

Application and special uses of MELCOR at NUBIKI

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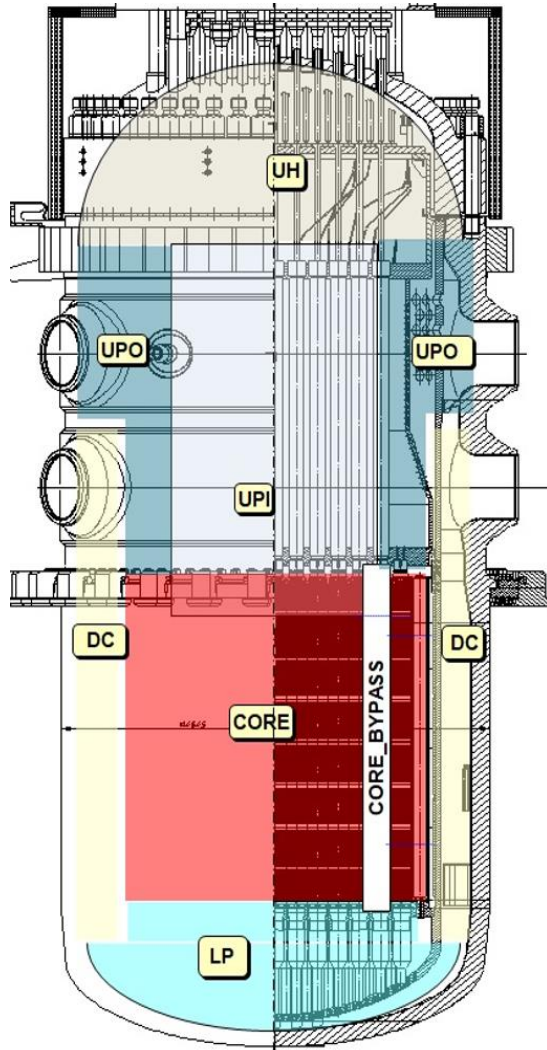
14th EMUG European MELCOR User Group

12-14.04.2023. Ljubljana, Slovenia

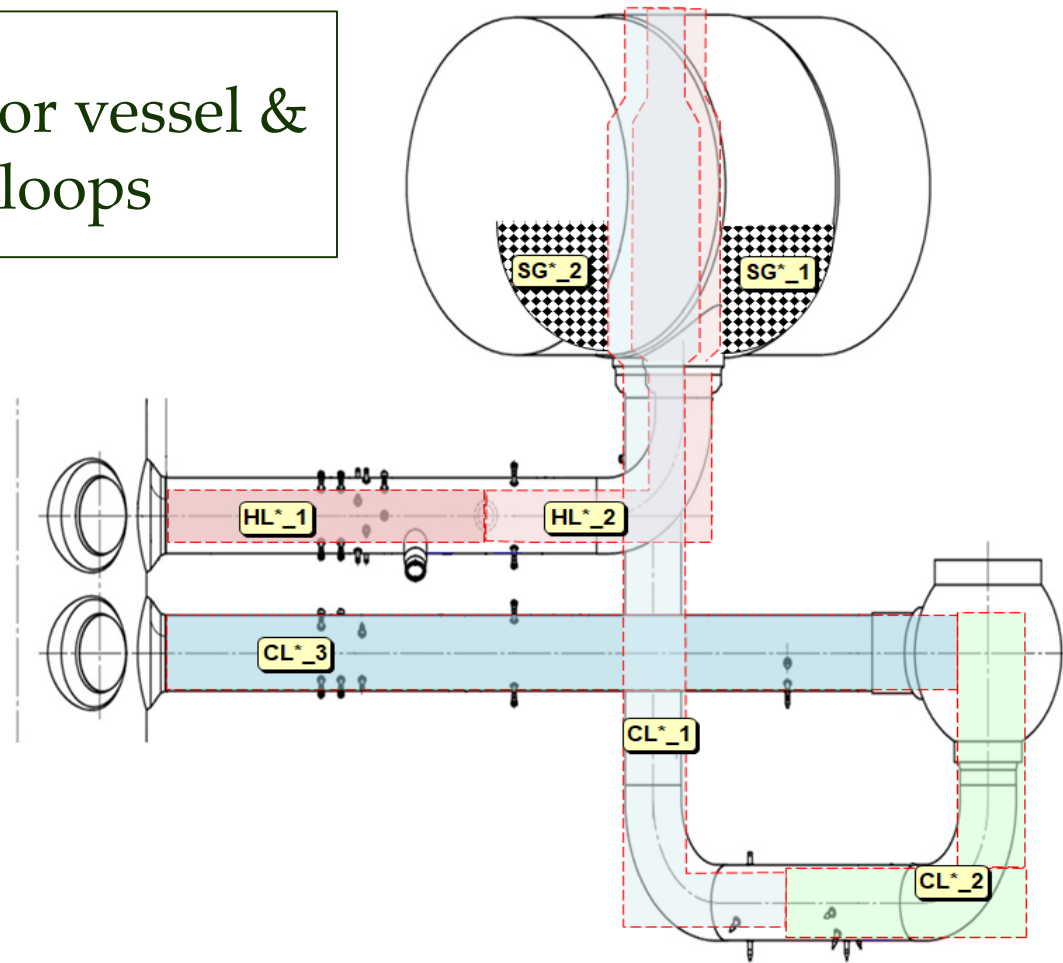
Contents

- Water cooled reactors VVER-1200, VVER-440:
 - DBA and SA scenarios
 - Open reactor calculations
 - SFP calculations
- ALLEGRO 75 MW HTGR (SMR) reactor
- Sandia Fuel Project – fuel air oxidation

VVER-1200 Reactor

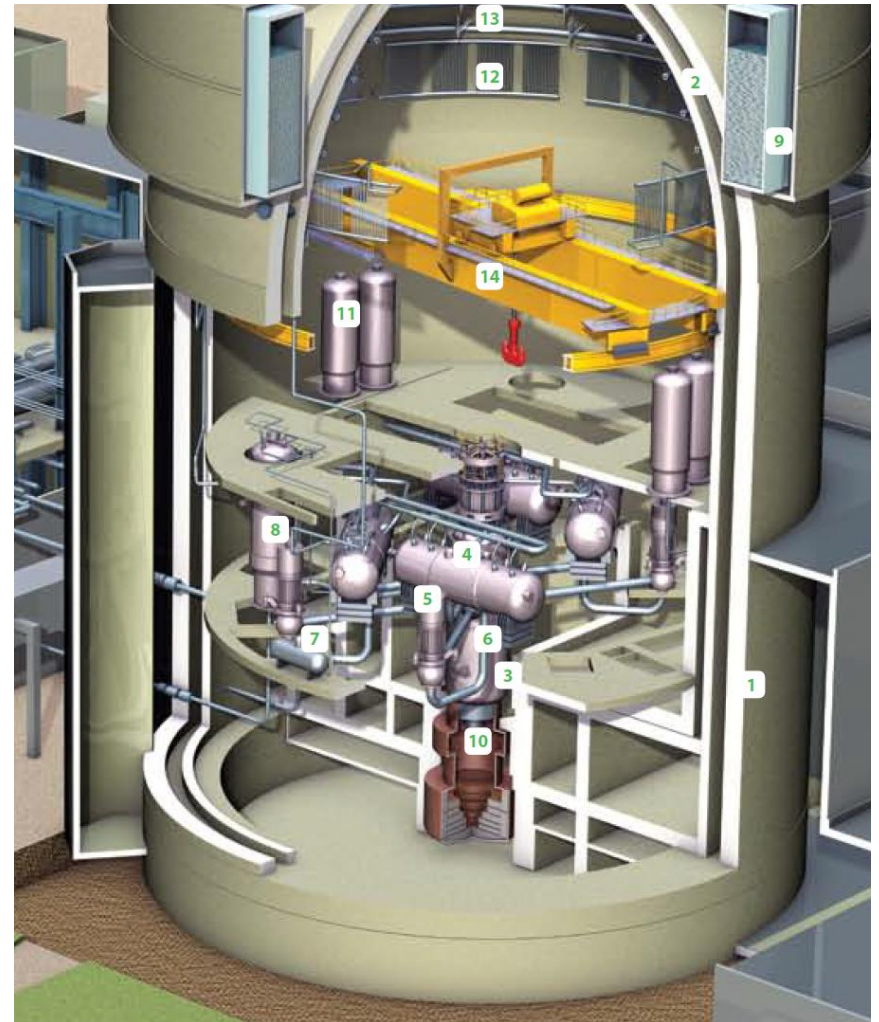


Reactor vessel & loops



VVER-1200 Containment

- Double containment
- Containment spray, autocatalytic hydrogen recombiners
- Passive heat removal tanks on the roof (for both containment and steam generator passive heat removal)
- Water cooled (vessel outer and melt upper surface) core-catcher



VVER-1200 Calculations

- SA – loss of active systems, additional malfunction in passive systems
- DBA – loss of active ECCS (line)
- Steam line break, with loss of ECCS and SGPHRS,
- Control rod ejection with SBLOCA, lack of active systems,
- 200% LBLOCA with SBO,
- SBLOCA with lack of active core cooling...

Most calculations were made with MELCOR 2.2.14959

This year we begun transition to version 21402, but probably will take the next step to the r2023.0 version

VVER-1200 Calculation Difficulties

Excessively slow calculation during

cond

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- Tra

cool

- Pre

stea

via

```
Restart requested from NCYCLE= 2035213 Read from NCYCLE= 2035213
*****USING MELCOR STANDARD EOS !*****
forrtl: severe (67): input statement requires too much data, unit 35, file D:\Nemy\MELCOR\T
_LH_mod_rerun14959\MG_SA\SS\3d_25mm-hp-lp-s\MEL_RST
Image          PC          Routine          Line          Source
Melcor.14959.lic. 00AB02CA  Unknown          Unknown       Unknown
Melcor.14959.lic. 00A50470  Unknown          Unknown       Unknown
Melcor.14959.lic. 00A4F64A  Unknown          Unknown       Unknown
Melcor.14959.lic. 00A3F604  Unknown          Unknown       Unknown
Melcor.14959.lic. 00A3DBA9  Unknown          Unknown       Unknown
Melcor.14959.lic. 008C6594  _NCG_MELGENRESTAR  1028  NCG_RW.F90
Melcor.14959.lic. 00939A67  _M_RW_RESTART_mp_   39   M_RW_Restart.f90
Melcor.14959.lic. 00785BFD  _M_MELCOR_mp_READ  770  M_Melcor.F90
Melcor.14959.lic. 00404F7F  _M_MELCORPROG_mp_  865  m_MelcorProg.f90
Melcor.14959.lic. 00401417  _M_MELCORPROG_mp_  214  m_MelcorProg.f90
Melcor.14959.lic. 00401046  _MAIN_             19   Melcor_NSI.f90
Melcor.14959.lic. 0110E0D3  Unknown          Unknown       Unknown
Melcor.14959.lic. 00A91BEF  Unknown          Unknown       Unknown
KERNEL32.DLL    755500F9  Unknown          Unknown       Unknown
ntdll.dll       77037BBE  Unknown          Unknown       Unknown
ntdll.dll       77037BBE  Unknown          Unknown       Unknown
```

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usly

- HS sensitivity coefficient 4055(1) & 4055(3) – permitted transient operations

VVER-1200 Calculation Difficulties

Code crashes – only shown in the command prompt

```

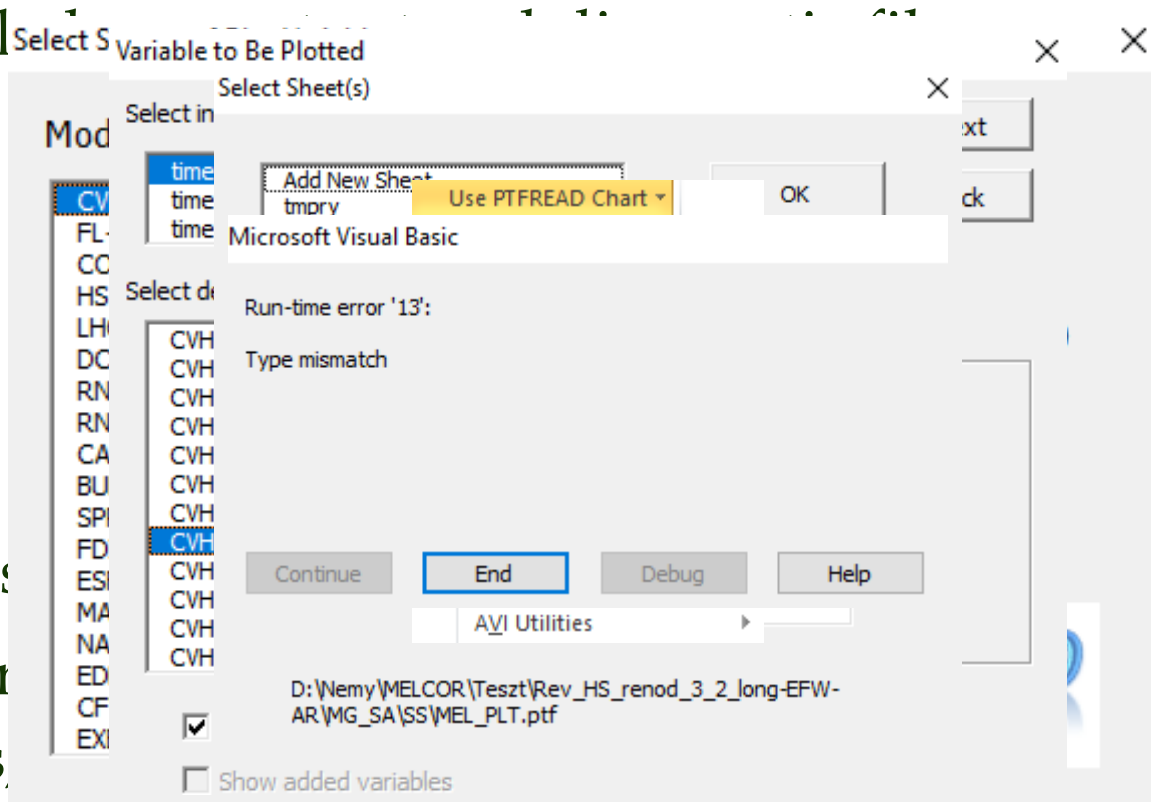
CYCLE= 2271300 T= 9.726646E+04 DT(MAX)= 1.000000E-01 CPU= 2.305519E+05
forrtl: severe (157): Program Exception - access violation
Image          PC          Routine          Line          Source
Melcor.14959.lic. 010B533B  _THS_HSRUN3_ip_TH  1108  hsrun3_NSI.f90
Melcor.14959.lic. 010B3BB8  _THS_HSRUN3        393  hsrun3_NSI.f90
Melcor.14959.lic. 0106470F  _THS_HSDBD        25   hsdbrd_NSI.f90
Melcor.14959.lic. 0078D9C9  _RUNSTEP_ip_PHYSI  293  RunStep.f90
Melcor.14959.lic. 0078D004  _RUNSTEP          101  RunStep.f90
Melcor.14959.lic. 0040160F  _M_MELCORPROG_mp_  229  m_MelcorProg.f90
Melcor.14959.lic. 00401046  _MAIN__           19   Melcor_NSI.f90
Melcor.14959.lic. 0110E0D3  Unknown           Unknown  Unknown
Melcor.14959.lic. 00A91BEF  Unknown           Unknown  Unknown
KERNEL32.DLL     755500F9  Unknown           Unknown  Unknown
ntdll.dll        77037BBE  Unknown           Unknown  Unknown
ntdll.dll        77037B8E  Unknown           Unknown  Unknown
  
```

```

CYCLE= 2058920 T= 7.237077E+04 DT(COR)= 1.000000E-01 CPU= 1.471316E+05
forrtl: error (65): floating invalid
Image          PC          Routine          Line          Source
01_Melcor.21402.1 010B5CD1  _COR_CORGE0       364  corgeo_NSI.f90
01_Melcor.21402.1 01054B51  _COR_CORRN4       645  corrn4_NSI.f90
01_Melcor.21402.1 00D5AD45  _COR_CORDBD       272  cordbd_NSI.f90
01_Melcor.21402.1 007F628A  _RUNSTEP_ip_PHYSI  232  RunStep.f90
01_Melcor.21402.1 007F581B  _RUNSTEP          103  RunStep.f90
01_Melcor.21402.1 004018DF  _M_MELCORPROG_mp_  224  m_MelcorProg.f90
01_Melcor.21402.1 00401042  _MAIN__           34   Melcor_NSI.f90
01_Melcor.21402.1 012CC8A3  Unknown           Unknown  Unknown
01_Melcor.21402.1 00B62F8F  Unknown           Unknown  Unknown
KERNEL32.DLL     755500F9  Unknown           Unknown  Unknown
ntdll.dll        77037BBE  Unknown           Unknown  Unknown
ntdll.dll        77037B8E  Unknown           Unknown  Unknown
  
```

VVER-1200 Calculation Difficulties

Excessive



PTFread is

- Not working on 64 bit systems

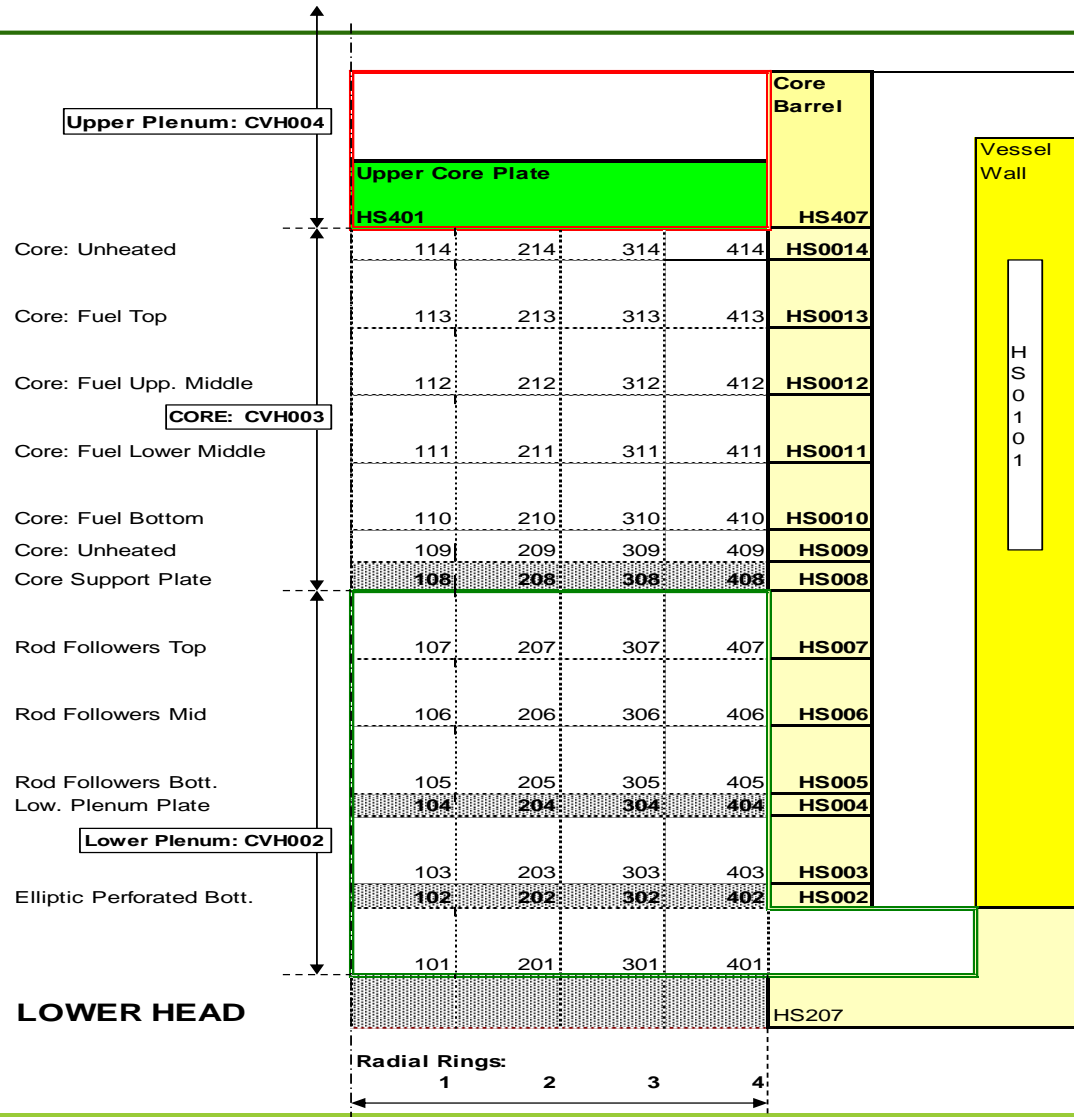
(64 bit

Special Application of MELCOR for VVER-440

- Elliptical RPV bottom (also VVER-1200)
- Horizontal SG (also VVER-1200)
- Rod followers – 2 level core
- Hexagonal (neutron trap) control rods
- Double loop seal in primary circuit
- External Reactor Vessel cooling
- EFW as fog?
- Shallow Suppression pool
- Passive spray (Bubbler condenser spillover)
- Long Term Cont. Cooling by air cooled IHX
- CAV-CORCON model interpretation

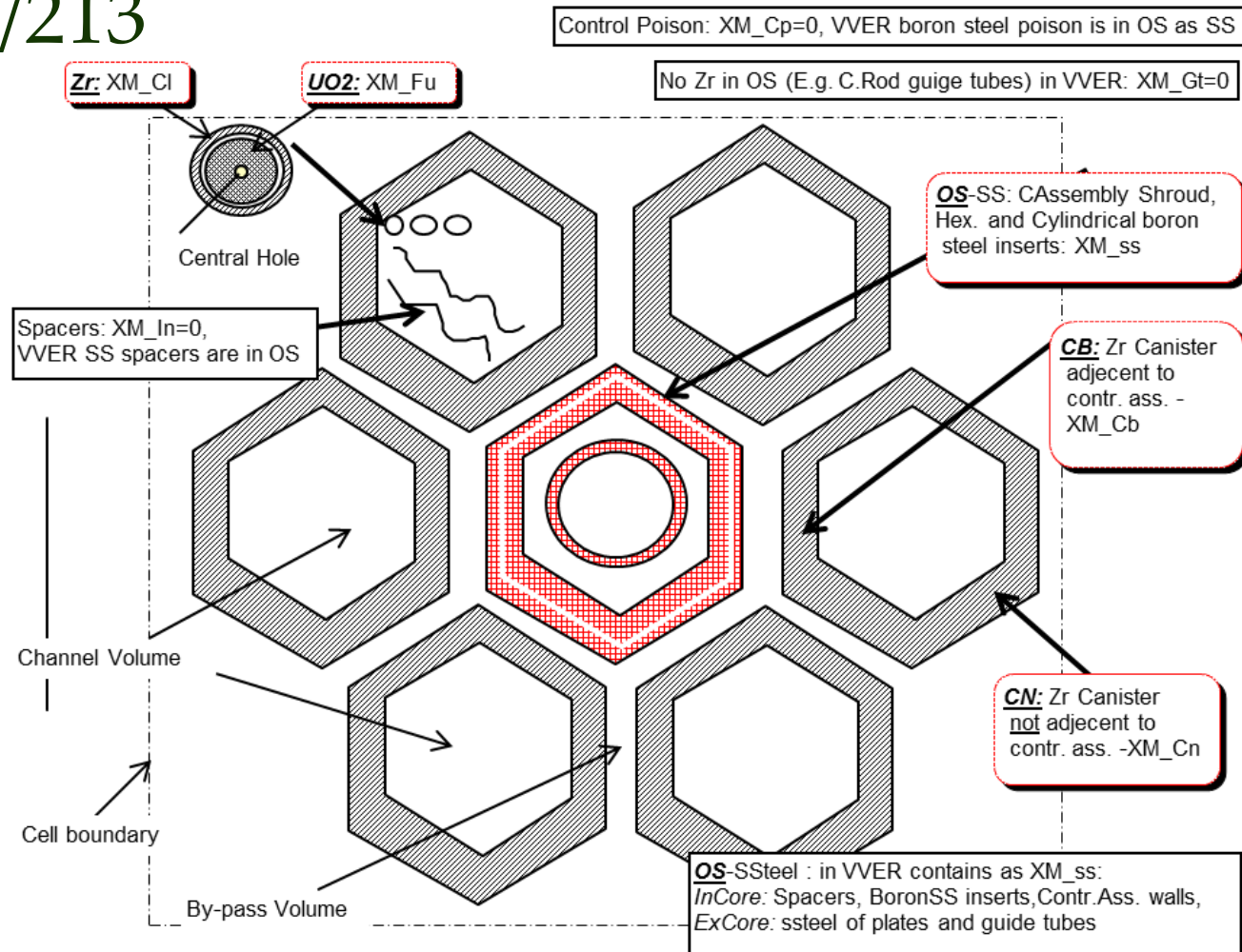
Two Level Core - Rod Followers

- VVER-440/213

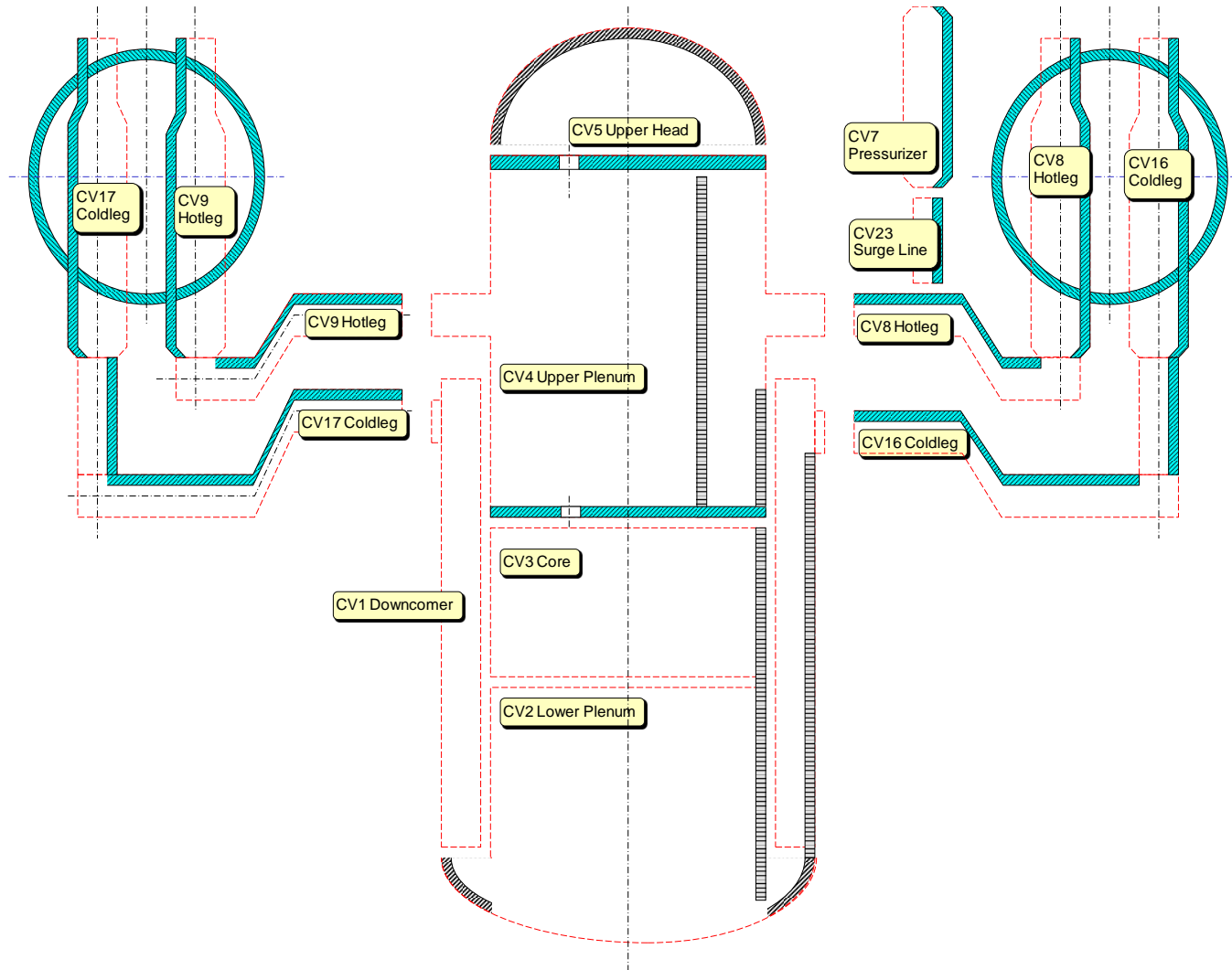


Hexagonal (Neutron Trap) Type Control Rods

- VVER-440/213

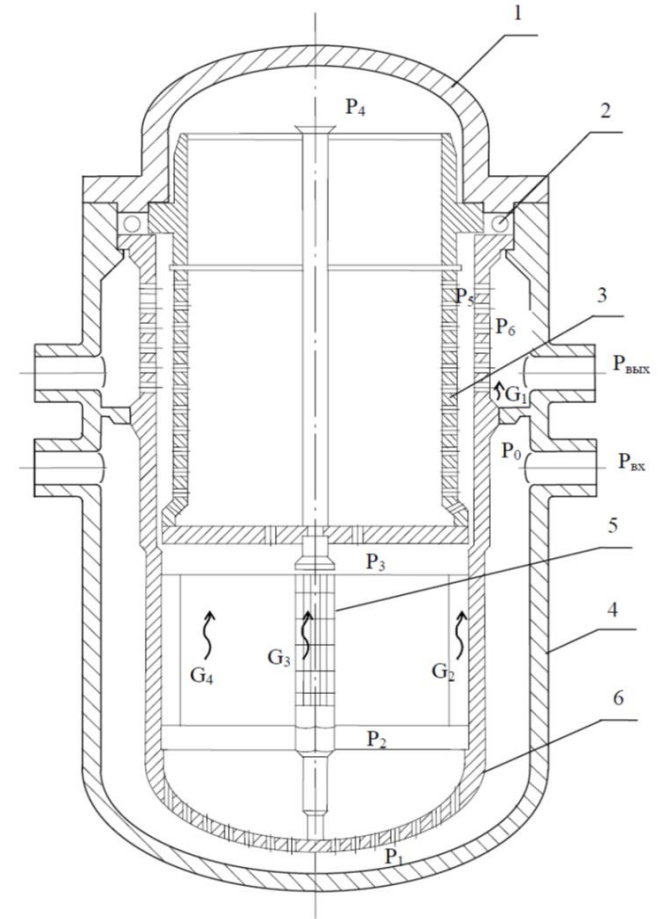
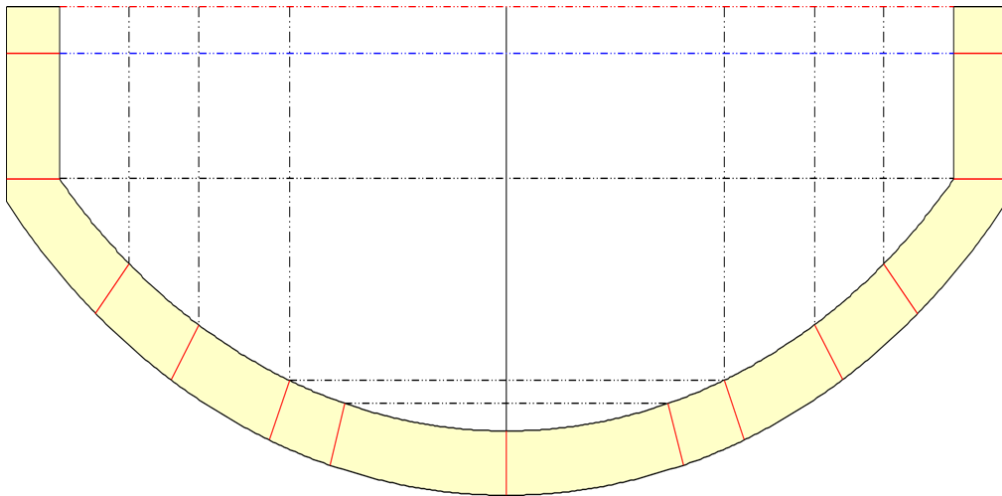


Double Loop Seals



Elliptical RPV Lower Head

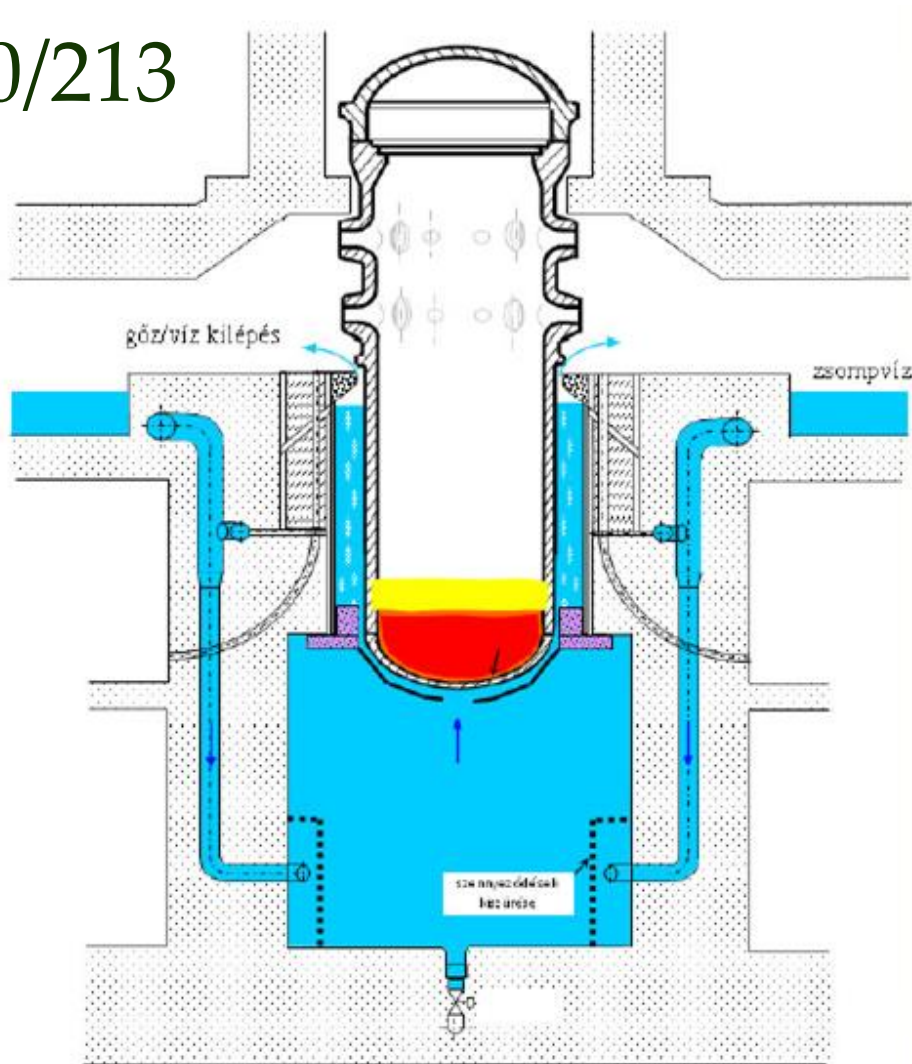
- VVER-440/213 and
- VVER-1200



1 – top head; 2 - tubular component; 3 - PTU; 4 - reactor vessel;
5 - fuel assembly; 6 – core barrel with supporting tubes and core baffle

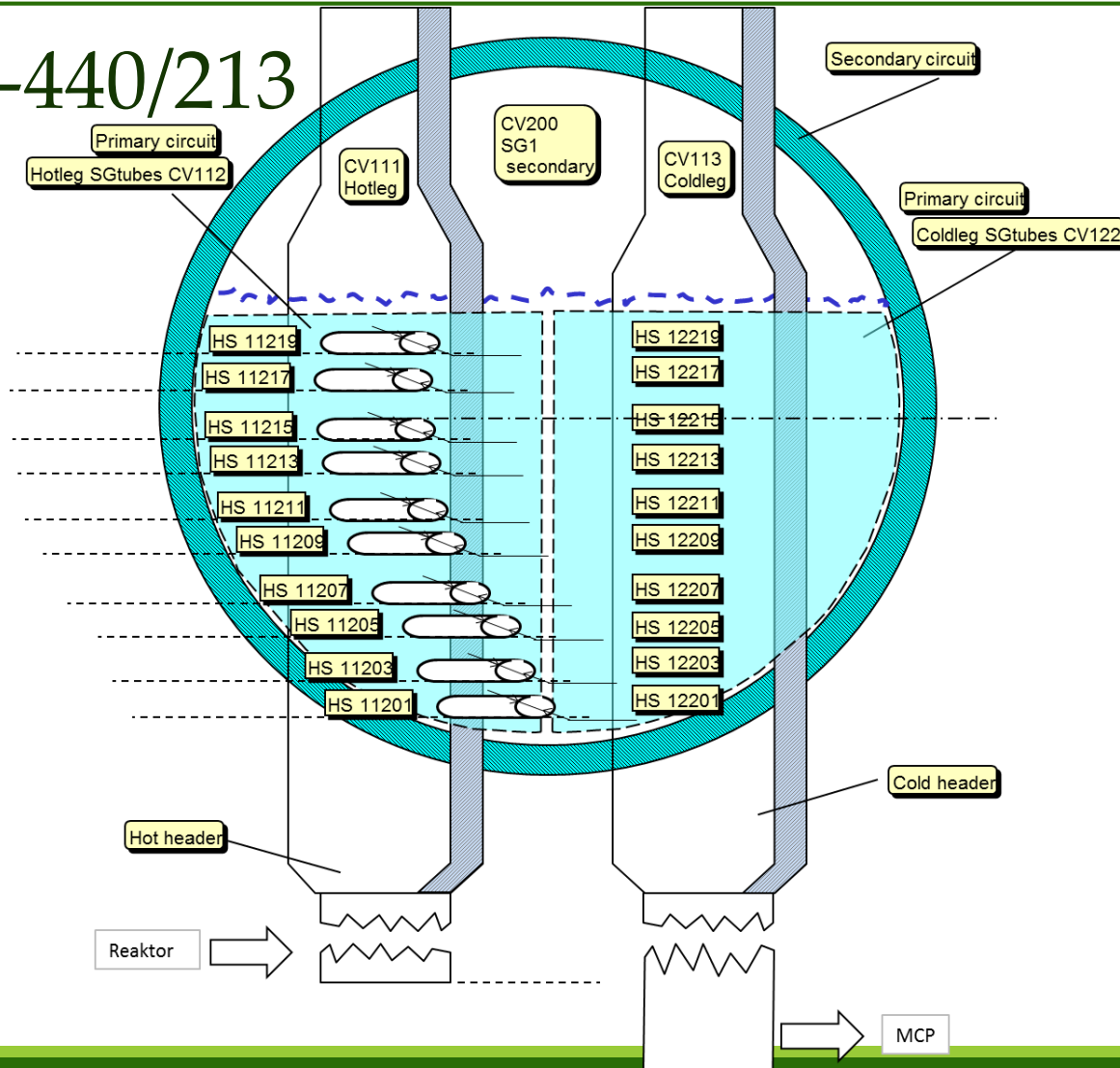
External Reactor Vessel Cooling

- VVER-440/213



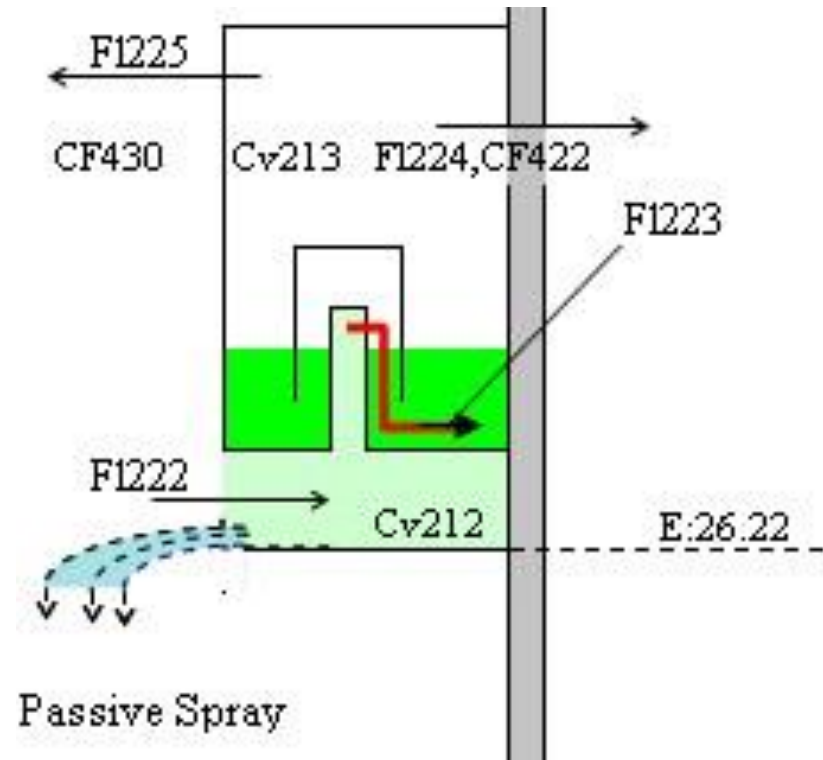
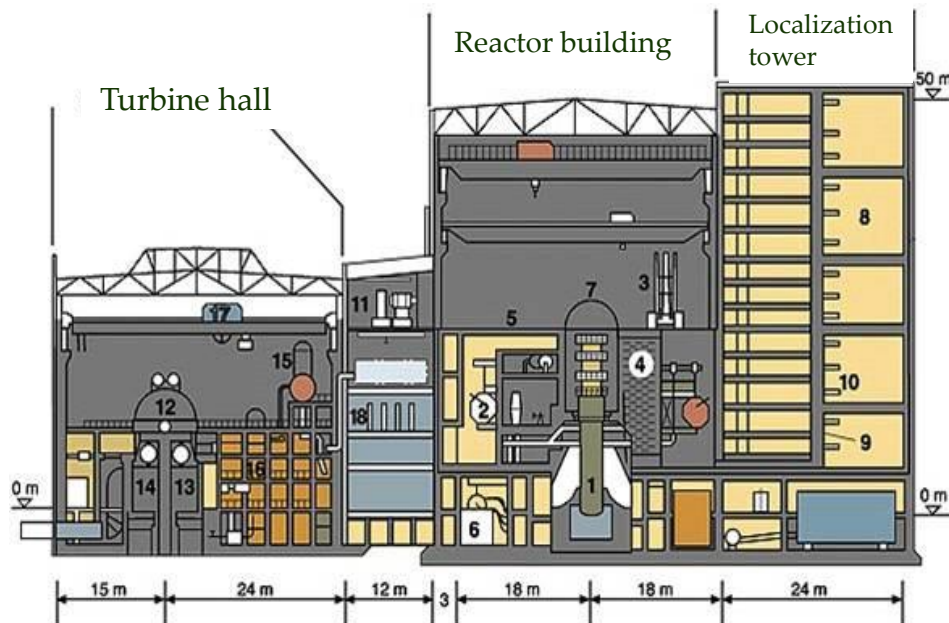
Horizontal SG and SG Tubes

- VVER-440/213



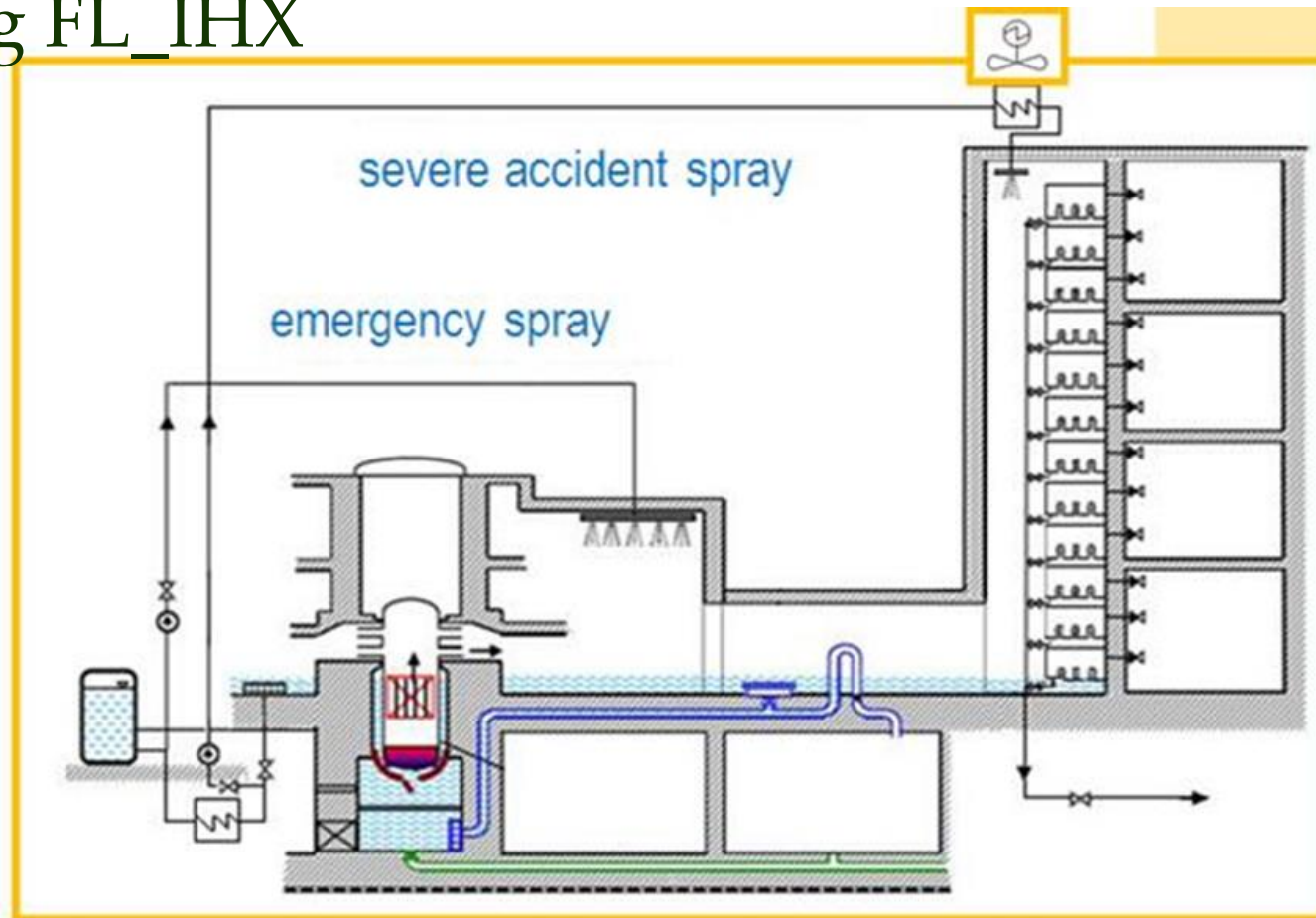
Suppression Pool With Shallow Pool

- VVER-440/213

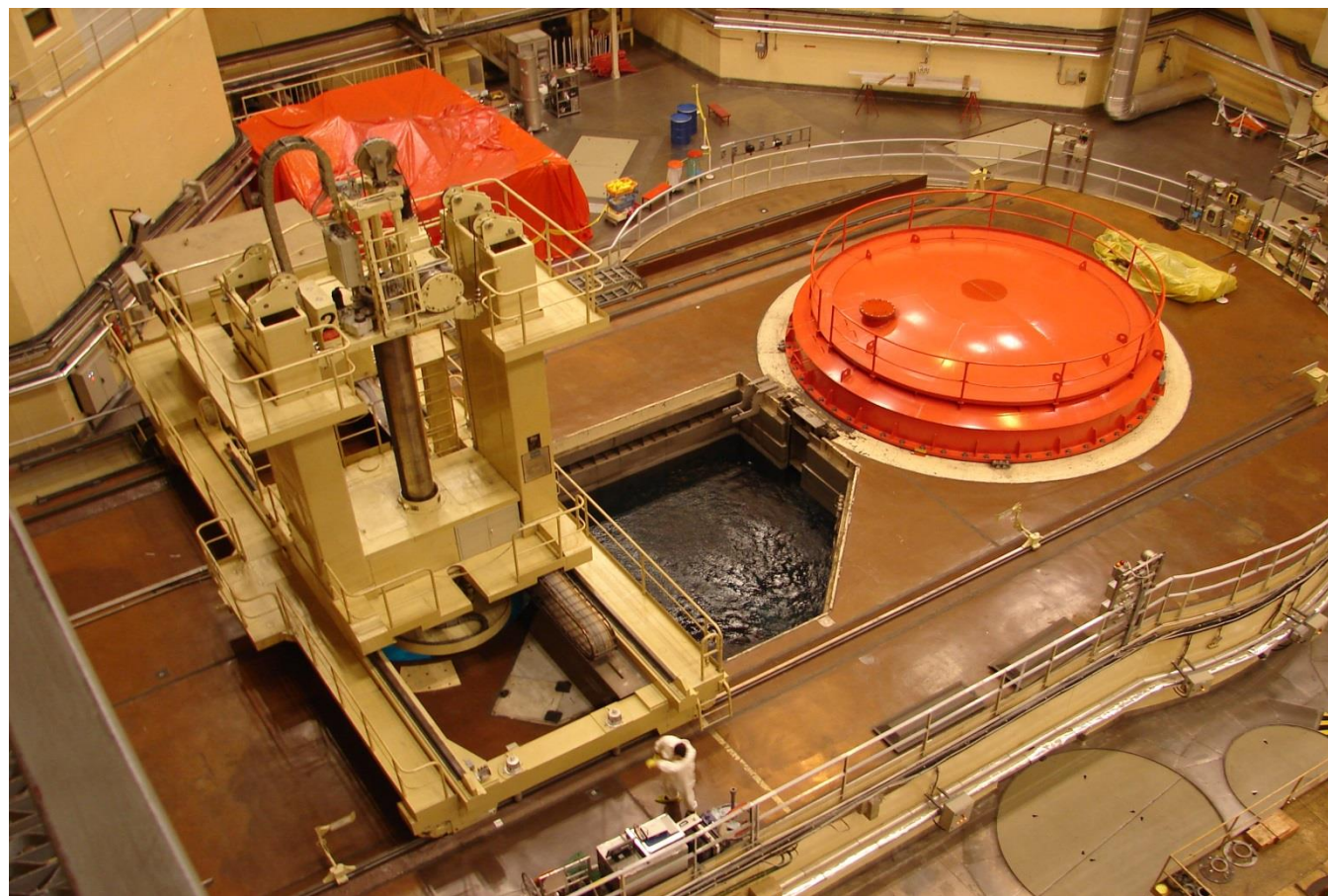


Long term Containment Cooling by External Heat Exchanger VVER-440

- Air cooled heat exchanger combined with spray - Using FL_IHX



SFP – VVER-440/213, VVER-1200



Confusion if a rectangular or a circular SFP should be modelled

Selecting different power densities in different part might be a problem.

The MELCOR COR package is designed in two-dimensional cylindrical geometry and nodalization of the SFP must fit within this framework.

Energy balance in CORCON

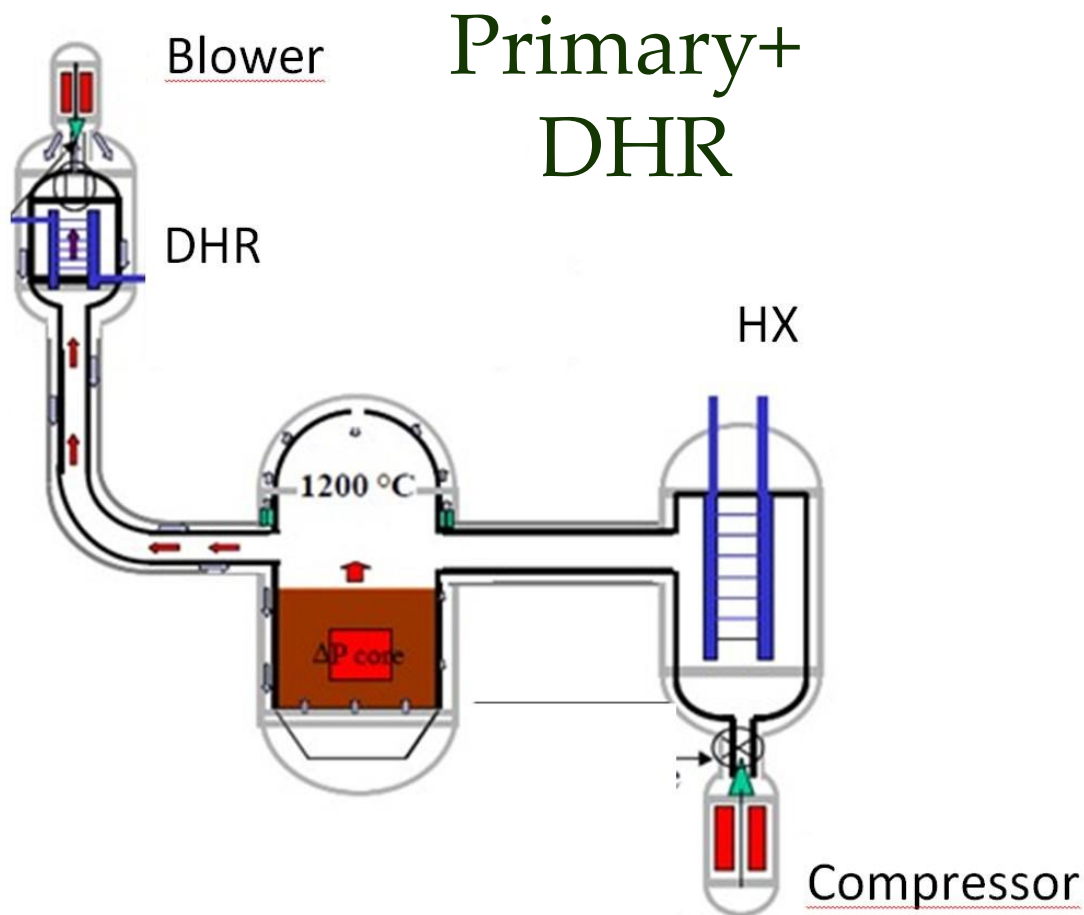
	Plot variable	
INTERNAL (DECAY) SOURCE (W)	CAV-DHR.10	Decay
CHEMICAL REACTION SOURCE (W)	CAV-QREA.10	Chem.react
HEAT LOSS TO CONCRETE (W)	CAV-QCNCT.10	Ablation
HEATUP OF ABLATION PRODUCTS (W)	Missing	
HEAT LOSS FROM SURFACE (W)	CAV-QSURF.10	Top toss
CHANGE IN POOL ENTHALPY (W) =		

Interpretation of variables and energy balance is confusing

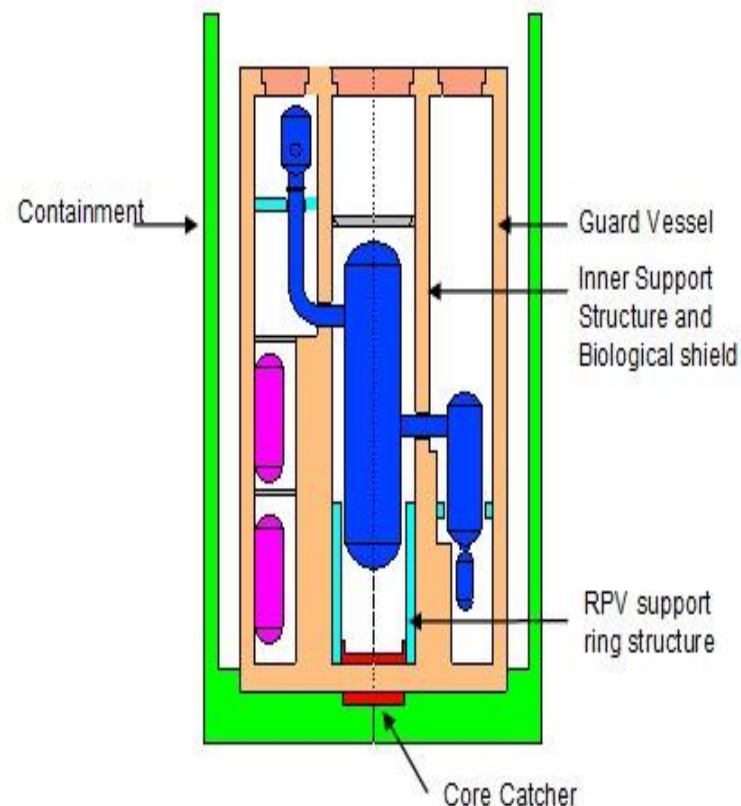
Heat of ablation products is missing from plot variables (CORCON report plots contain them)

POOL ENTHALPY CHANGE can not be derived from these data

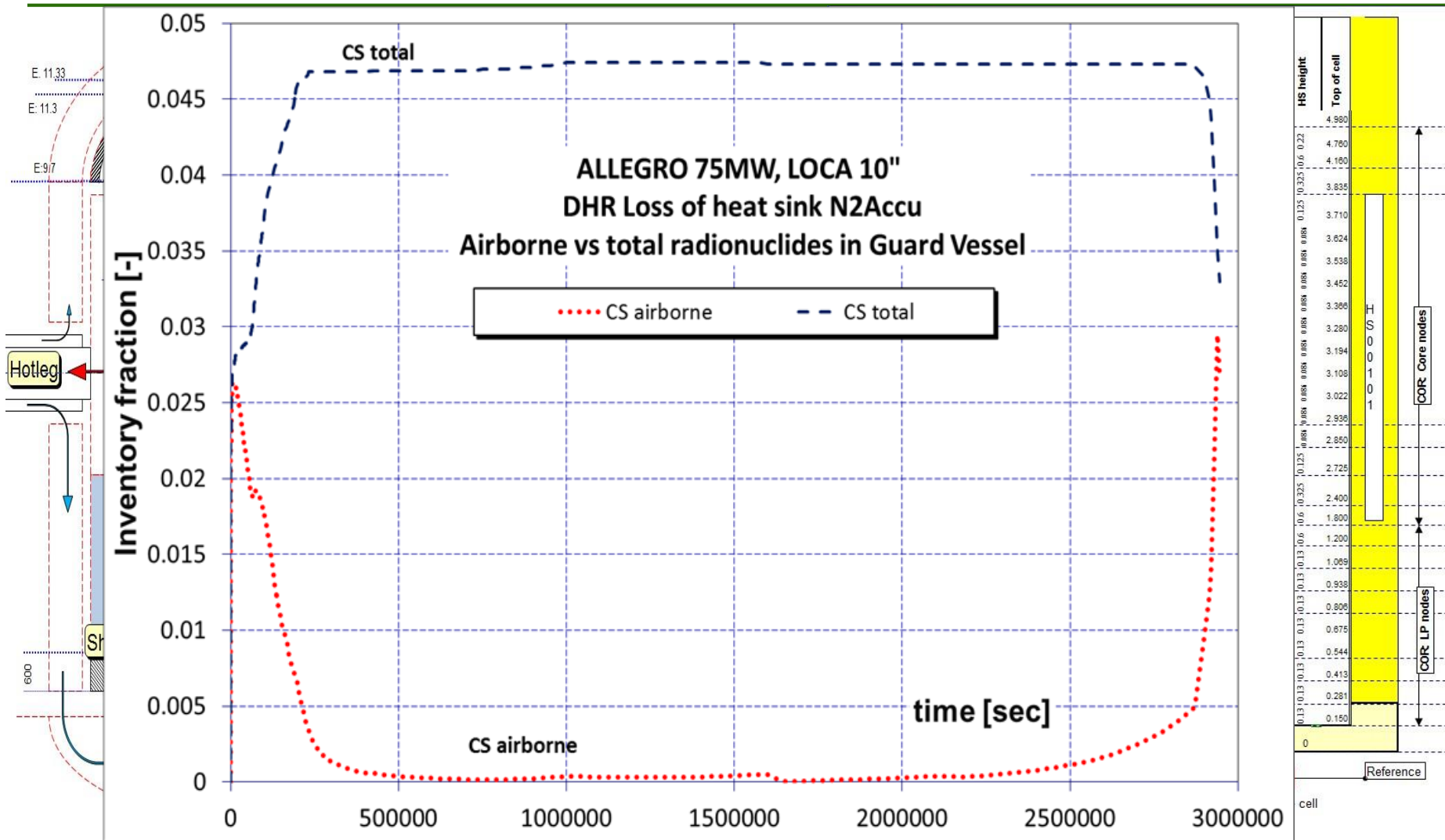
Modelling of Conceptual Design of the Allegro 75 MW reactor



Containment + Guard Vessel



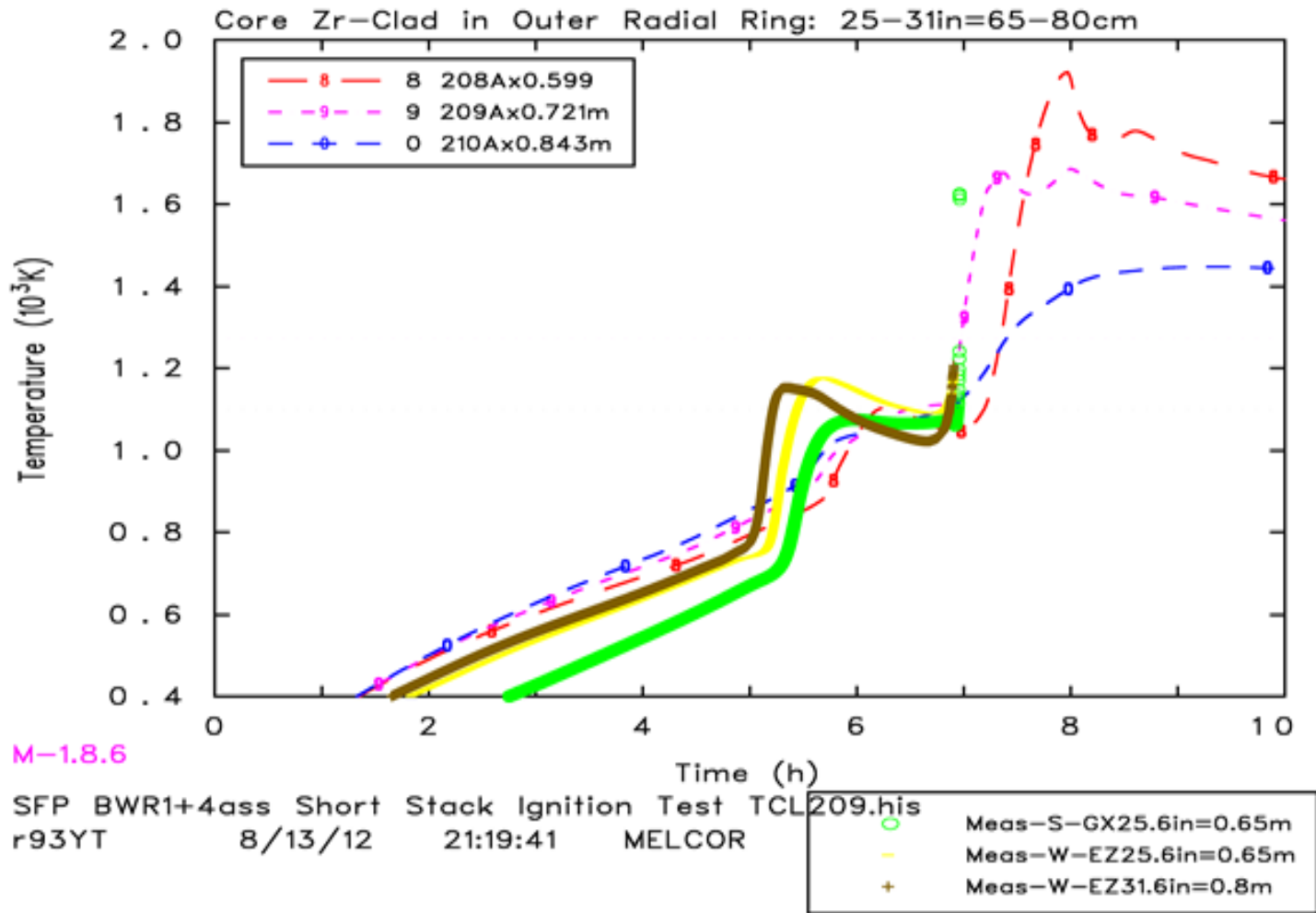
Allegro 75 MW Primary + Core model



SANDIA FUEL Project

1+4 BWR FE air oxidation

MELCOR



Present and future capabilities

MELCOR users at NUBIKI:

- Experience with 35 years: 1 researcher
- Experience with 20 years: 1 researcher
- Experience with 5 years: 1 researcher
- Future: encouraging



**Thank you for your kind
attention!**
