

**FSUE SRI SIA “LUCH”
IBRAE RAS
FSUE EDO “GIDROPRESS”**

**Comparison results of pretest PARAMETER-SF4 test
numerical modeling**

Presented by T.Yudina

*15th International QUENCH Workshop
Karlsruhe, 3-5 November, 2009*

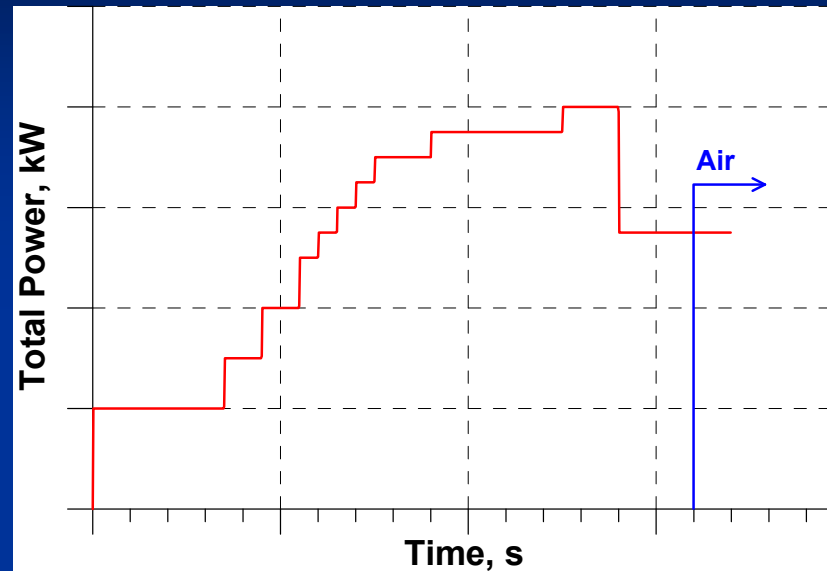
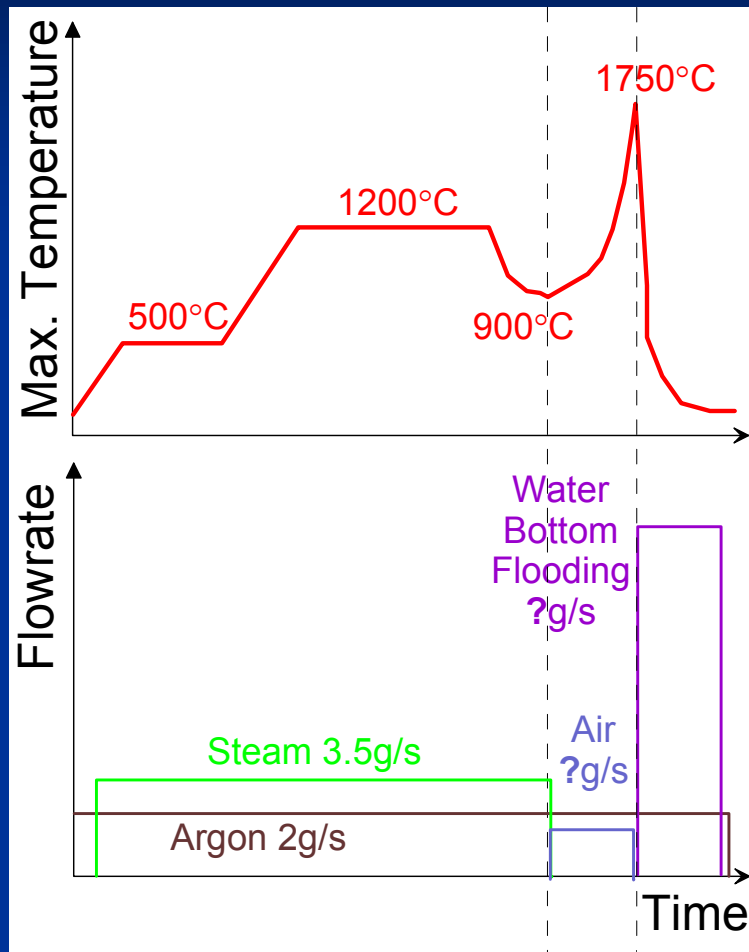
PARAMETER programme

1. Financial support – I S T C (Project#3194, 3690)
PARAMETER-SF1, -SF2 , -SF3, -SF4 have been performed
2. The basic participants:
FSUE SRI SIA “LUCH”
IBRAE RAS
FSUE EDO “GIDROPRESS”
3. Another participants:
A.A. Bochvar FSUE VNIINM
A. I. Leipunsky SSC RF-IPPE
RSC “Kurchatov Institute”
4. Foreign collaborators (Project#3690):
FZK, JRC-ITU, GRS (Germany)
PSI (Switzerland)
EdF, CEA (France)
AEKI (Hungary)
INRNE (Bulgaria)

Used codes and participants

- SOCRAT – IBRAE
- ICARE/CATHARE – NSI RRC KI-IRSN
- ATHLET-CD – GRS
- RELAP/SCDAPSIM MOD3.2 (RELAP) – JSC
OKB “GIDROPRESS”
- MAAP4 – EdF
- SCDAP/RELAP/IRS (RELAP/IRS) – PSI

SF₆ test scenario (proposed by Jon Birchley)



Agreed parameters and conditions:

- Oxide scale thickness – 300 μm (~514 μm in QUENCH-10)
- Cladding temperature before air ingress start – 900°C (as in QUENCH-10)
- Significant period of oxygen starvation at air ingress phase (about 2 min in QUENCH-10)
- Target temperature – 1750°C to avoid significant excursion/degradation during reflow (~1950°C in QUENCH-10)

Air oxidation model availability

Code	Heat of reaction	Kinetic
SOCRAT	√	as in steam
ICARE/CATHARE	√	√
ATHLET-CD	√	√
MAAP4	√	√
RELAP/SCDAPSIM	-	-
SCDAP/RELAP/IRS	√	√

Air oxidation models are available but need verifying



unreliability of predicted data

PARAMETER-SF4 tested bundle

Bundle type

1000

- number of fuel rods

19

- heated

18

- unheated

1

Fuel rod

- cladding, mm

∅

9,13/7,73

(Zr1%Nb)

-pellets

UO₂

- heater length, mm

1275

Spacer grid

Zr1%Nb

Shroud

Zr1%Nb

-SF4

cylindrical

Peripheral rods

12

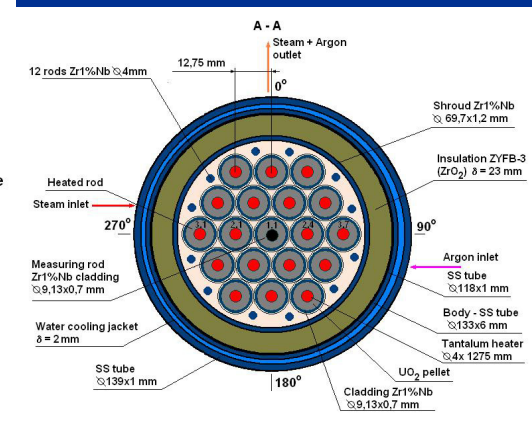
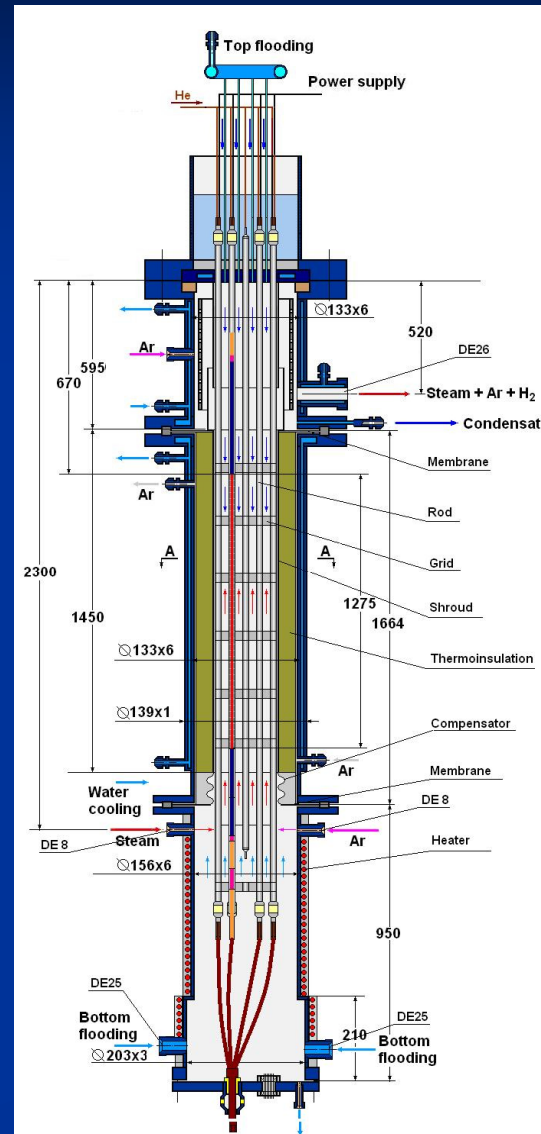
Heater

Ta

Thermal insulation

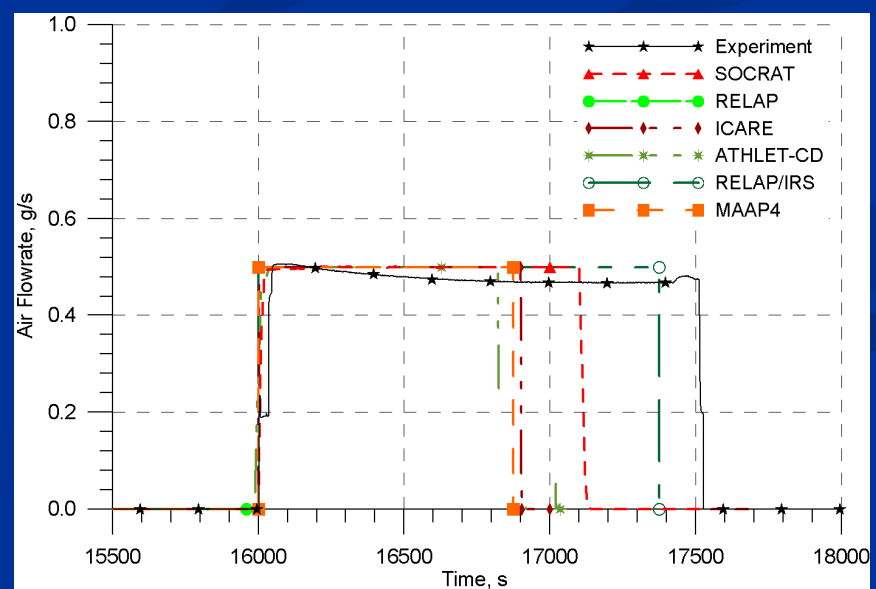
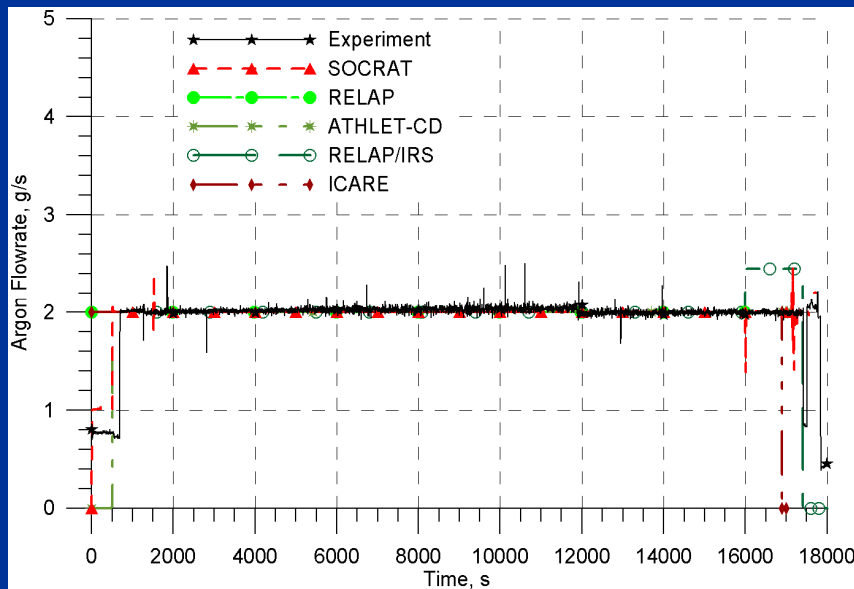
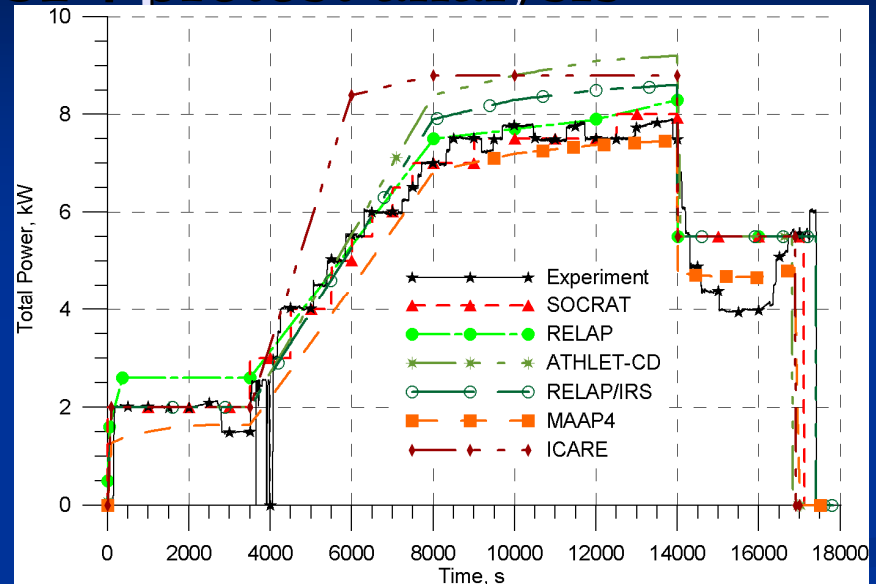
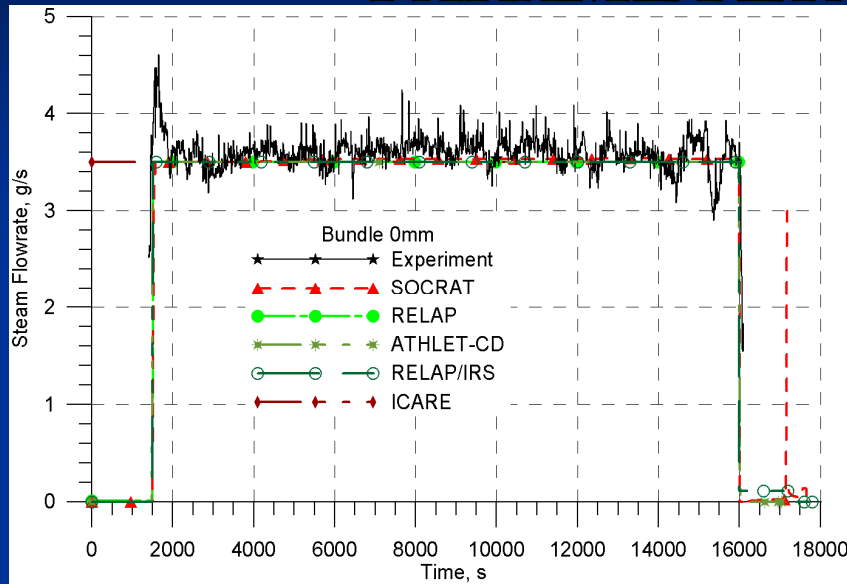
ZrO₂

ZYFB-3

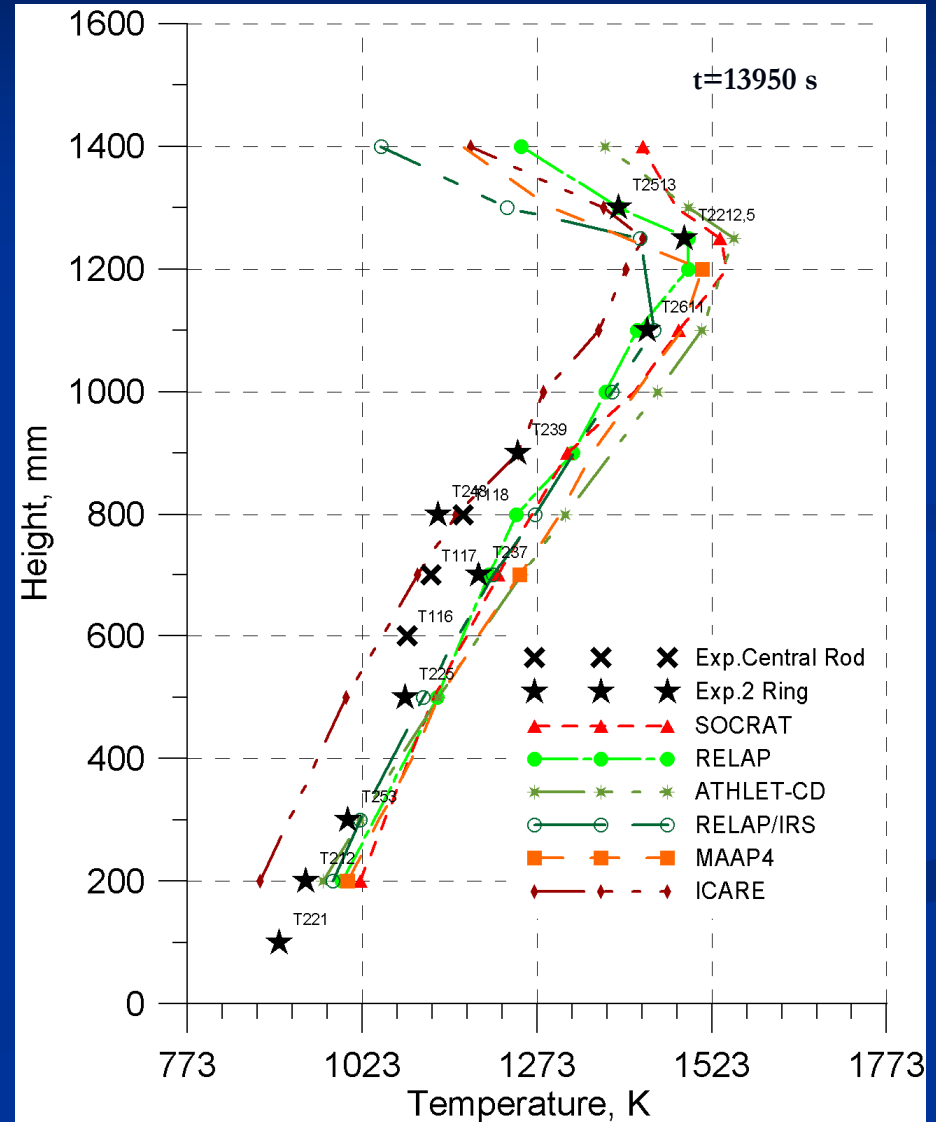
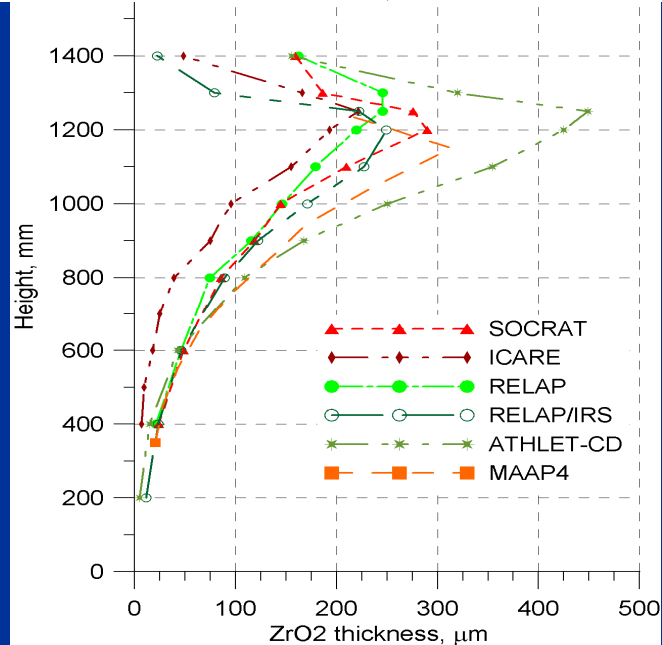
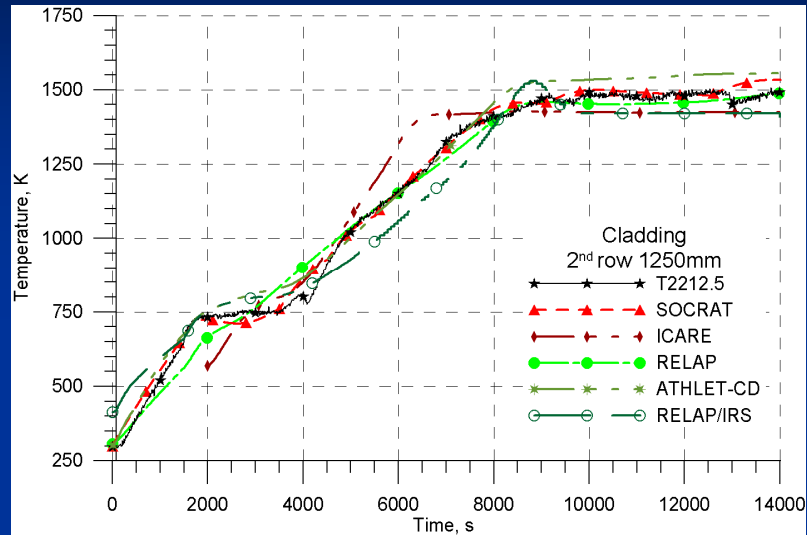


Boundary conditions

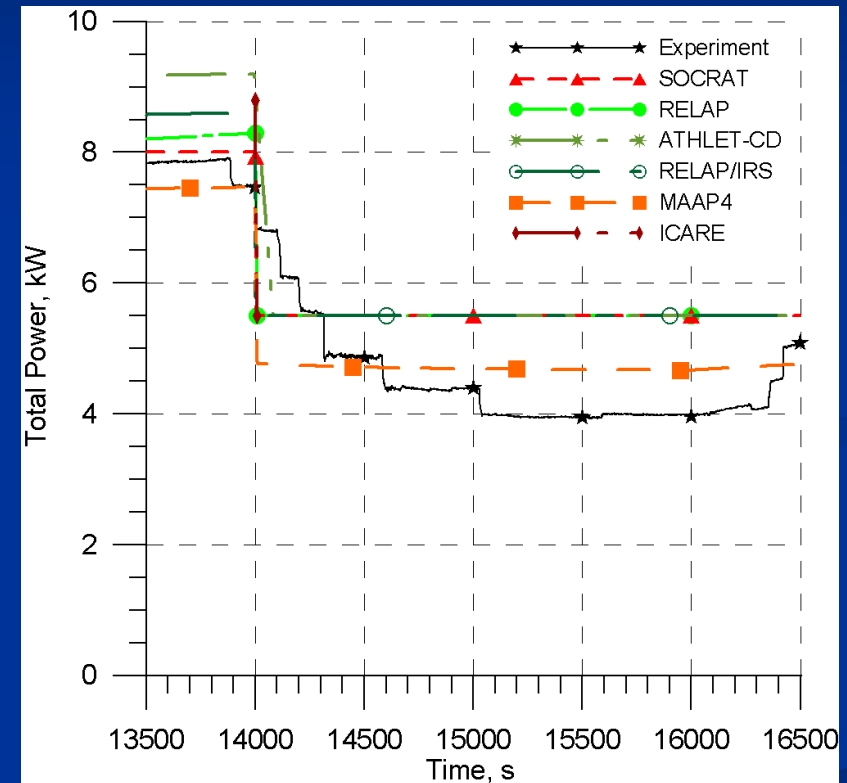
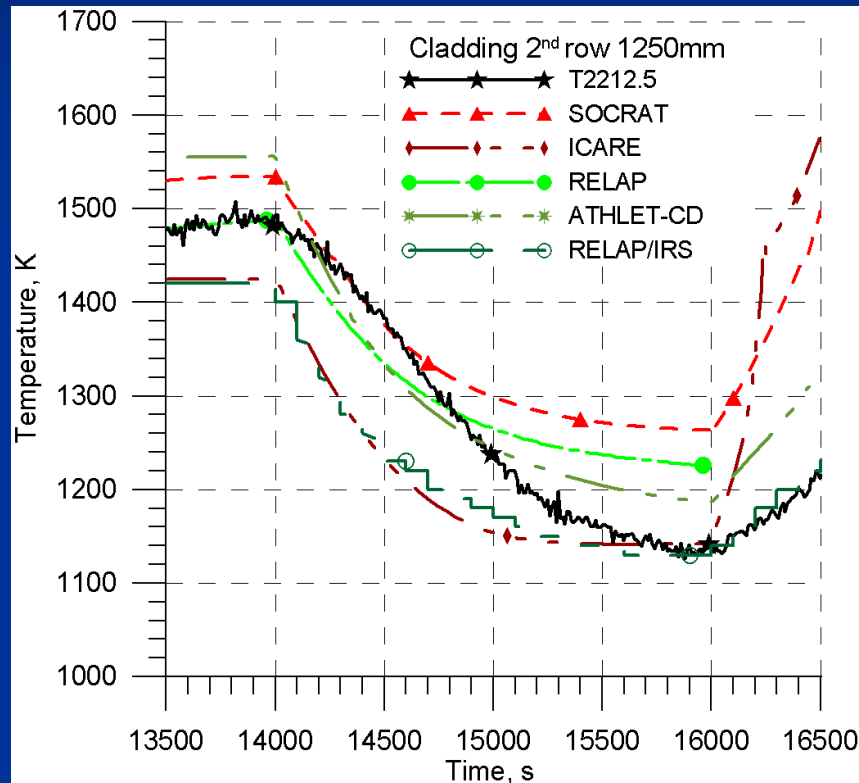
PARAMETER-SF4 pretest analysis



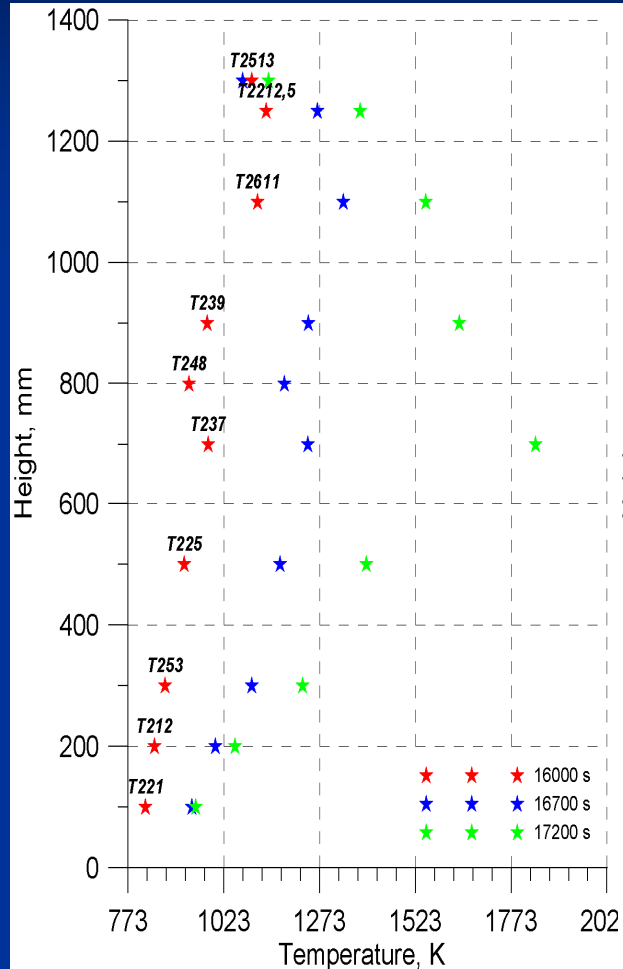
SF4 pretest calculations against experimental data. Pre-oxidation phase. Cladding temperature



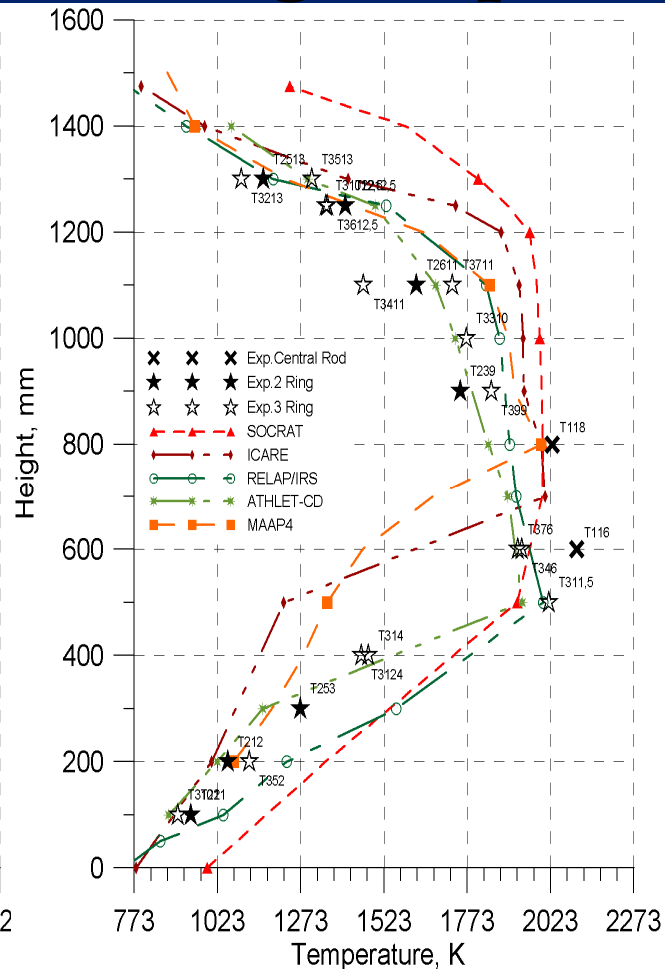
SF4 pretest calculations against experimental data. Cool-down phase



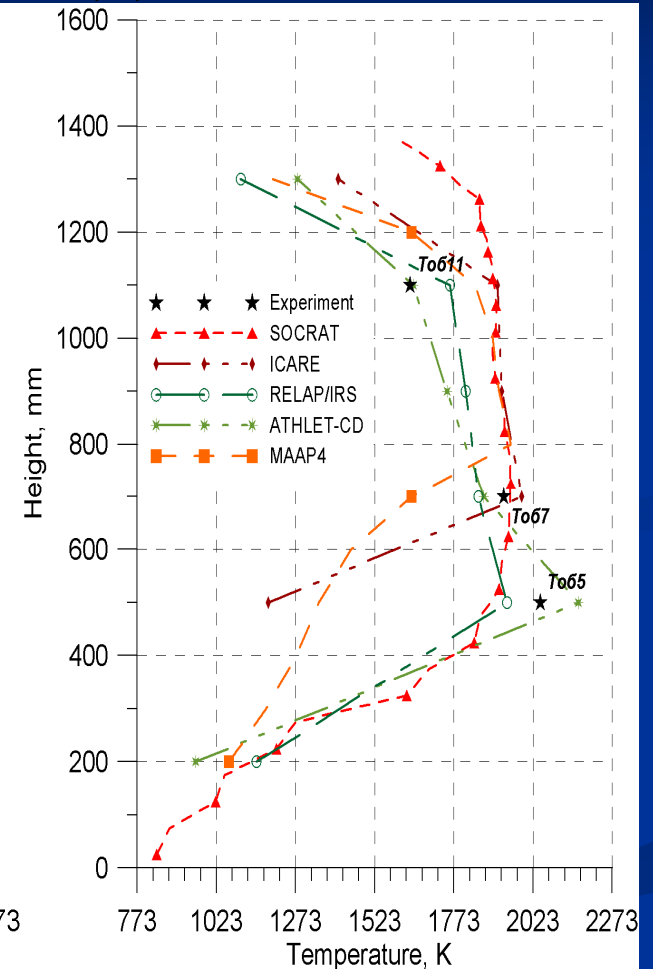
SF4 pretest calculations against experimental data. Air ingress phase (1).



Temperature profile evolution at air ingress phase

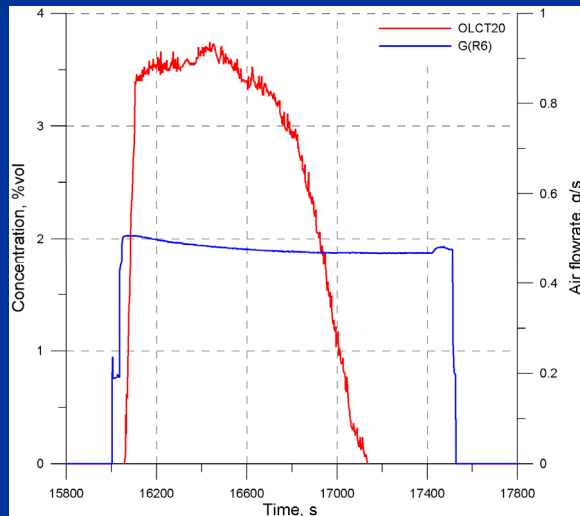
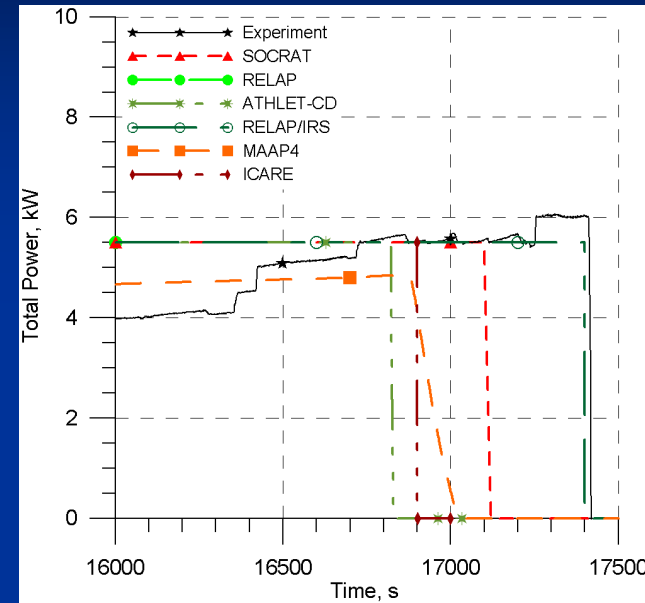
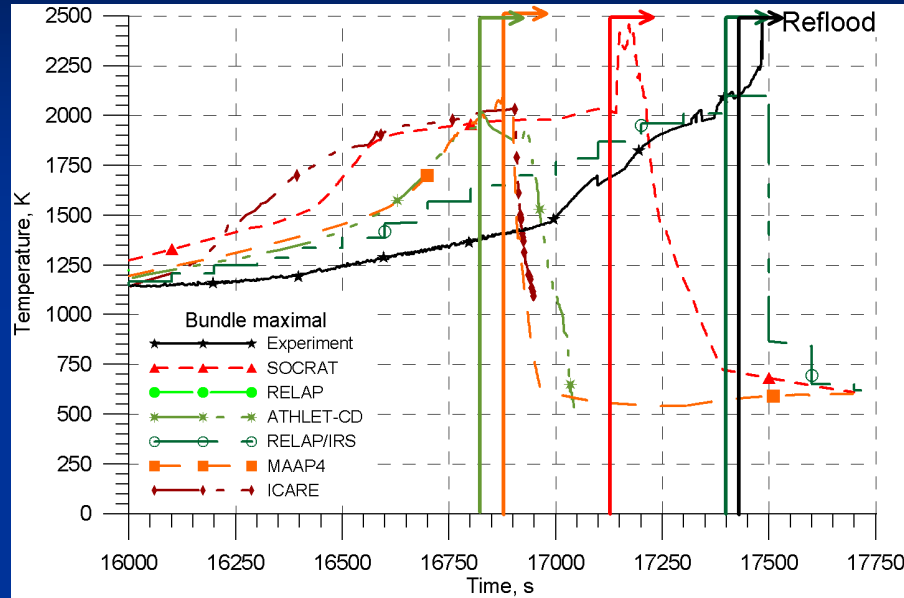


Claddings temperature before flooding onset



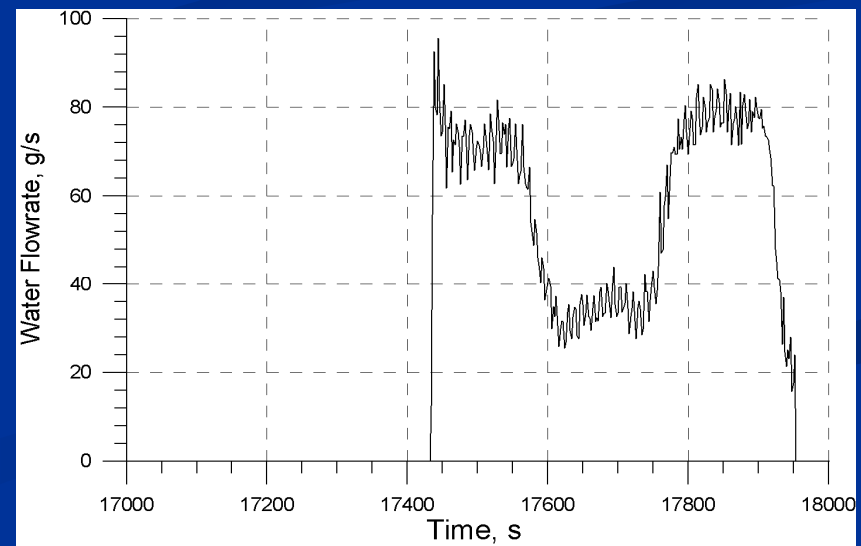
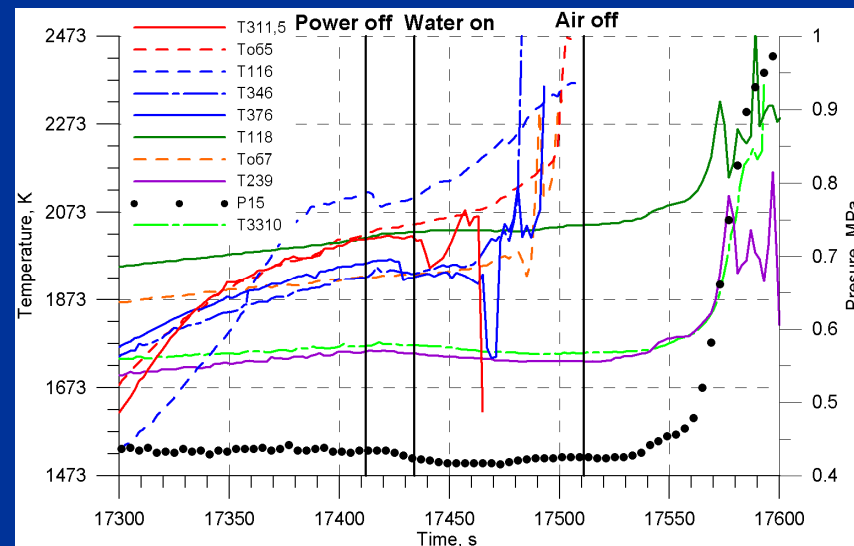
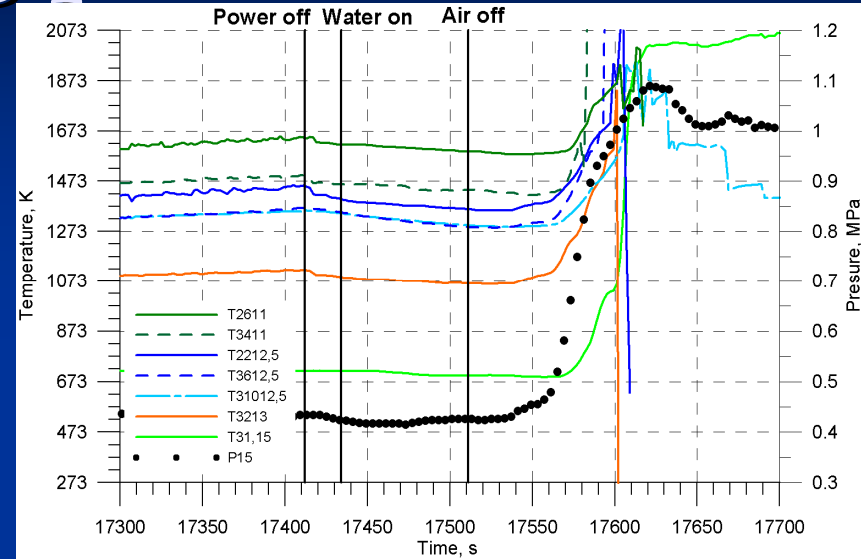
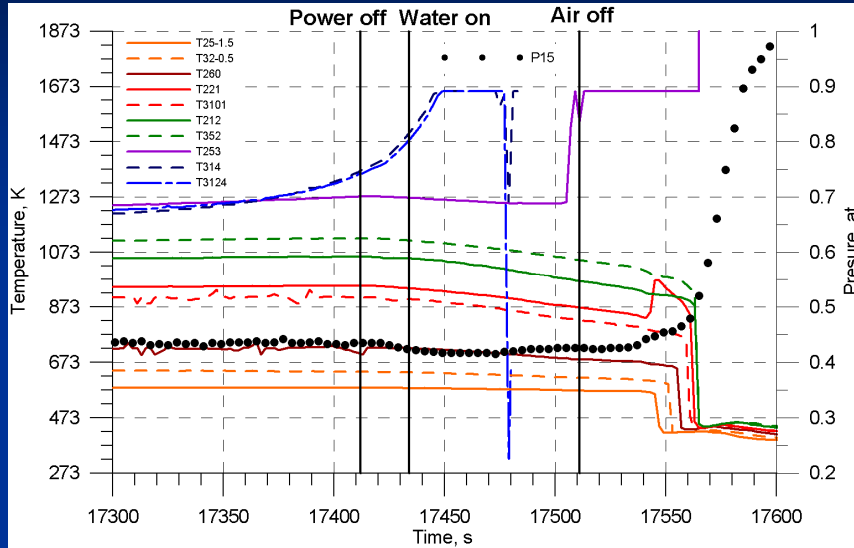
Shroud temperature before flooding onset

SF4 pretest calculations against experimental data. Air ingress phase (2).

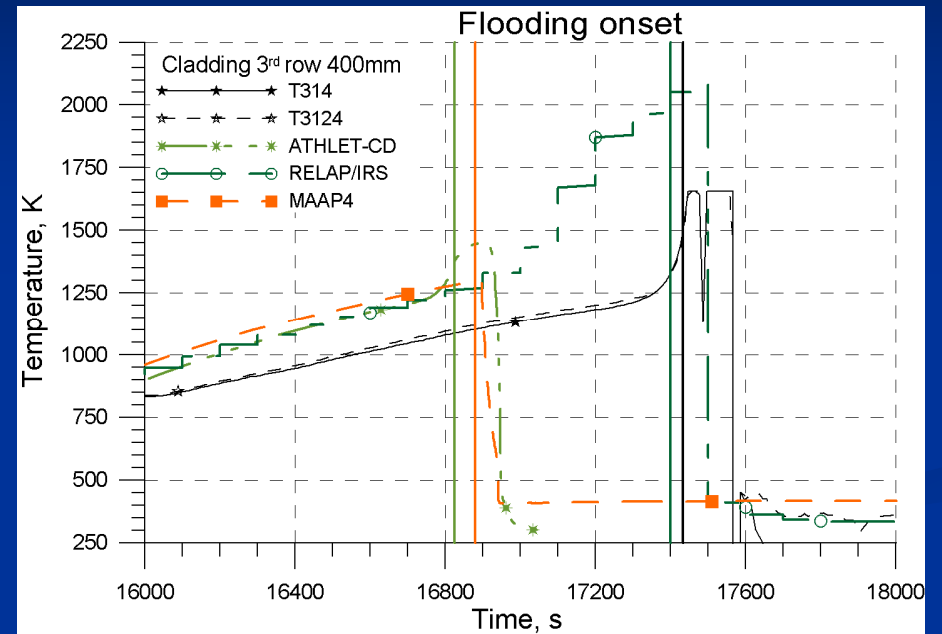
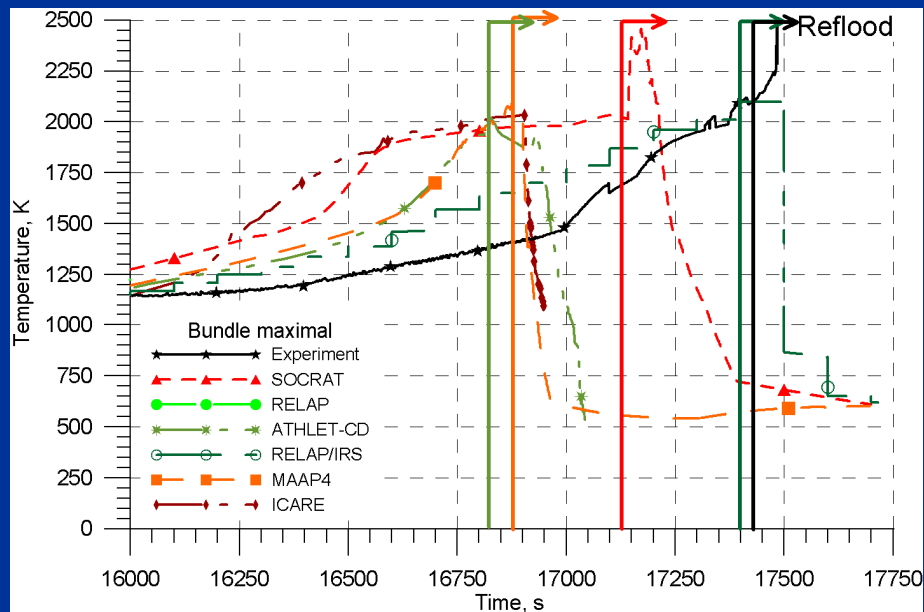


Code	Starvation onset, s/ Temperature, C	Starvation duration, s
ATHLET	16700/1450	125
MAAP4	16721/1500	160
RELAP/IRS	16750/1550	600
SOCRAT	16560/1600	600
SF4 test	17120/1680 – OLCT20	310

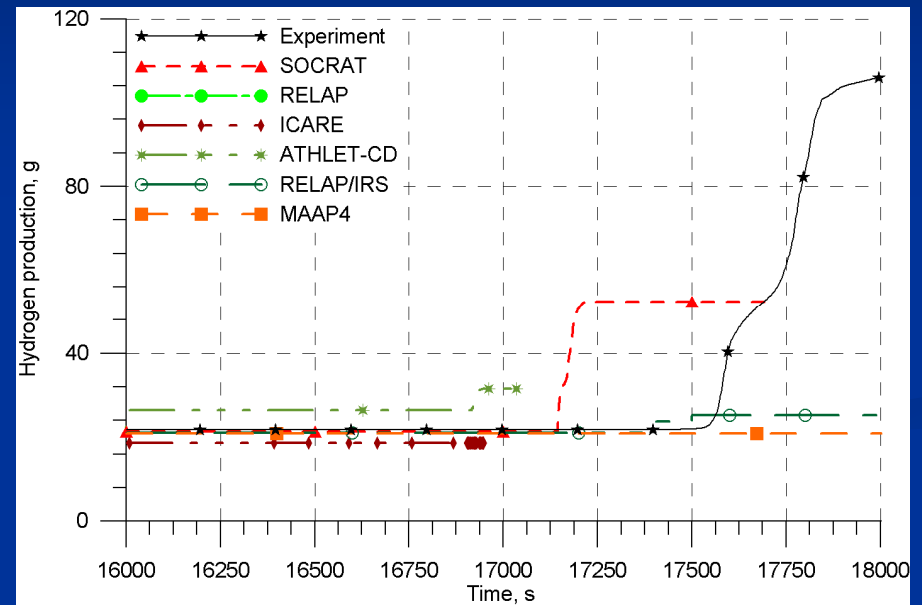
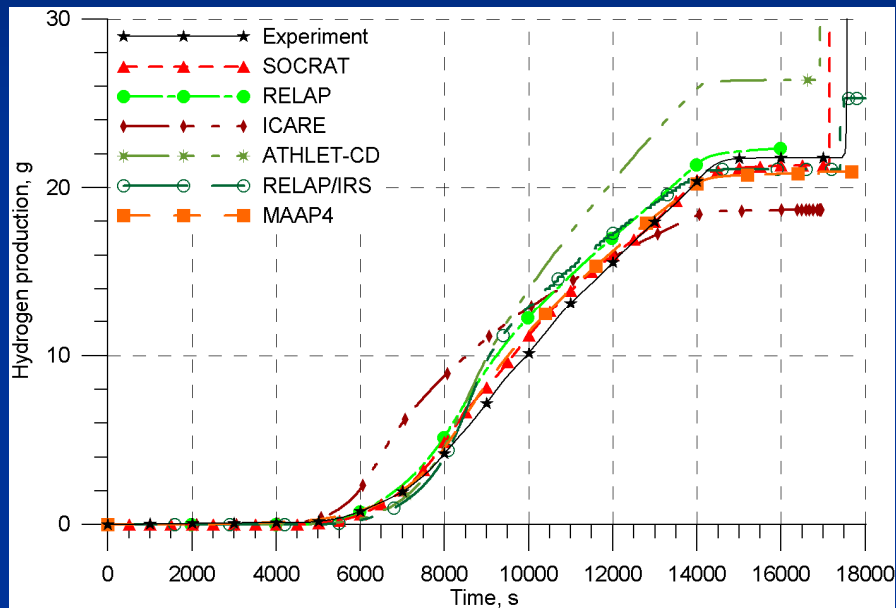
Flooding phase



Flooding phase



Hydrogen release



Main outcomes

- SF4 test was performed in accordance with proposed scenario except for flood stage.
- Proposed air flowrate to be 0.5 g/s allowed obtaining prolonged oxygen starvation.
- Hot spot location before flood onset was predicted over rather extended zone 500-800 mm but it covered measured data (500 mm).
- In the calculations melting was predicted at elevation of 400 mm. Status of the bundle after the test will be presented in the following presentation.

Main outcomes

- Large hydrogen mass released in the test evidences melt oxidation occurred at flood stage.
- Calculated and measured temperature histories at flood stage are different. Posttest calculations are needed to interpret the obtained experimental results.

Acknowledgement

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- Ch. Bals (GRS)
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