

Results of pre- and posttest calculations of PARAMETER-SF experiments

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PARAMETER programme

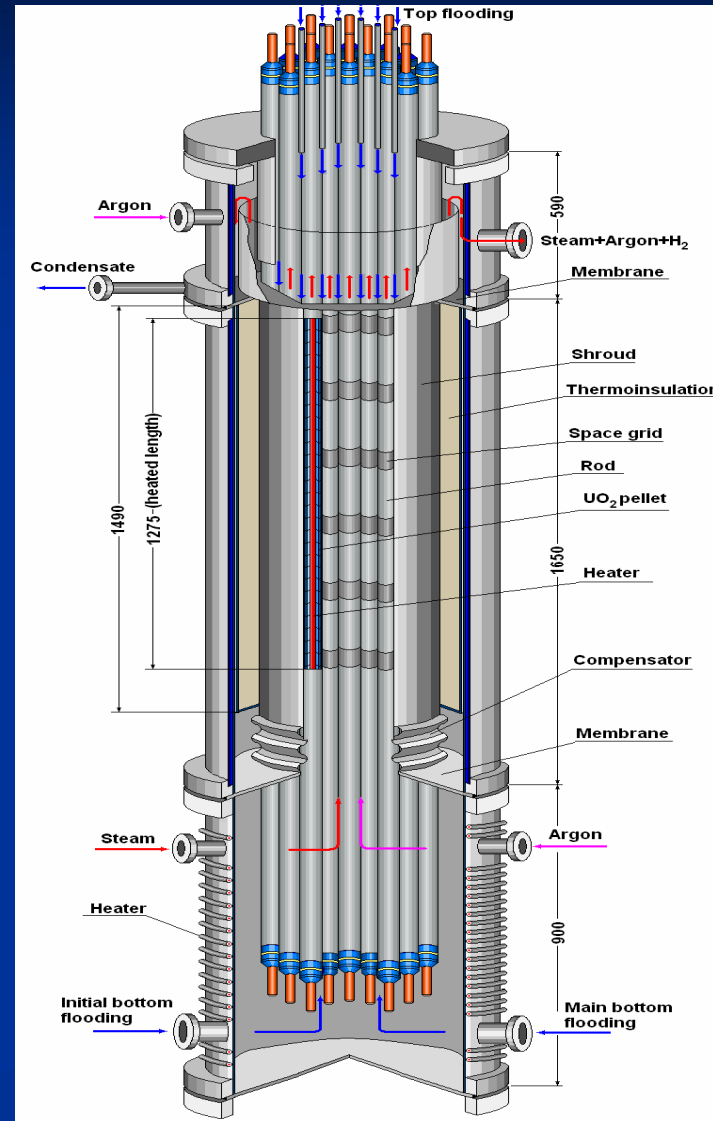
1. Financial support – I S T C (Project#3194, 3690)
PARAMETER-SF1, -SF2 , -SF3 have been performed
PARAMETER-SF4 are foreseen
2. The basic participants:
FSUE SRI SIA “LUCH”
IBRAE RAS
FSUE EDO “GIDROPRESS”
3. Another participants:
A.A. Bochvar FSUE VNIINM
A. I. Leipunsky SSC RF-IPPE
RSC “Kurchatov Institute”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

Used codes and participants

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

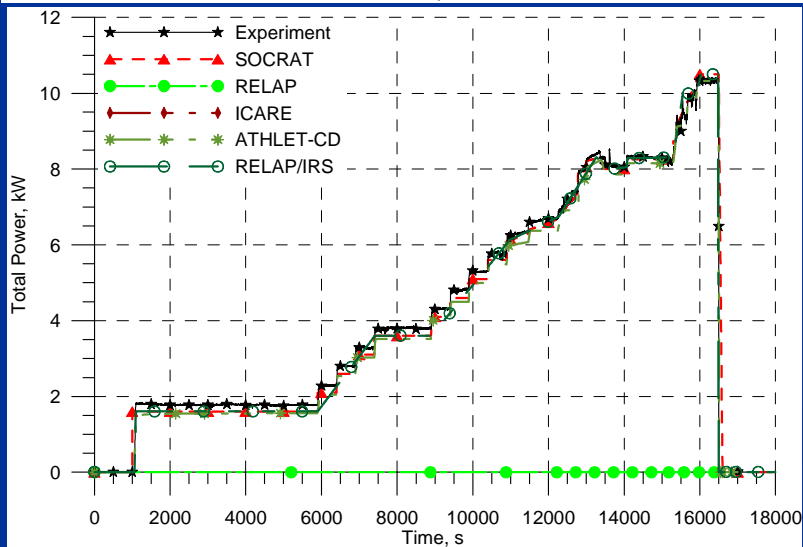
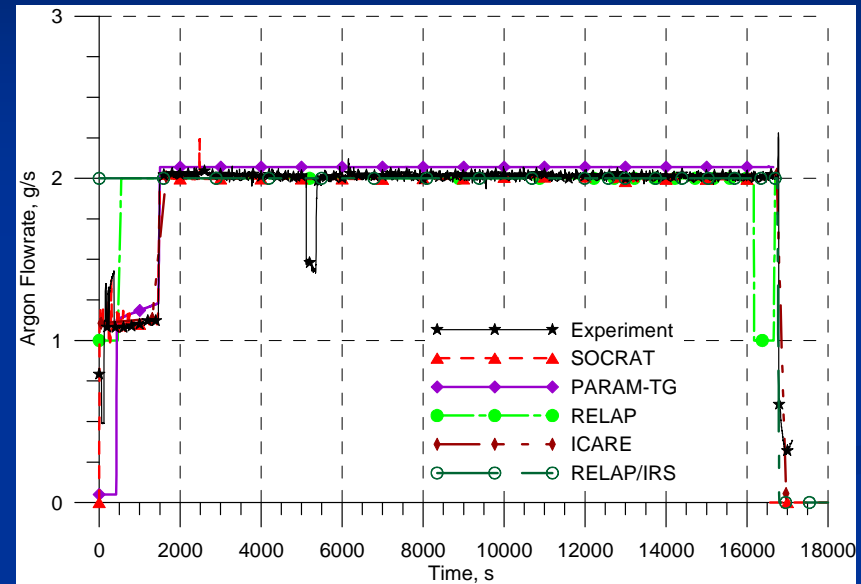
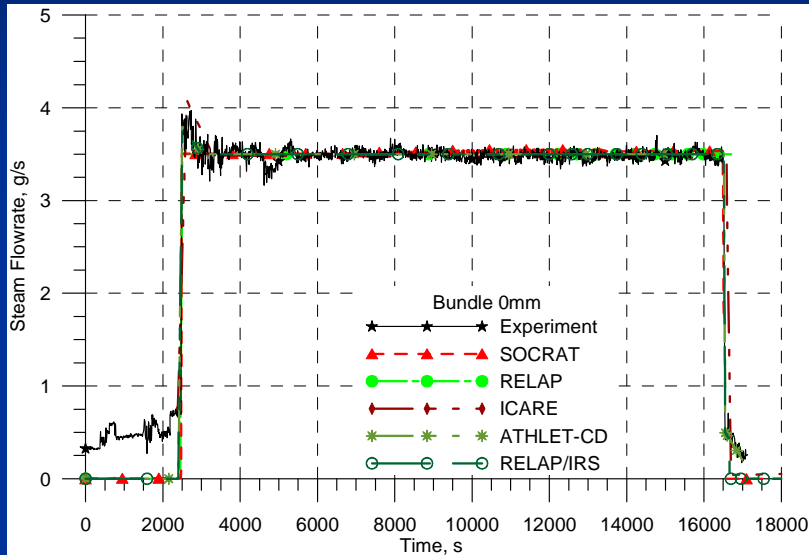
PARAMETER-SF test bundle

Bundle type	VVER-1000
- number of fuel rods	19
- heated	18
- unheated	1
Fuel rod	
- cladding, mm	Ø 9,13/7,73 (Zr1%Nb)
- pellets	UO ₂
- heater length, mm	1275
Spacer grid	Zr1%Nb
Shroud	Zr1%Nb
-SF1	hexahedral
-SF2, -SF3, -SF4	cylindrical
Heater	Ta
Thermal insulation	ZrO ₂ ZYFB-3



PARAMETER-SF2 post-test calculations

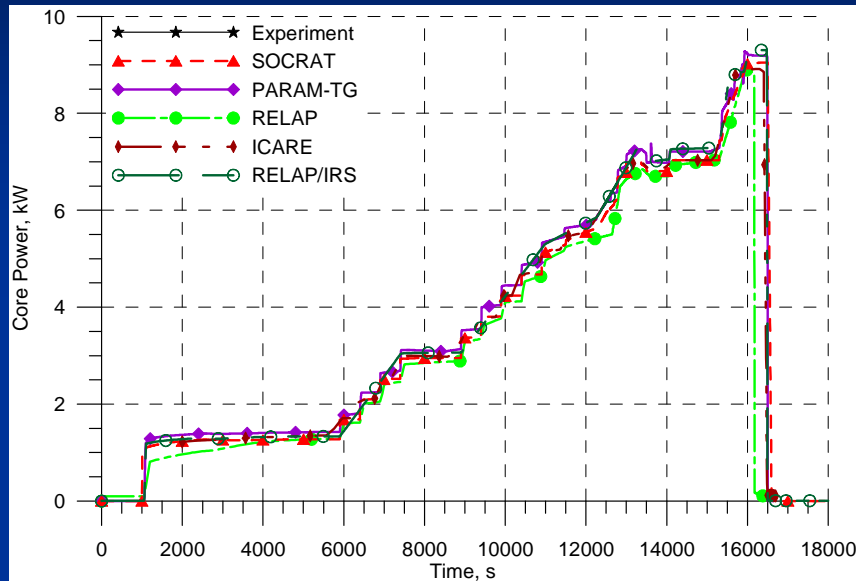
Initial and boundary conditions



ICARE/CATARE
Experimental thermoinsulation
temperature used as boundary
conditions

Heat balance

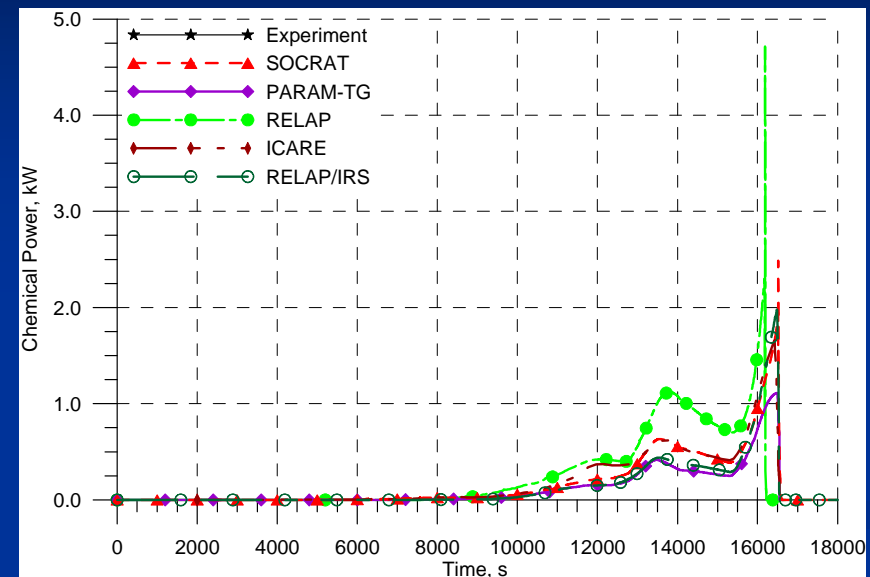
PARAMETER-SF2 post-test analysis



Joel heating power

Pre-oxidation phase ~ 7kW

Before flooding onset ~ 9.5kW



Oxidation reaction power

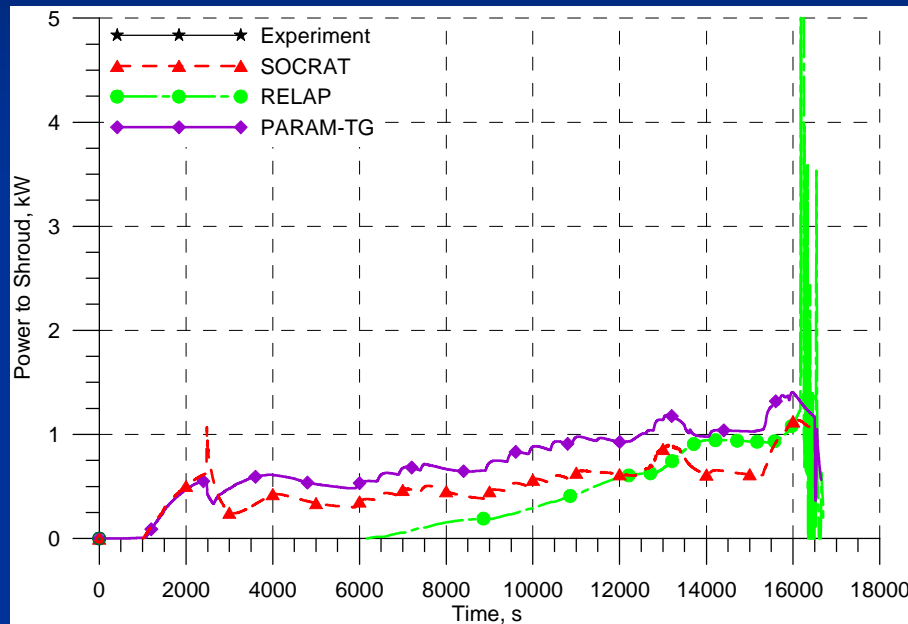
Pre-oxidation phase - up to 1kW

Before flooding up to 2.3 kW

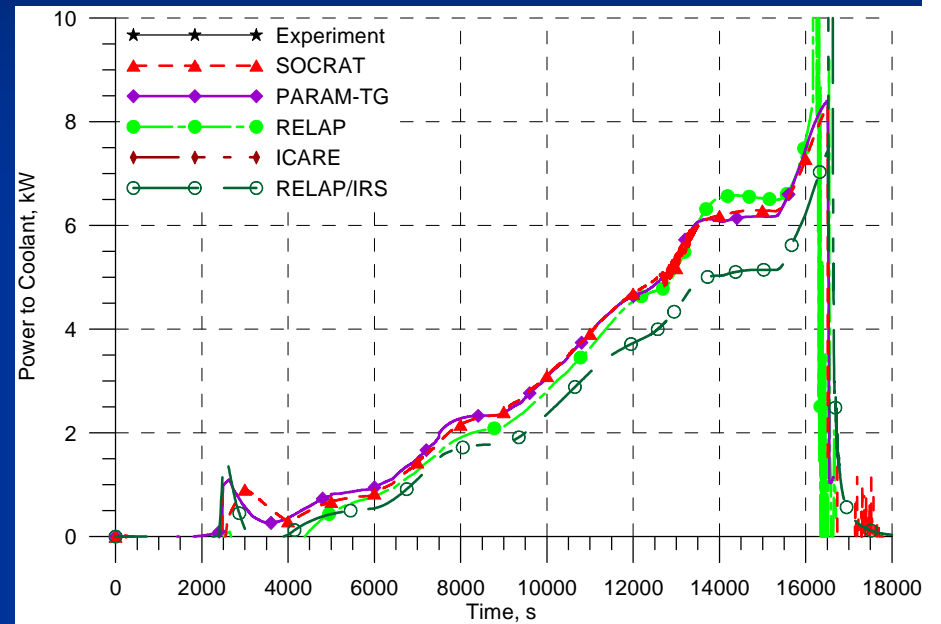
Flooding phase up to 2.5 kW

Heat balance

PARAMETER-SF2 post-test analysis



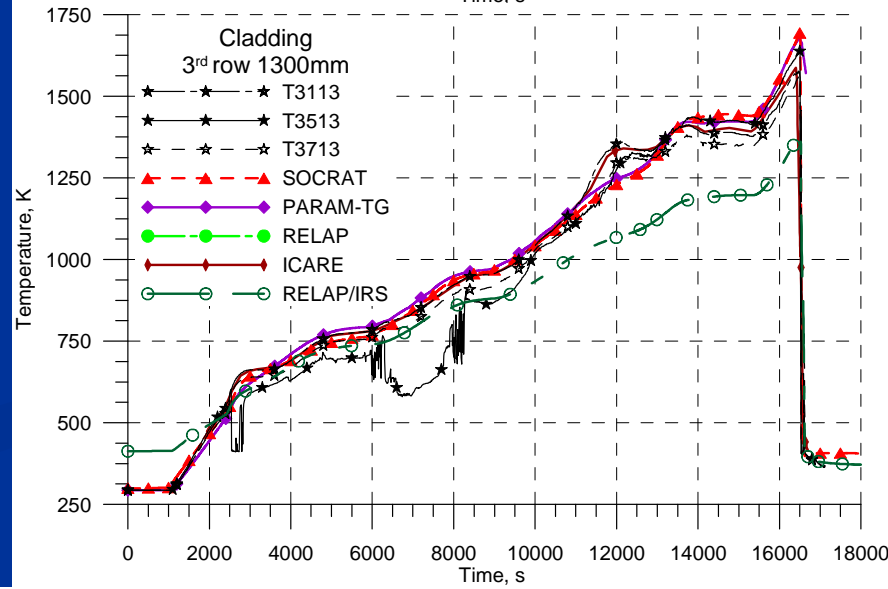
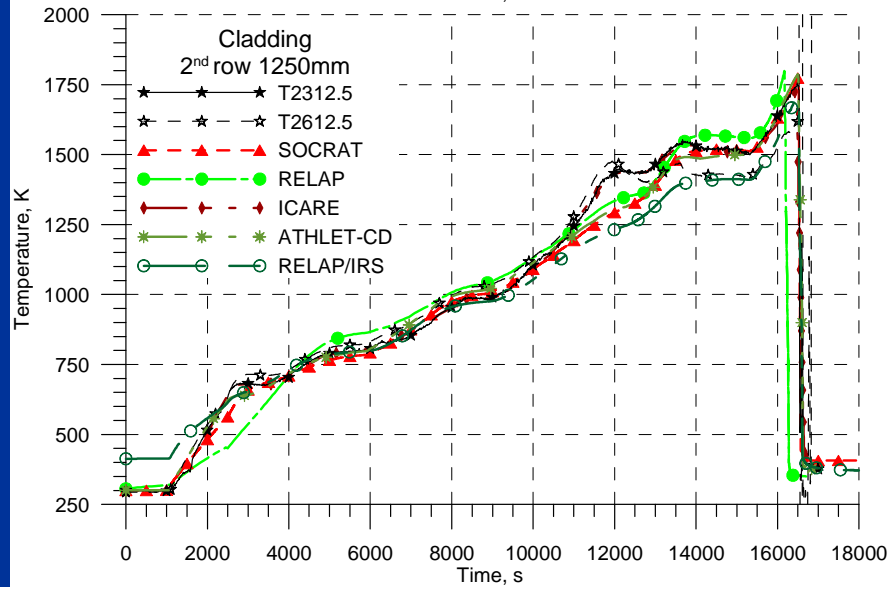
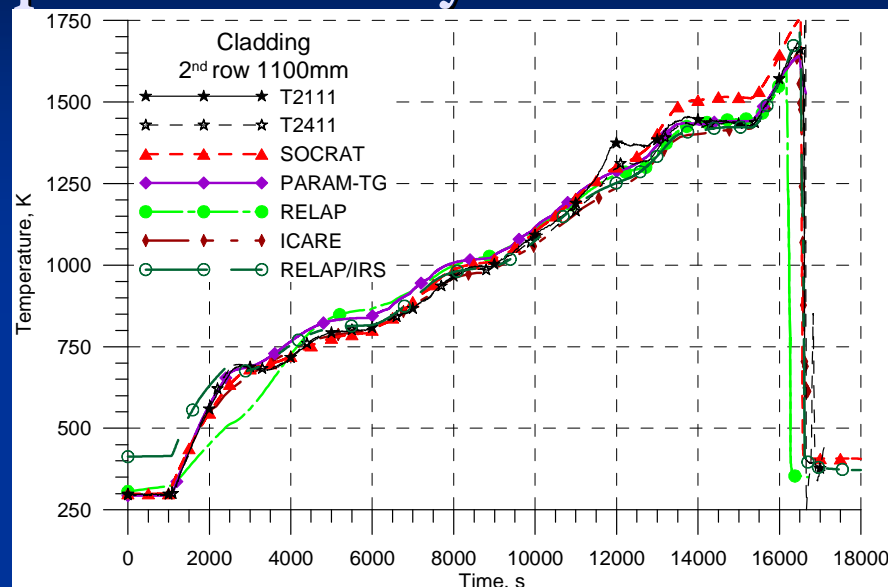
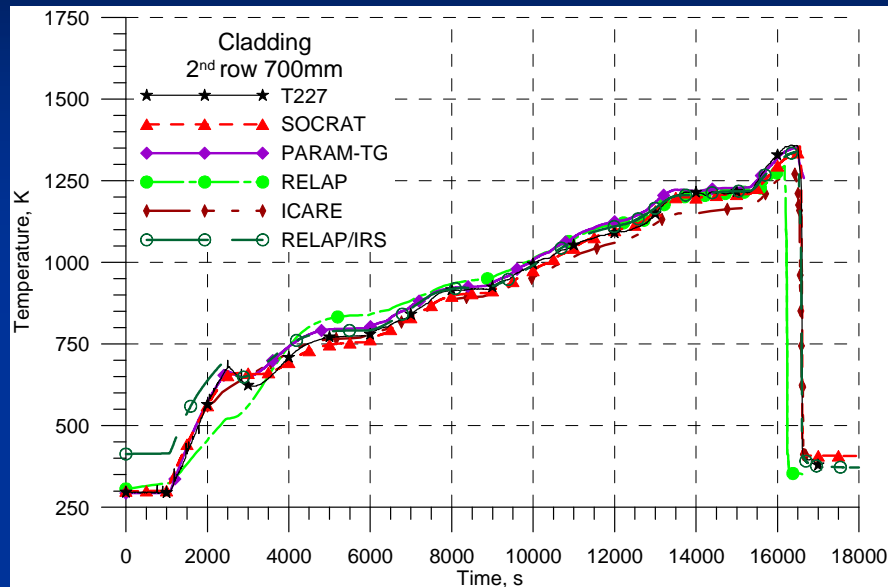
Radial heat loss through shroud
Pre-oxidation phase ~ 0.5 -1 kW
Transient and flooding phase ~ 1 kW



Coolant heating power
Pre-oxidation phase ~ 6 kW
Before flooding onset ~ 9 kW

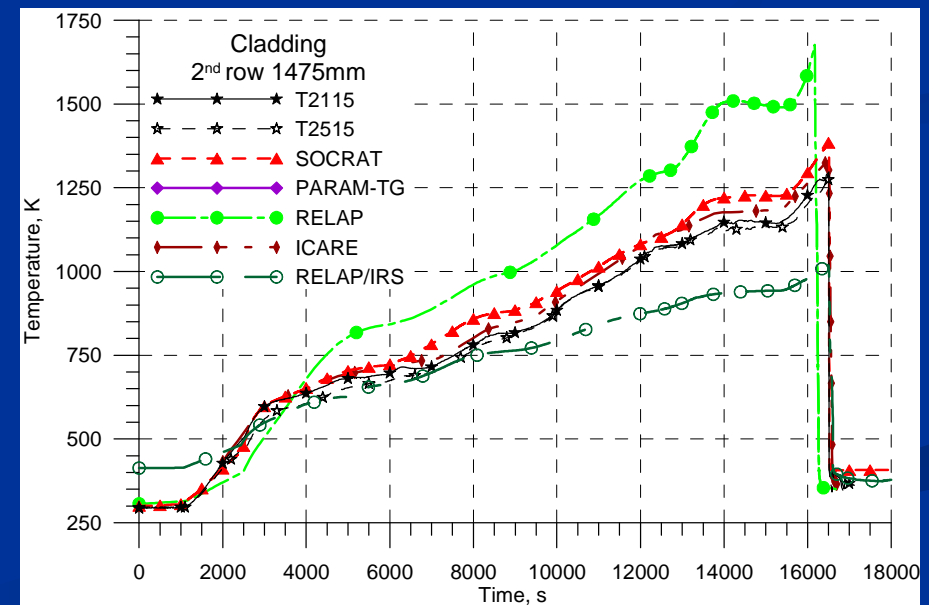
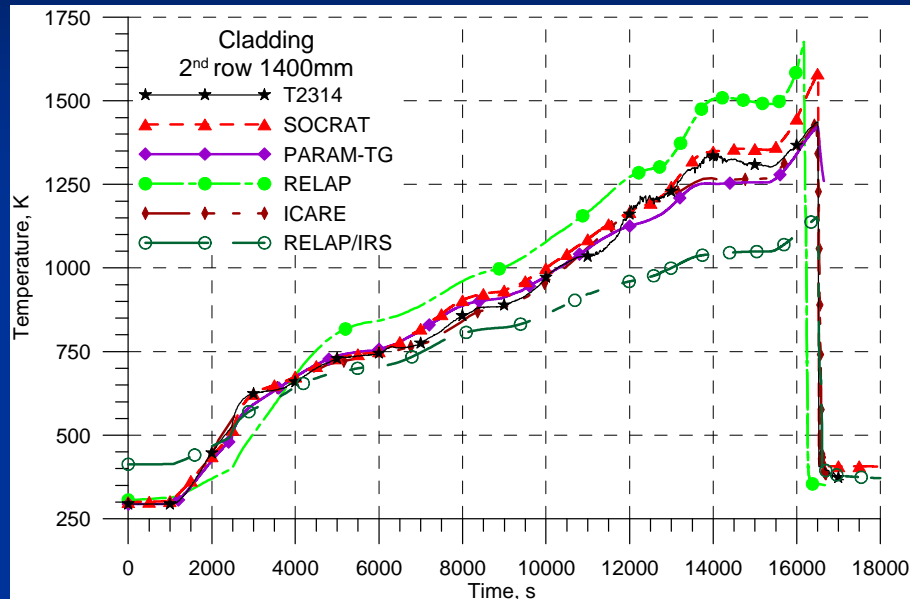
Claddings temperature evolution

PARAMETER-SF2 post-test analysis



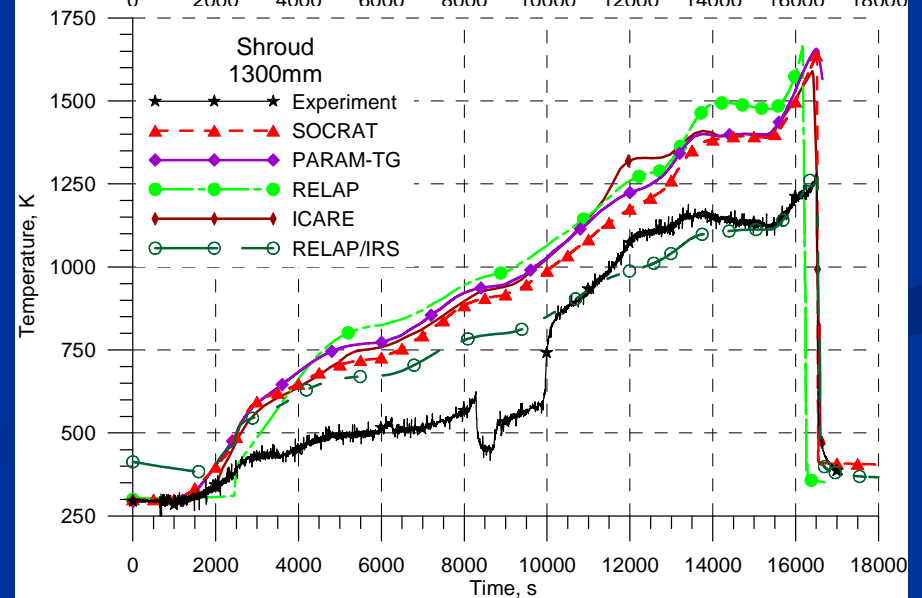
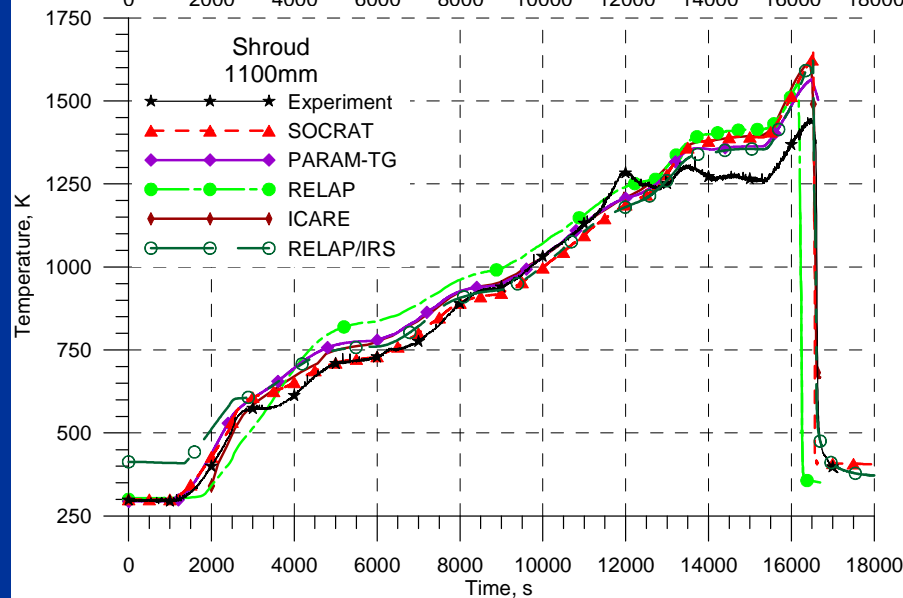
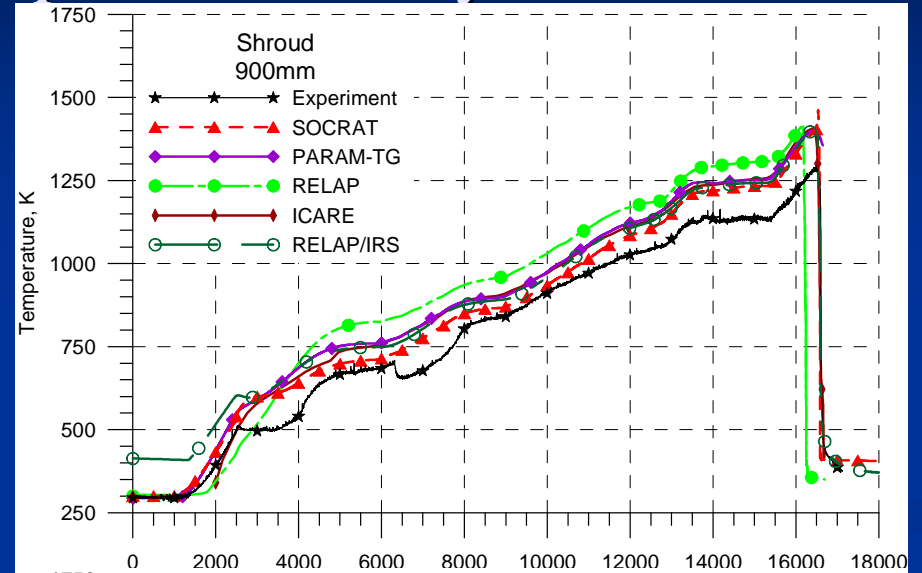
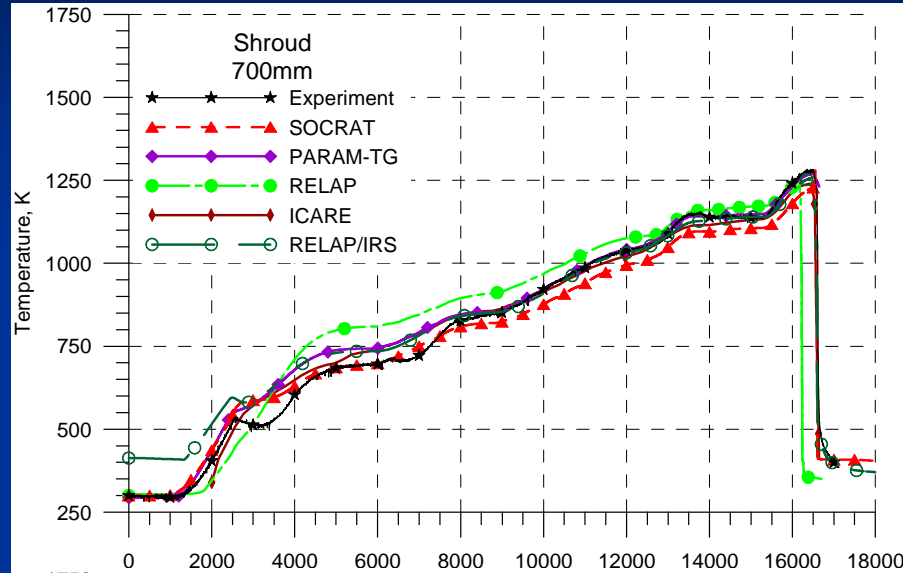
Claddings temperature evolution

PARAMETER-SF2 post-test analysis



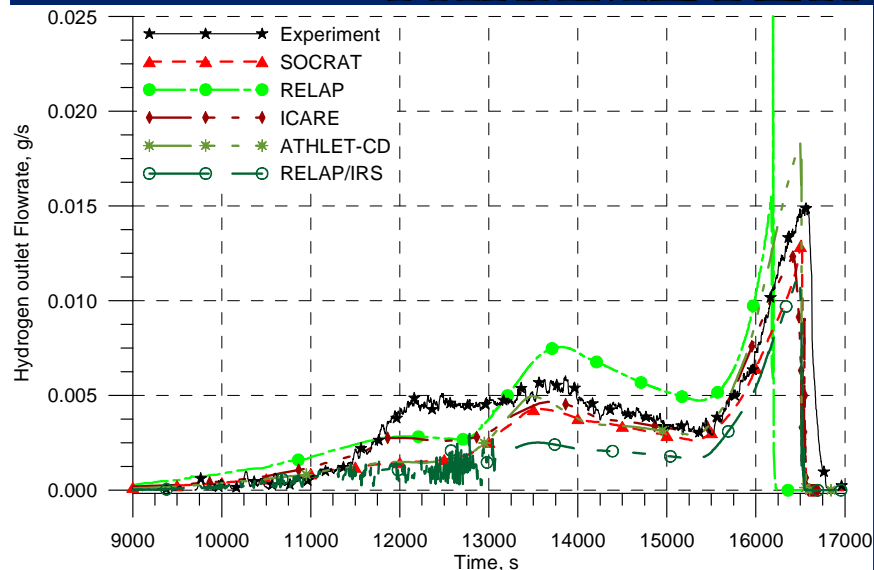
Shroud temperature evolution

PARAMETER-SF2 post-test analysis

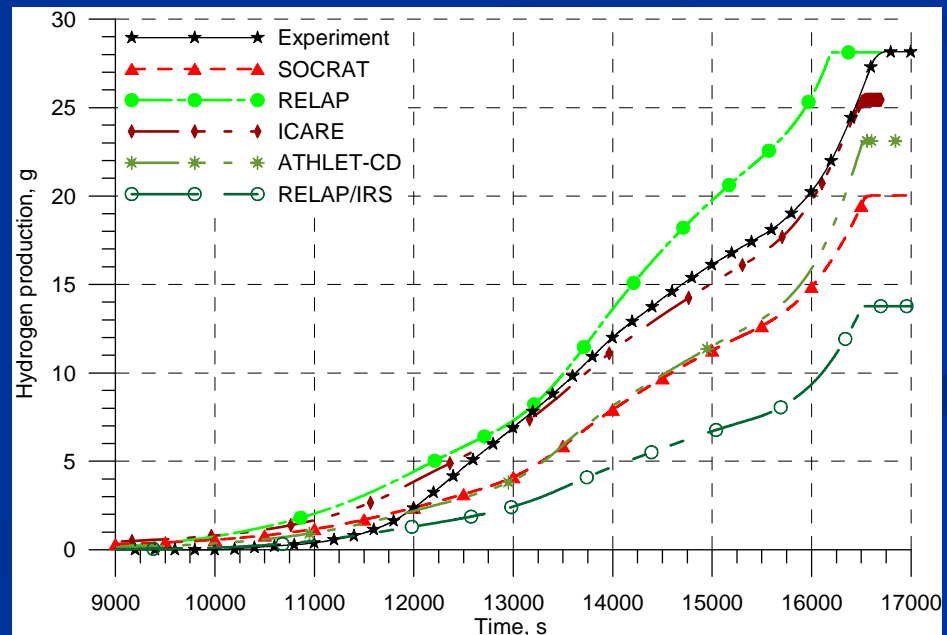


Hydrogen release

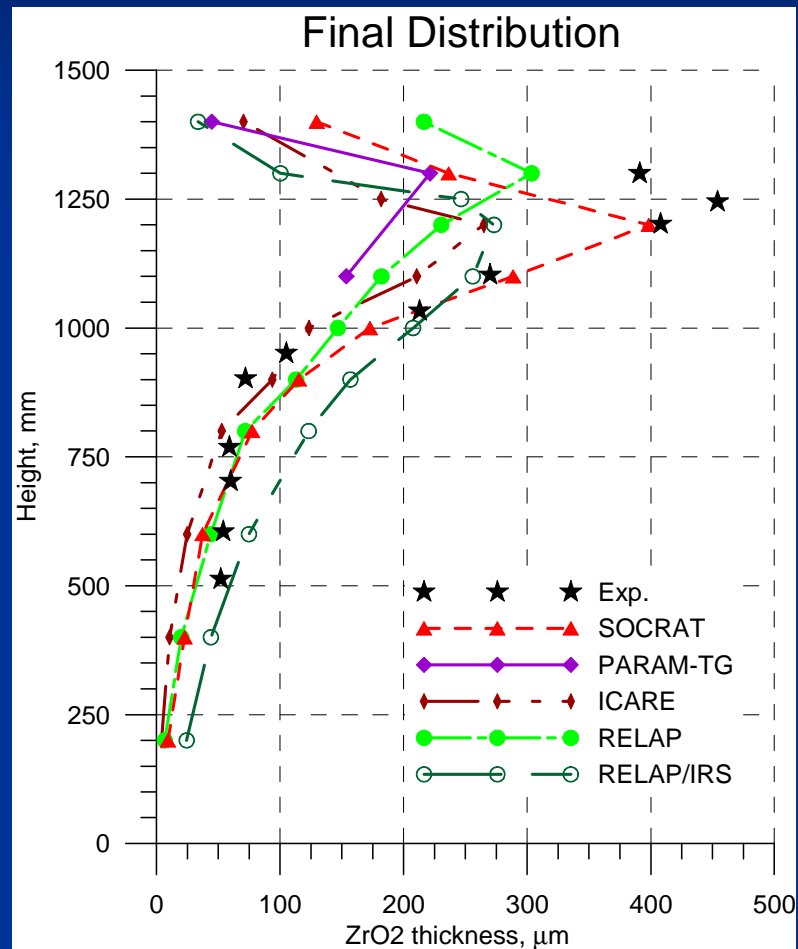
PARAMETER-SF2 post-test analysis



Hydrogen release
 Experimental ~28 g
 ICARE ~ 25.5 g
 ATHLET ~ 23 g
 SOCRAT ~ 20 g
 RELAP – 28 and 13.5 g
 No hydrogen release at flooding phase



Cladding oxide scale thickness profile PARAMETER-SF2 post-test analysis

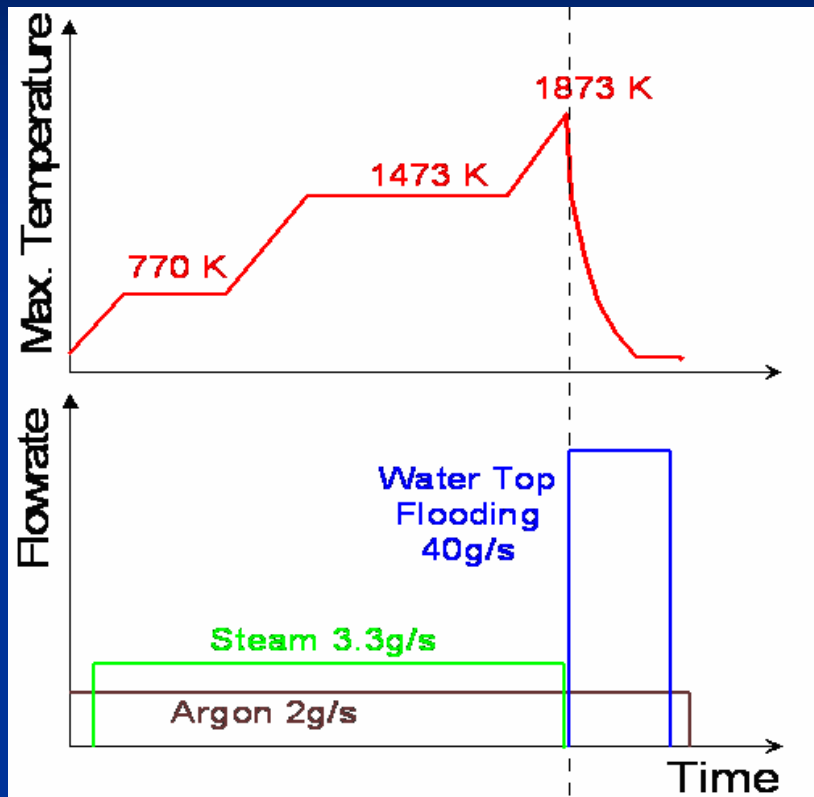


Main outcomes from SF₂ post-test calculations

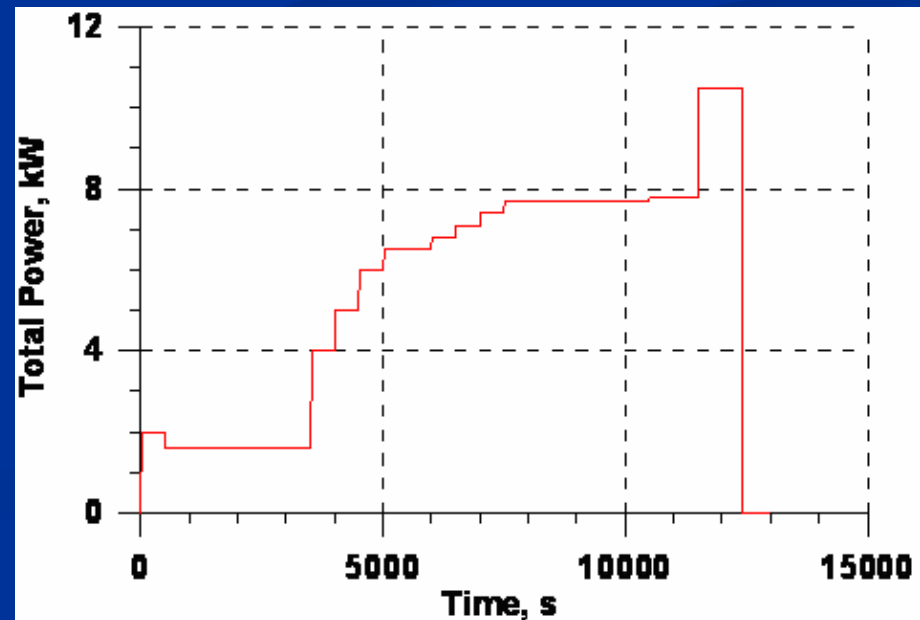
- Post-test calculations and experimental data on temperature evolution are in a good agreement over heated zone except temperature “hump” at 12000 s
- The most codes underestimate hydrogen total amount.
- The codes well describing hydrogen total amount underestimate cladding oxide thickness at the hottest spot.

PARAMETER-SF3 pre-test calculations

Initial and Boundary conditions

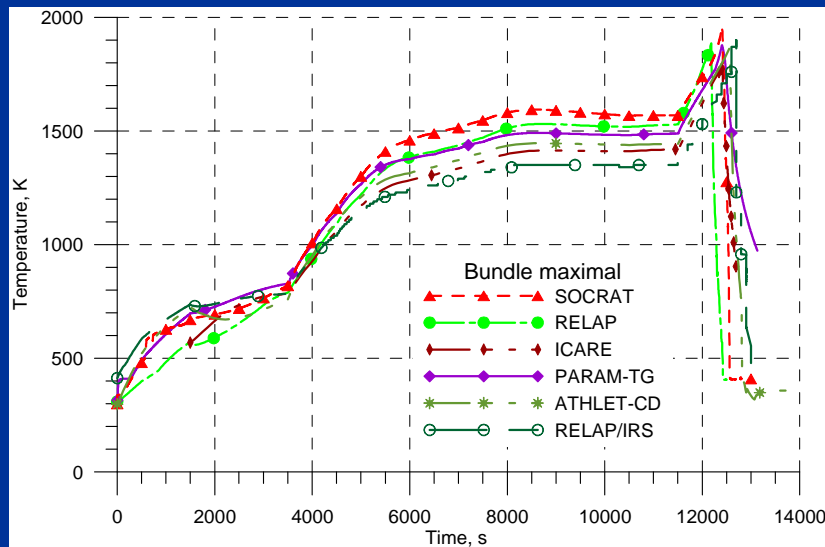
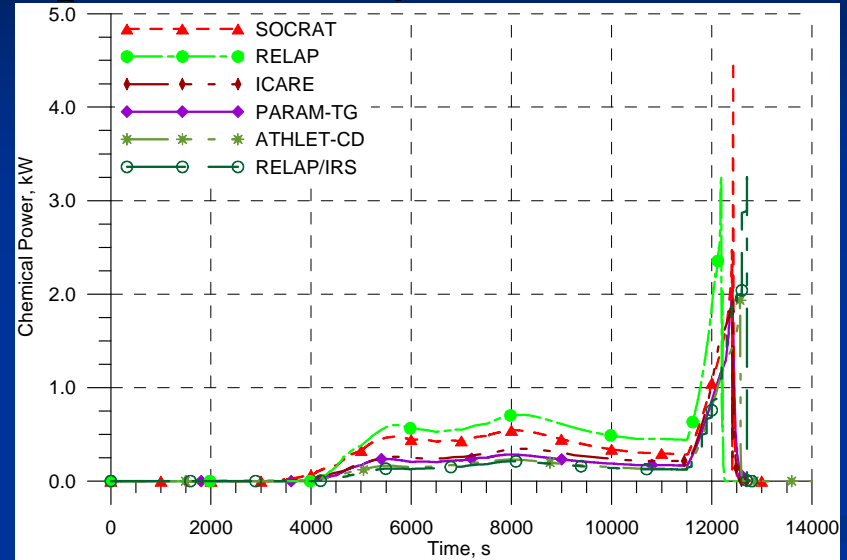
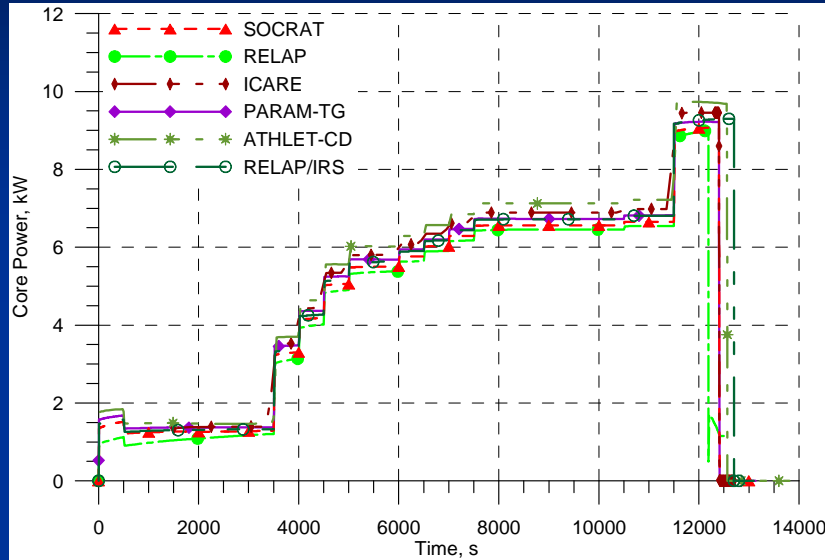


Electrical power
Pre-oxidation phase ~ 7.7 kW
Transient phase ~ 10.5 kW



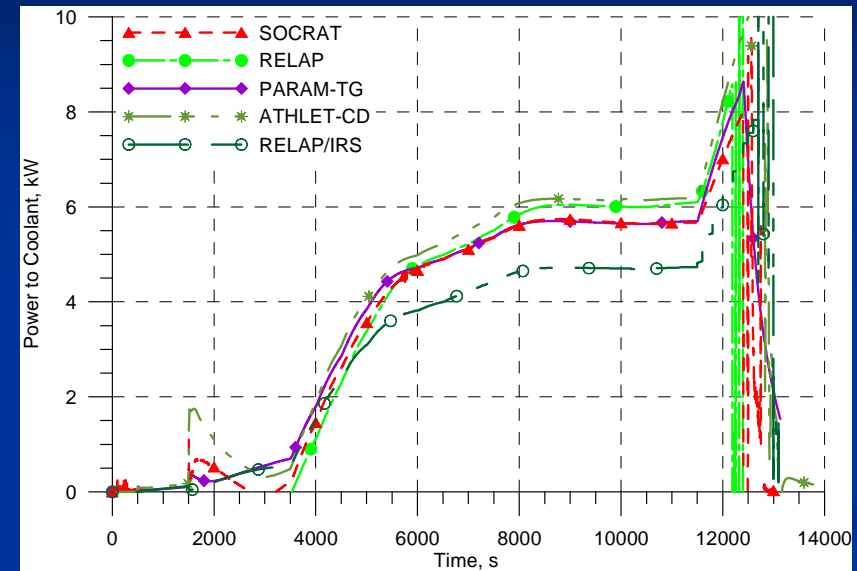
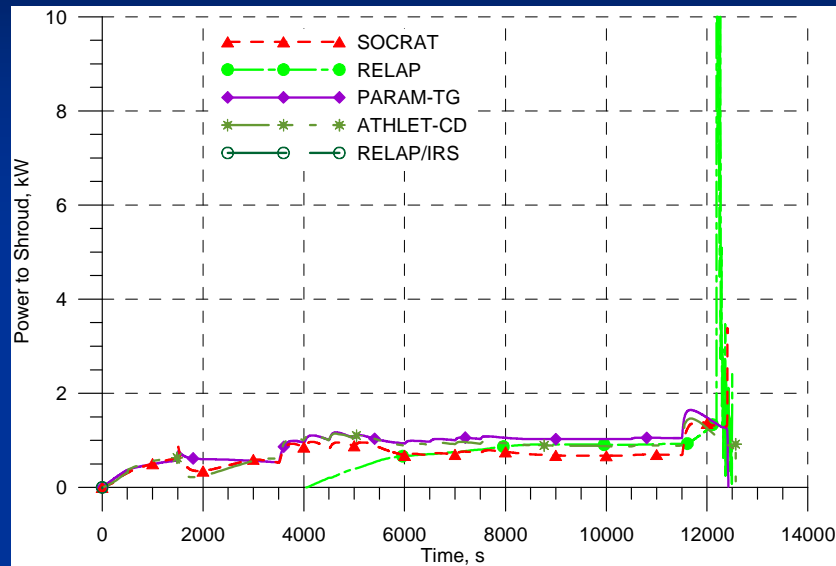
Heat balance

PARAMETER-SF3 pre-test analysis



Heat balance

PARAMETER-SF3 pre-test analysis



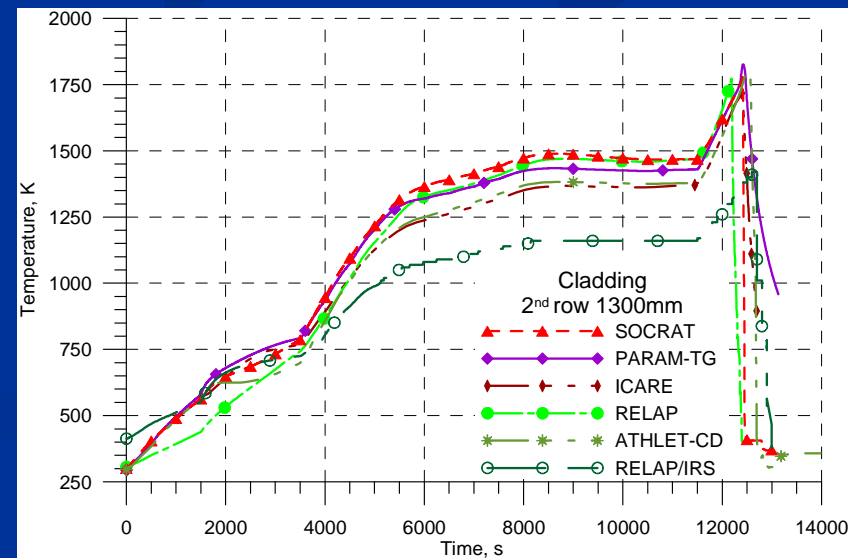
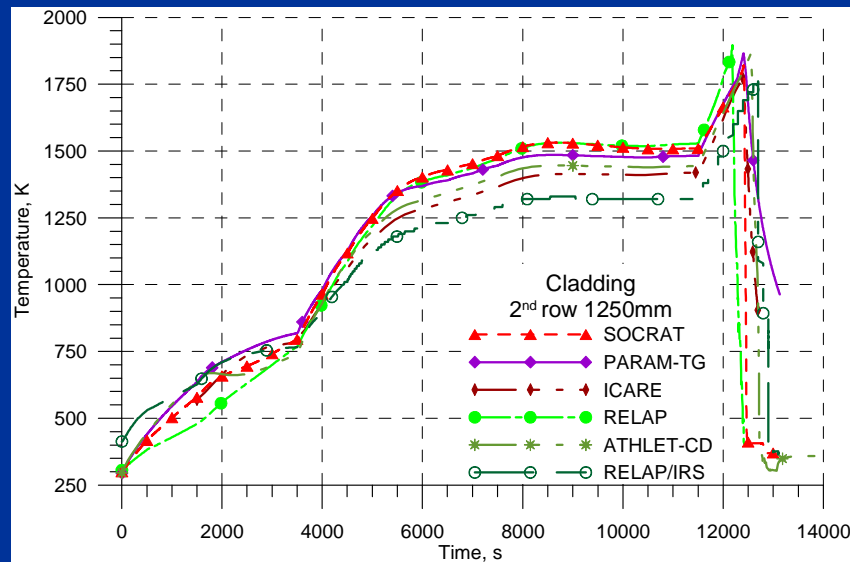
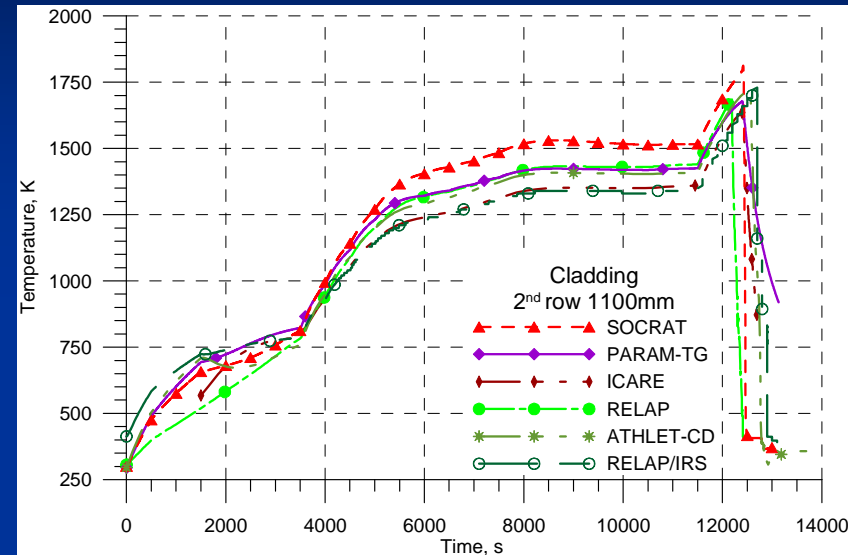
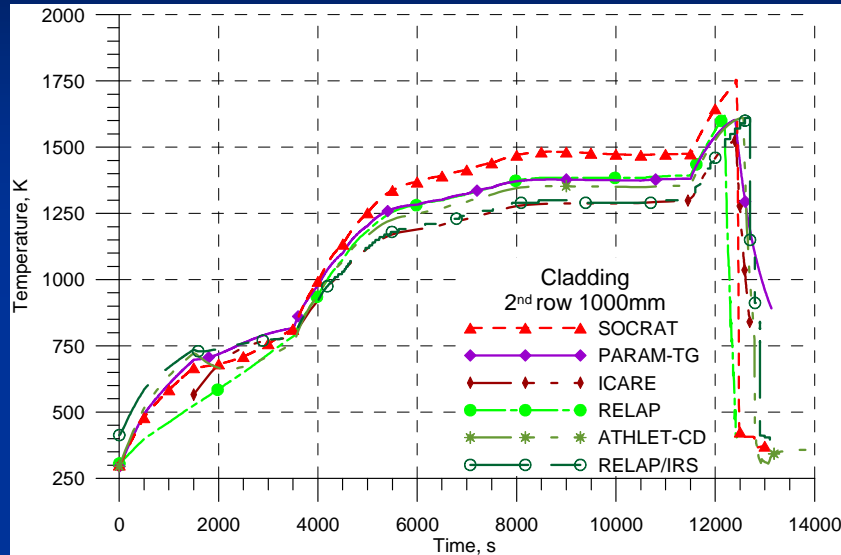
Heat loss through shroud

at pre-oxidation phase

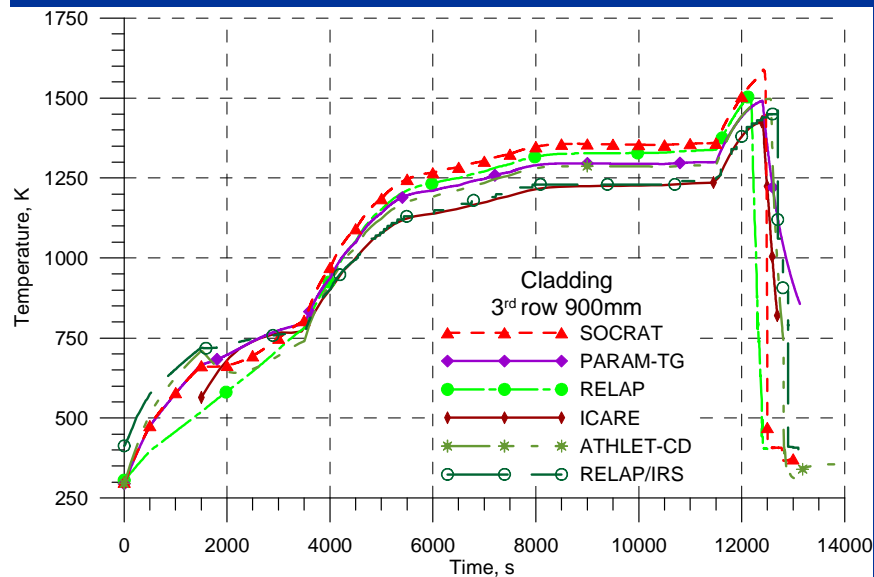
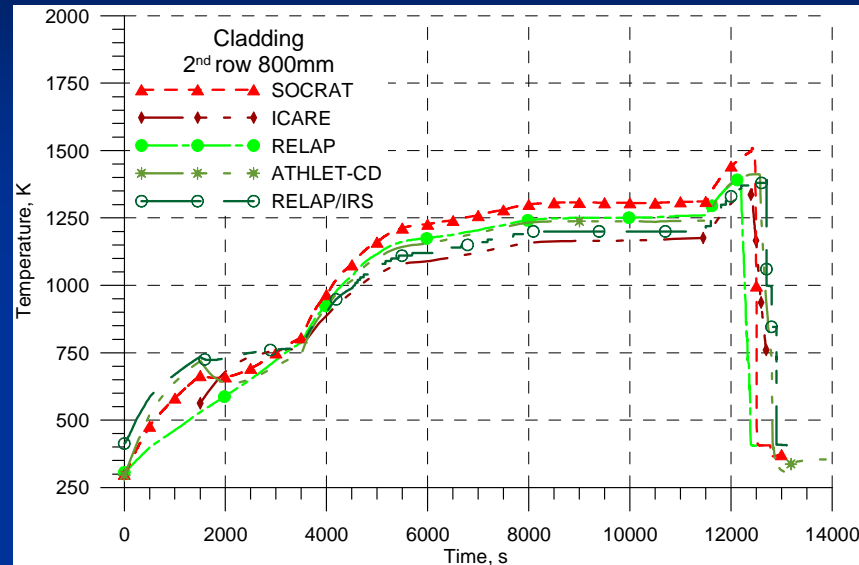
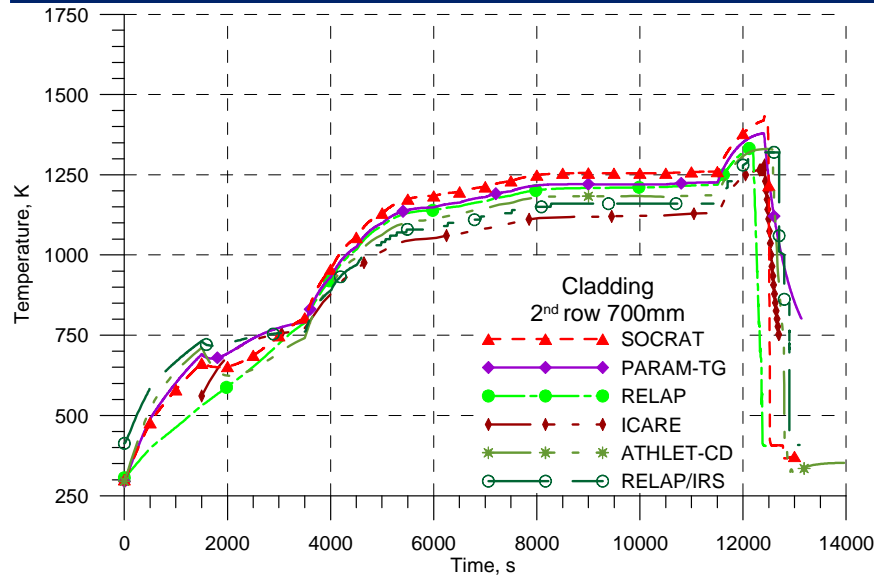
~15% of core power over 0-1275 mm

Claddings temperature evolution - hottest zone

PARAMETER-SF3 pre-test analysis

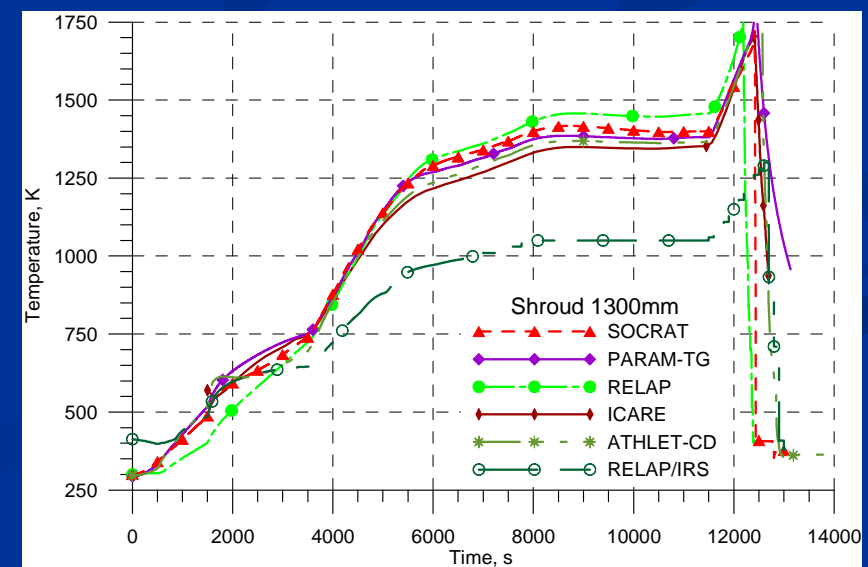
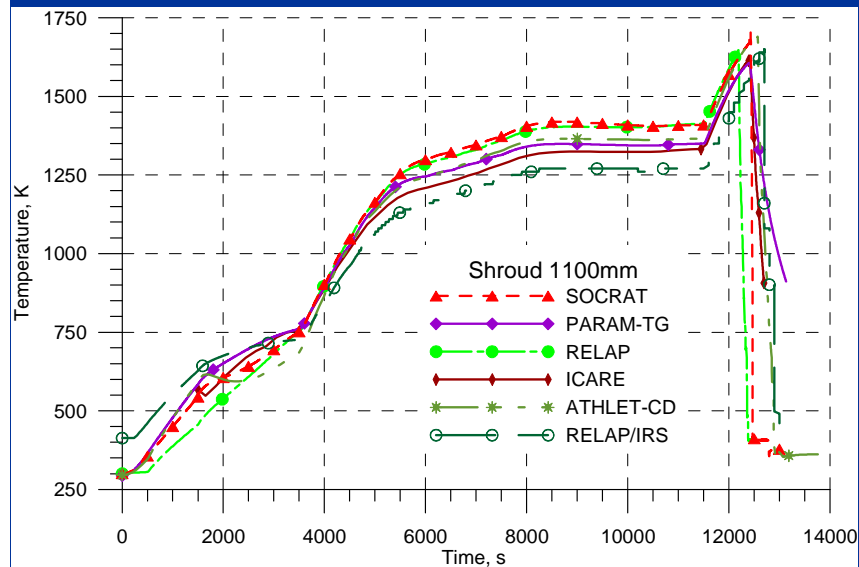
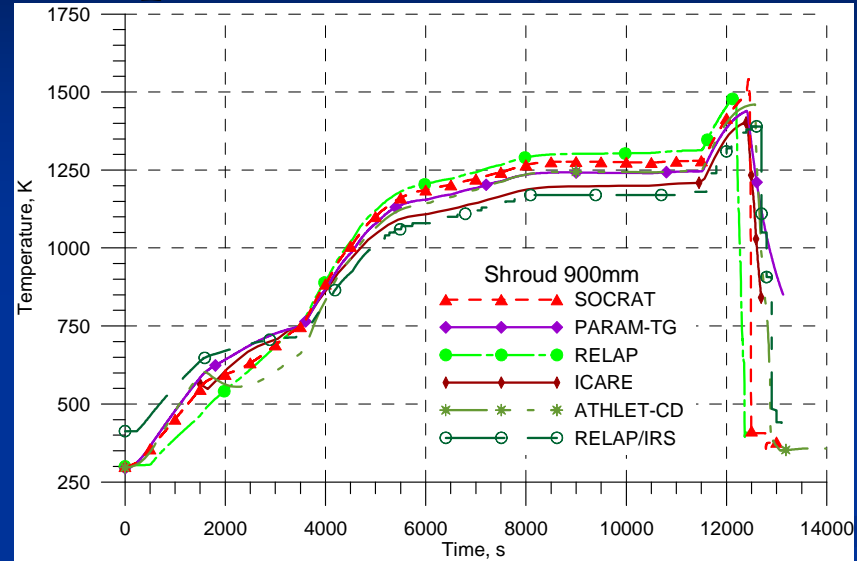
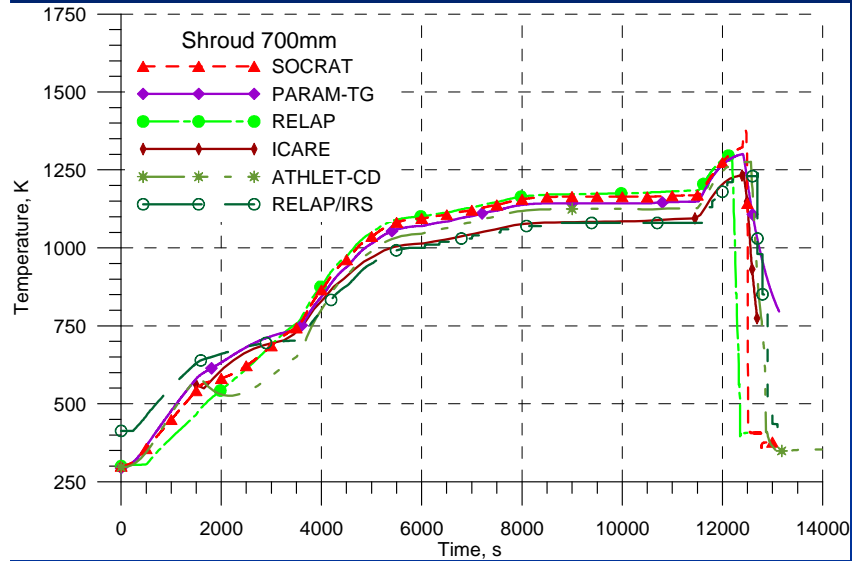


Claddings temperature evolution: 700-900 mm PARAMETER-SF3 pre-test analysis



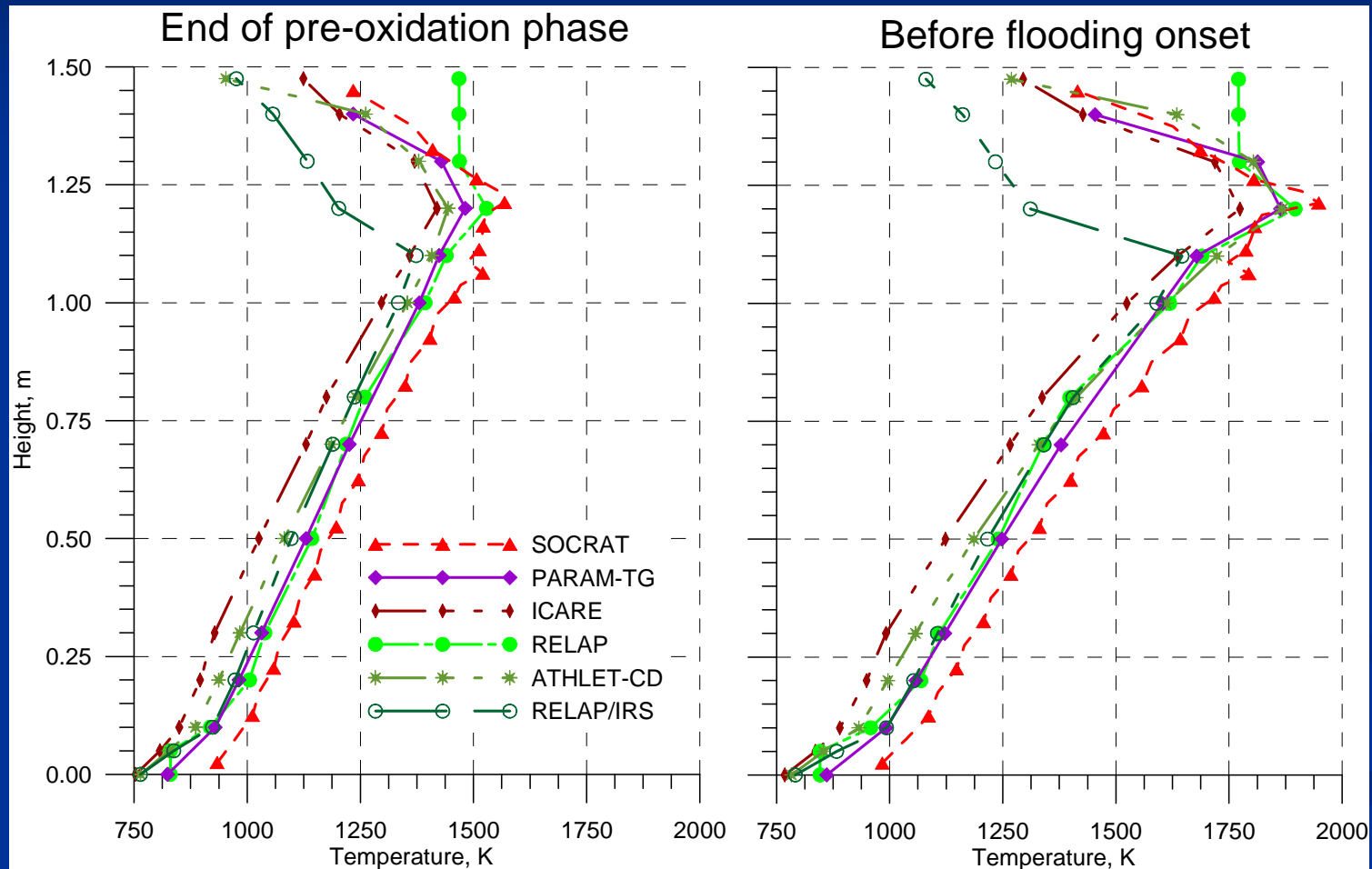
Shroud temperature evolution

PARAMETER-SF3 pre-test analysis



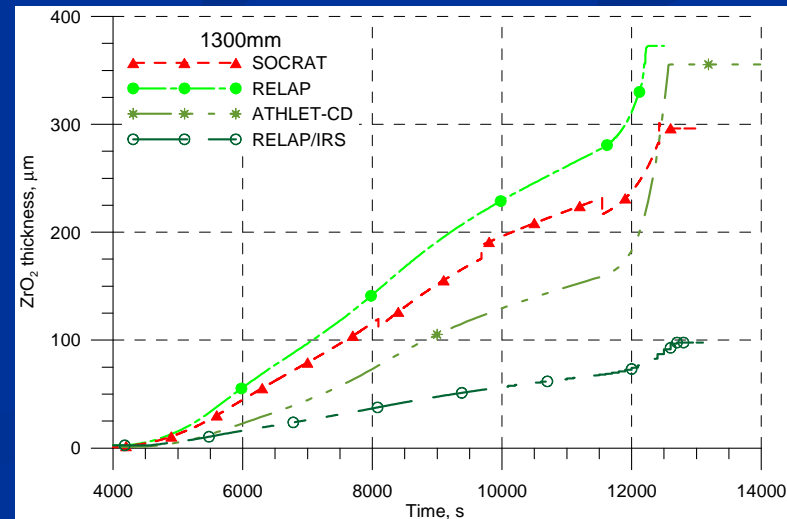
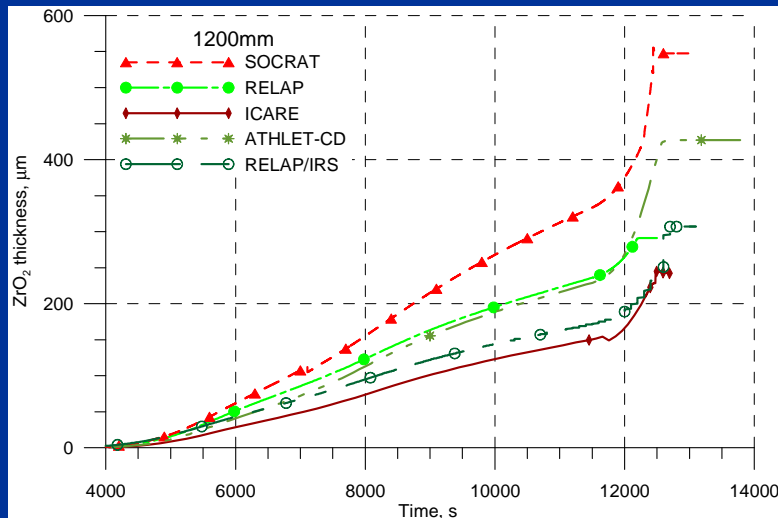
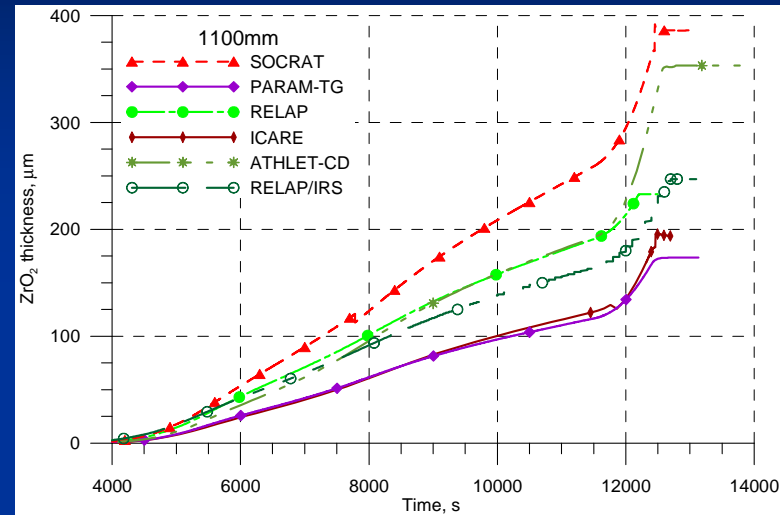
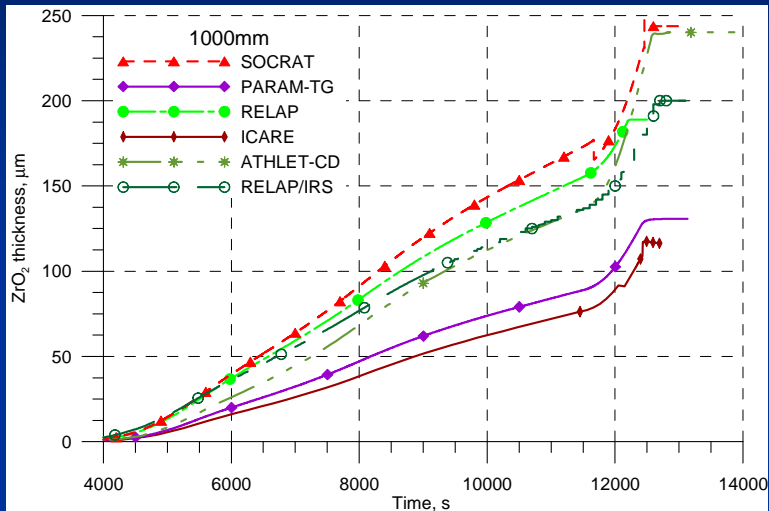
Temperature profile

PARAMETER-SF3 pre-test analysis



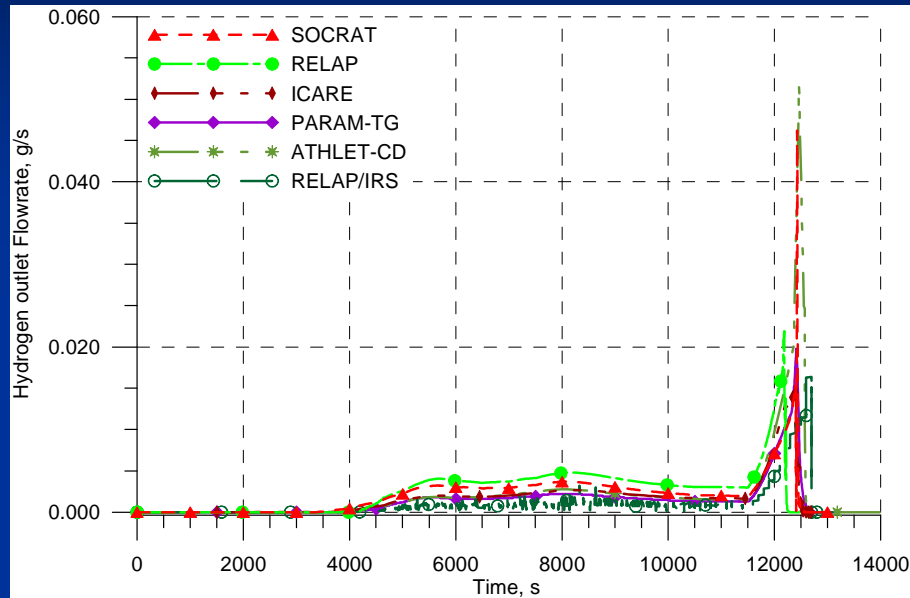
Oxide scale thickness

PARAMETER-SF3 pre-test analysis



Hydrogen release

PARAMETER-SF3 pre-test analysis



Hydrogen release predicted ~ 13-32 g
No extra hydrogen release at the
flooding stage

