Spent Fuel Pool (SFP) Loss of Heat Sink Severe Accident calculated by MELCOR and GASFLOW

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The Task

- **MAIN GOAL: Provide SFP Severe Accident release data for PSA-1 and PSA-2**
- **INITIAL and BOUNDARY Conditions are the PSA-1 states**

No	Description	Shutdown type	Decay power (kW)	Total water (m^3)
01	SFP full loaded	Full repair	3600	335
05	Regular (yearly) refueling	Regular	1600	160

- **LIMITING cases will be analyzed**
  1. – SFP fully loaded (lower racks: 676 FA + a full core on upper racks)
  5. – Regular refueling (676 FA on lower racks incl. 78 freshly unloaded FA)

The Task

- **Cases to be analysed**
- **SFP open or covered by concrete plates;**
- **SPF loading is full or regular;**
- **Ventilation state:**
  - No ventilation in operation – discharge to environment via the RHall
  - Ventilation path without filter via the stack
  - Ventilation path WITH FILTER via the stack

- **ANALYSES PERFORMED**
  Fully loaded SFP
  (676 FA lower racks + full core in upper racks
  GASFLOW – flow pattern calculation for MELCOR Flowpath selection

  Regular refueling
  (676 FA in lower racks incl. 78 freshly unloaded ones)
  MELCOR release calculations

MELCOR SFP Regular refueling – activity release

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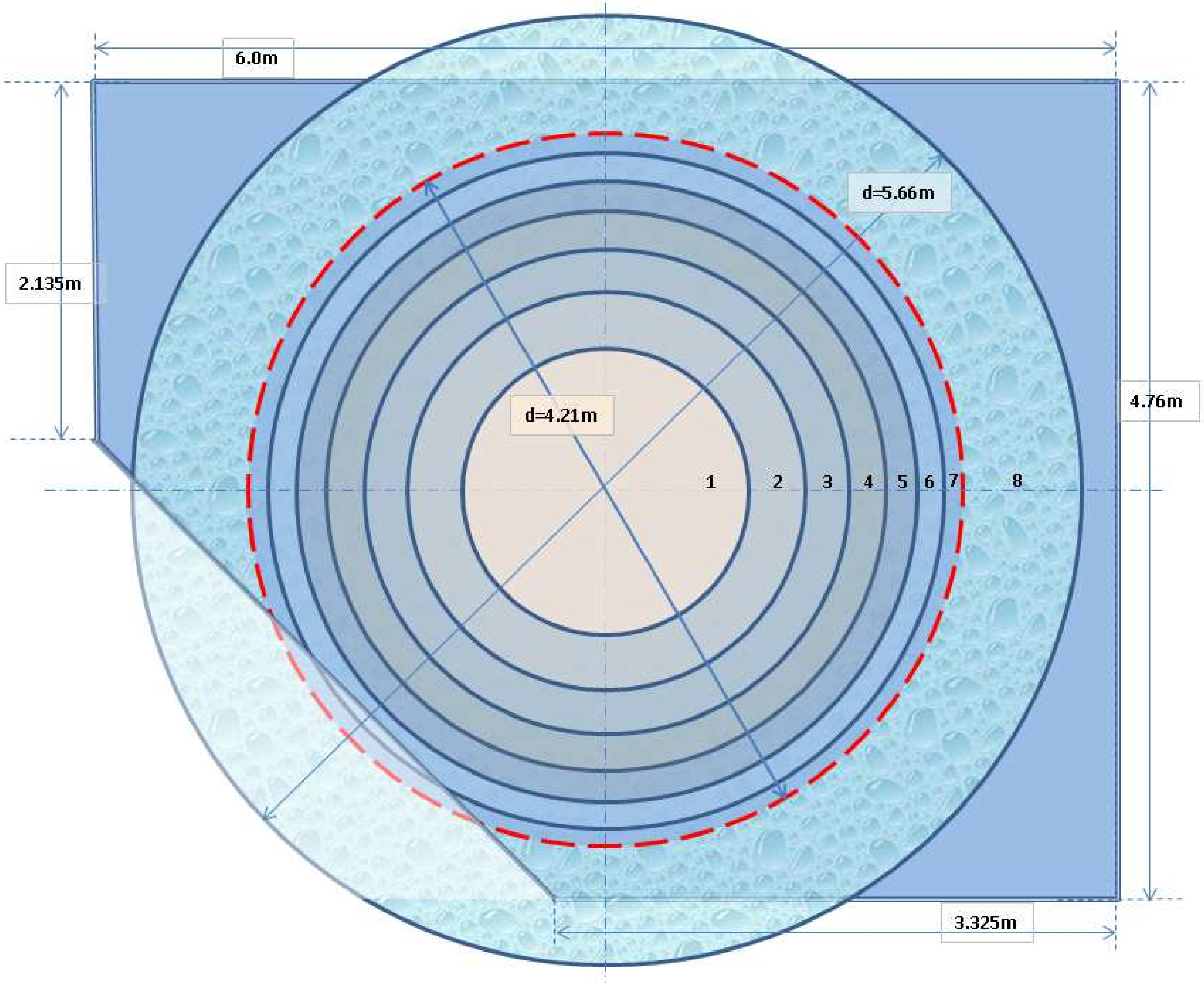
- MELCOR 1.8.6 used for loss of heat sink SFP accident
- **CONDITIONS**

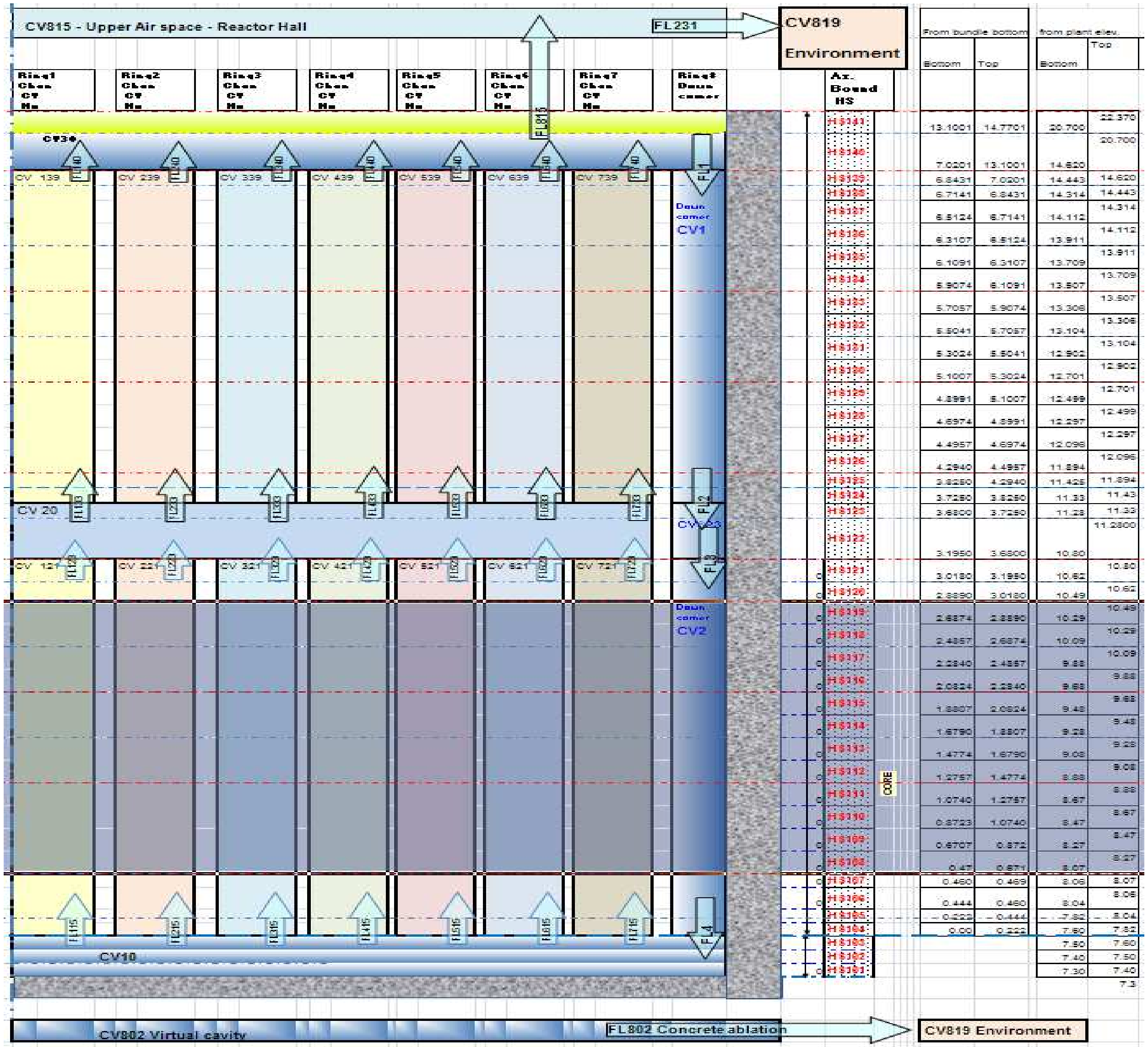
- Decay power: 1604 kW
- 676 FA (78 freshly unloaded)
- 156 m3 water
- Time since shutdown: 345h
- Ventilation:
  - absent – discharge to RH
  - Delivery from outside+ Discharge without filter via the stack
  - Delivery from outside+ Discharge WITH filter via the stack

MELCOR SFP model



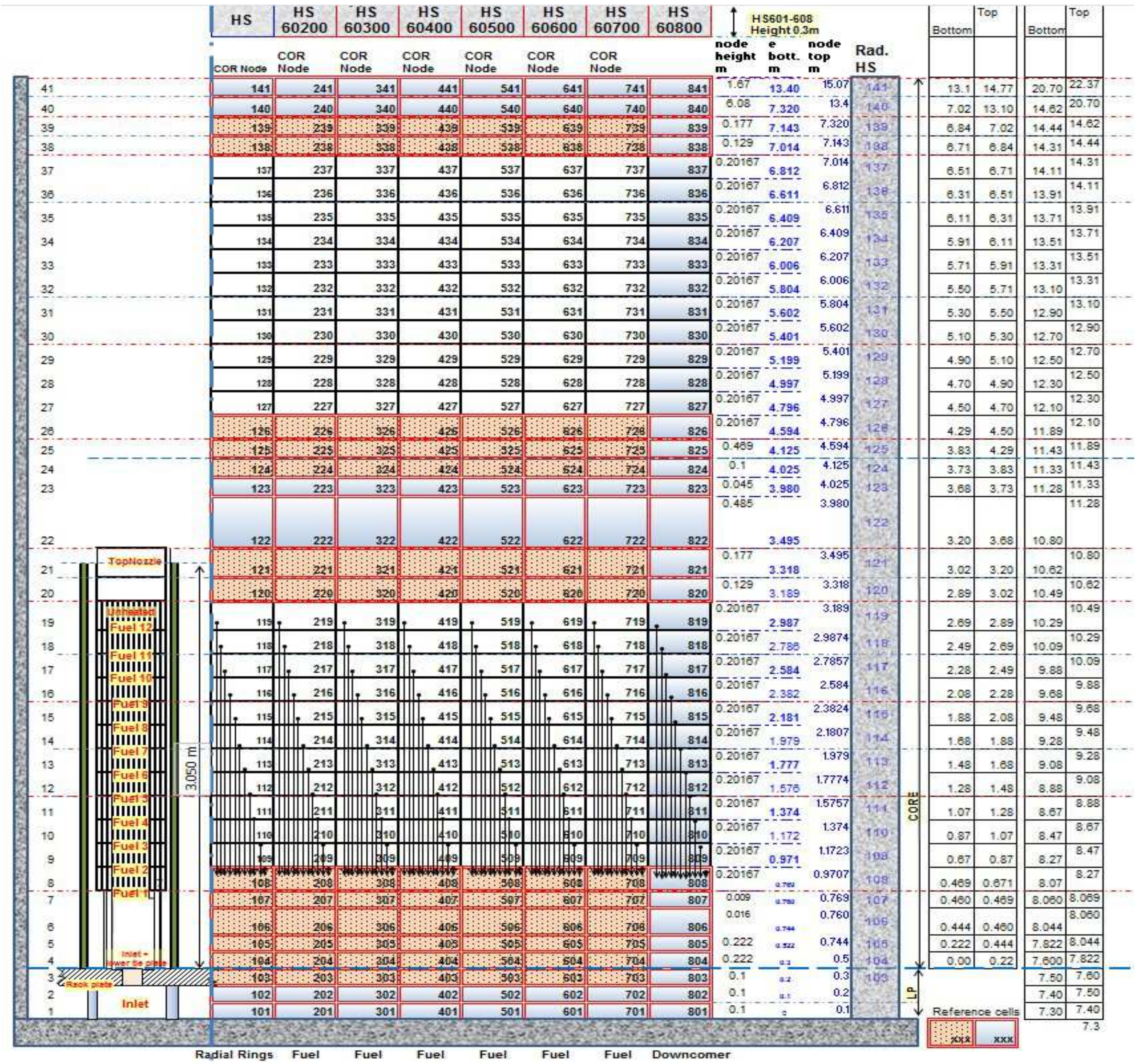
- Concentric rings approach
- 7 fuel rings
- 8. ring is a downcomer

MELCOR Thermal hydraulic model



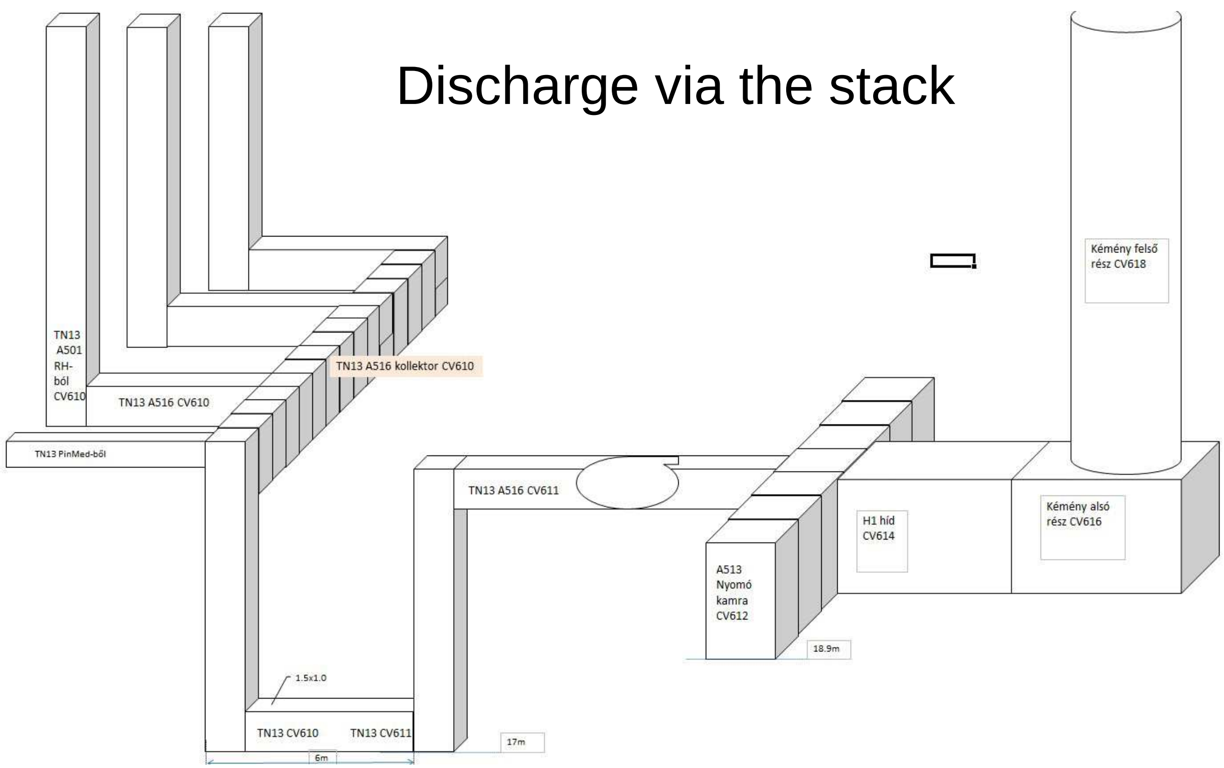
- **SFP covered by concrete plates – release through the gap between the plates and or to ventilation path**
- **First the water heat-up then it boils away**
- **SFP SS platted concrete walls are modelled as CORE BOUNDARY HS**

MELCOR CORE model



- **SFP interpreted as a core**
- **Calculations up to SFP bottom liner failure**

MELCOR ventilation model



- **Charging + discharge ventilation without filter**
- **Charging + discharge ventilation WITH filter**
- **Vent ducts modelled with CVs FL and HS**

- **Filter capacity (default DF):**
  - Aerosols: 1000
  - Vapor:100

MELCOR Thermalhidraulics: typical results

SFP walls and ceiling	SFP phases	Time,h	Time,h
	Initial event (loss of heat sink)		0
	Upper pool saturated		12.3
	Top fuel uncovery		55.4
	FA exit temperature over 550C		71.7
	Water level below 1m		73.5
SFP concrete cover plates over 1273K		86.6	
	Ring1 Zr-H2O reaction		74.5
	Ring1 gap release		74.7
	FA bottom dry		83.1
SFP wall>1273K		86.3	
	Ring1 lower support plate fails		91.1
	Ring1 lower support plate melts		91.5
	SFP bottom steel liner fails		93.9
	Lower pool dry-out		101.2

Preparations for SFP without cover but with „air curtain”

No	Task	Cover	Charge	Configuration
10.	SFP FP release	NO	Full/Regular	RH Vent without filtration Vent with filtration
11.	SFP FP release	NO	Full/Regular	RH Vent without filtration Vent with filtration
12.	SFP FP release	NO	Full/Regular	RH Vent without filtration Vent with filtration

Problems with FP release interpretation

NG release fraction to environment is smaller than that of CsI

Results show that fraction of NG remains in fuel

however no intact fuel remains in the core

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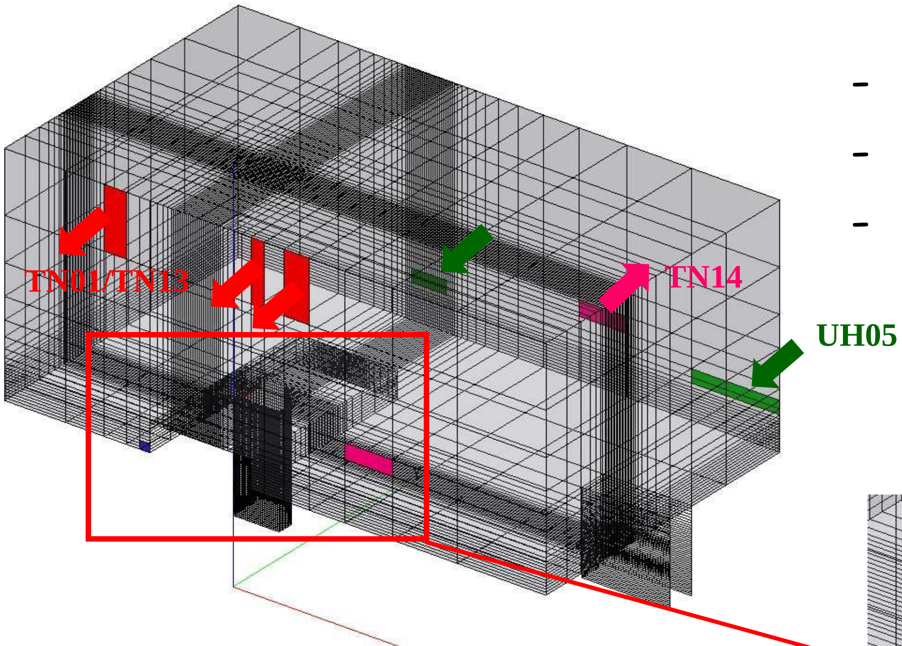
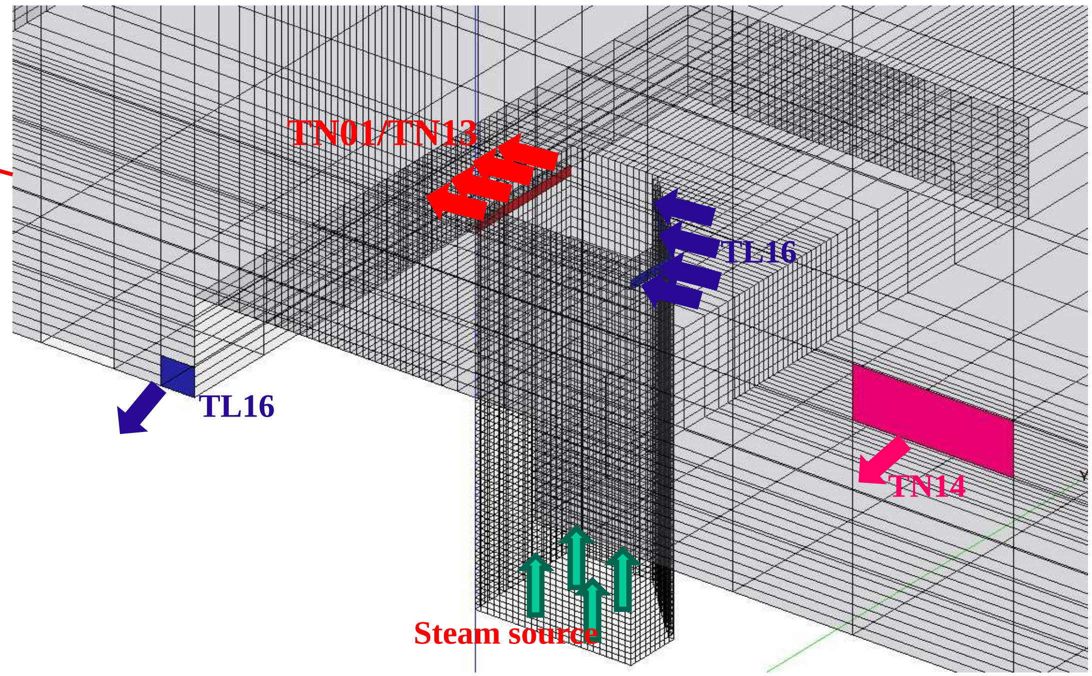
GASFLOW calculations for SFP with „air curtain” to prepare MELCOR input data

GASFLOW model



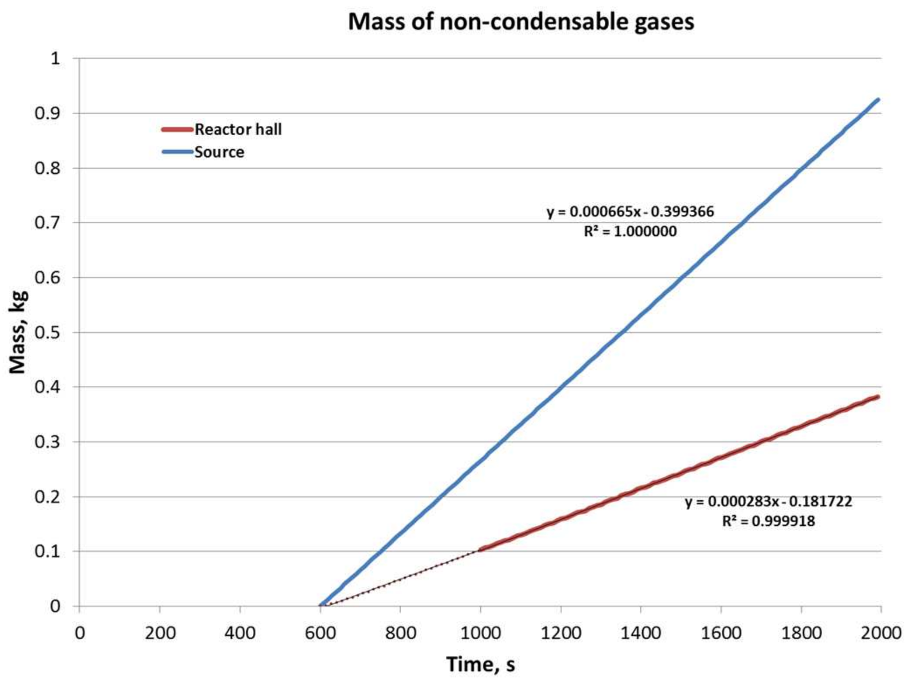
- Half of RH considered
- Level zero= top of FA
- Ventilation with constant flow



- Steam flow: in 3 phases
  - evaporation: a few g/s
  - Boil-away: several hundred g/s, at 100°C
  - After uncovery: reduced g/s, superheated steam

Calculation procedure

Goal: Determine the fraction of boil-away flow directed to RH despite the „air curtain" at SFP water level



- Steam source from SFP:
  - From -200s: evaporation – 11.8 g/s steam
  - 200s-400s boil-away: 1595 g/s (266 g/s), 100°C
  - 400s- : reduced g/s superheated steam
  - 600s- : 1% NG to avoid condensation effect
- 1000 s- : after initial transient the NG discharged to RH linearly increases
- Determination of fraction to RH:
  Rate of mass increase dischaged to RH related to massrate at SFP water level exit

Calculation results

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Ventilation states

- Discharge by ventilation without filters, air curtain injects to RH
- Discharge by ventilation without filters, No air curtain
- Discharge by ventilation WITH filters, air curtain injects to RH
- Discharge by ventilation WITH filters, NO air curtain
-

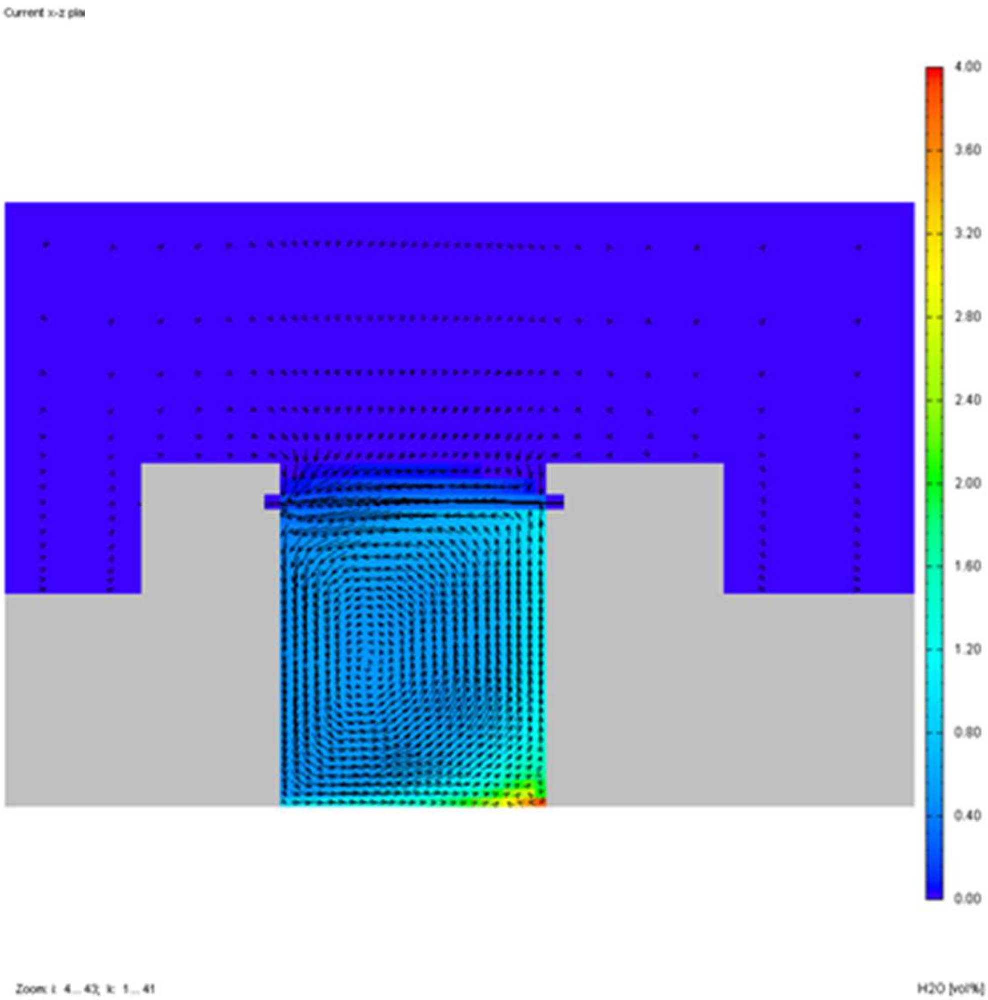
SFP state

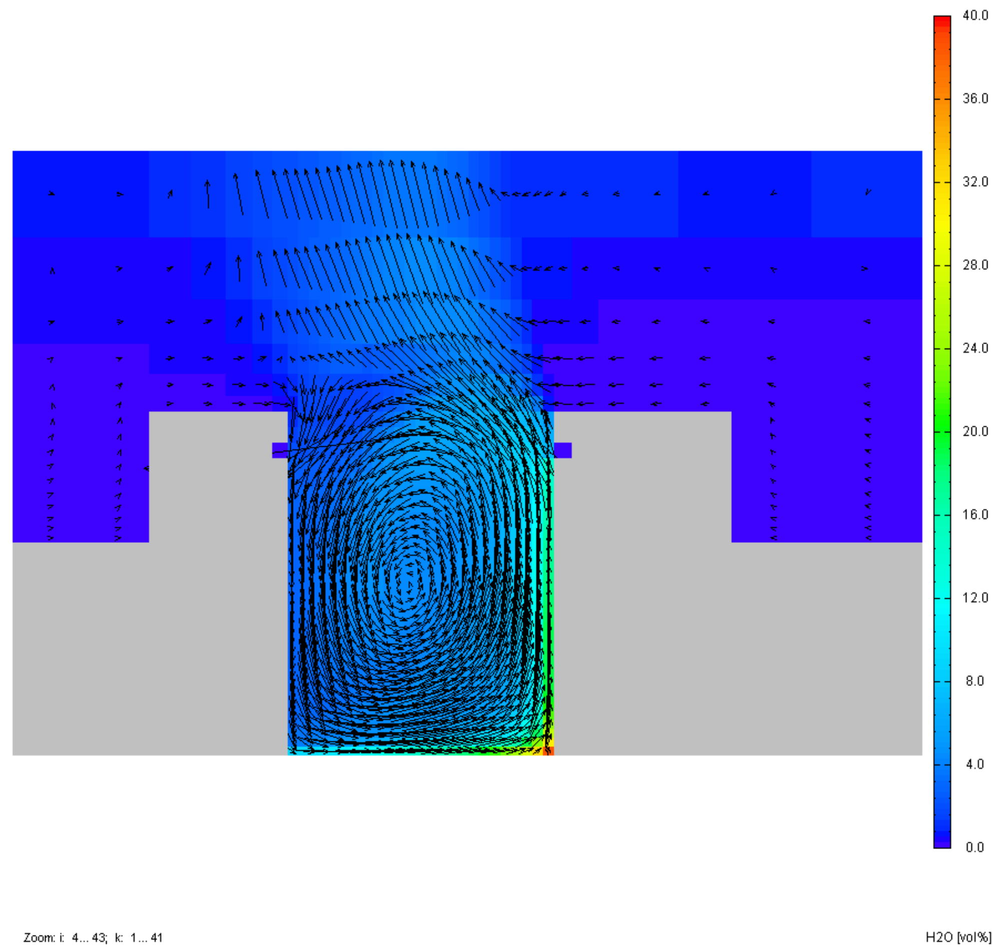
a. Fully loaded

b. Regular refueling

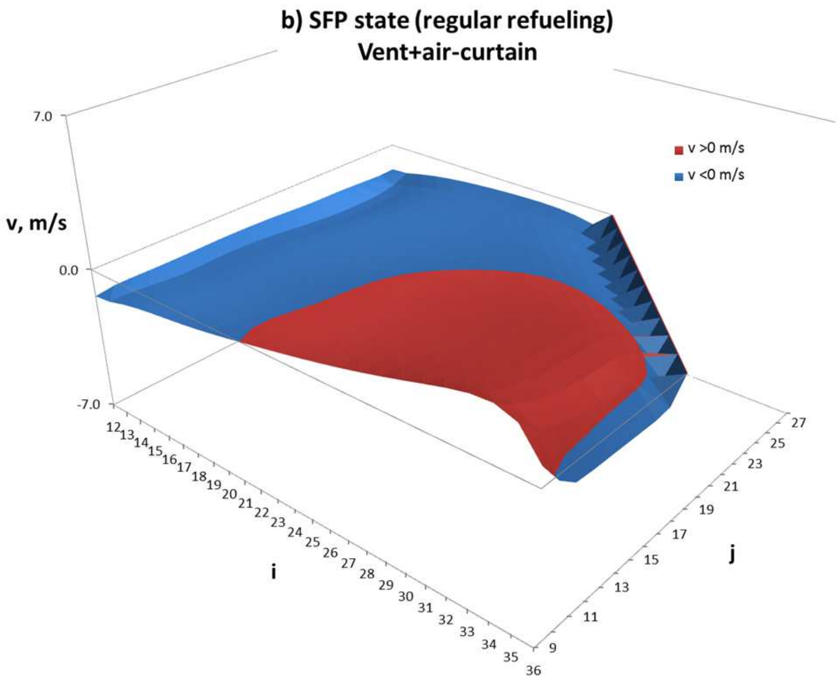
General results

- During evaporation air curtain prevents steam discharge to RH from SFP
- Hot boil-away steam breaks the air curtain





Qualitative results



- „air curtain" suck-away results in a suction of air from RH to SFP
- At the same time there is a outward flow at SFP top to the RH