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Minutes of the fourth RP general meetings

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MAXIMA – Grant Agreement n° 323312

Methodology, Analysis and eXperiments for the "SafetyIn MYRRHA Assessment"

EC project officer: Mykola DZUBINSKY

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Contents

The progress of the work of four technical work packages of MAXSIMA was discussed during the last Technical Review Meeting, held at NRG in Petten, the Netherlands on March 8, 2017.

It was agreed that since several WPs and several tasks in the on-going WPs are completed, another MAXSIMA Review Meeting will be organized on an adhoc basis.

After an introduction by Paul Schuurmans (SCK•CEN), and highlighting two items: the end of the third reporting period asking for input on the work progress and achievements and resources utilization and next to this, special attention was drawn to the pending deliverables and dissemination; publications and dissemination activities.

As for the technical Work Packages, the following were discussed:

- WP2: Safety Analysis in support of MYRRHA
- WP3: Core Component Safety
- WP4: Steam Generator & Cooling Safety
- WP5: Fuel Safety

I. WP 2 Safety analysis in support of MYRRHA

Work Package leader D. Castelliti reporting.

The WP2 activities are finished. Task 2.1 and Task 2.3 activities have been concluded and all the Deliverables have been finalized and submitted to the EC.

On this last Technical Review Meeting on 8 March 2017 in Petten, two presentations were discussed in the WP2 session:

- WP2 current activities status
- Task 2.2 activities overview

Task 2.2 activities have been concluded and the final D2.4 was finalized with the implementation of the last results by May 2017.

The second presentation focused on the last activities of Task 2.2. Being the final Task 2.2 presentation, an overview of the most interesting conclusions drawn from the whole Task 2.2 has also been provided. Additionally, an overview of the D2.4 summary has been provided.

The last Operational transients (in Critical Mode) results have been shown. Most relevant transients in Sub-Critical Mode have also been shown: the fact that Sub-Critical Mode transients have only been studied by SCK•CEN excluded the chance to discuss about comparative results. Most of the presentation, however, has been devoted to an overview of the most representative studies performed in Task 2.2 and on the main Task 2.2 outcomes, findings and conclusions.

The main conclusions of the deterministic analysis of Unprotected Loss Of Flow (ULOF), Control Rod Ejection (CRE) and Protected Double Loss of Flow: such transients have been considered the most representatives and have been also studied with COBRA subchannel code coupled with MCNPx neutronic code (by CIEMAT) and with SIMMER-III code (in the frame of Task 2.3). Moreover, the Uncertainty + Sensitivity (U + S) analysis for these representative cases has been shown in its main conclusions.

Finally, the general conclusions of the Task 2.2 activities have been summarized in a few synthetic points:

- The deterministic analysis has shown a good agreement between participants for all transients examined and compared; the System Thermal-Hydraulics (STH) codes have proven to converge on shared conclusions.
- The first application of U + S methodology to MYRRHA safety analysis has shown satisfactory and promising results:
    - The input uncertainties propagation is well visible in safety-relevant output parameters.
    - A good agreement between participants on U + S main findings and conclusions can be found.
    - However, an objective difficulty has been found, during the different meetings and iterations, to determine an agreed input parameter list (and associated uncertainty bands) to be used as a basis for the U + S analysis. A convergence has been achieved but this has been identified as the most complex point of the whole U + S analysis.
- Coupled applications (COBRA + MCNPx) looks promising but still requiring a certain amount of effort to be considered as reliable as more "conventional" calculation tools. This topic will be furtherly developed in the MYRTE Project.

II. WP 3 Core component safety

Work Package leader K. Litfin reporting.

Task 3.1 Thermal hydraulic fuel assembly blockage experiments

Julio Pacio (KIT) presented the status of the thermal hydraulic fuel assembly blockage experiments. New results from the first measuring campaign for the small blockage scenario C1 and E1 were presented and the current status of the second measuring campaign was shown. The second measuring campaign is supposed to start on April 19th and the results will be included in the final deliverable D3.4 that will be finalized before the end of third reporting period. A draft of D3.4 is already available and is distributed among the involved partners for discussion. The final version of D3.4 was submitted on June 15, 2017.

Task 3.2: Safety rod system tests in Heavy Liquid Metal

No presentation was given regarding this task. The experiments for the Safety rod system tests in heavy liquid metal are finished. The results of the 3 measurement campaigns have been presented on the last meeting and the final deliverable D3.6 was issued in November 2016.

Task 3.3 Fuel Blockage Simulation

Heleen Doolaard (NRG) presented new results of the post-test simulations for the fuel assembly blockage. These results have been included into the draft version of the deliverable D3.7 that is also distributed among the involved partners for discussion. As soon as the experimental results from the second measuring campaign of task 3.1 were available, the deliverable was finalized in June 2017.

In December 2017, the deliverable was updated with recommendations of post-test simulations. In detail, it describes the numerical assessment of various types of fuel blockages in wire-wrapped rod bundles representing MYRRHA fuel assemblies. Firstly, pre-test analyses of internal blockage experiments in the KALLA laboratory at KIT show that single sub-channel

blockages result in acceptable temperatures, while blocking the 6 central sub-channels leads to very high temperatures. The post-test analuses of the single sub-channel blockages show a reasonable prediction of the fluid temperature and pressure drop, but an over prediction of the blockage temperature. A large number of sensitivity studies is performed, showing small sensitivity to most modelling parameters and large sensitivity to leakage paths between blockages and fuel pins and to increased thermal conductivity of the blockage. Finally, the interaction between 7 fuel assemblies is modelled and several blockages are applied at the inlet header of the central fuel assembly. The side-inlets in the inlet heaader highly reduce the influence of a blockage at the inlet of the inlet header. Since the mean outlet temperature will be monitored, it can be assumed that such an inlet blockage will be detected very quickly and the reactor can be scrammed timely, avoiding the computed temperatures.

Task 3.4: Numerical analysis of the MYRRHA control rod system

No presentation was given regarding this task. The results of the CFD modelling have been presented on the previous Technical Review Meeting in October 2016 in Karlsruhe and the final deliverable D3.7 was issued in March 2017.

III. WP 4 Steam Generator and cooling safety

Work Package leader A. Del Nevo reporting.

The main objectives of this work package are related to the studies on safety aspects related to leakage or rupture of steam generator in the reactor vessel.

Task 4.1 SGTR Propagation

Alessio Pesetti (UNIPI) presented the status of Task 4.1. He highlighted the objectives of the experimental activity. He re-called the pre-tests calculations by SIMMER-III and SIMMER IV codes, executed for designing the test section and the experiments. CIRCE facility has accomplished the tasks planned in MAXSIMA Project. Four experiments have been executed according with the test specifications. Alessio Pesetti also presented the experimental initial and boundary conditions, highlighting they were coherent to MYRRHA design specifications. About 140 signals were acquired in each test, providing the time trends of pressures, of temperatures, mass flow rate, strains, valves position. Preliminary analysis evidenced good repeatability of main parameter trends. Moreover, pressurized tubes (surrounding the injector one) maintained their integrity during injection. Exp. data analysis and post-test activity by SIMMER-IV code is still in progress.
Deliverable D4.3 was issued on June 22, 2017.

Task 4.2 SGTR Bubble Characteristics

Alessandro Del Nevo (ENEA) presented the status of Task 4.2. He stated summarizing and confirming what was communicated during the meeting at KIT. The delay with respect the time schedule was accumulated because the refurbishment of the facility. Basically, it was connected with the procurements (orders and contracts) from November 2015 up to June 2016 for un-predictable reasons (i.e. new ENEA procedures, new administrative software, new national procurement code, etc.). Then, he presented the status of the activity the planning of the experiment and the procedure for the execution of the experiments. The devices in charge of simulating the leaks, manufactured with laser technics have been

characterized with SEM. He added that a secondary detection system has been finally identified and acquired.

He concluded that the tests and the experimental campaign will be completed by end of April 2017, as planned during the meeting at KIT in November 2016.

Task 4.3 Bubble transport validation

Dmitry Grishchenko (KTH) provided a summary of Task 4.3.He pointed out the technical challenges and approach pursued to accomplish the task. He detailed the principles of low pressure bubble generation, the facility design and the current status of the facility construction and of work, showing photos.

He concluded that the manufacturing and assembly of the facility is currently finalized, nevertheless commissioning tests were postponed due to internal KTH issues. He concluded that the issue should be solved soon and that the activity will be finalized by the deadline of the third RP.

IV. WP 5 Fuel Safety

Work Package leader C. Roth reporting.

Status of the works planned to be carried out, in terms of submitted deliverables and accomplished milestones, has been presented by the WP leader. It was mentioned that tasks 5.2 and 5.3 have been finished, the sole activity in progress being Task 5.1 – Transient testing of MYRRHA fuel for determination of pin failure threshold.

Task 5.1 – Transient testing of MYRRHA fuel for determination of pin failure threshold

Milestone M37 (delayed) is planned to be accomplished till end of March 2017, and the deliverable D5.11 will be submitted till end of April 2017.

The work progress made in the last period, has been presented by speakers as follows:

Csaba Roth (RATEN ICN) presented the status of preparation of transient experiments on MYRRHA type fuel segments to be done in the TRIGA-ACPR reactor in Romania. Irradiation capsule is ready for use, manufacturing, tests and licensing process being finished. The test fuel transport arrived to Pitesti just before the technical meeting (milestone M36).

Brian Boer (SCK•CEN) presented a summary of activities related to the test fuel fabrication completion and fuel transportation to ICN.

An informal meeting was held to discuss technical details and the progress of the preparations for the first pulse experiment with the participation of Csaba Roth, Andreea Udrea (RATEN ICN) and Brian Boer (SCK•CEN). Csaba Roth presented the technical problems encountered during the recent finished instrumentation exercises/tests. It was agreed that the test programme should started even if there are some doubts on the optimal TC fixing solution. They will be clarified by the end of project which is aimed to validate the experimental development and methodology. It was agreed also that the target value of energy deposition for the first irradiation test will be equal to 350J/gOU2 for the 7% enrichment test fuel segment.