



NUBIKI NUCLEAR SAFETY RESEARCH INSTITUTE


BEYOND DESIGN BASIS ACCIDENT CALCULATION OF ALLEGRO GASCOOLED FAST REACTOR

Dr. Gábor L. Horváth

horvathlg@nubiki.hu

MELCOR European Users Group

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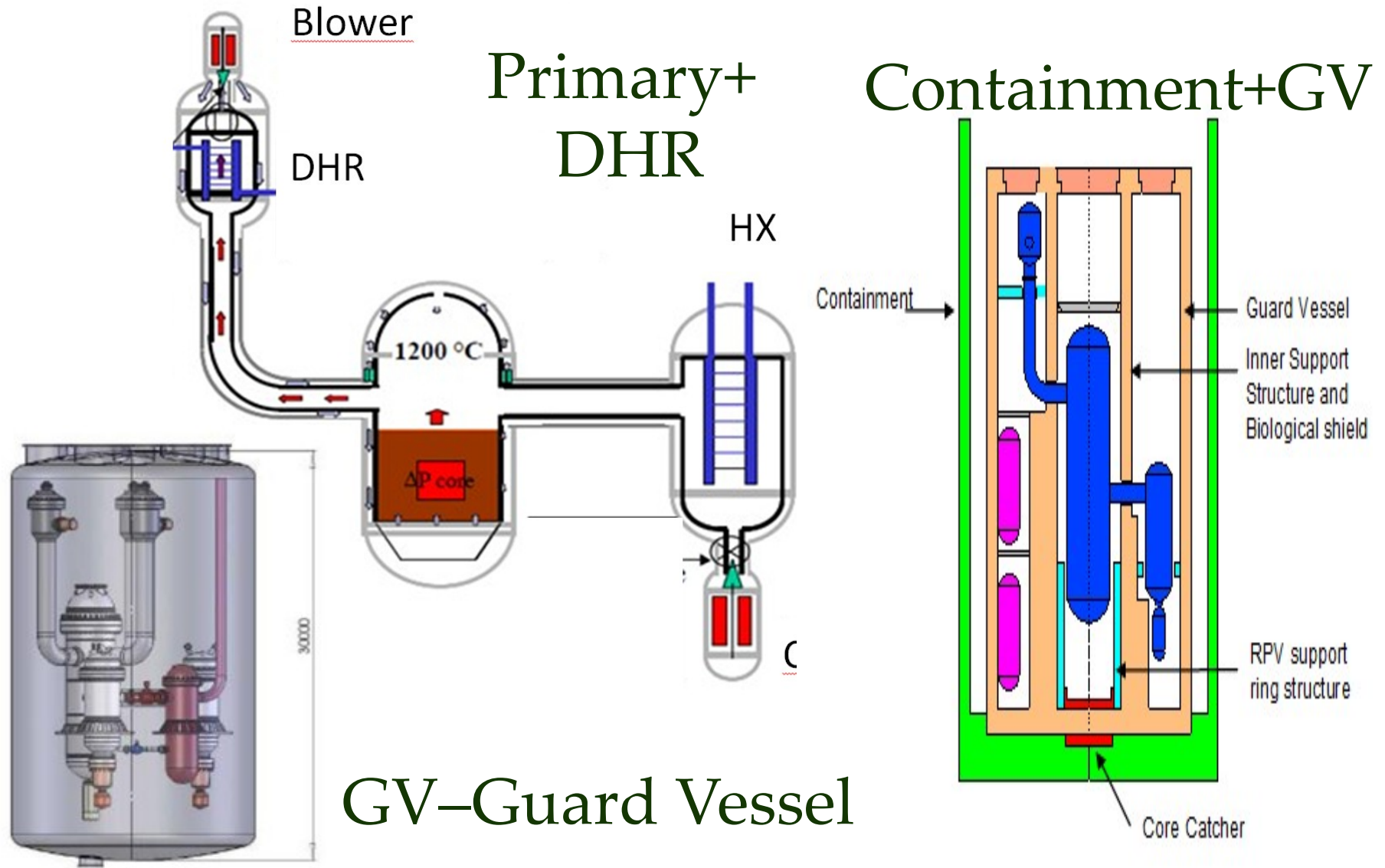


- Background of calculations
- ALLEGRO 75 MW reactor
- MELCOR model
- Previous calculations
- 10 inch LOCA Beyond Basis Accident
- Radioactivity release
- Radioactivity release mechanisms
- Extent of radioactivity release
- Tasks to do

Background - Scope

- ALLEGRO 75MW is under development in the frame of V4 countries (PL,Cz,SL,HU)
- NUBIKI Share: Severe accident calc.
- MELCOR selection has been based on:
 - Experiment recalculations
 - Steady-state calc.
 - Compare to Cathare
- Main goals – study processes in gas cooled reactors:
 - severe accident thermal hydraulics
 - Fission product transport
 - Establish accident management procedures

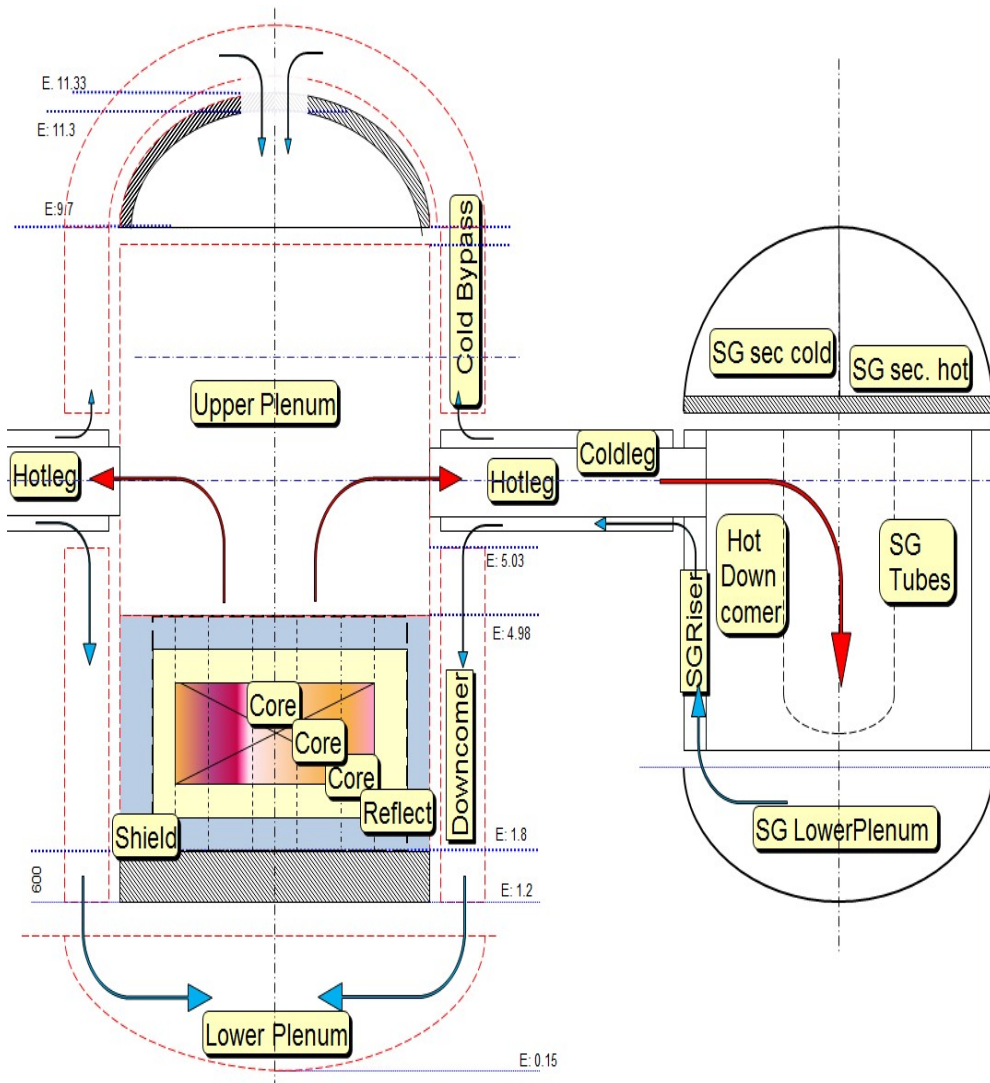
75 MW Fast Breeder



Allegro 75 MW – model parts

- 2 loop primary circuit + pony motor
- reactor protection
- Secondary circuit
- DHR heat exchangers + DHR gas blowers
- Nitrogen accumulators

Allegro 75 MW – Primary + Core model



	Upper Plenum: CVH15					Core Barrel	HS height	Top of cell
	CV5	CV6	CV7	CV8	CV9			
Head	Core	Core	Core	Ref+Sh	Shield			4.980
Shield	126	226	326	426	526	HS0026	0.125	4.780
Reflector	125	225	325	425	525	HS0025	0.0	4.180
Unheated	124	224	324	424	524	HS0024	0.0	3.835
Fuel 10	123	223	323	423	523	HS0023	0.125	3.710
Fuel 9	122	222	322	422	522	HS0022	0.125	3.624
Fuel 8	121	221	321	421	521	HS0021	0.125	3.538
Fuel 7	120	220	320	420	520	HS0020	0.125	3.452
Fuel 6	119	219	319	419	519	HS0019	0.125	3.366
Fuel 5	118	218	318	418	518	HS0018	0.125	3.280
Fuel 4	117	217	317	417	517	HS0017	0.125	3.194
Fuel 3	116	216	316	416	516	HS0016	0.125	3.108
Fuel 2	115	215	315	415	515	HS0015	0.125	3.022
Fuel 1	114	214	314	414	514	HS0014	0.125	2.936
Unheated	113	213	313	413	513	HS0013	0.125	2.850
Reflector	112	212	312	412	512	HS0012	0.125	2.725
Shield	111	211	311	411	511	HS0011	0.125	2.400
Core Supp. Plate	110	210	310	410	510	HS0010	0.0	1.800
Empty	109	209	309	409	509		0.0	1.200
Empty	108	208	308	408	508	608	0.13	1.089
Empty	107	207	307	407	507	607	0.13	0.938
Empty	106	206	306	406	506	606	0.13	0.806
Empty	105	205	305	405	505	605	0.13	0.675
LP Plate??	104	204	304	404	504	604	0.13	0.544
Empty	103	203	303	403	503	603	0.13	0.413
Empty	102	202	302	402	502	602	0.13	0.281
Empty	101	201	301	401	501	601	0.13	0.150
LOWER HEAD							0	

Radial Rings: 1 2 3 4 5 6 Reference cell

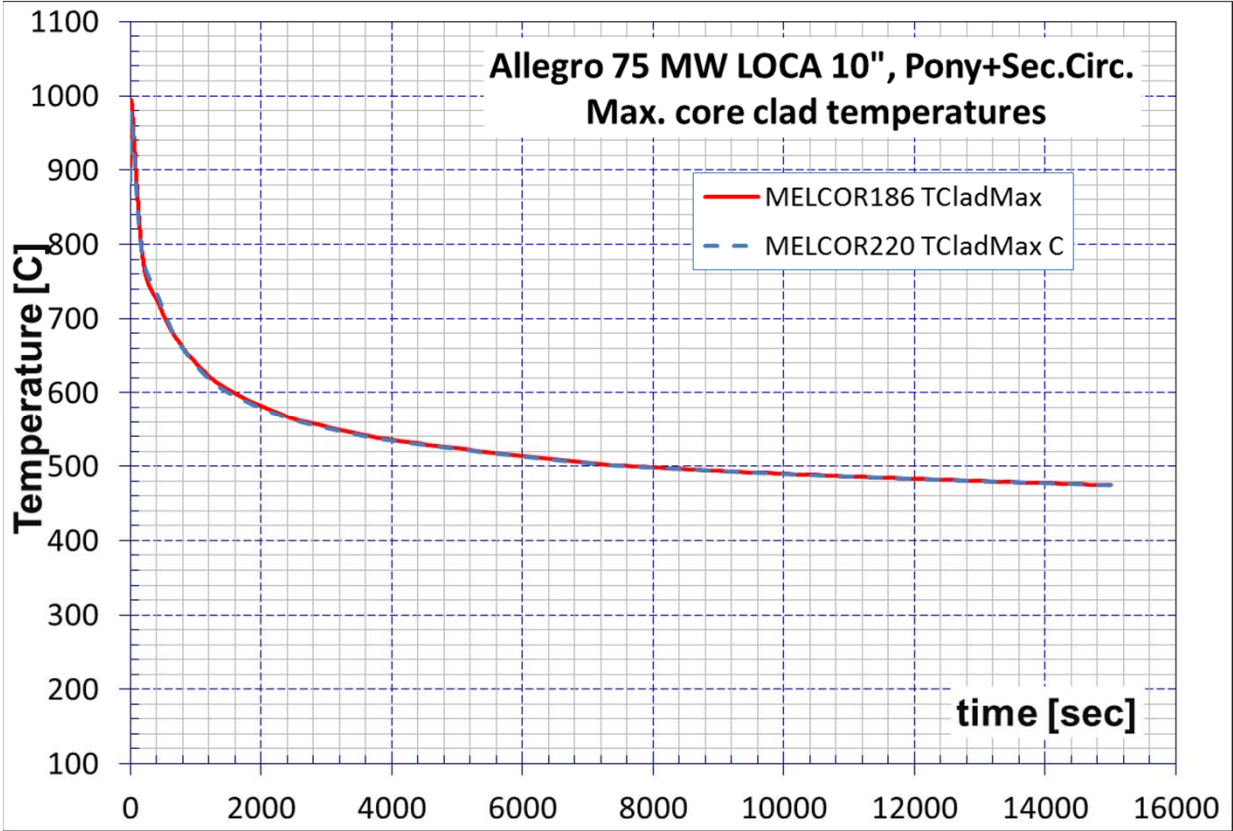
Allegro 75 MW – MELCOR 1.8.6 vs. 2.2

- MELCOR core is suitable to calculate 75 MW gas cooled reactor
- MELCOR is able to calculate steady state and transients of ALLEGRO 75 MW reactor
- DBA calculations agree with Cathare results

Allegro 75 MW – Exploratory studies



MELCOR 1.8.6 and 2.2 calculations agree well



Allegro 75 MW – BDBA accidents

10 inch Coldleg LOCA initial conditions

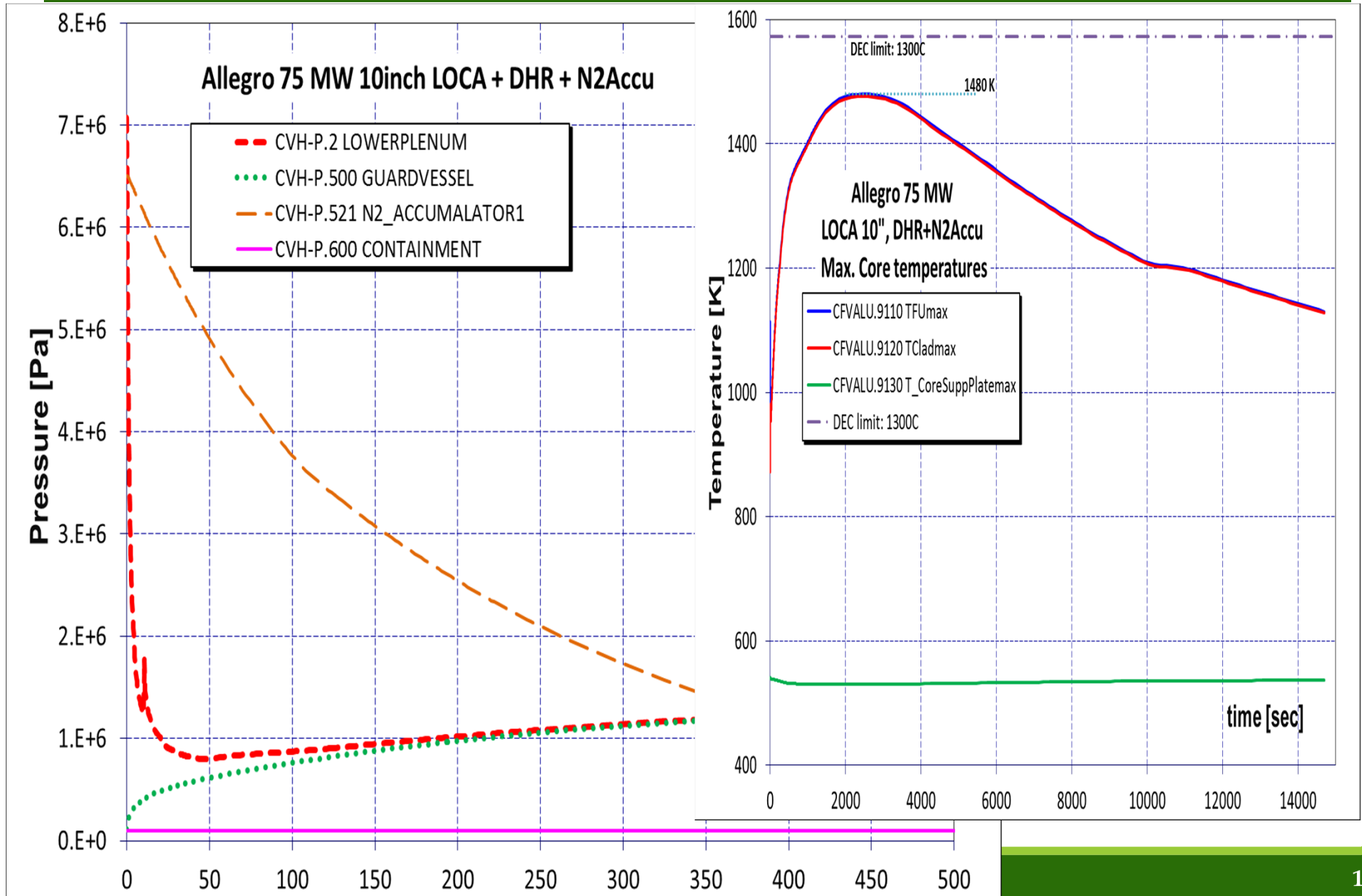
Accident	N2 accum.	Pony Motor+ Sec. Circ.	DHR- HX	DHR- blower	DEC limit
LOCA	On	No	Natural circ.	No	1573 K

N2 accum. M3	GV leak	GV init. pressure	Containment leak	DHR water reserve
2x200	0.1 vol%/d	1 bar	7e-5m2	74m3

Allegro 75 MW – 10inch LOCA events

Events	Time
Cold leg LOCA d=0.254 m	0.0
N2 accumulator ON	0.15 s
SCRAM	0.2 s
DHR – HX valve ON	20.2 s
Gap release ring 1	209 s
Fuel cladding temperature >1300 K	430 s
Fuel cladding temperature starts to decline	3000 s
Fuel cladding temperature below 1000K	7h
End of calculations	2.3d

Allegro 75 MW – 10 inch LOCA results



Allegro 75 MW – BDBA accidents 10 inch Coldleg LOCA Main results



Parameter	
Primary and GV pressure stable after 400s	12 bar
Decay heat after 1 day	1 MW
Max. cladding temperature (below 1573 K DEC limit)	1480 K
DHR HX water saturated	0.5 d
DHR HX water reserve exhausted	8 d
GV max. temperature (around t=0s)	510 K
GV stable temperature after 4-5 days	350 K
Containment initial vacuum is over (leakage starts)	1.4 d

Allegro 75 MW – BDBA accidents 10 inch Coldleg LOCA Activity release

Gap release =

In 2/3 of core after – 200-300s

Initial gap activity (% of core inventory):

XE: 3%

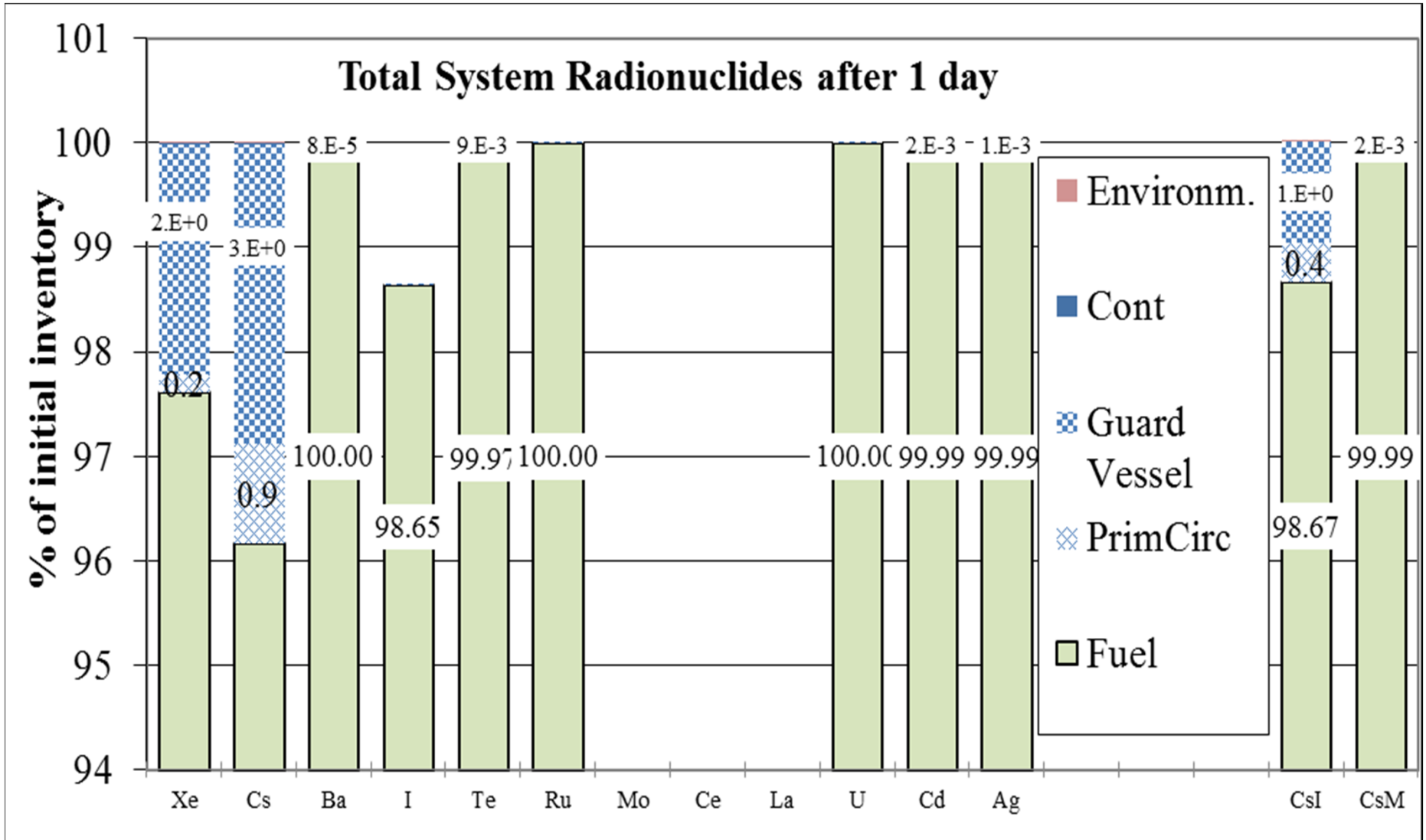
I2: 1.7%

Cs: 5 %

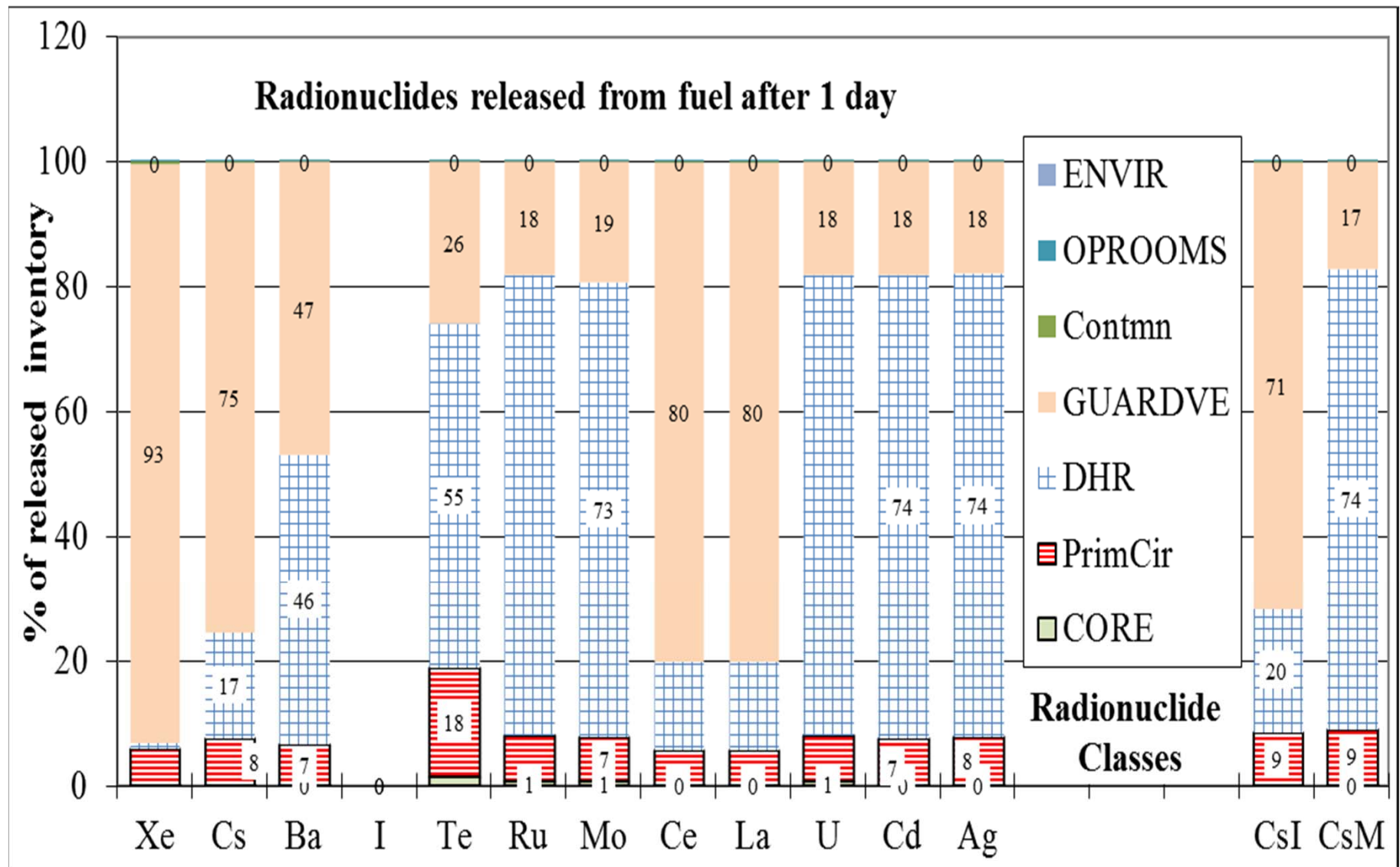
BA: 0.0004%

TE: 0.01%

Allegro 75 MW – 10inch LOCA activity distribution



Allegro 75 MW – 10inch LOCA activity released from fuel



Allegro 75 MW – BDBA accidents 10 inch Cold leg LOCA Activity release



Most of activity released from fuel (3.8%) stays in:

- primary circuit
- GV and
- DHR

Allegro 75 MW – BDBA accidents 10 inch Cold leg LOCA Main processes

DHR HX– thermophoresis:

36x 1000s

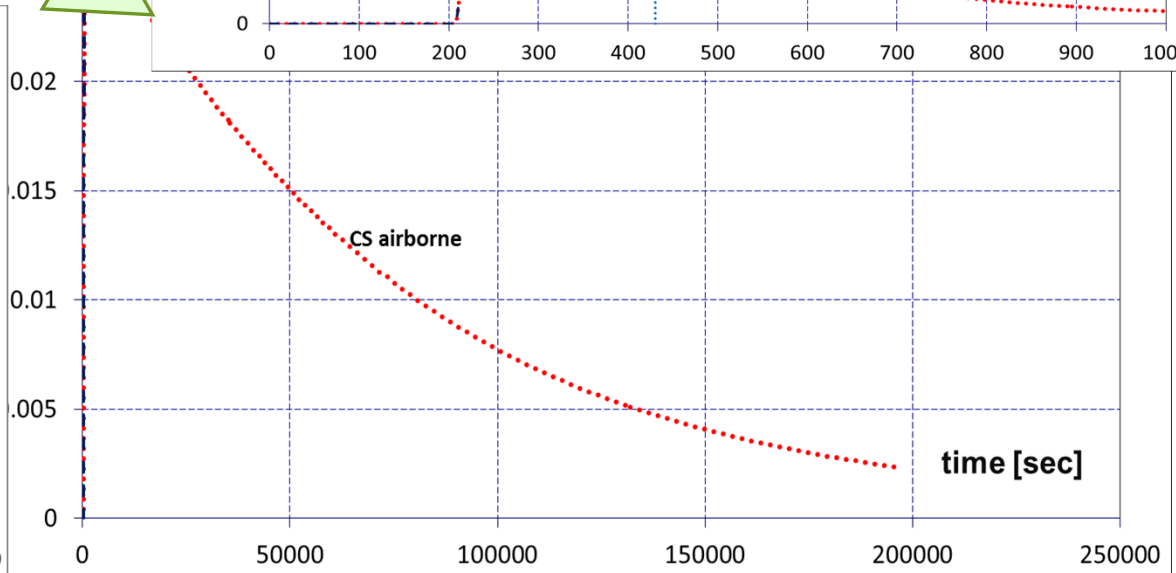
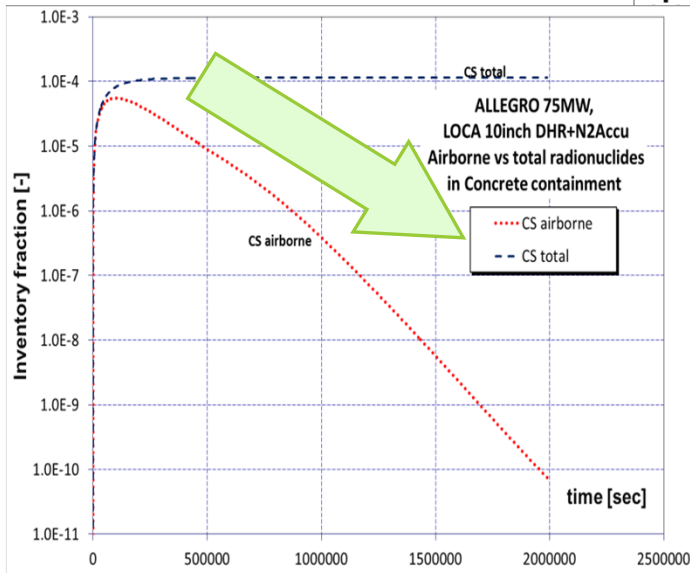
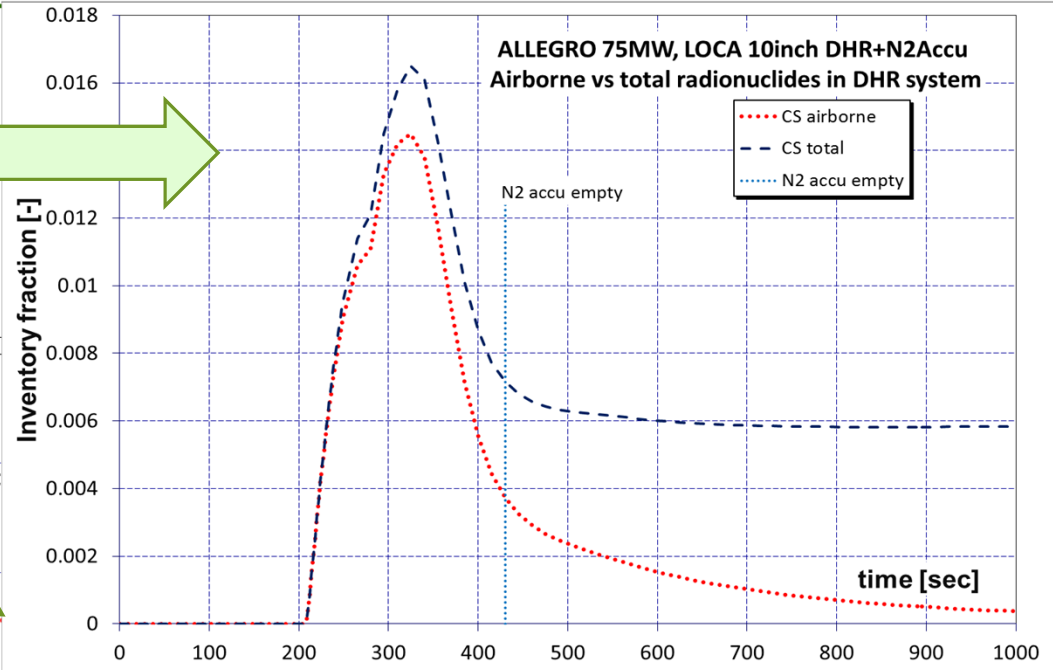
GV–

Gravitation + thermophoresis

12x 2.3d

Containment

Gravitation: 150x 11.5d



Allegro 75 MW – BDBA accidents

Conclusions

- 10 inch LOCA is a BDBA accident with N2 accu and DHR HX (natural circulation) without core melt but with core damage
- Max release from fuel is 3.8% of core inventory
- With no water in system (no diffusiophoresis) the aerosol deposition is very slow
- Primary circuit + GV + DHR-HX + Containment gives 5 orders of magnitude radioactivity retention up to 1 day
- Containment gives 2 orders of magnitude retention in 10 days

Allegro 75 MW – Calculations performed

N o	Accident	N2 accu	Pony Motor+ Sec.Circ	DHR- HX	DHR- blower	T clad. Max.
1	DBA	No	On	No	No	1030 K
2	DBA	No	No	Blower	On	1005 K
3	BDBA	On	No	Natural	No	1480 K

Allegro 75 MW – BDBA accidents

Future

- Include new design features – ceramic cladding might be a problem
- Calculate severe accidents
- Calculate accident management measures
- MELCOR 2.2 is to be used as it proved to be suitable for gas cooled reactors – use of He is without problem

Thank you for your attention

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