REDUCTION OF RADIOLOGICAL ACCIDENT CONSEQUENCES

WP:	**WP2 “METHOD”**
Task:	T2.1.1 “Review of release evaluation methodologies”
Speaker:	Dorel OBADA
Affiliation:	IRSN
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REDUCTION OF RADIOLOGICAL CONSEQUENCES OF DESIGN BASIS & DESIGN EXTENSION ACCIDENTS

- **Objective** : Review and harmonize methods for evaluation of the radiological consequences
  - To evaluate Radiological consequences, release source term is required
- Task 2.1.1: Review of the release evaluation methodologies
- Template to describe the source term evaluation:
  - From isotopic inventory to release outside of containment
  - For LOCA and SGTR
- 3 reactor types:
  - PWR (IRSN) & PWR (Tractebel & Bel V)
  - VVER (SSTC NRS) & VVER (ARB NPPS)
  - BWR (LEI)

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Source term evaluation in LOCA scenario

- Isotopic inventory
- Elements volatility
- FP release from fuel to the containment
- Iodine chemistry and CSS operation
- Containment building leak rate
- FP release to the environment

Isotopic inventory

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	PWR	VVER	BWR
Code and method used	IRSN : VESTA code (IRSN), Monte-Carlo Tractebel & Bel V : Deterministic, ORIGEN-2 code	SSTC NRS : Deterministic, based on fuel supplier data, additional calculations with specific codes (SCALE, MCNP, etc.) ARB : Supplied by the fuel supplier + additional calculations with ORIGEN and SCALE codes	SCALE code
Discretization	IRSN : Average of 8 different fuel types (based on irradiation and core management) Tractebel & Bel V : Only volatile FP inventory is used in the calculation(ORIGEN-2 for LOCA)	SSTC NRS : Average of several different types of similar fuel assembly ARB : Average of 4 different types of similar fuel assembly (similar irradiation)	One BWR 10x10 fuel bundle
Burn-up considered	IRSN : Realistic burn-up distribution for each assembly type at end of cycle Tractebel & Bel V : 650 days full operation at 3135 MW_{th} (end of cycle);	SSTC NRS : Realistic BU distribution for each assembly type at end of cycle ARB : Maximum BU for each assembly type	Average burn-up
Conditions	IRSN : Power at end of cycle	SSTC NRS : Steady state at full nominal power ARB : Full power at end of cycle	Steady state at full nominal power
% of ruptured fuel rods	IRSN : 33% Tractebel & Bel V : 100%	SSTC NRS : 100% ARB : 100%	55,5%

Fission products volatility

	IRSN	Tractebel/Bel V	SSTC NRS	ARB NPPS	LEI
Xe	noble gas	noble gas	noble gas	noble gas	noble gas
Kr	noble gas	noble gas	noble gas	noble gas	noble gas
Cs	Volatile		volatile	volatile	volatile
Rb	Volatile				volatile
Te	Volatile		semi-volatile		volatile
I	Volatile	volatile	volatile	volatile	volatile
Br	Volatile				volatile
Ag					volatile
Sr	semi-volatile		semi-volatile	semi-volatile	semi-volatile
Ba	semi-volatile		semi-volatile		semi-volatile
La	semi-volatile		low volatile	low volatile	semi-volatile
Eu	semi-volatile				semi-volatile
Ru	low volatile		low volatile	semi-volatile	low volatile
Ce				low volatile	semi-volatile
Pu			low volatile		low volatile

- Differences in the list of considered FPs
- Different definitions of volatility for several elements

Fission products release into the containment

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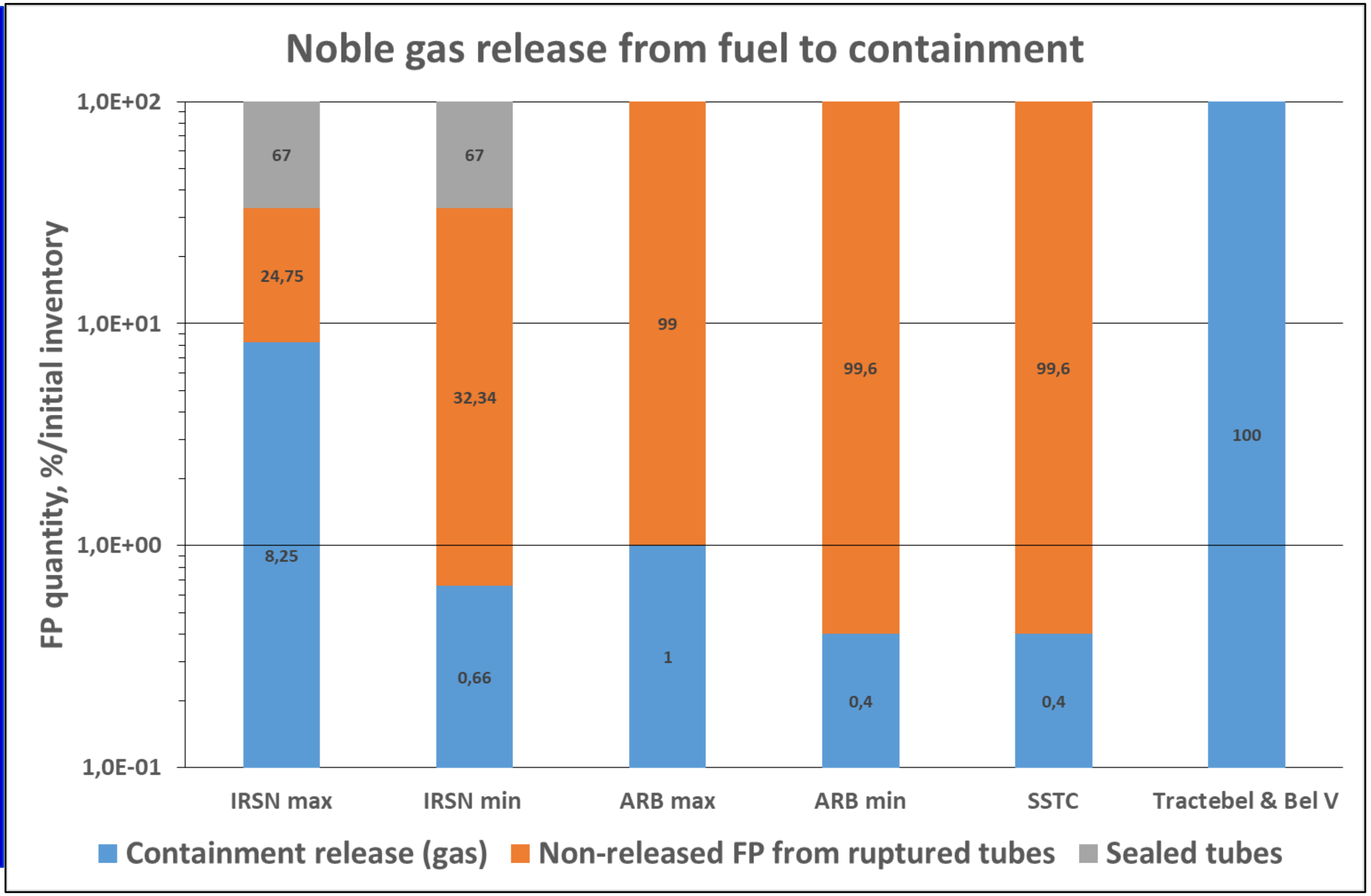

Contributing hypotheses:

- Fuel release rate
- Fuel rods failure rate

Fission products release into the containment

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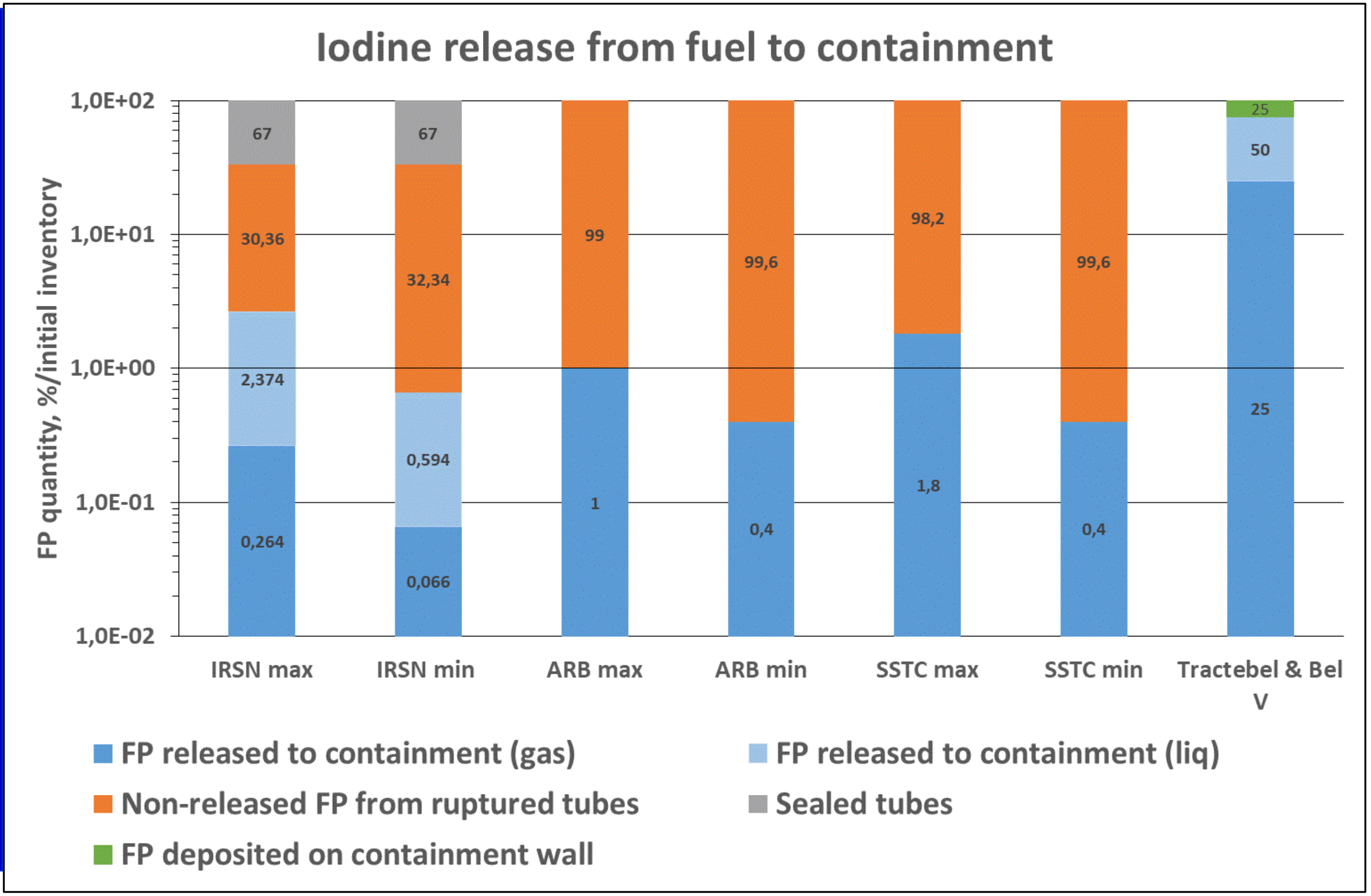


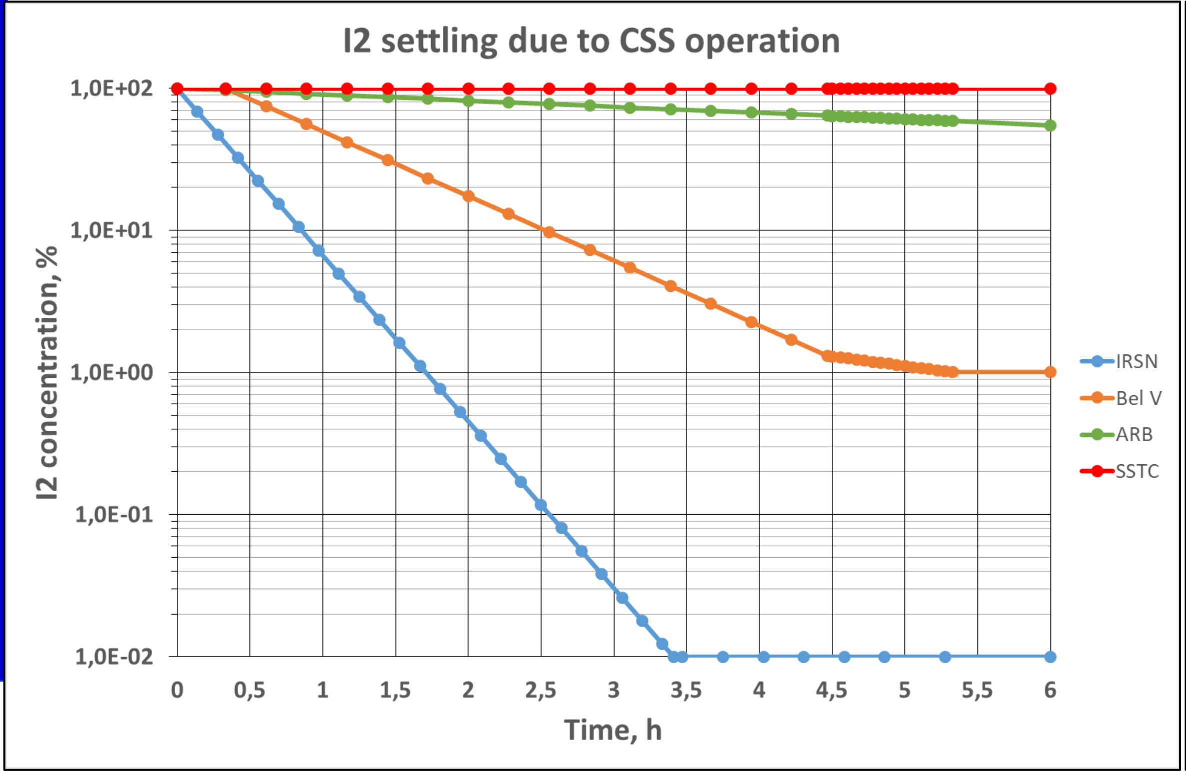
Contributing hypotheses:

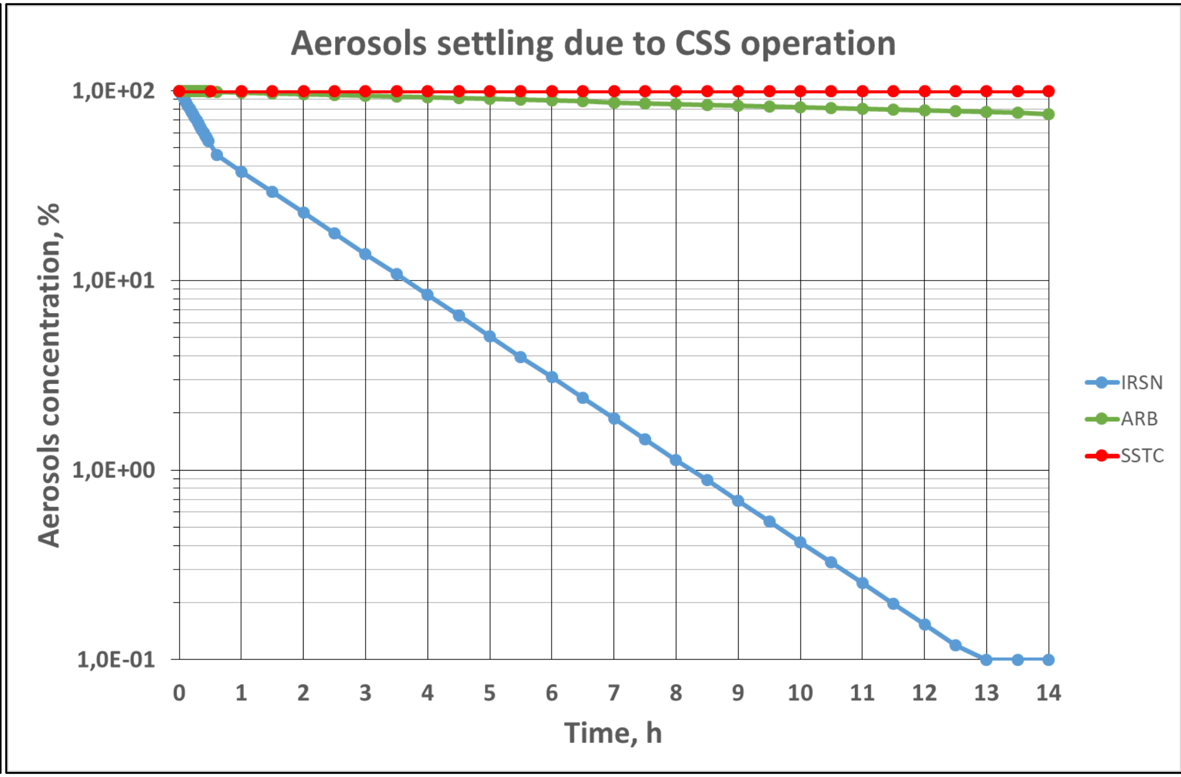
- Fuel release rate
- Partitioning between the liquid/gas phase of the containment
- Fuel rods failure rate

Iodine chemistry in the containment and CSS operation

- Instantaneous modelling: all iodine species are considered initially at the break and do not evolve
- Time-dependent modelling: iodine species undergo chemical reactions and evolve over time

- Major differences regarding the operation and the efficiency of the containment spray system





Containment building leak rate

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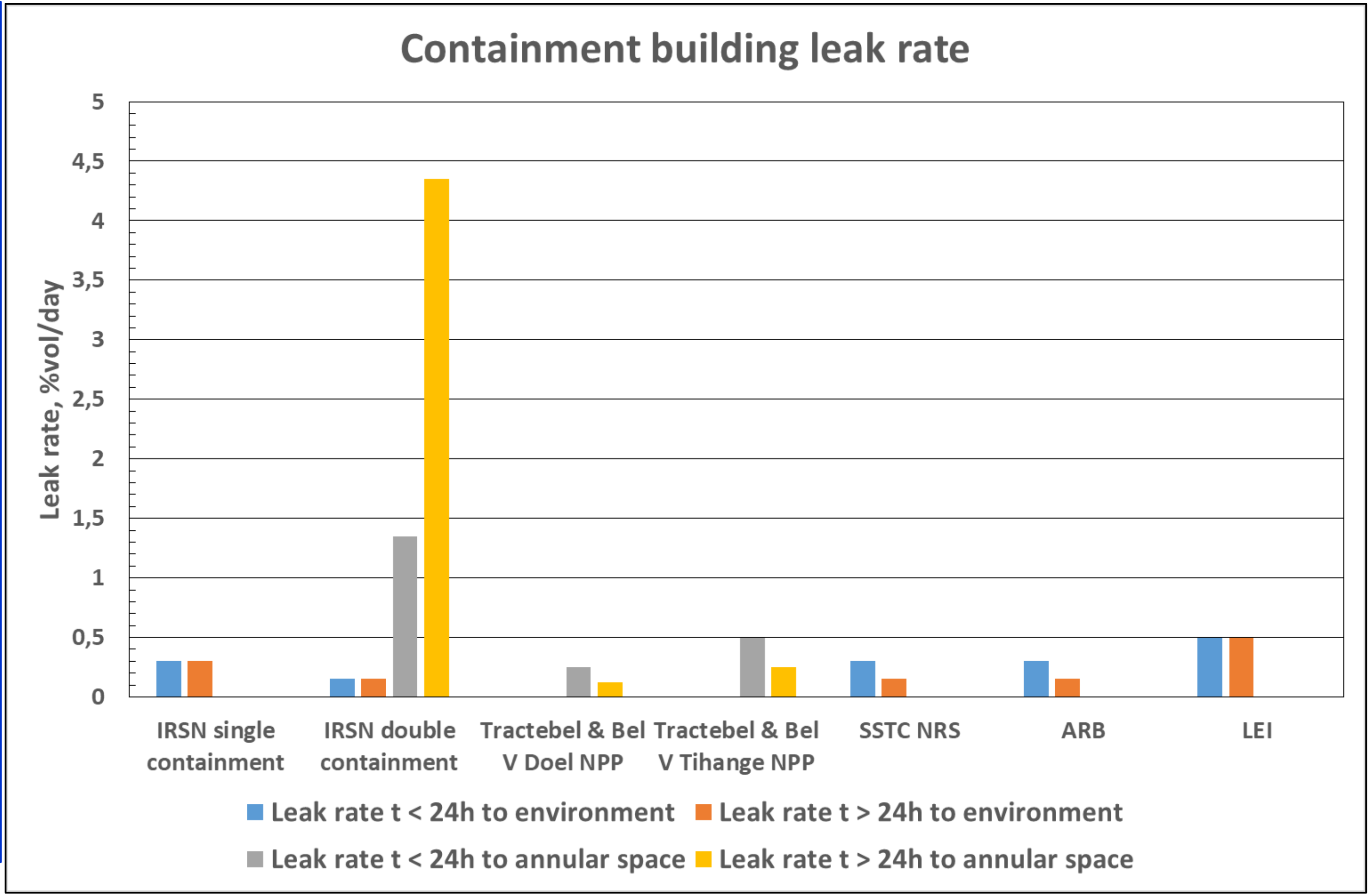

- Most hypotheses are conservative and assume a 100% release to the environment, bypassing the auxiliary buildings;
- Containment maxium leak rates are broadly similar between project partners, but the leak rate evolution is different;
- For IRSN double containment units, 1.35% vol/day and 4.35% vol/day leaks are collected in the annular space between the two containments;

Fission products release to the environment

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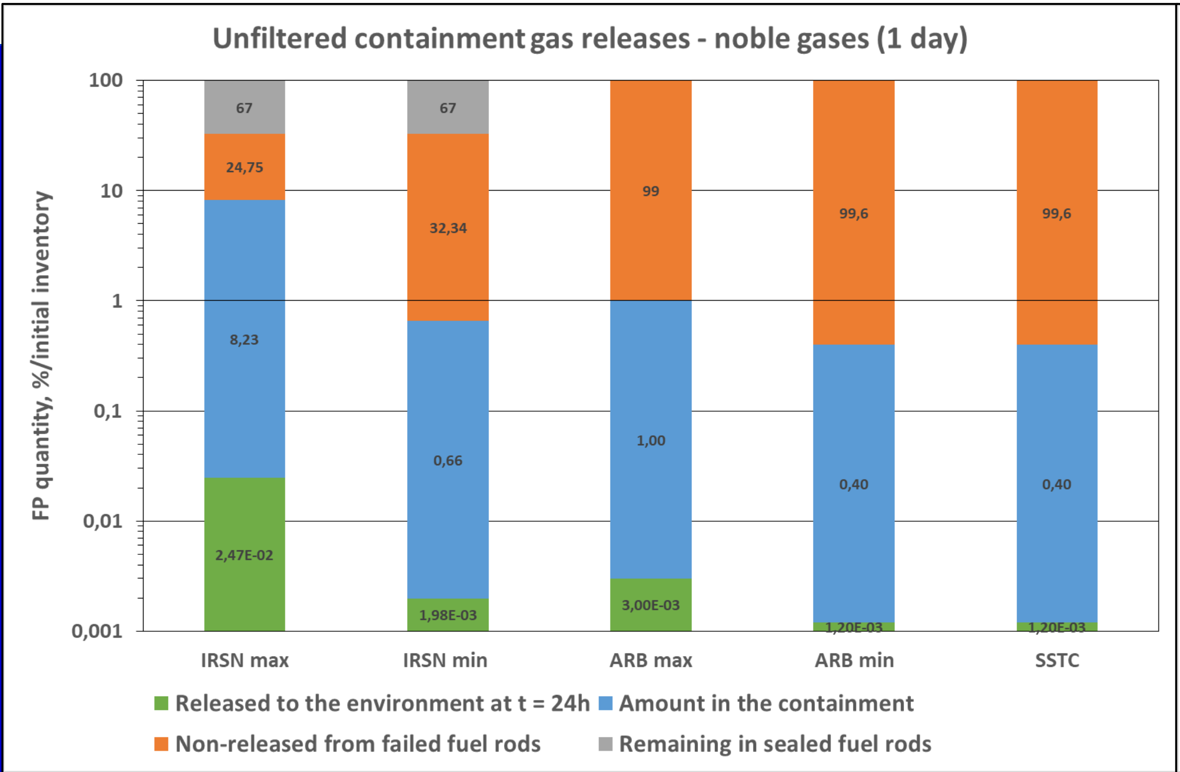

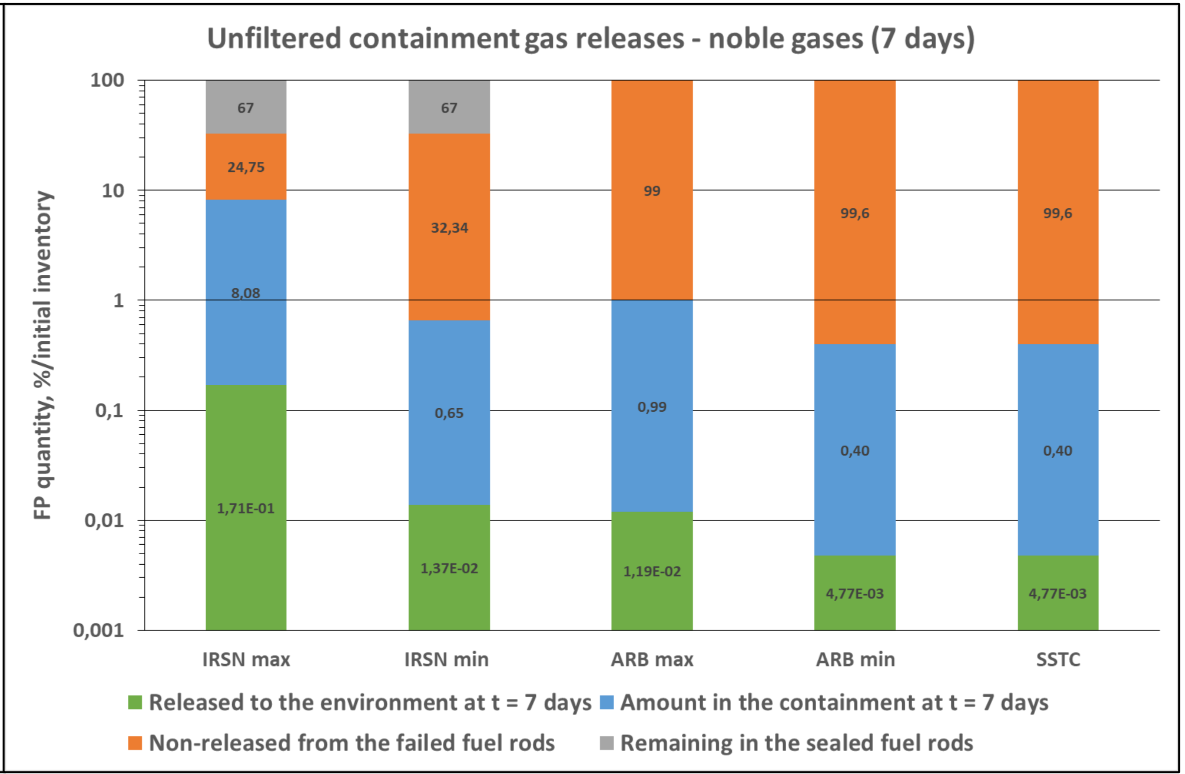

Most impactful hypotheses for the noble gases release:

- FP release rate from fuel (i.e. « IRSN max » column)
- Containment leak rate

Fission products release to the environment

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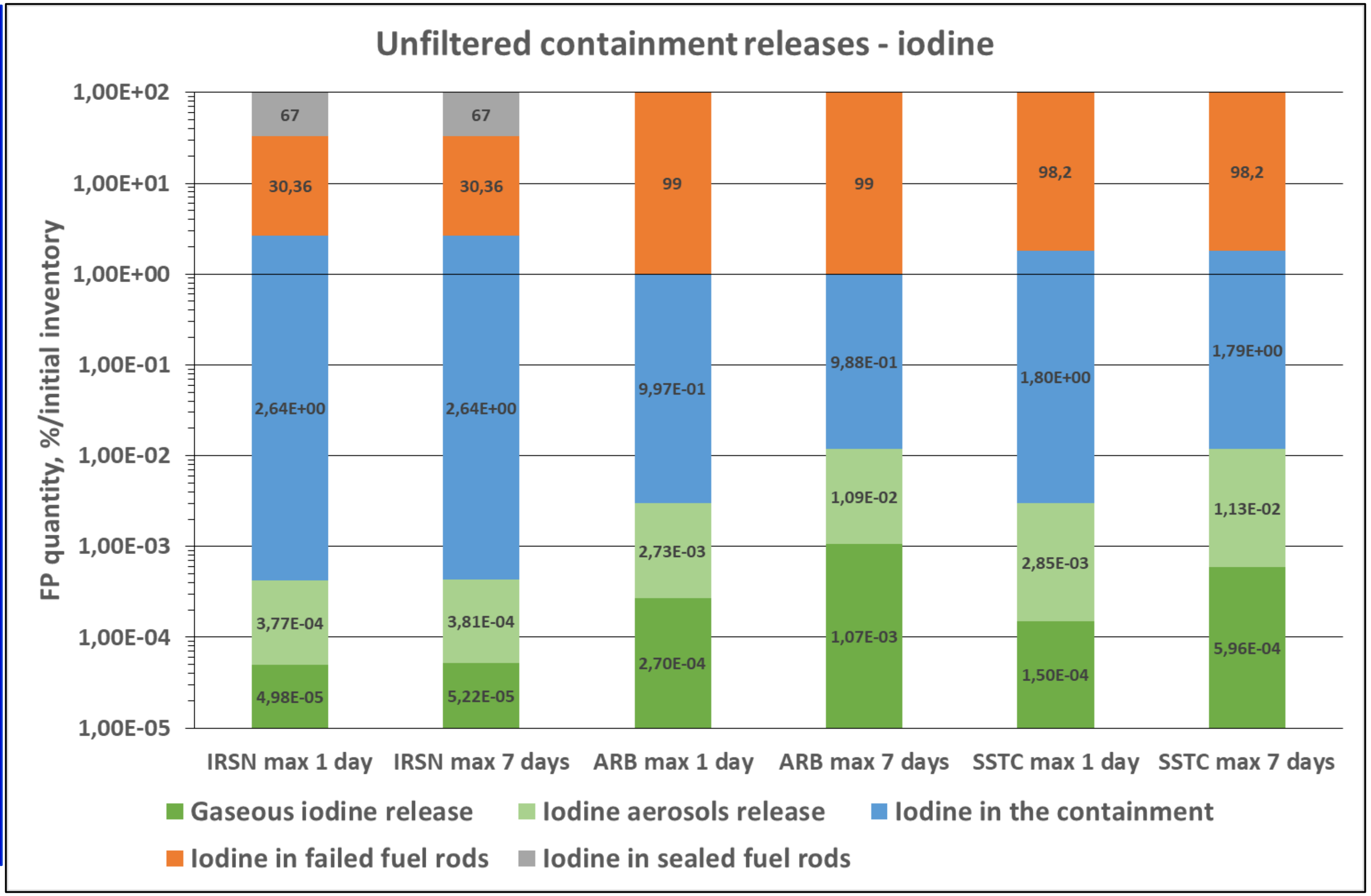

Most impactful hypothesys for the iodine species release:

- Containment Spray System operation => molecular iodine and aerosol settling

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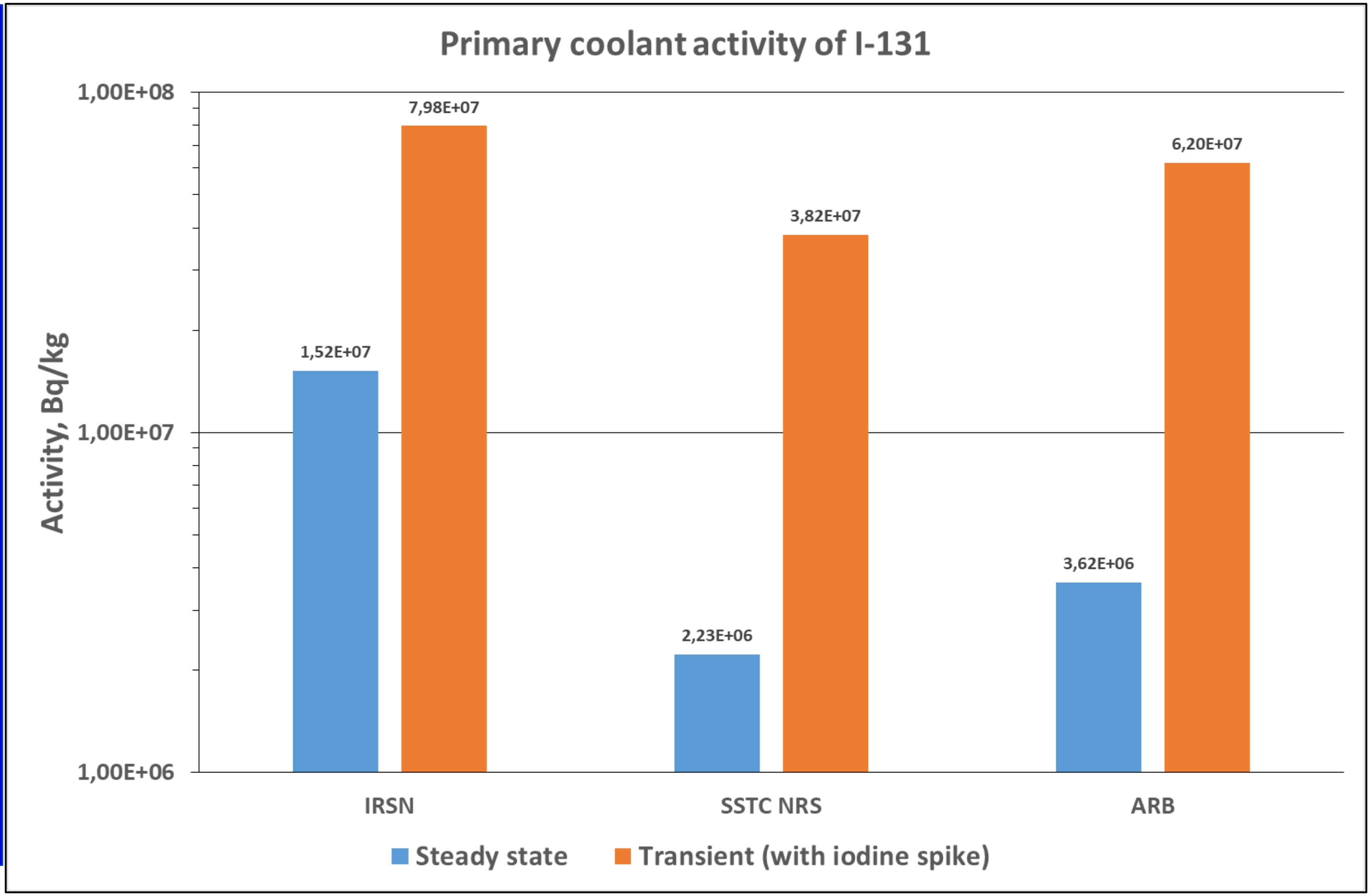
OF DESIGN BASIS & DESIGN EXTENSION ACCIDENTS

Source term evaluation in SGTR scenario

- Primary coolant activity
- Iodine distribution in the Steam Generator
- Iodine release to the environment

Primary coolant activity



Primary coolant activity:

- Evaluated differently for different reactor types
- Different list of fission products considered by every partner

Major differences regarding iodine speciation at the break:

- Molecular and particulate iodine
- Molecular, particulate and organic iodine
- No speciation at all (no discrimination between iodine species)

Iodine distribution in the SG:

- 1st approach – partitioning coefficients between liquid and gas phases of the SG (realistic or conservative)
- 2nd aproach – phenomenological distribution (flashing, atomisation, SG dry-out)

Iodine release to the environment

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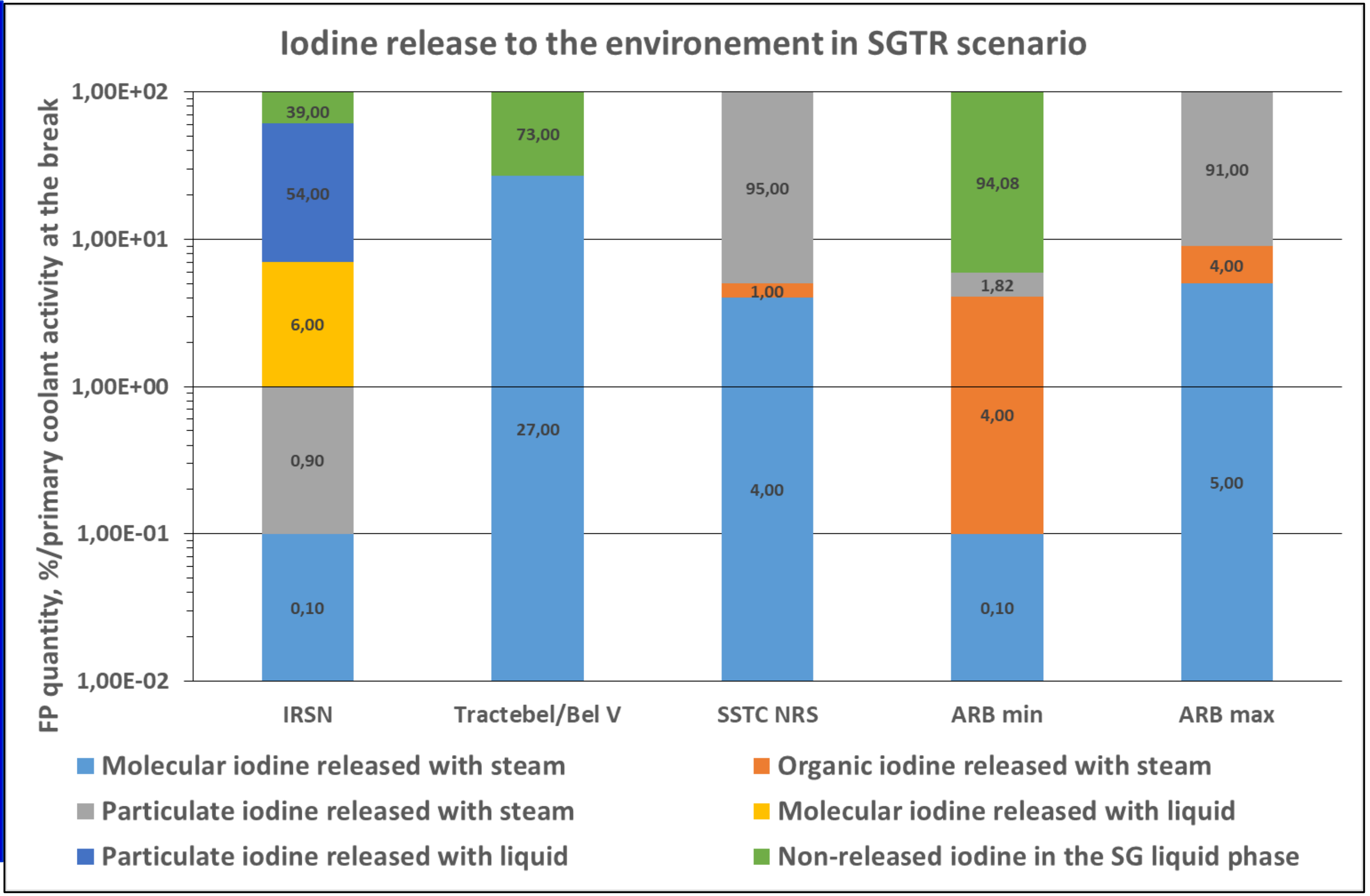

Most impactful hypotheses for the iodine species release:

- Iodine distribution between liquid/steam in the SG (i.e. 100% to steam or not)
- Liquid releases to the environment

Secondary loop retention: only considered by Tractebel & Bel V in the evaluation of SGTR source term

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Conclusion

- General trend: source term evaluation methodologies differ among the project partners

- Few hypotheses and approaches are similar (eg. core discretization for LOCA scenario)

- The source term in the environment can vary significantly based on the assumptions used in the methodology

Thank you!

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