The 10th European Review Meeting on Severe Accident Research (ERMSAR2022), Akademiehotel, Karlsruhe, Germany, May 16-19, 2022

ERMSAR Talk 327

Preliminary Uncertainty and Sensitivity Analysis of the ASTEC simulations results of a MBLOCA scenario at a Generic KONVOI Plant using FSTC tool

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Introduction

- Work is made in cooperation with Framatome GmbH in the frame of WAME project
- WAME project (2019-2022) was financed by the Federal Ministry of Economics Affairs and Climate Action (BMWi) in the frame of activity ‘Maintaining Competence in Nuclear Technology’

Main goal of the project: develop methodology and the tool for fast source term prediction in case of severe accident

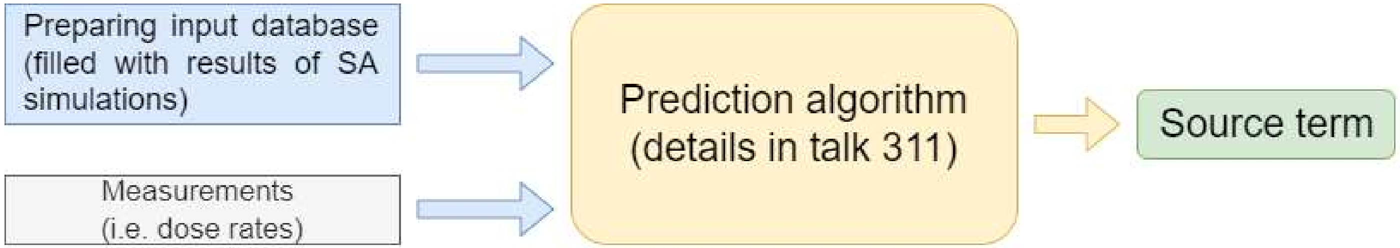
More details about prediction algorithm and its application examples: in talk 311 “Prediction of the Radiological Consequences of a Severe Accident Scenario in a Generic KONVOI Nuclear Power Plant ”

This talk is focused on U&S analysis of severe accident simulations

- Generic KONVOI NPP
- MBLOCA scenario up to basemat rupture
- SA code: ASTEC 2.2b
- Tool for U&S analysis – in-house Fast Source Term Calculation (FSTC)

Fast Source Term Calculation (FSTC) tool

- Scheme of FSTC tool in frame of performing source term prediction

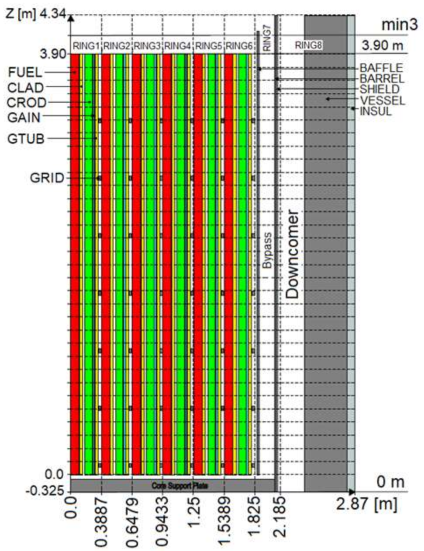


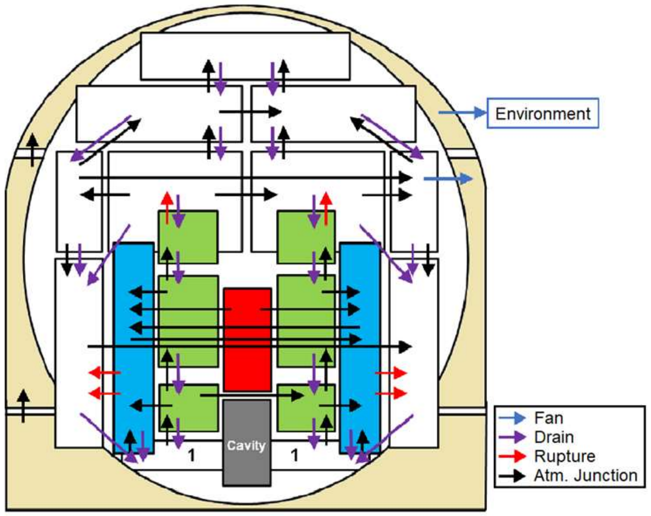
- Scheme of the part of FSTC tool in frame of U&S analysis

FSTC tool info:

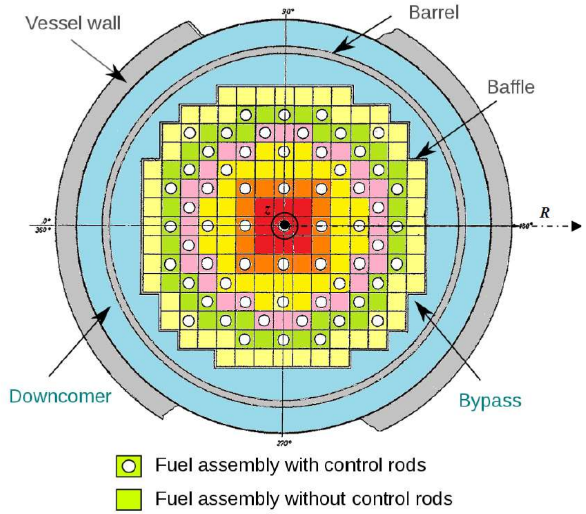
- Python language
- Modular structure
- Coupled with ASTEC SA code
- Sampling – SRS, LHS
- Option of correlated uncertain input parameters
- Pearson, Spearman, distance correlation coefficients

KONVOI NPP ASTEC model





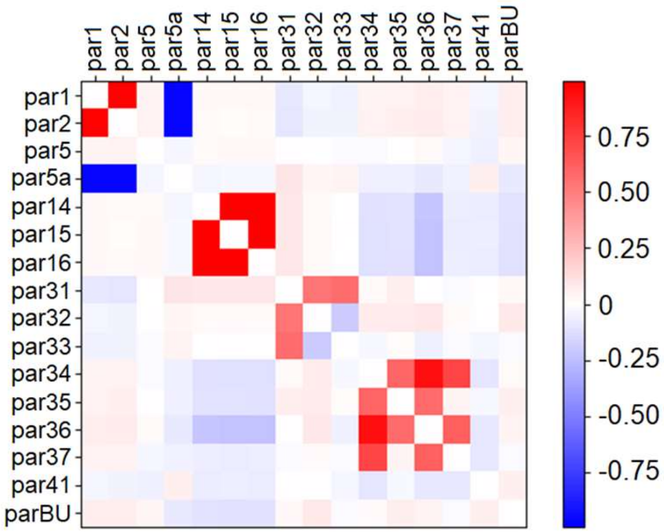
[Gabrielli F., Stakhanova A., Sanchez-Espinoza V.H., Pauli E., Hoefer A., Feldmann H., "Impact of realistic fuel inventories on the radiological consequences of a severe accident scenario in a generic KONVOI plant by means of the ASTEC code", Kerntechnik 2022, 21. - 22. Juni 2022, Hyperion Hotel, Leipzig, Germany]



[Gómez-García-Toraño, I., 2017. Further development of Severe Accident Management Strategies for a German PWR Konvoi plant based on the European Severe Accident Code ASTEC (PhD Thesis). Fakultät für Maschinenbau, Karlsruhe Institute für Technologie, Karlsruhe, Germany.]

- ASTEC 2.2b is used
- All ASTEC modules are activated
- Model is based on generic input deck from EU CESAM project [EC. "D40 .42 – 1st set of reference NPP ASTEC input decks", CESAM FP7-GA-323264, (2015).]
- Fuel inventories calculated with ORIGEN-ARP code
- Containment leakage to the annulus
- No filtering
- Simulation up to basemat rupture

Uncertain input parameters



Iman-Conover method is used to correlate input parameters

- Normal distribution – 6 parameters;
- Triangular – 5;
- Uniform – 4;
- Beta - 1

Parameter	Meaning
par1	Correction factor for the ratio S/V of the fuel pellets due to roughness
par2	Correction factor for the ratio S/V of the fuel pellets for the limited steam access
par5	Geometrical diameter of the grain
par5a	Standard deviation of geometrical diameter of the grain
par14	Threshold Temperature of the cladding Dislocation [K]
par15	Threshold Temperature of the oxide layer Dislocation [K]
par16	Threshold thickness of the oxide layer [mm]
par31	Particle mean thermal conductivity (J/m/K)
par32	Average specific heat (J/kg K) of the aerosol
par33	Particle mean density (kg/m3)
par34	Particle minimum geometrical radius (m)
par35	Particle maximum geometrical radius (m)
par36	Shape factor relative to particle coagulation
par37	Shape factor relative to Stokes velocity
par41	Coefficient for the leakage rate
parBU	Effective full power days

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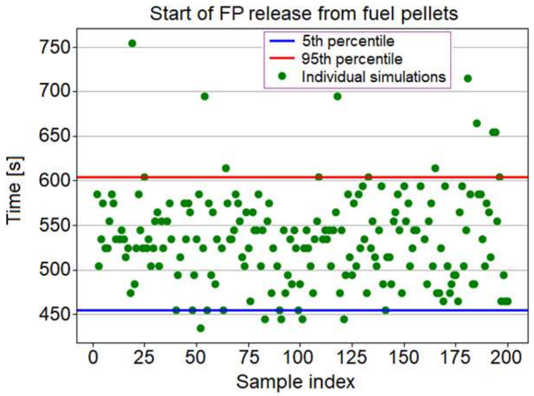
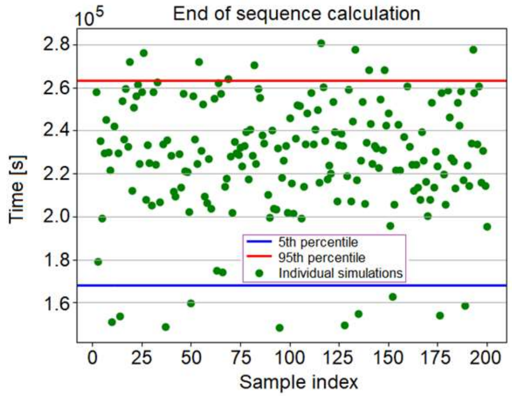
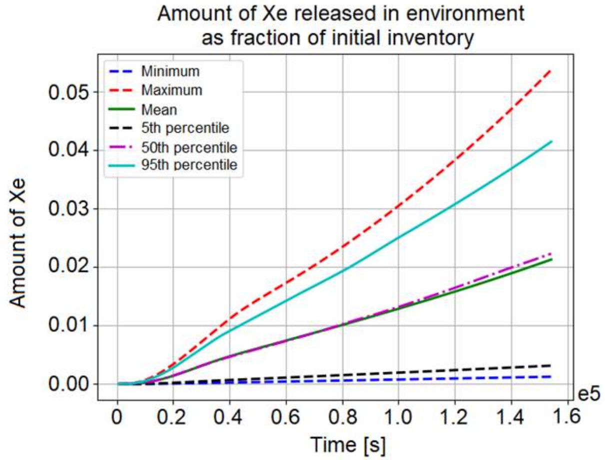
Uncertainty and sensitivity analysis

[Time of start of FP release and end of calculation for 200 simulations]

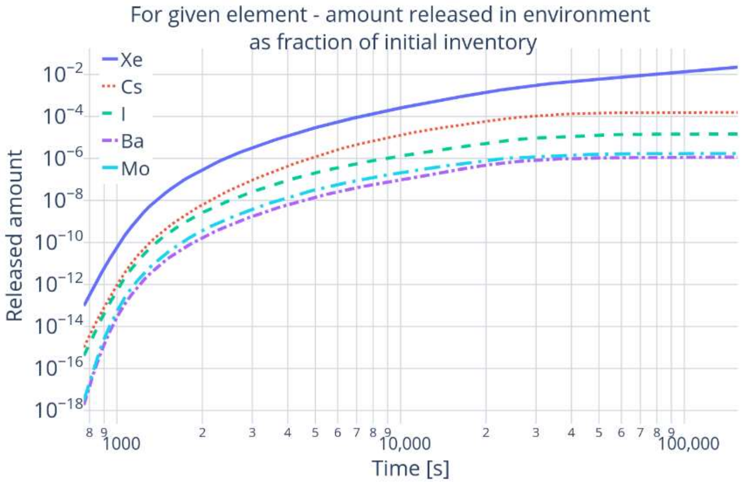


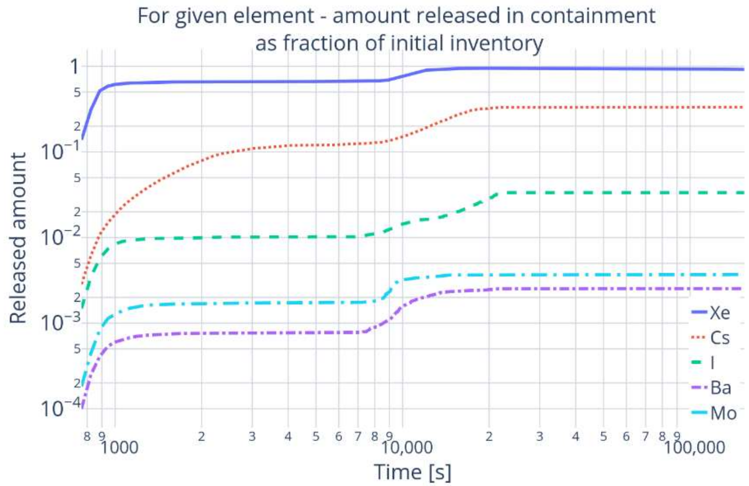


[Example of simple statistics]

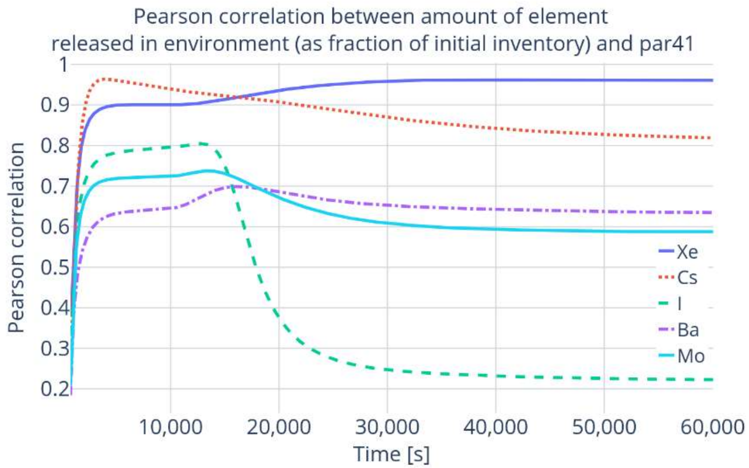


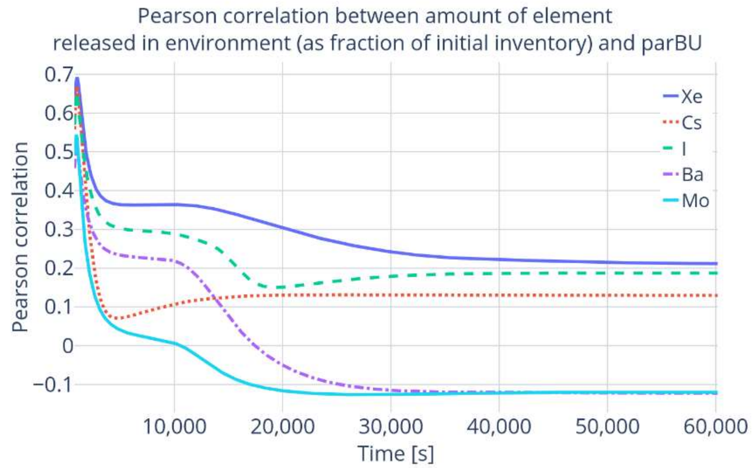
[Median amount for 4 elements released in environment and containment]

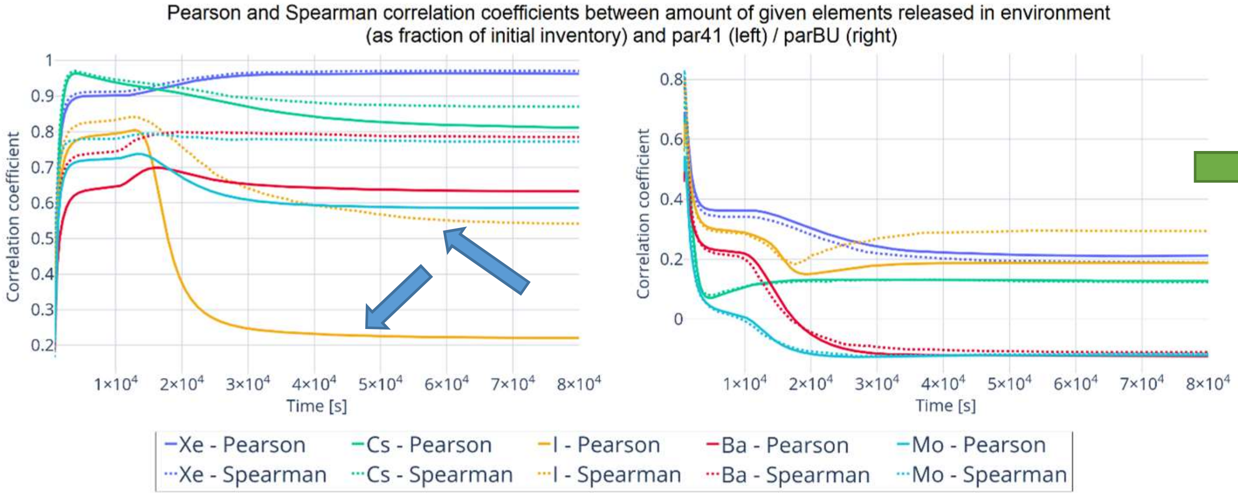


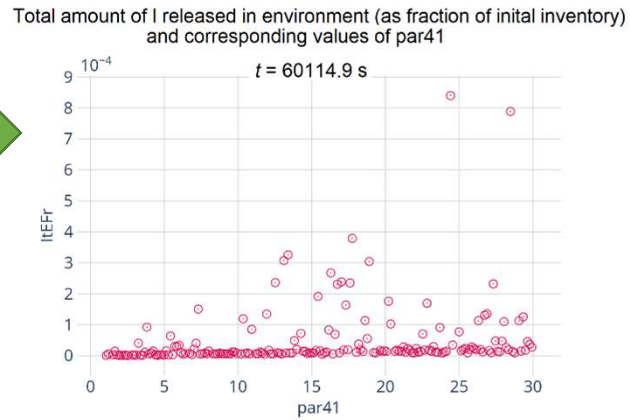


Uncertainty and sensitivity analysis









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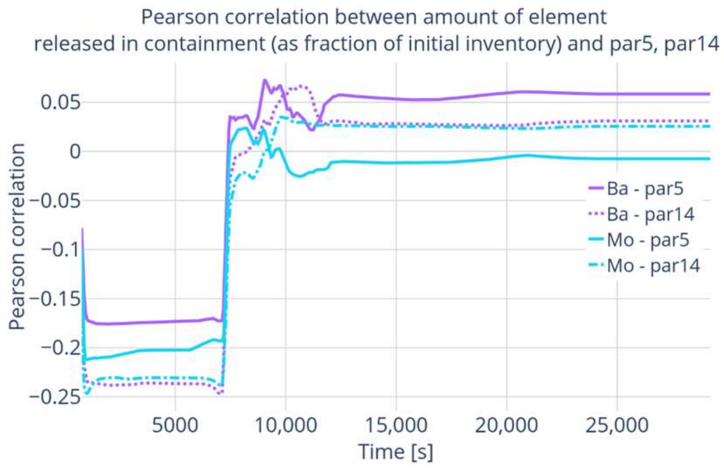
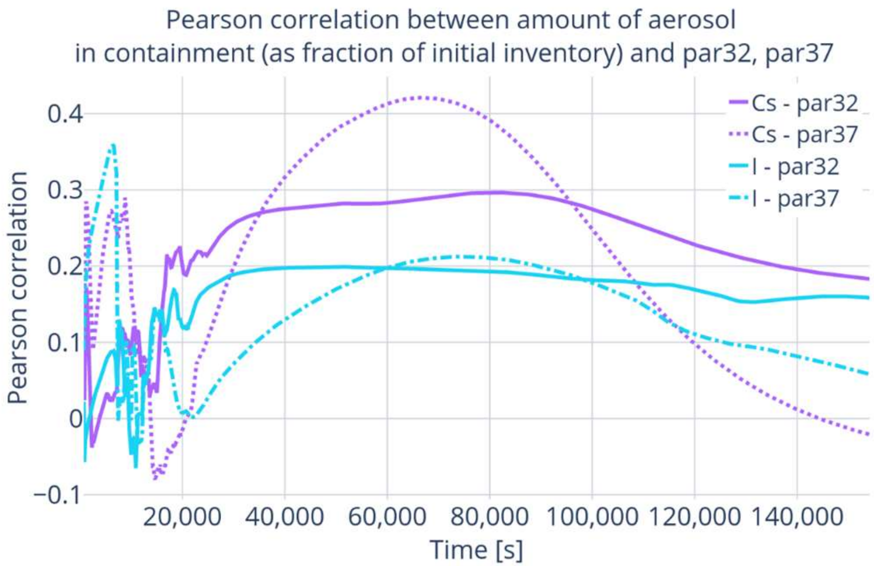
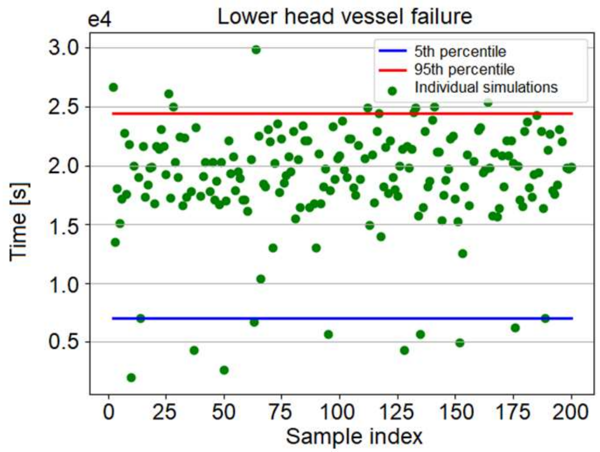
Uncertainty and sensitivity analysis



- For most of the uncertain input parameters Pearson and Spearman correlations are lying in the range [-0.1; 0.1] both for release in containment and environment
- Slight effect from some input parameters could be seen at the beginning of the process on the release of low-volatile elements into the containment
- In the middle of the process: effect from aerosol model parameters on Cs and I aerosols in containment





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Conclusions

- ✓ Fast Source Term Calculation (FSTC) tool developed in KIT in the frame of the WAME project
- ✓ Tool has capabilities for U&S analysis and source term predictions (for that purpose, MOCABA algorithm developed by Framatome was implemented in the tool)
- ✓ U&S analysis of MBLOCA scenario on KONVOI NPP was performed using FSTC tool and ASTEC SA code
- ✓ Among 16 selected uncertain input parameters the most important are parameters related to the leakage rate (between containment and annulus) and burnup
- ✓ Effect from parameters related to aerosols could be seen at the later stages of the accident – after lower head vessel failure

Thank you for your attention!

Acknowledgements

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