MELCOR activities at Warsaw University of Technology (WUT), Institute of Heat Engineering

Michał Gatkowski

Piotr Darnowski

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Severe Accident activities at WUT

- Two projects SARWUT (2013-2014) and INSPE (2014-2015).
- SARWUT – safety analysis, transients, heat removal disturbances and severe accidents.
- INSPE – scholarship program for Nuclear Engineers.
- RELAP, CATCHARE, TRACE, MELCOR, MACCS, CFD.
- No MELCOR nor Severe Accident simulation experience before.
- MELCOR 2.1 code: EPR, Zion PWRs and simple generic BWR.
- LBLOCA, SBO and variations.
- Main purpose: Gain basic knowledge and experience with SA and initiate research in the field.

ITC INSTYTUT TECHNIKI CIEPLNEJ INSTITUTE OF HEAT ENGINEERING

INSPE

sarwut

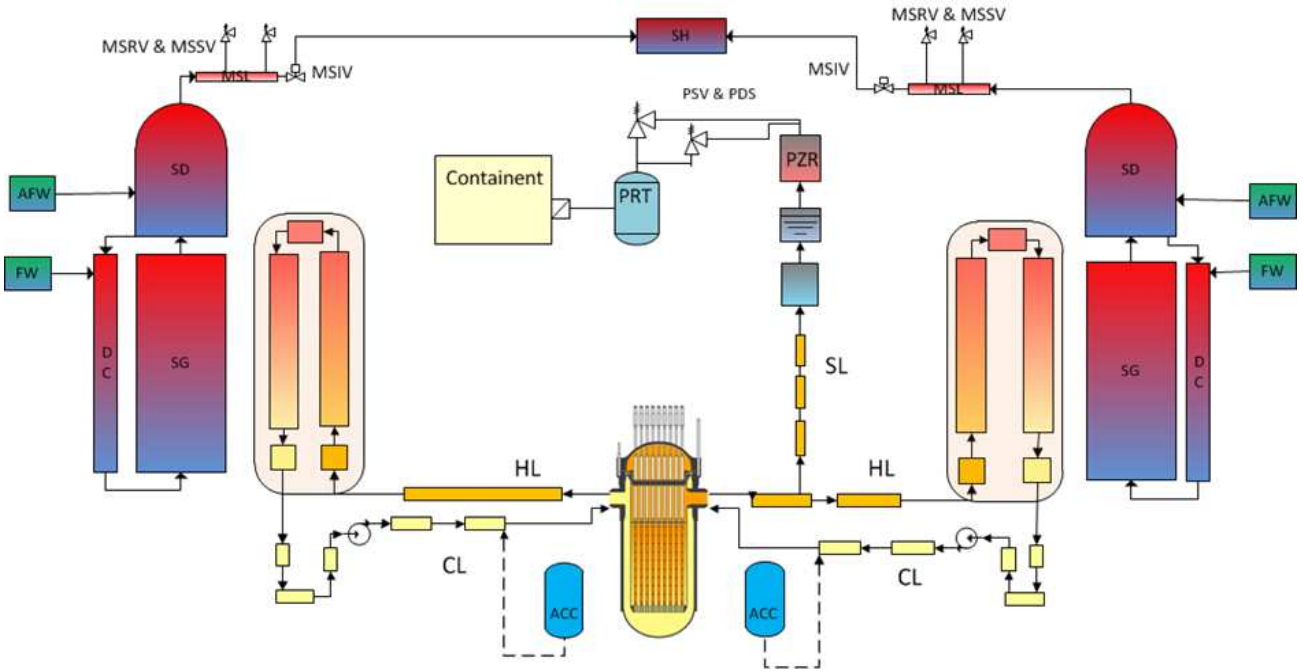
Support

Cooperation with:

- National Atomic Energy Agency (PAA) – close cooperation, constant support and experience exchange. Point of contact with U.S. NRC .
- National Centre for Nuclear Research (NCBJ) – SA knowledge exchange
- Areva – technical support, 2 workshops, comparison exercise with MAAP results.
- GE-Hitachi Nuclear Energy – workshop, internships

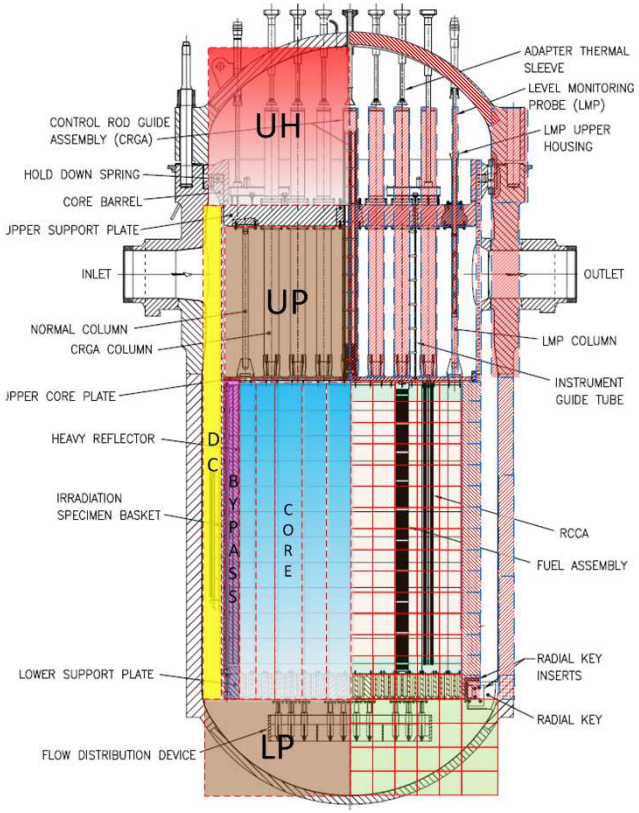
EPR model development

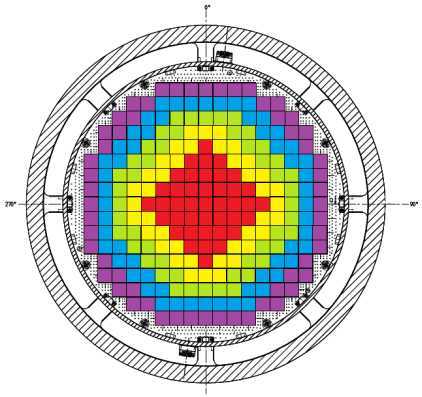
- EPR selected during early stage of the project as a one of potential PWR design for Polish NPP program.
- Model based on publicly available data (hence, it is rather „EPR type” PWR model).
- Relatively simple model.

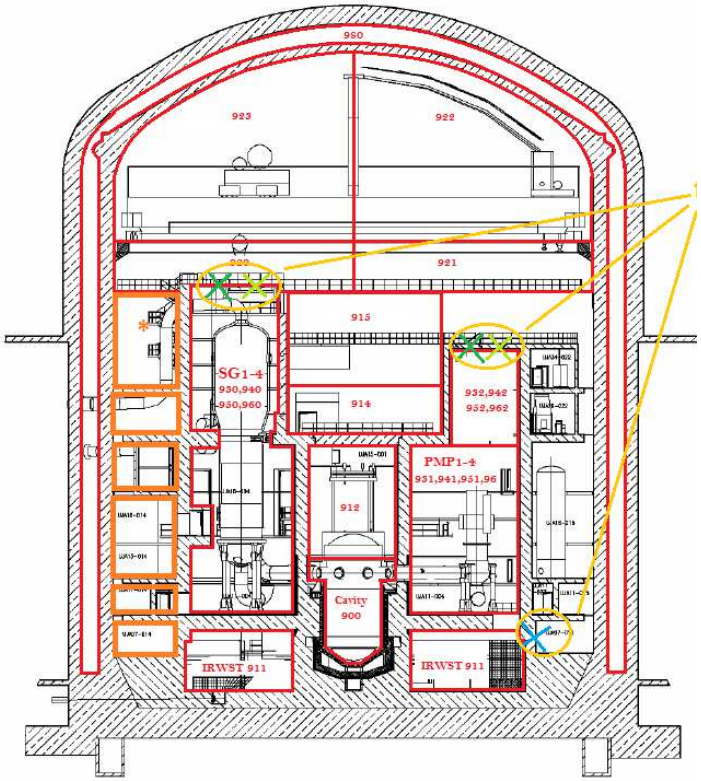


Model development

- Basic RPV, core (19 levels, 6 rings), RCS systems developed at acceptable level.
- New more detailed RPV necessary to develop.
- One CV containment.
- Detailed containment was developed but it is under general refurbishment – it under predicts containment pressure.

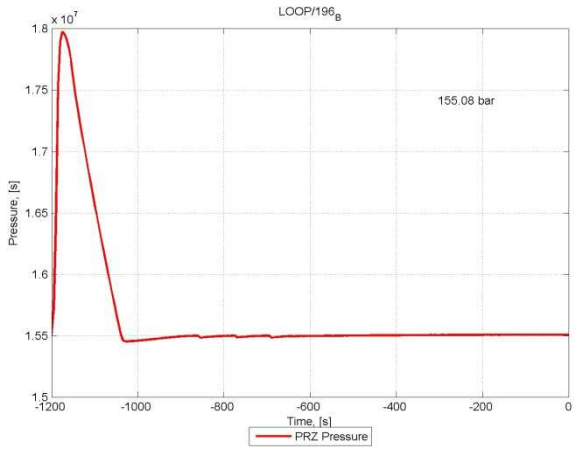




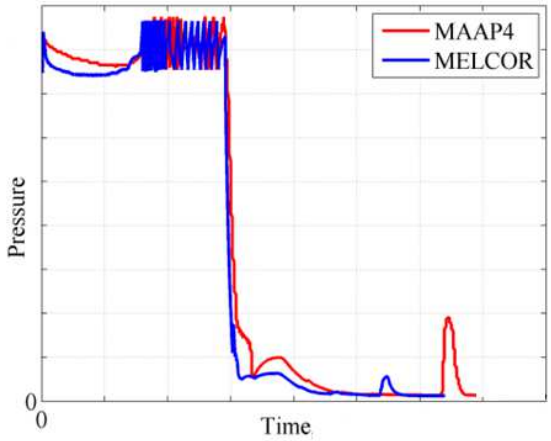


Steady State

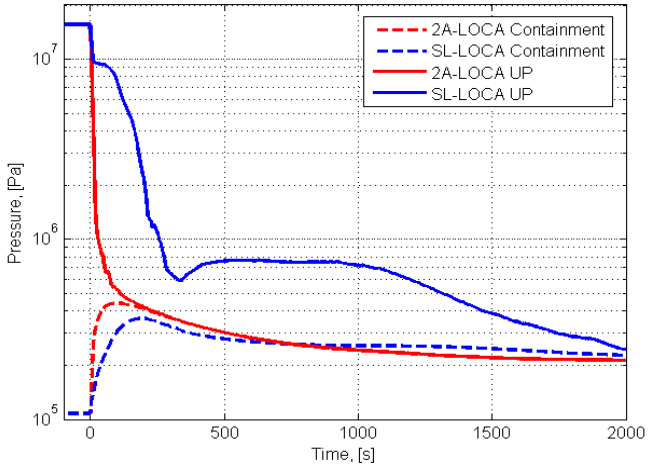
INITIAL CONDITIONS	*MELCOR*
Core power [MW$_{th}$]	4590
PZR pressure [bar]	155
PZR level [m] / Water mass [kg]	6.73 /22512
SG collapsed water level [m]	14.93
SG feed water temp.[K]	503.15
SG secondary side pressure [bar]	77
Steam flowrate (per SG) [kg/s]	657.51
Steam flowrate x3 SG [kg/s]	1972.6
RCS flowrate (4 loops) [kg/s]	22614
RCS flowrate (1 loop) [kg/s]	5633
RCS flowrate (3 loops) [kg/s]	16980
Water mass x1 SG [kg]	78027
Water mass x3 SG [kg]	234018
Water mass RCS [kg]	271179



Example model results



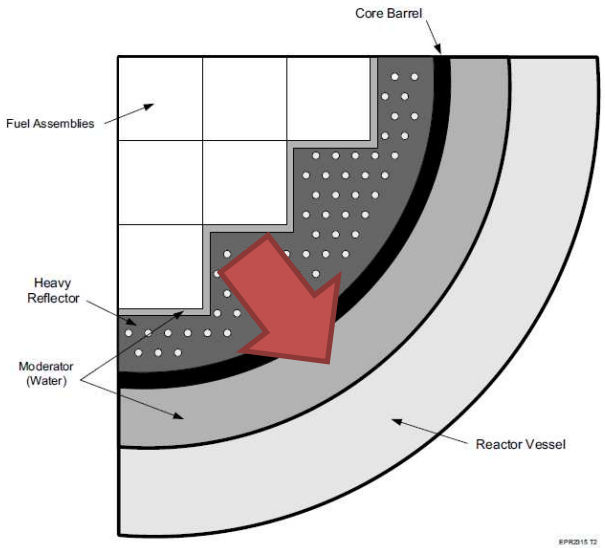
Total SBO In-Vessel Phase
MAAP-MELCOR Comparison

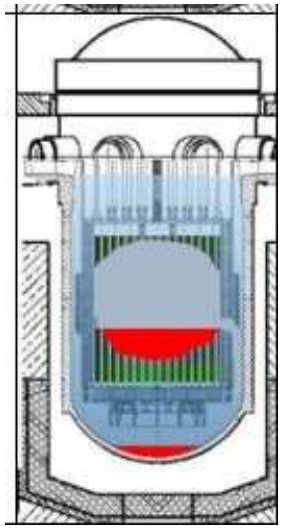


Comparison of LB-LOCAs
SL-LOCA and 2A-LOCA

Problem #1 – Heavy Reflector

- Heavy Reflector (HR) is a part of Heat Structure (HS) package (at this stage of development).
- HS degassing (DEGAS) option generates errors and intentionally it is off.
- Several tons of steel mass are not available for melt.
- No corium relocation to the lower plenum through heavy reflector (melt-through).
- Relocation after the core plate failure.

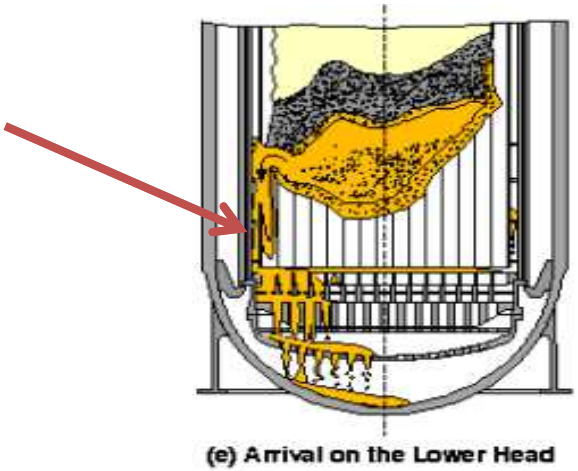


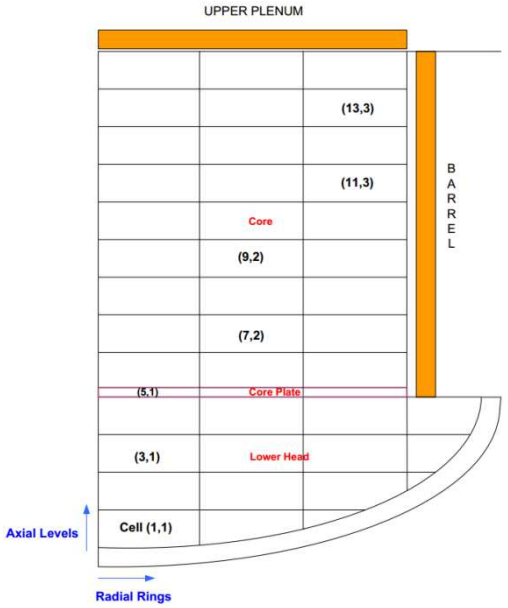


- Areva claims that corium should relocate through Heavy Reflector to the downcomer and to lower plenum.
- only a slight part of the HR is expected to melt.
- Core bypass are small holes in the HR.

Problem #1 – Heavy Reflector

- MELCOR relocates through the bypass (TMI type). Not through the downcomer.
- 1st potential solution use DEGAS for HR.
- 2nd solution: add heavy reflector as a part of COR model.
- 3rd solution: add HR and downcomer as a part of COR model and RPV as core outer HS. (is it possible/allowed?)





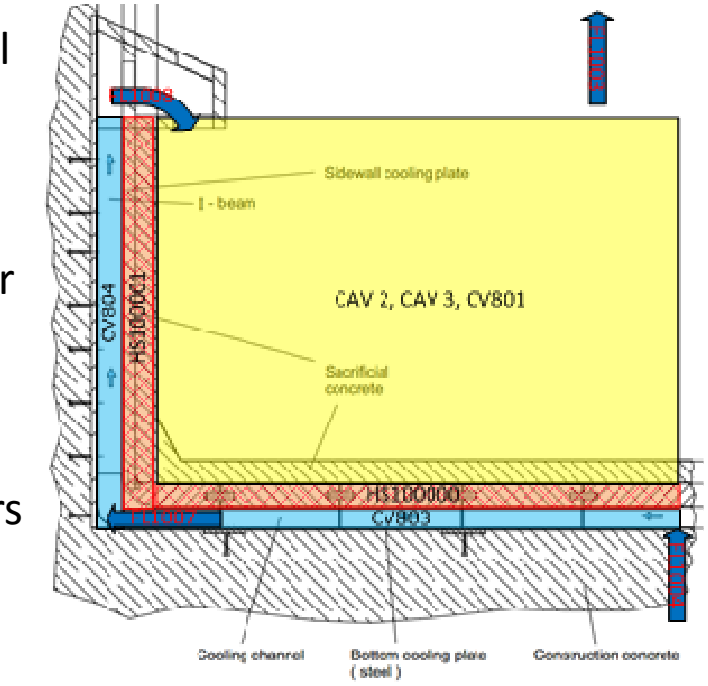
Problem #2 - Core Catcher

- Core catcher model development – problematic. Standard MELCOR does not allow heat removal from bottom of the CAVity by CVH package.
- We attempted to develop („artificial”) model with HS and Control Functions but it was not satisfactory. In our opinion not enough information are available in MELCOR control functions arguments inventory.

Current approach (which in fact doesn’t solve the problem):

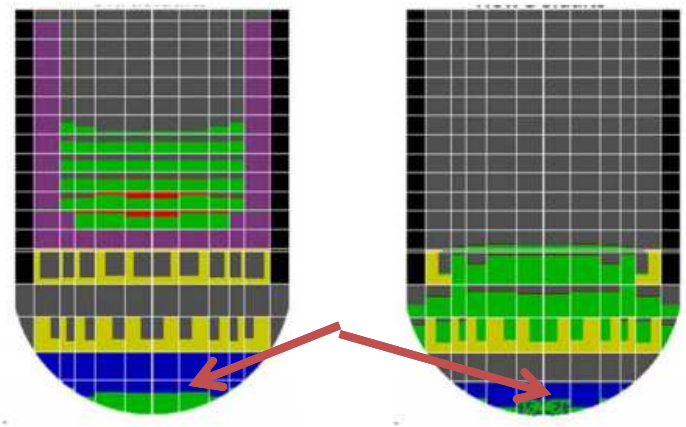
- 2 CAVities – one for sacrificial material and one for steel plate .
- Turn-off ablation after the end of sacrificial material ablation.
- Assume (!) that the corium is cooled by the core catcher
- Simply add water to the core catcher with no priori heating.

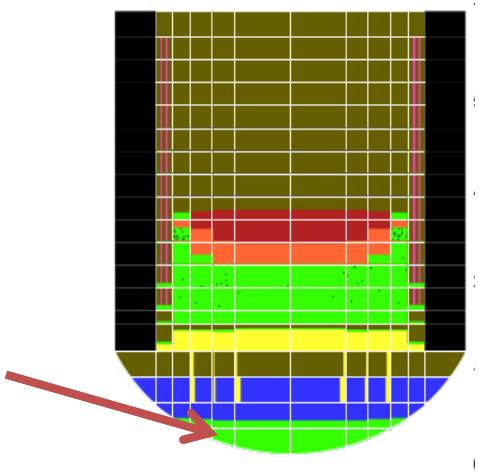
- Different problem: Selection of heat transfer parameters between corium and coolant (COND.OX, COND.MET, BOILING). Recommended by SOARCA program are 10.0/5.0/5.0 respectively.



Problem #3 – Material in Lower Plenum

- Several tons of debris material was spotted in LP, before core plate failure.
- We are not convinced if it is physical.
- We did not find information about that issue in MELCOR Manuals or other documents.
- Is it a problem with our COR model? We can say that mateiral is relocated throught the core plate perforations?
- We spotted such phenomena in former EMUG presentation.





From: EMUG 2010, New ‚Best Practice' Default Values for MELCOR 2.1

Plans

- Further EPR model development is necessary.
- New RPV detailed nodalization, new containment model and other.
- Plans to work with Fukushima plant and eventually TMI.
- We would like to analyze some experiments and ISPs - to learn code usage with experimental data.
- In short time we should obtain access to OECD/NEA Databank.
- We are waiting for sodium coolant in MELCOR.
- Waiting for an access to the ASTEC code.
- Experiments with condensation phenomena.
- We are open for cooperation.

Thank you

E-mails:
michal.gatkowski@itc.pw.edu.pl
piotr.darnowski@itc.pw.edu.pl
piotr.mazgaj@itc.pw.edu.pl

Links:
www.eng.itc.pw.edu.pl
www.inspe.itc.pw.edu.pl
www.nuclear.itc.pw.edu.pl