Mitigation and analysis of fission products transport (MANTRA)

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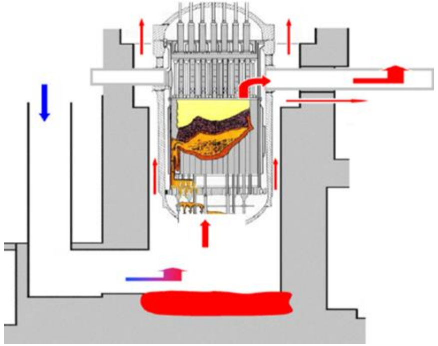
Objectives of MANTRA

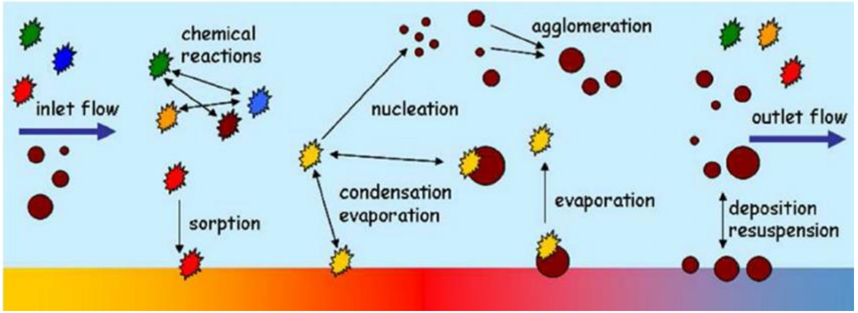
Primary circuit and containment conditions

- The aim is to investigate the transport, chemistry and mitigation of gaseous and particulate fission products in severe accident conditions.

- The emphasis is on the phenomena, which are poorly-known internationally or not considered in the current severe accident analysis codes due to the lack of information.



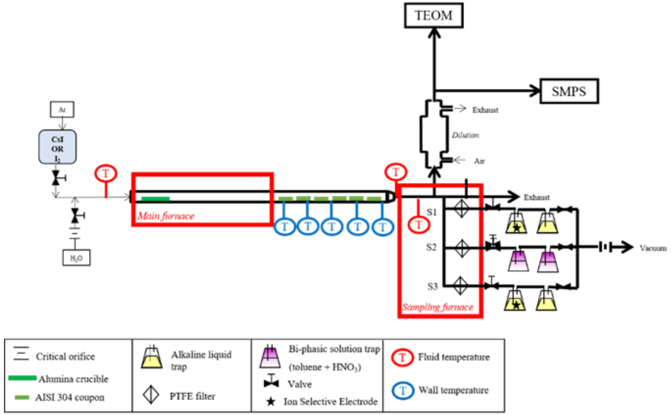
T. Haste et al. NED 2009

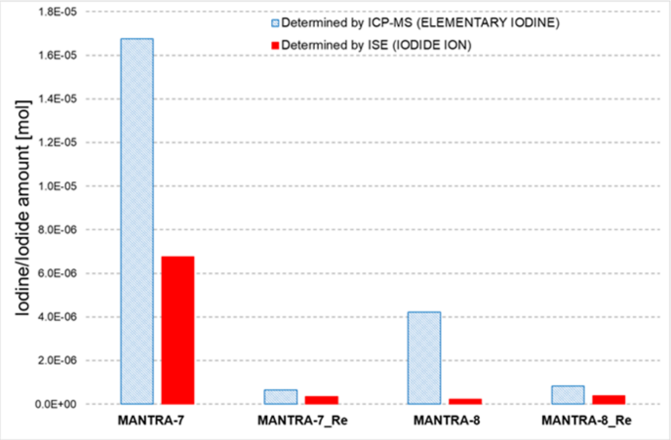


L. Cantrel et al. NED 2014

Primary circuit chemistry of I and Cs

Formation of gaseous iodine from surface deposits of FPs



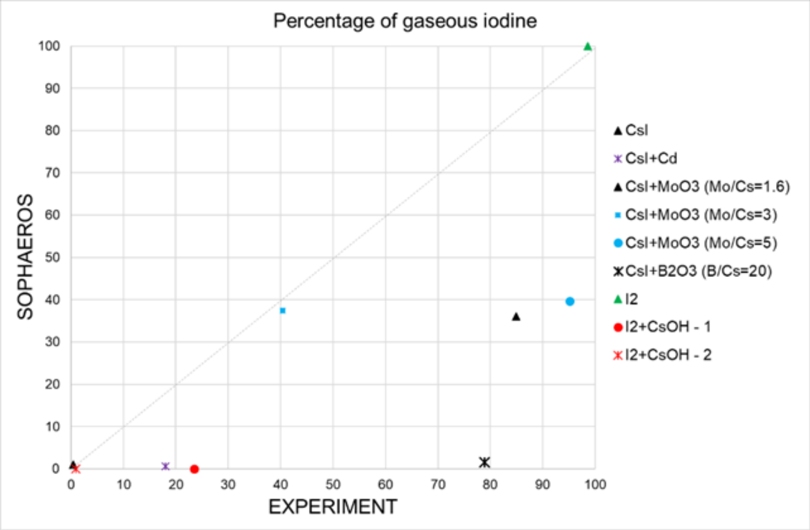


Precursor	Carrier gas
CsI particles	Ar/H_2O (86.7/13.3 vol-%)
Deposited CsI	Ar/H_2 (95/5 vol-%)
CsI particles	Ar/H_2O (86.7/13.3 vol-%)
Deposited CsI + H_3BO_3 gas	Ar/H_2 (95/5 vol-%)

- Deposited CsI particles were subjected to revaporization process in Ar/H_2 atmos-phere:
  - Gaseous iodine was released from the deposits.
  - When H_3BO_3(g) was present in the carrier gas (Ar/H_2), the fraction of gaseous iodine released was higher.
- The surface deposits could be an important source of gaseous iodine in a long term.

Primary circuit chemistry of I and Cs

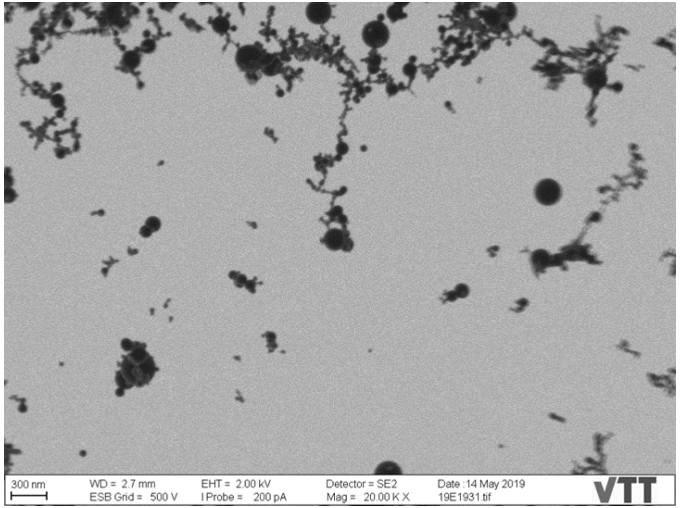
Formation of I(g): Experimental vs. analytical (ASTEC) values

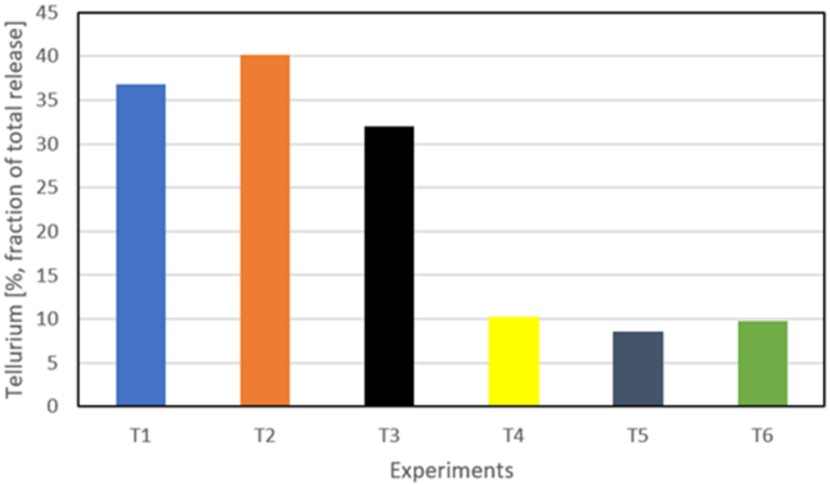


- Good agreement on the behaviour of compounds between SOPHAEROS models and the experimental results for pure compounds (I_2, CsI).
- Differences in results when another compound was considered in the chemical system.
  - Especially looking at the release of gaseous iodine from the deposits, the amount of gaseous iodine was systematically underestimated.
- Need to take into account condensed-phase reactions.

Primary circuit chemistry of tellurium

NKS-R collaboration with Chalmers University of Technology and Oslo University

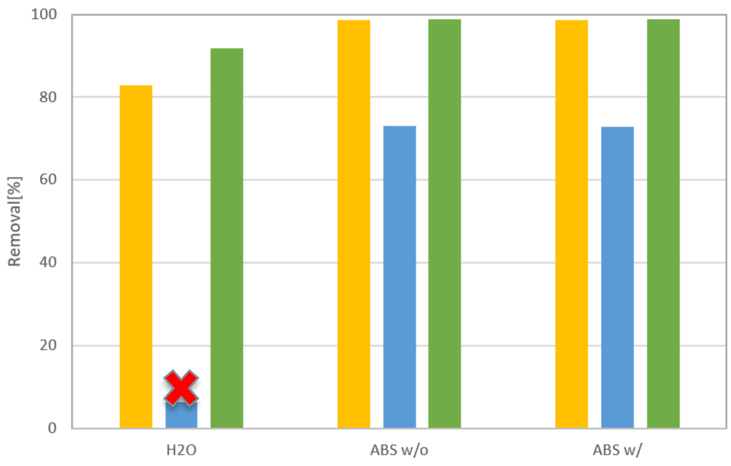


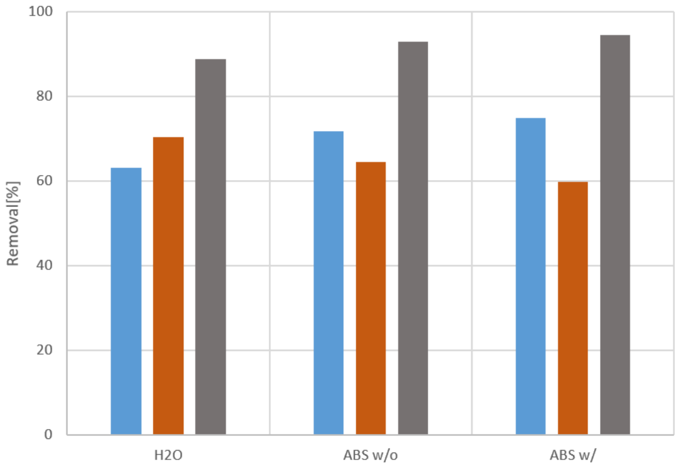


- Tellurium speciation when entering the containment building (circuit 1200 °C to 30 °C).
- Fraction of tellurium transported through the model primary circuit (in comparison to the release) was higher in the air atmosphere (Experiments T1 to T3) than in the nitrogen atmosphere (Experiments T4 to T6):
  - Aerosol 30-40% (air), Aerosol 7-10% (nitrogen)
  - Gas 3.3-5.2% (air), Gas 1.4-2.2% (nitrogen)

Mitigation of airborne tellurium using the containment spray system

NKS-R collaboration with Chalmers University of Technology and Oslo University



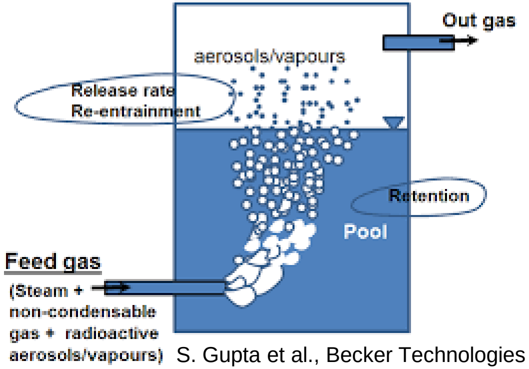


- Mitigation of Te species (metallic tellurium precursor) in air and nitrogen atmospheres.
- Removal efficiency was high for Te (and TeO_2) in an air atmosphere,
  but the removal efficiency for metallic tellurium decreased in a nitrogen atmosphere.

Pool scrubbing

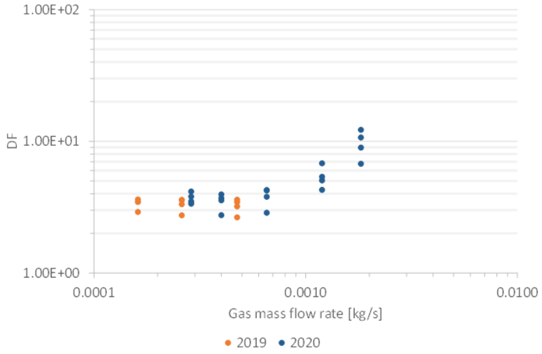
Retention of gaseous and aerosol FPs in containment pools

- Aerosol retention in supression pool conditions at 20 to 100 °C was investigated with experiments (CATFIS project) and subsequent simulations (CASA project) of experiments with ASTEC and MELCOR severe accident analysis codes. -> Work continues in MANTRA and ANSA projects.



S. Gupta et al., Becker Technologies

- Preliminary decontamination factor (DF) results:
  - Experiments were performed with CsI aerosol at 20 °C varying the pool depth from 0.1 to 0.7 m and non-condensable N_2 flow rate through the pool from 17 to 110 l/min.
  - Significant increase in the DF at high flow rates, ASTEC V2.1.1.6 resulted in low DF values.
    - Similar observation also by other authors [Herranz et al., 2018].
- Further studies are needed especially in the area of high flow rates and elevated pool temperatures.



Long-term severe accident management

Exploit the lessons learnt e.g. from the Fukushima accident

- Quite new topic in MANTRA
  - Focus on the review of knowledge on the long-term issues – what happens during the next decades after an accident
  - Later experimental work
- Content of the first summary report:
  - Chemical form and morphology of caesium contamination after a severe accident.
    - Post-accident investigations at and around the Fukushima plant site provide a broad scope of information.
  - Compared with the Chernobyl accident data.
  - Latest developments in the clean-up methods of caesium contamination.

References

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