ÚJV Řež, a.s.

Results of TH benchmark on GFR

Petr Vácha (petr.vacha@ujv.cz)
Nuclear Research Institute Rez

10th EMUG, 25th - 27th April 2018, Zagreb, Croatia

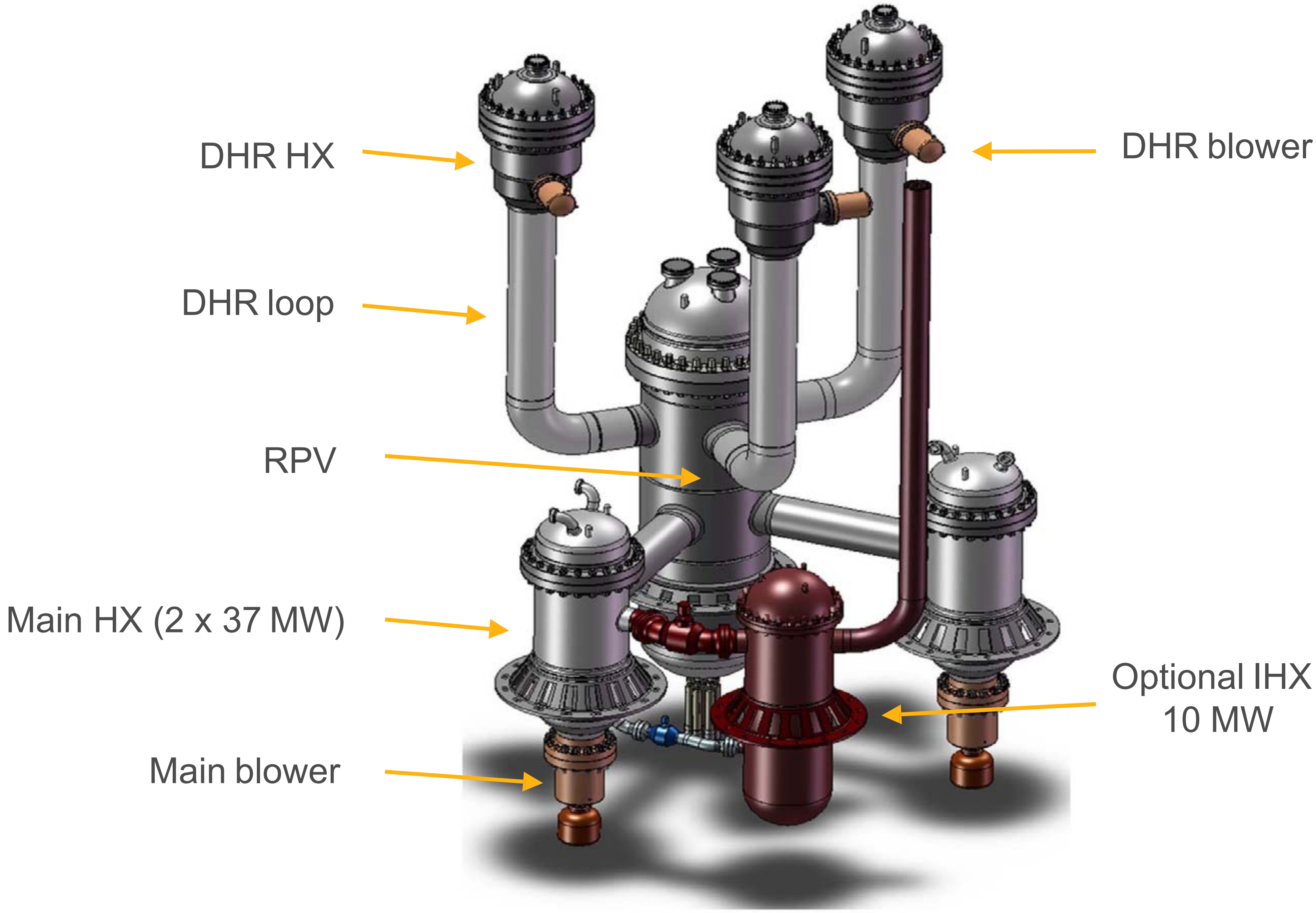
Contents

- What is ALLEGRO
- Code-to-code TH benchmark
- Problems I have encoutered

GFR ALLEGRO - specifications

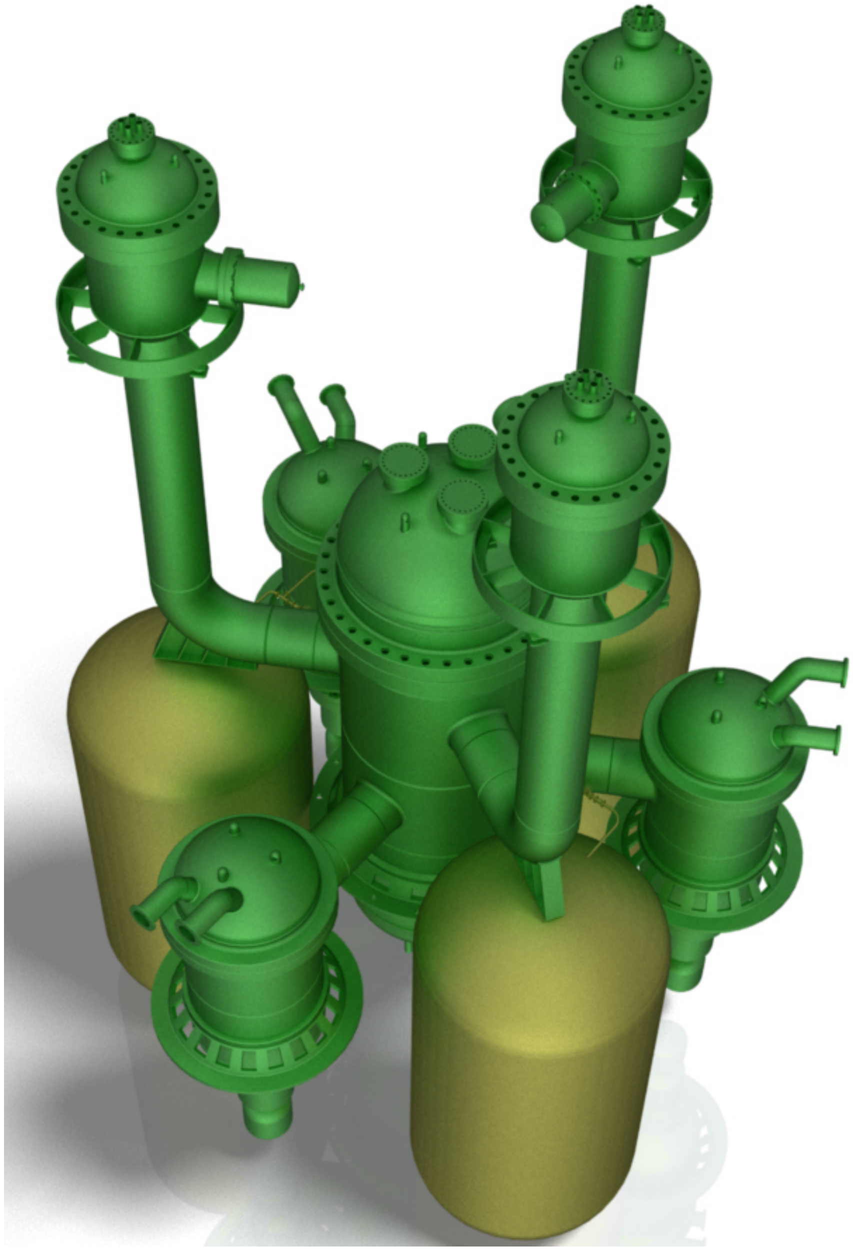
- **ALLEGRO concept:**
  - Reactor unit size: 75 MWt
  - Core power density: 100 MWt/m^3
  - Coolant: He
  - Nominal pressure: 7 MPa
  - Fuel forms: MOX pin-type (starting core)
    Ceramic pin-type (refractory core)
  - Core outlet temperature: 530°C (starting)
    850°C (refractory)

ALLEGRO 75 MWt (2009)



ALLEGRO 75 MW (2018)

- **ALLEGRO 2018 concept:**
  - **3 main cooling loops (120°)**
  - **3 DHR system loops (120°C)**
  - **Emergency coolant injection system**
  - **New design of the DHR system HX**
  - **Improved safety – all protected transients within DBA**



ALLEGRO TH code-to-code Benchmark (1/3)

- **Purpose**
  - Comparison of codes and users capabilities, unifying (and improving) input decks,

- **Codes**
  - RELAP3D (VUJE),
  - CATHARE2 (MTA-EK, VUJE), MELCOR 2.2 (UJV)

- **Status**
  - First evaluation done, second round of the benchmark underway

ALLEGRO TH Benchmark (2/3)

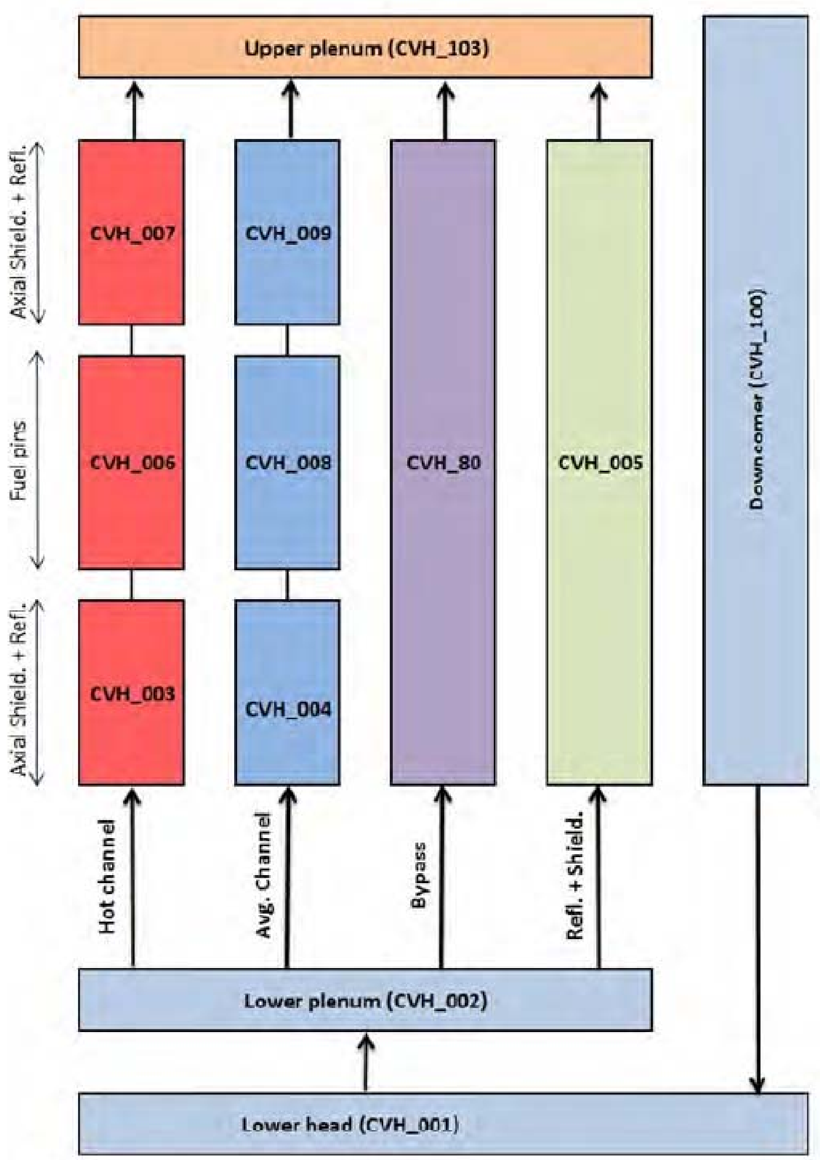
- **2 Transients selected for the transient calculation comparison**
  - LOCA on main cold duct
  - SBO

- **Compared results**
  - Over 60 compared values for the steady state
  - Over 40 compared values for the transients (Temperatures, pressures, mass flow ratess, etc.)

ALLEGRO TH Benchmark (3/3) – steady state

Property	Refference value	MELCOR value	Acceptable error (%)	MELCOR error (%)
Core inlet temperature (°C)	260.0	259.1	0.5	0.35
Core outlet temperature (°C)	516.0	513.88	0.5	0.41
Core inlet pressure (MPa)	7.0	6.99	0.1	0.13
Core mass flow rate (kg/s)	56.45	56.79	2.0	0.6
Core pressure drop (kPa)	84.0	84.8	10.0	0.95
MHX pressure drop (kPa)	20.0	15.94	10.0	19.9
MHX area water side (m2)	121.02	134.56	10.0	11,19

Core nodalization in MELCOR (CVH- FL)



Core nodalization in MELCOR (COR)

Channel

ring / level	1	2	3	4	5	6	7
25	CVH_007	CVH_009	CVH_009	CVH_009	CVH_005	CVH_005	CVH_100
24	CVH_007	CVH_009	CVH_009	CVH_009	CVH_005	CVH_005	CVH_100
23	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
22	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
21	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
20	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
19	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
18	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
17	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
16	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
15	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
14	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
13	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
12	CVH_006	CVH_008	CVH_008	CVH_008	CVH_005	CVH_005	CVH_100
11	CVH_003	CVH_004	CVH_004	CVH_004	CVH_005	CVH_005	CVH_100
10	CVH_003	CVH_004	CVH_004	CVH_004	CVH_005	CVH_005	CVH_100
9	CVH_002	CVH_002	CVH_002	CVH_002	CVH_002	CVH_002	CVH_100
8	CVH_002	CVH_002	CVH_002	CVH_002	CVH_002	CVH_002	CVH_100
7	CVH_001	CVH_001	CVH_001	CVH_001	CVH_001	CVH_001	CVH_100
6	CVH_001	CVH_001	CVH_001	CVH_001	CVH_001	CVH_001	CVH_100
5	CVH_001	CVH_001	CVH_001	CVH_001	CVH_001	CVH_001	CVH_001
4	CVH_001	CVH_001	CVH_001	CVH_001	CVH_001	CVH_001	
3	CVH_001	CVH_001	CVH_001	CVH_001	CVH_001		
2	CVH_001	CVH_001	CVH_001	CVH_001			
1	CVH_001	CVH_001	CVH_001				

Bypass

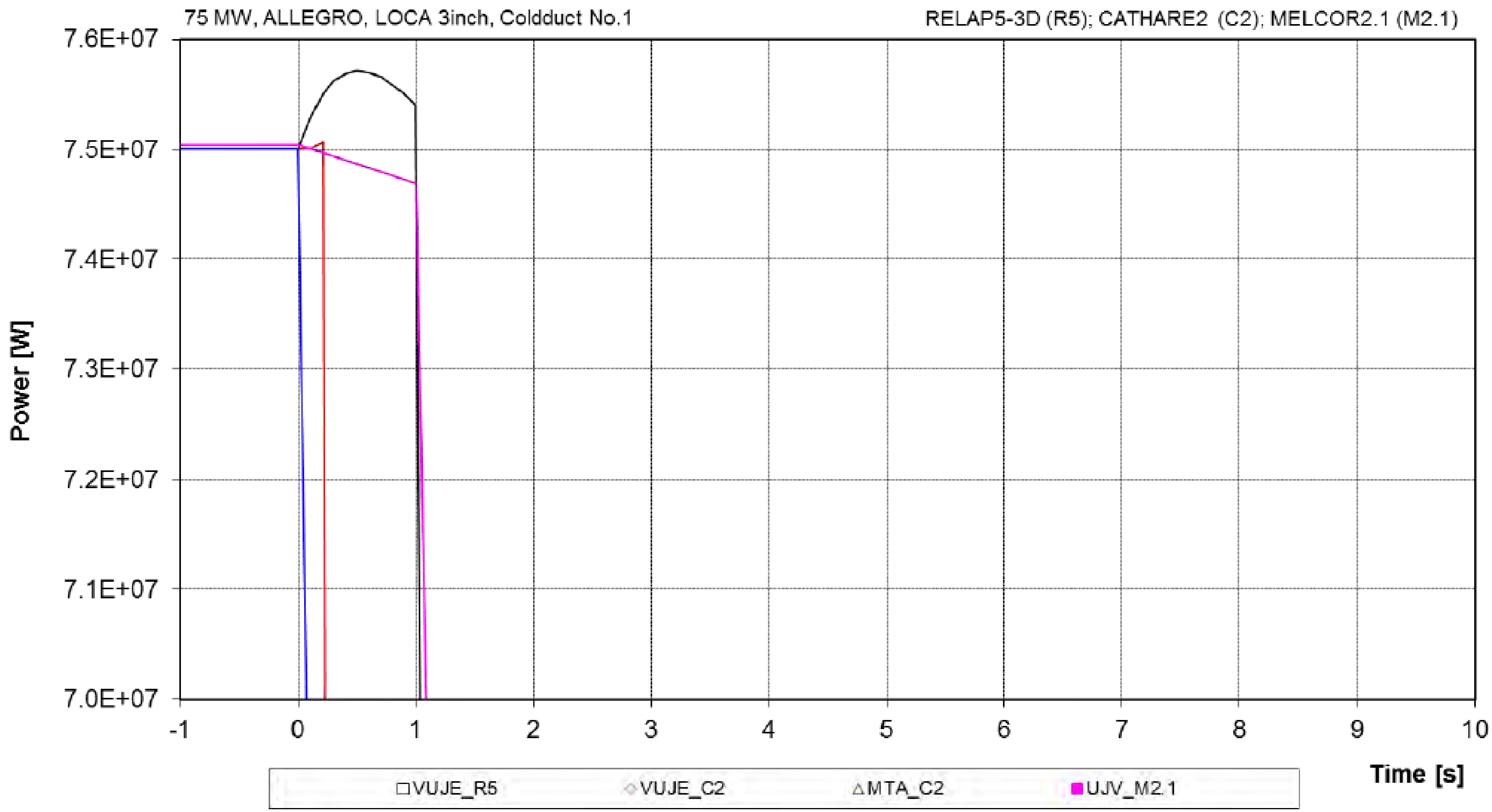
ring level	1	2	3	4	5	6	7
25	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-
23	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
22	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
21	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
20	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
19	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
18	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
17	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
16	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
15	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
14	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
13	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
12	CVH_080	CVH_080	CVH_080	CVH_080	-	-	-
11	-	-	-	-	-	-	-
10	-	-	-	-	-	-	-
9	-	-	-	-	-	-	-
8	-	-	-	-	-	-	-
7	-	-	-	-	-	-	-
6	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-
4	-	-	-	-	-	-	
3	-	-	-	-	-		
2	-	-	-	-			
1	-	-	-				

Legend: Downcomer; Lower head Lower plenum; Support plate; Shielding; Reflector; Fuel

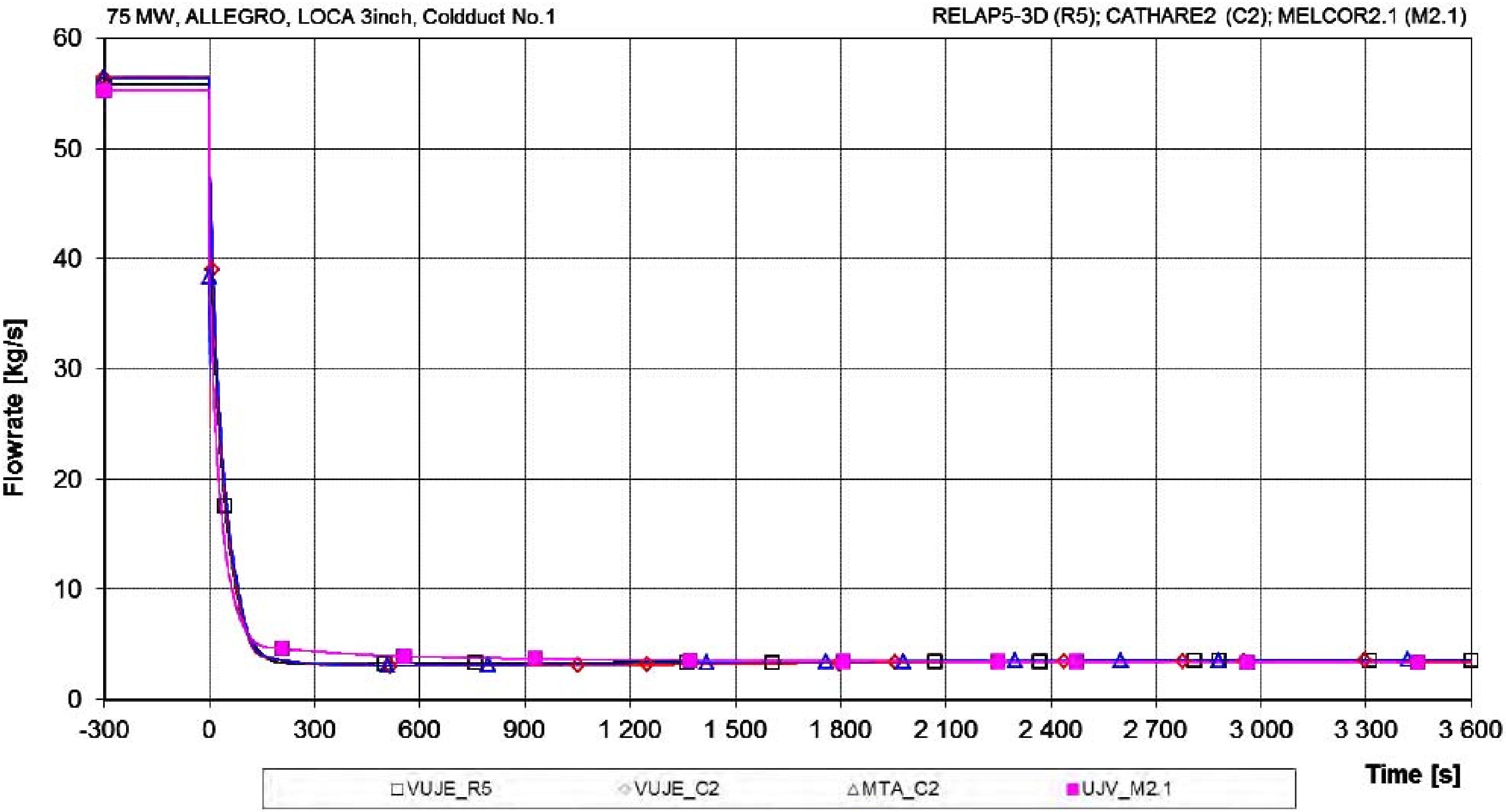
Results of LOCA 75mm

- Core power
- Core mass flowrate
- Maximum cladding temperature
- MHX feedwater inlet temperature
- Break mass flow rate

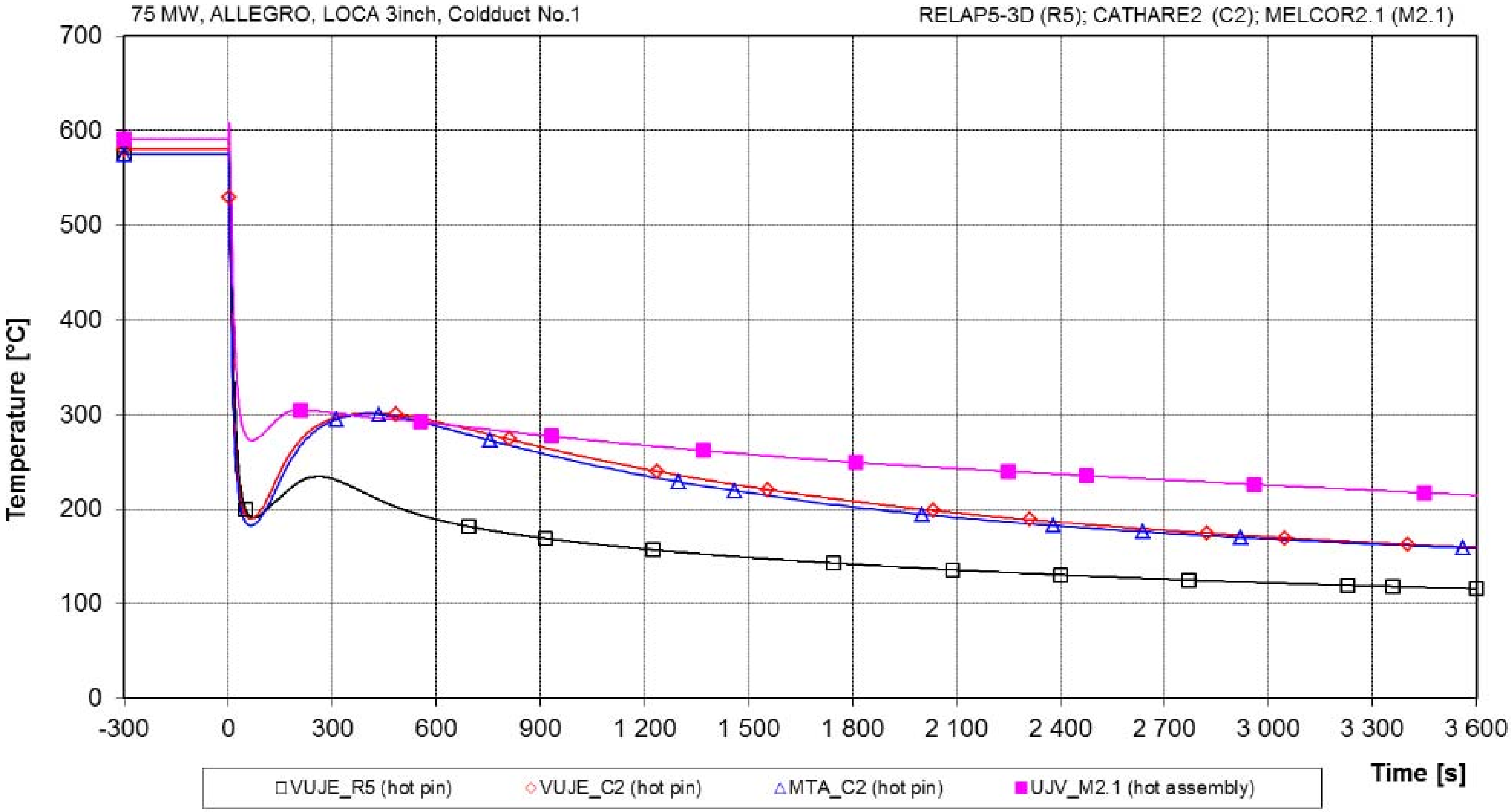
LOCA 75mm results – core power



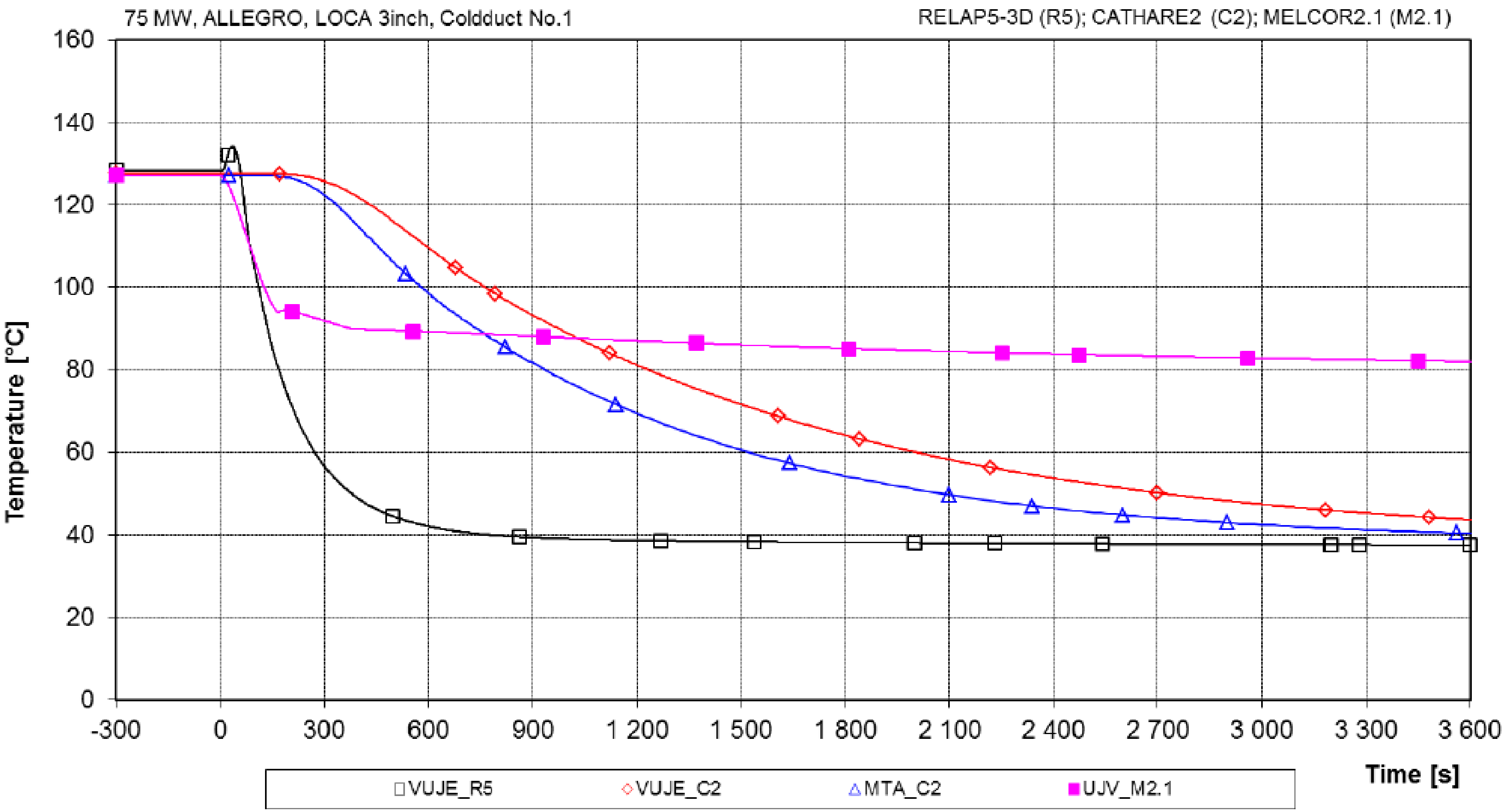
LOCA 75mm results – core mass flowrate



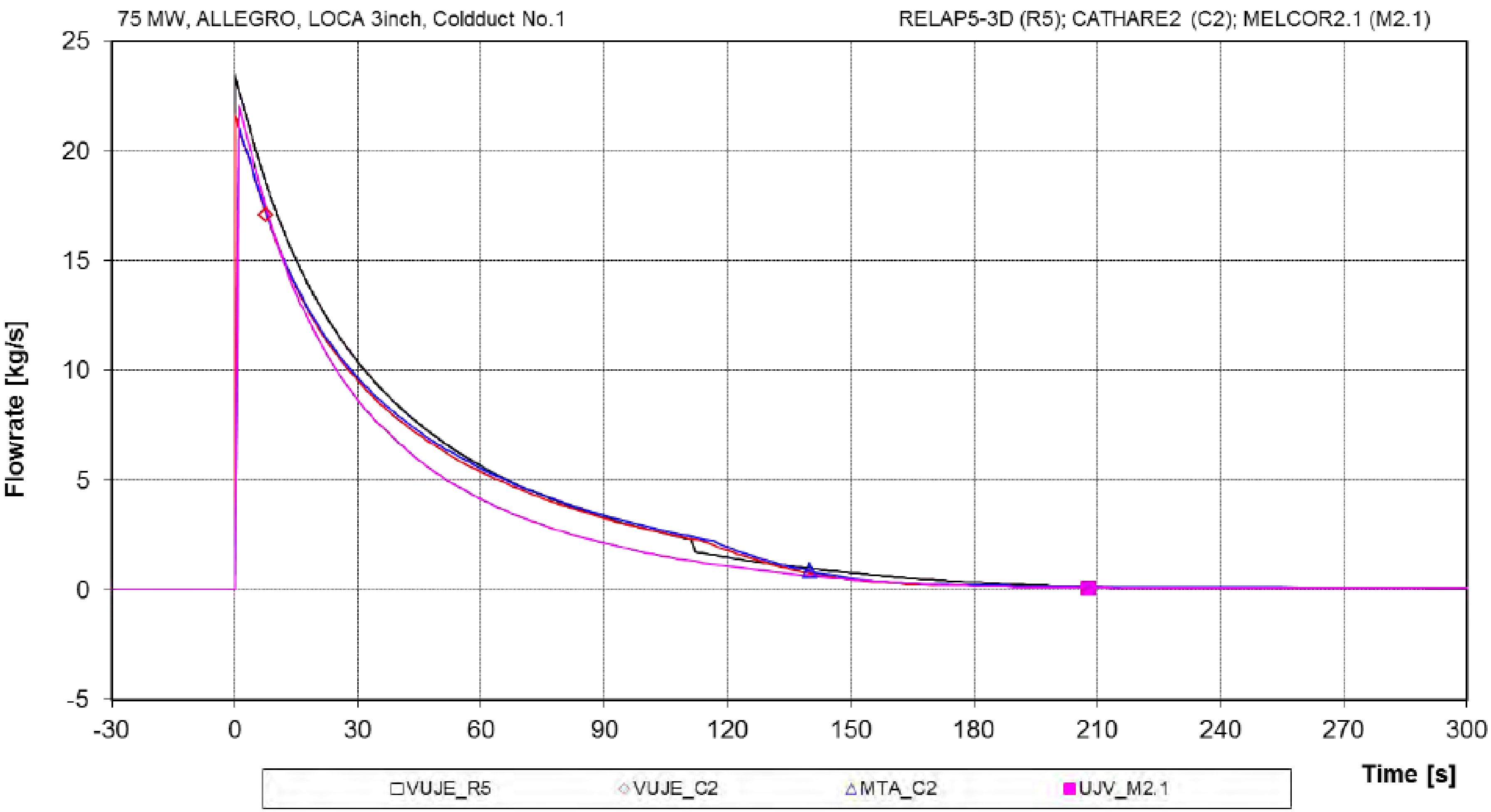
LOCA 75mm results – maximum cladding T



LOCA 75mm results – MHX feedwater inlet T



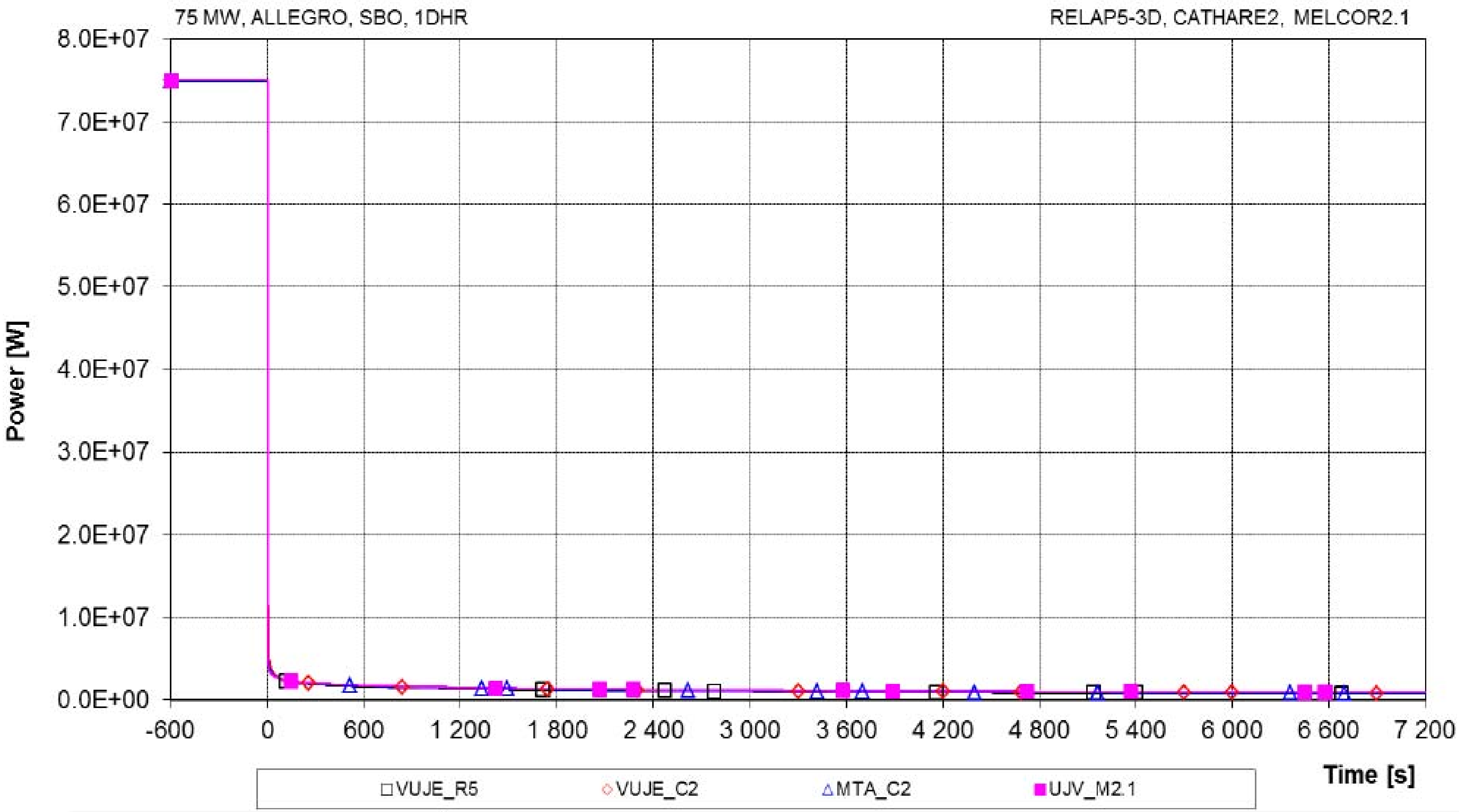
LOCA 75mm results – Break mass flow rate



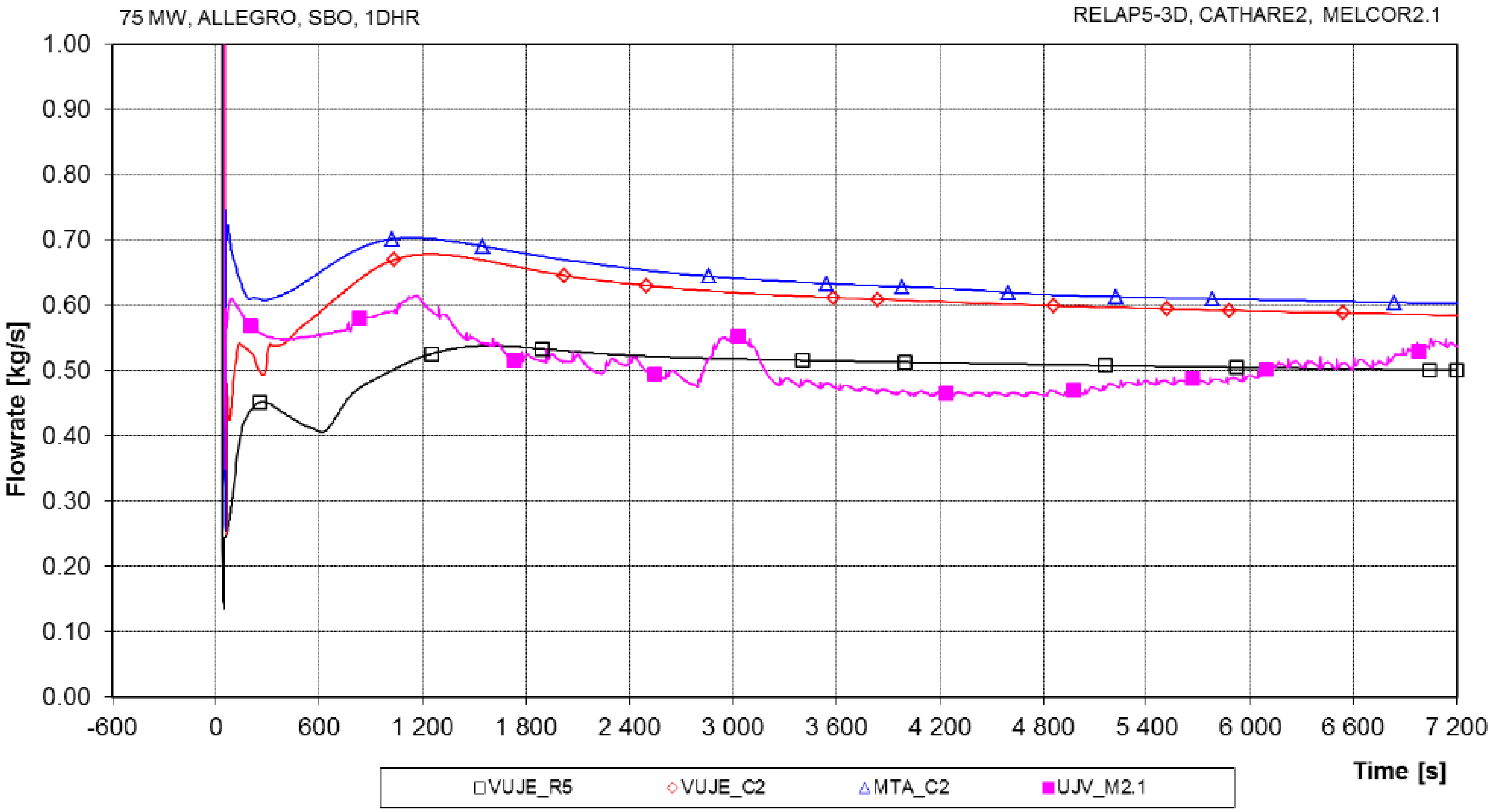
Results of SBO

- Core power
- Core mass flowrate
- Maximum cladding temperature
- Core inlet pressure
- DHR HX flowrate (He side)

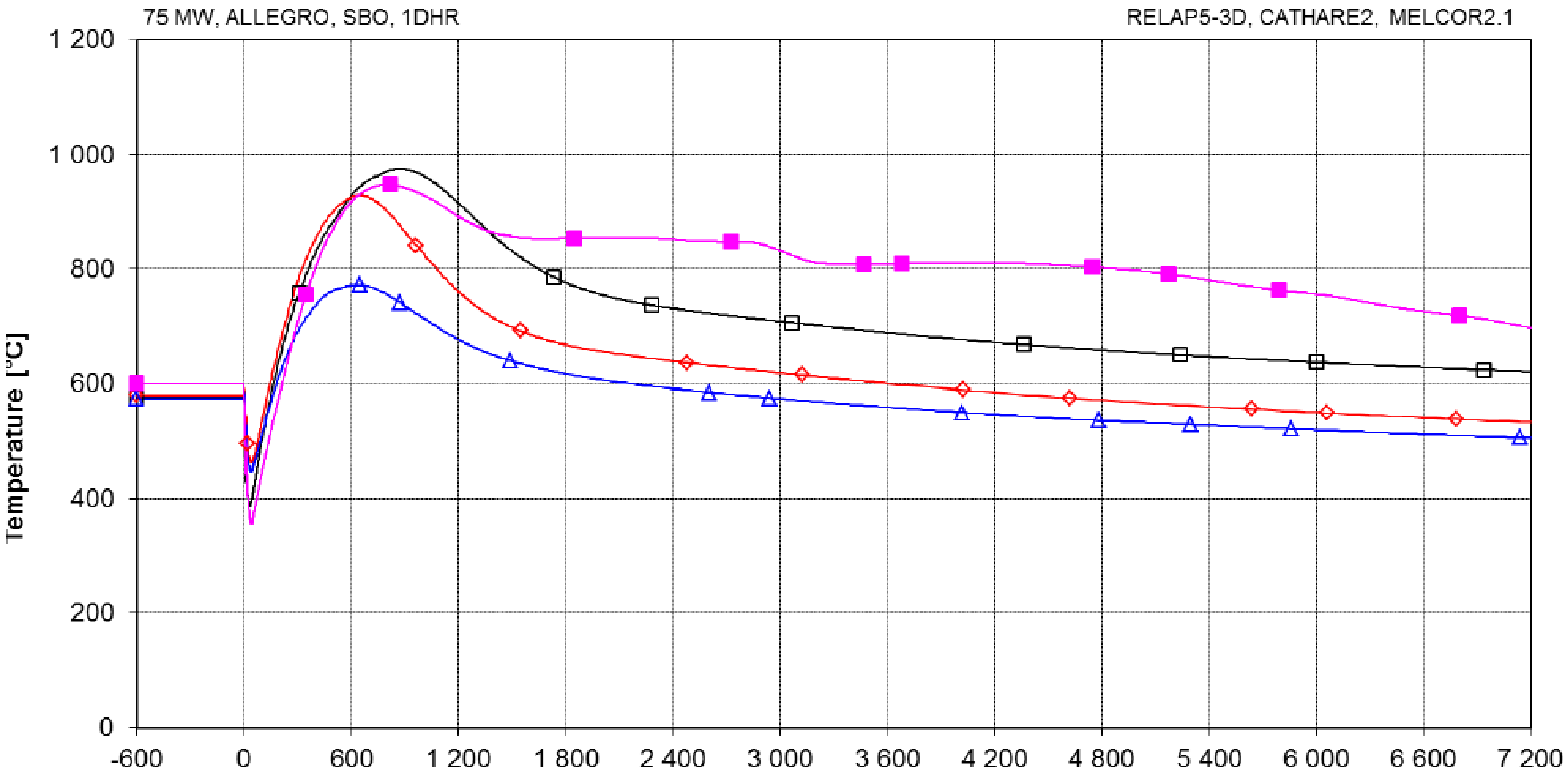
SBO results – core power



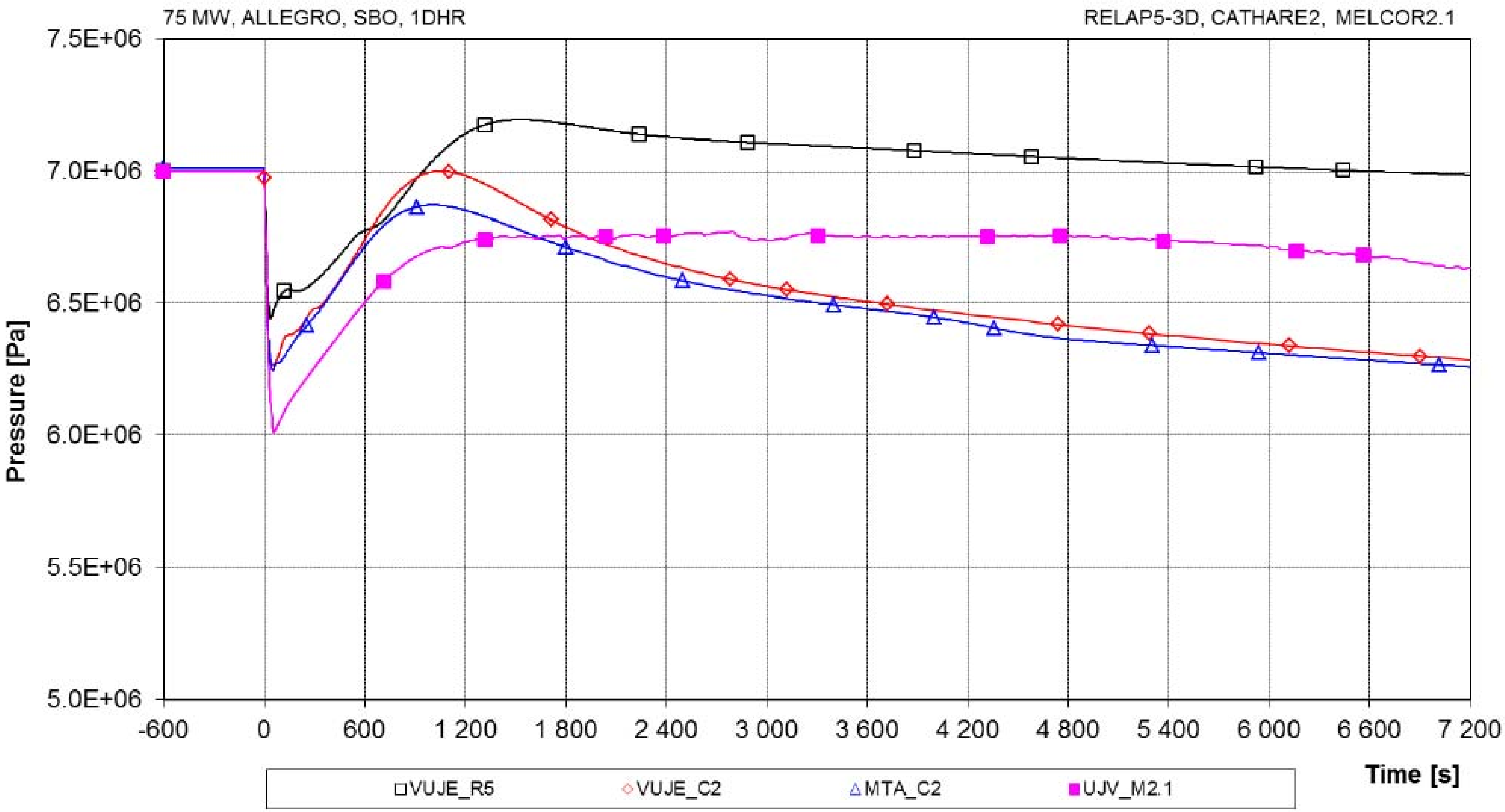
SBO results – core mass flowrate



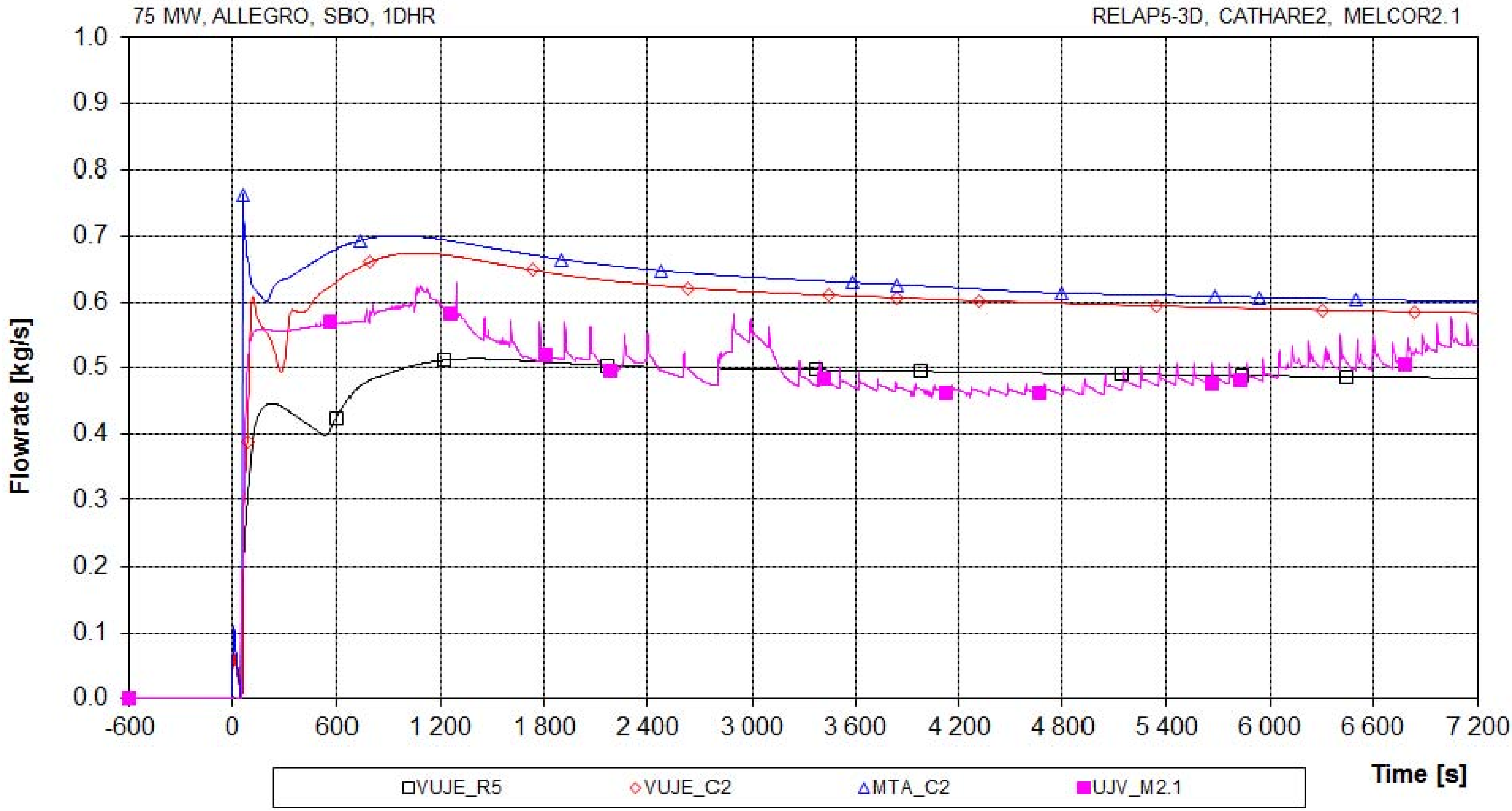
SBO results – maximum cladding T



SBO results – Core inlet pressure



SBO results – DHR HX flowrate (He side)



Issues – point kinetics model

```
COR_PKM01     0.00      7.029E+07
COR_PKM02     'CF_10' 'CF_11' !External reactivity from cntrl. rods and neutron source
COR_PKM03     3
                                      1   RDOP       2   ! fuel density
                                      2   RFUF       2   ! fuel temperature
                                      3   RMODF      1   ! coolant temperature
COR_TAVG      2
                                      1        13-22   1-3      MOD    Zr
                                      2        13-22    1-3     FU      UO2
```

```
ERROR: Error on card: COR_PKM02
the Reactivity name CF_10 IS NOT FOUND
ERROR: Error on card: COR_PKM02
the Reactivity name CF_11 IS NOT FOUND
ERROR: Error in table: COR_PKM03 Row: 1
the Reactivity name CF_11 IS NOT FOUND
ERROR: RECORD Error(s) occur in the first pass of MELGEN inputs for COR Package    IS REQUIRED
  3 ERRORS WERE DETECTED DURING PROCESSING OF COR INPUT DATA
```

Conclusions

- Detailed ALLEGRO TH benchmark has been prepared, comparing 3 codes and 5 users
- Qualitatively, MELCOR is capable to calculate the transients in ALLEGRO in the same way as CATHARE and RELAP
- Quantitatively, most of the differences in results are in in correspondence with the differences in the codes.
- Comparison of critical flow models in LOCA breaches should be done
- „Round 2“ of the benchmark si foreseen after full evaluation of the results