE-22, Praha, July 2014
- B. Chanaron, S. Kliem, D. Lakehal, D. Bestion, V. H. Sanchez, N. Crouzet, The European NURESAFE Simulation Project For Reactor Safety, to presented at ICONE-22, Praha, July 2014
- Matej Tekavčič, Boštjan Končar, Ivo Kljenak, Simulation of flooding waves in vertical churn flow, to be presented at CFD4NRS-5, Zurich, sept. 2014
- D. Bestion, D. Lakehal, N. Tregoures, D. Lucas, H. Anglart, B. Niceno, G. Hazi, L Vyskocil, Multiscale thermalhydraulic analyses performed in the NURESAFE project, to be presented at ICONE-22, Praha, July 2014
- M. Calleja, V. Sanchez, J. Jimenez, U. Imke, R. Stieglitz, R. Macian; Coupling of COBAYA3/SUBCHANFLOW inside the NURESIM platform and validation using selected benchmarks. ANE 71 (2014)145-158.
- M. Calleja, J. Jimenez, V. Sanchez, U. Imke, R. Stieglitz, R. Macián; Investigations of boron transport in a PWR core with COBAYA3/SUBCHANFLOW inside the NURESIM platform. ANE 66(2014) 74-84.



The image on the left shows the state of the fuel computed by the DRACCAR code before the reflooding stage without fuel relocation in the balloons (which is the case for low burn up fuel) while the right picture shows the influence of the fuel relocation, as expected for high burn up fuels, on the temperatures.

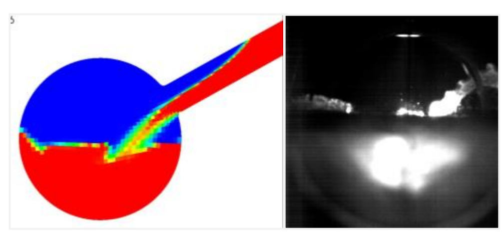
Within the NURESAFE project, IRSN and ENEA are performing the validation of the reflooding model of the DRACCAR code on such type of deformed bundle geometry based on the SEFLEX, THETIS and ACHILLES experimental programme.

4. NEPTUNE-CFD SIMULATION OF TOPFLOW PTS TESTS



After developing and validating two-phase CFD models in NEPTUNE-CFD for PTS investigations on the basis of separate effect tests (IGUCHI, Boneto-Lahaye, Air-Water Stratified flows (AWST), Steam-Water Stratified flows (SWST), KAERI-KAIST data, COSI data) the TOPFLOW tests are now simulated. Air-water tests were in good agreement with data (NURISP project). Steam-water tests are more challenging.

The first difficulty is to predict a possible stratification of the flow in the inclined feed pipe. This good agreement was obtained after having paid a particular attention to the quality of the grid in the region connecting the main pipe to the branch pipe.



The picture on the right shows a test with stratified flow and the left picture is the simulation with NEPTUNE-CFD

The turbulent mixing in the jet region, in the whole horizontal leg and in the downcomer is a major phenomenon affecting the efficiency of the condensation at the free surface and controlling the temperature field. The figure below shows temperature iso-contours in a simulation.

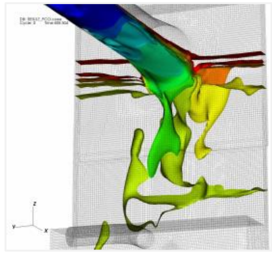
- M. Calleja, J. Jimenez, U. Imke, V. Sanchez, R. Stieglitz, José J. Herrero, R. Macián; Implementation of hybrid simulation schemes in COBAYA3/SUBCHANFLOW coupled codes for the efficient direct prediction of local safety parameters. ANE 70 (2014) 216-229.
- S. Sánchez-Cervera, N. García-Herranz, José J. Herrero, D. Cuervo; Effects of cross sections tables generation and optimization on rod ejection transient analyses, submitted to Annals of Nuclear Energy
- S. Sánchez-Cervera, N. García-Herranz, José J. Herrero, O. Cabellos, Optimization of multidimensional cross-section tables for few-group core calculations, submitted to Annals of Nuclear Energy
- N. Zheleva, N. Petrov, G. Todorova, N. Kolev, Generation and Testing of XS Libraries for VVER Using APOLLO2 and TRIPOLI4, SNA + MC 2013, Paris, 2013, October 27-31

LIST OF DELIVERED REPORTS DOCUMENTS

D62.21 - NURESAFE Project Quality Plan

SP1 reports and documents:

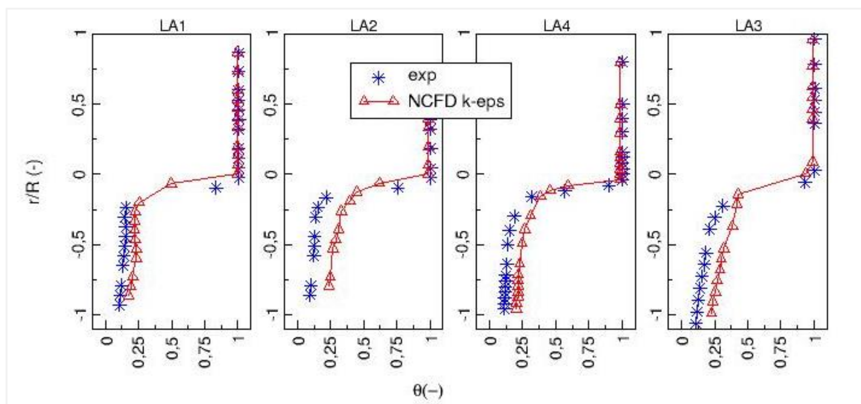
- D11.01 Detailed work plan of WP1.1
- D11.12 Specifications for SCANAIR integration
- D11.14 Adjusted TRIO-U API for coupling with core kinetics codes
- D11.15 First version of integrated ATHLET/DYN3D coupling
- D11.22 Report on FLICA UQ results for BWR ATWS
- D12.01 Detailed work plan of WP1.2
- D12.11 PWR MSLB Specification Report
- D12.21a Full system input models (ATHLET) qualified for MSLB
- D12.21b Full system input models (CATHARE) qualified for MSLB
- D12.22 Full core FLICA input model qualified for MSLB
- D13.01 Detailed work plan of WP1.3
- D13.11 BWR ATWS Specification Report
- D13.21 Full system ATHLET input model qualified for ATWS
- D13.22 Full core CTF input model qualified for ATWS
- D13.24 Nodal-level X-S library parameterized for ATWS
- D14.01 Detailed work plan of WP1.4
- D14.21 Full system CATHARE RPV input model qualified for MSLB
- D14.22a Full core FLICA input model qualified for MSLB
- D14.22b Full core CTF input model qualified for MSLB
- D14.24 TRIO-U input model of VVER-1000 RPV (up to core inlet)
- D14.25 Nodal-level X-S library parameterized for MSLB
- Min-101 Minutes of the first SP1 meeting
- Min-102 Minutes of the second SP1 meeting



NEPTUNE_CFD calculation of a TOPFLOW-PTS test, iso-surfaces of temperature in the downcomer region: the cold plume (in green) along external downcomer wall is unstable

NEPTUNE_CFD calculation of a TOPFLOW-PTS test versus measurements: non-dimension vertical temperature profiles. The vertical coordinate r is divided by the cold leg radius R, The non-dimensional temperature $\theta = \frac{T - T_{\min,CL}}{T_{sat} - T_{\min,CL}}$ where $T_{\min,CL}$ is the minimum temperature found in the cold leg.

Present NEPTUNE_CFD simulations are performed with physical models developed and validated on other experiments (mainly AWST and SWST). The comparison of predicted temperatures with TOPFLOW data shows correct trends but a problem remains with regard to the consistency of the free surface heat transfer when comparisons with the COSI experiment (done in NURISP project) are done. Some more effort should be spent on this point, which may involve developments in the way the free surface heat transfer depends on surface waviness.



5. MULTI-PHYSICS SIMULATION OF 3D CORE THERMAL-HYDRAULICS AND 3D NEUTRON KINETICS

The use of higher-fidelity codes in safety analyses contributes to the reduction of conservatism in the obtained results. Usually 3D neutron kinetic core models comprise 1D thermal-hydraulic models for the description of the coolant flow. A more advanced option is the coupling with a sub-channel code.

Within the NURESAFE project the 3D neutron kinetic core model DYN3D is being coupled with the Computational Fluid Dynamics (CFD) Code TRIO_U. This coupling will allow carrying out safety analyses for nuclear reactors at a qualitatively new level.

Both codes are already implemented into the NURESIM code platform. For the coupling of both codes the most advanced NURESIM coupling interface ICoCo is used.

- Min-103 Minutes of the third SP1 meeting

SP2 reports and documents

- D21.01. Detailed Program of Work of WP 2.1
- D22.01. Detailed Program of Work of WP 2.2
- D23.01. Detailed Program of Work of WP 2.3
- D24.01. Detailed Program of Work of WP 2.4
- D21.11. Report on the theoretical bases of ITM and phase average model coupling
- D22.11. Benchmark Definition for WP 2.2
- D23.11. Benchmark Definition for WP 2.3
- D22.11.17. State-of-the-art for the CFD Simulation of Boiling Flow in the Reactor Core
- Min-201: Minutes of the first SP2 meeting
- Min-202: Minutes of the second SP2 meeting
- Min-203: Minutes of the third SP2 meeting

SP3 reports and documents

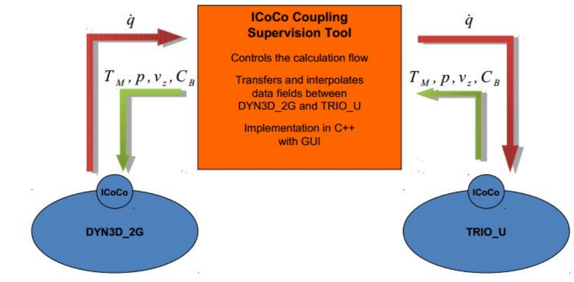
- D31.01 Detailed Program of Work of the Work Package 3.1 “Multiscale and Multiphysics Simulation of LOCA”
- D32.01 Programme of work for WP32
- D33.01 Program for Development and Validation within WP 3.3
- Min-301: Minutes of the first SP3 meeting
- Min-302: Minutes of the second SP3 meeting
- Min-303: Minutes of the third SP3 meeting

SP4 reports and documents

- Min-303: Minutes of the third SP3 meeting
- D41.01 Detailed work plan of WP4.1
- D43.01 Detailed work plan of WP4.3
- D42.11 1st delivery of sat (a building and testing software)
- D43.11 Delivery of URANIE platform, at the end of first year

SP5 reports and documents

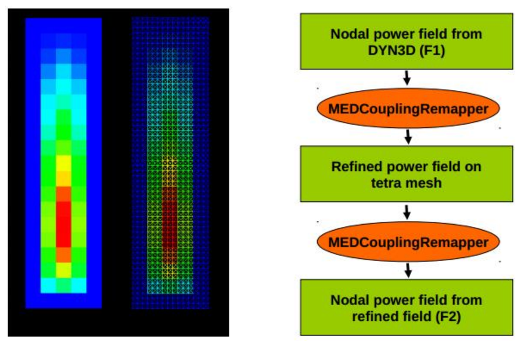
- D51.01 Core physics training sessions
- D52.01 Thermal hydraulic training courses
- D53.01 Uncertainty training courses
- D54.01 SALOME platform training sessions



Coupling and data exchange between DYN3D and TRIO_U using the ICoCo interface

The physical data interface between the codes is located at the level of the volumetric heat release rate into the fluid. The CFD code TRIO_U calculates the fluid dynamics in the reactor coolant inside the core. It provides the velocity, temperature, density and boron concentration fields to DYN3D. Based on these parameters DYN3D determines the nuclear power, calculates the fuel temperature distribution and the heat transfer to coolant. The volumetric heat source is given back to TRIO_U.

The transfer of the data between the meshes of both codes is organised via MEDCoupling Remapper function of the NURESIM platform. The use of this tool ensures the conservation of the quantities to be transferred between the very different meshes.



Transfer of the nodal DYN3D power to the TRIO_U mesh

After the implementation of the coupling it will be tested on a minicore problem developed during the NURISP project. Then the application to realistic full core problems is planned.

CONTACT

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