R&D capability on nuclear power safety assessment in Vietnam

Kick-off Meeting for ASEAN Network on Nuclear Power Safety Research and the 2nd ASEAN Workshop on Nuclear Power Safety Research

Doan Quang Tuyen

Vietnam Atomic Energy Institute (VINATOM), MOST, Vietnam

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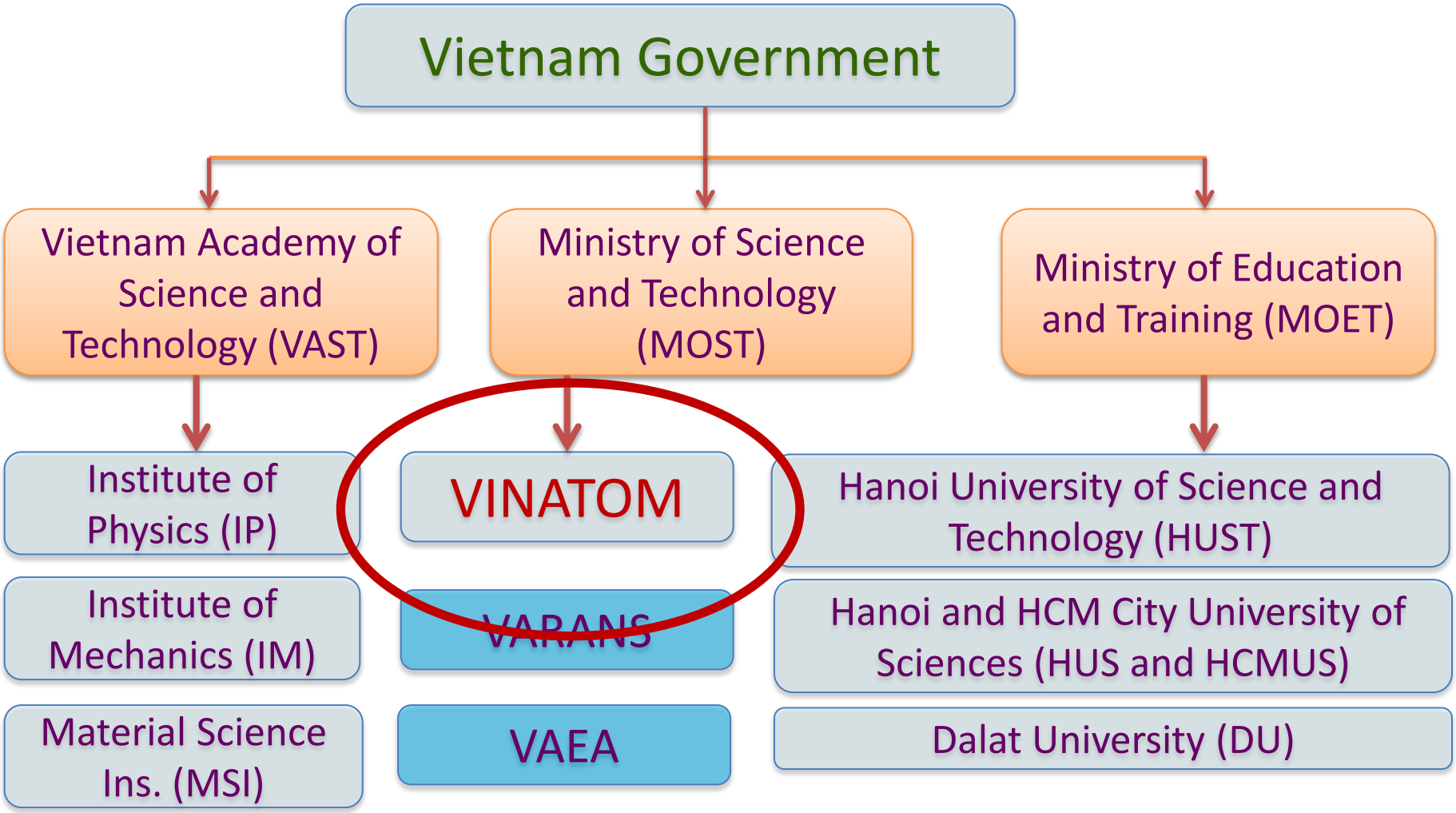
- Current research activities
  - Fuel
  - Reactor analysis
  - Severe accident
- Proposals for research collaborations
- Conclusion

Safety Research Organizational Structure



Safety Research Organizational Structure

Safety Analysis Activities

1) **Institute for Nuclear Science and Technique (INST/VINATOM):**
   - Nuclear Safety Center
   - Nuclear Energy Center
2) **Nuclear Training Center (VINATOM)**
3) **Hanoi University of Science and Technology (HUST)**
4) **Vietnam Atomic Energy Agency (VAEA)**
5) **Vietnam Agency for Radiation and Nuclear Safety (VARANS)**
6) **Relevant universities**

Safety Research Organizational Structure

Working groups on Nuclear Power Safety

1) **Reactor physics:**

   INST/VINATOM: Phạm Như Việt Hà *(Ph.D),* **Trần Việt Phú, Nguyễn Hữu Tiệp, Trần Vĩnh Thành), Mr. Khánh (Japan, TokyoTech)**

2) **Thermal hydraulic:**

   INST/VINATOM: Hoàng Minh Giang *(Ph.D),* **Đinh Anh Tuấn,**

   HUST: Hoàng Văn Thái *(Ph.D)*

   VARANS: Dương Thanh Tùng *(Ph.D)*

   Lê Trí Dân *(Ph.D in Japan)*

3) **Severe accident:**

   VINATOM HQ: Trần Chí Thành *(Ph.D)***, Hoàng Sỹ Thân** *(Ph.D)***, Đoàn Mạnh Long**

   Mrs. Hương and others Ph.D students *(Ph.D in Korea)*

4) **Ph.D students in Russia: Mrs. Thuỷ (Material science)**

Current research activities

Computer code

- **Fuel:** FRAPTRAN, FRAPCON
- **Reactor physics:** MCNP5, PARCS,
- **Thermal-hydraulic :** CATHARE , RELAP5, COBRA-TF, MARS
- **Severe accident:** MELCOR, MAAP4

Current research activities

Fuel:

Vietnam Atomic Energy Agency (VAEA):

Verification of TVS-2006 fuel rod design of VVER-1200/ASE-2006 reactor under steady-state condition using FRAPCON 3.5 code (2015)

- Thermal-mechanical
- Strength
- Oxide thickness and hydrogen concentration
- Deformation

Safety evaluation of TVS-2006 fuel rod under transient conditions of VVER-1200 (AES-2006) reactor using FRAPTRAN 1.5 code (2015)

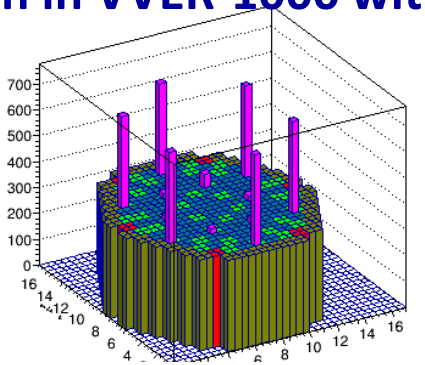
Current research activities

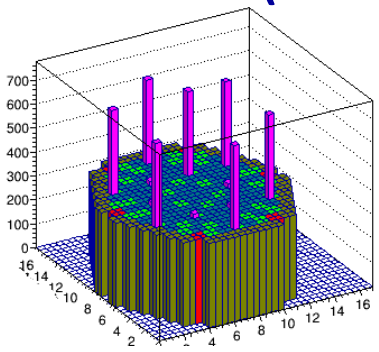
Reactor analysis:

Vietnam Agency for Radiation and Nuclear Safety (VARANS): Analytical study of control rod ejection in VVER-1000 with PARCS code (2014)

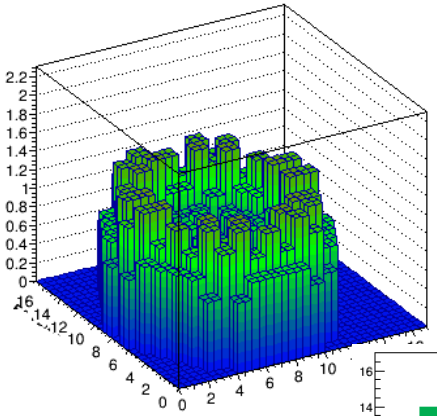
Ejection of a control rod bundle at 100% nominal power

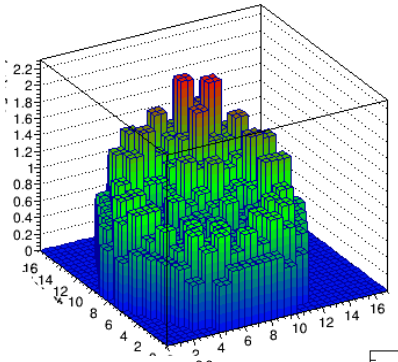
- Control rod positions





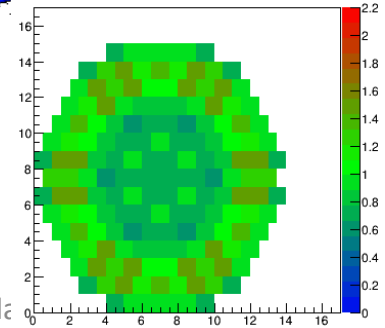
- Power distribution

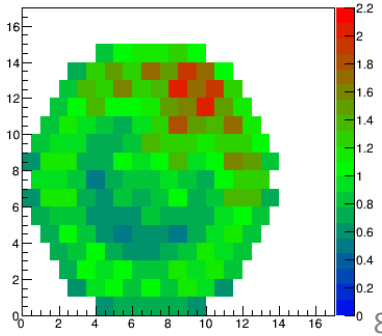




- Cross section of power distribution.

t=0s





t=0.2s

Current research activities

Reactor analysis:

Nuclear Safety Center (INST/VINATOM), Joint project supported by KAERI (2009-2010)

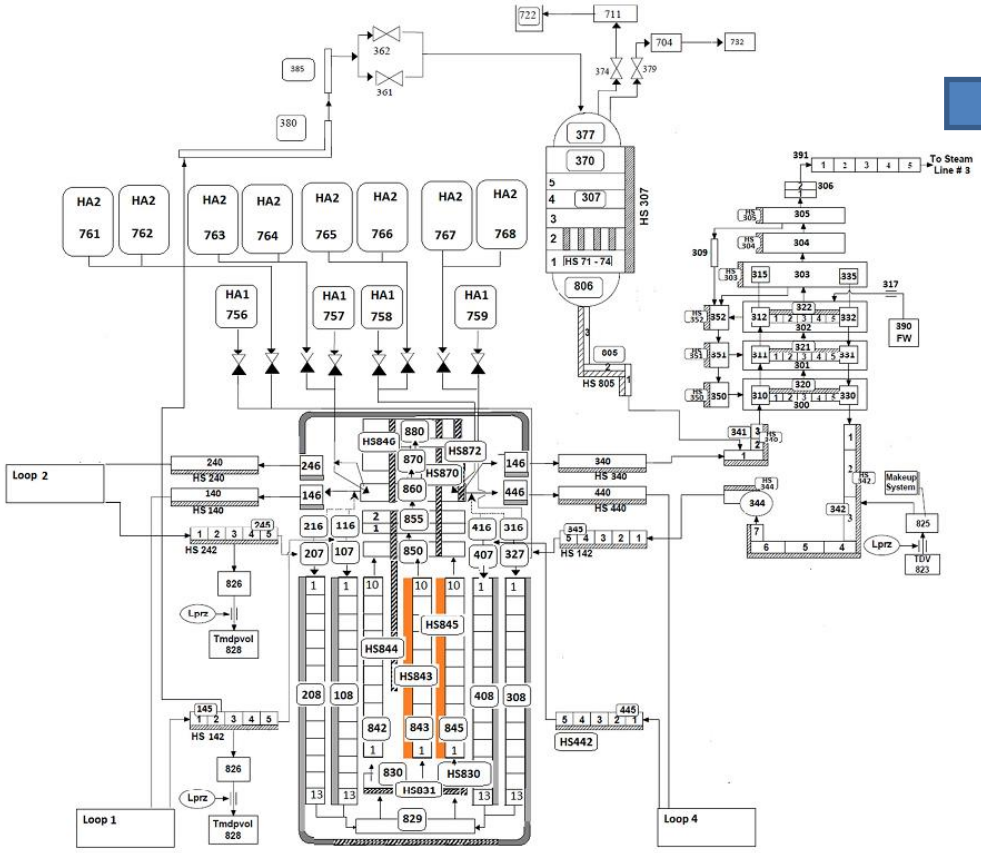
- Reactor: APR-1400
- Codes: RELAP5, MARS
- Exercise: LOCA, LOFA, RIA

CATEGORY	APR1400	Ulchin 3,4	NOTE
Thermal-Hydraulic Design			
- Core Thermal Power (MW_{th})	3,983	2,815	
- NSSS Thermal Power(MW_{th})	4,000	2,825	RCP Power included
- Design Pressure, MPa (psia)	17.23 (2,500)	17.23 (2,500)	
- Coolant Flow Rate, Kg/s (lb/hr×10^6)	20991 (166.6)	15309 (121.5)	
- Hot Leg Temp, K (F)	597 (615)	600 (621)	
- Cold Leg Temp, K (F)	563 (555)	569 (564.5)	
- Loop Number	2	2	

Current research activities

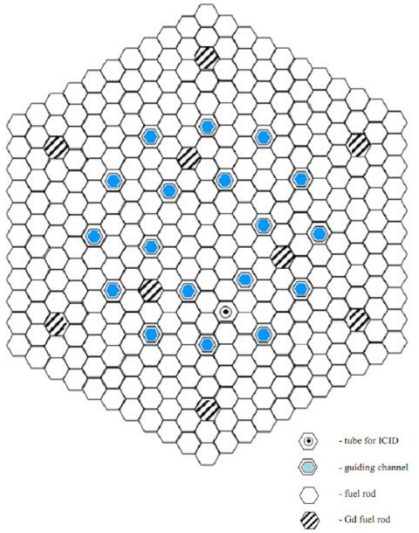
Reactor analysis:

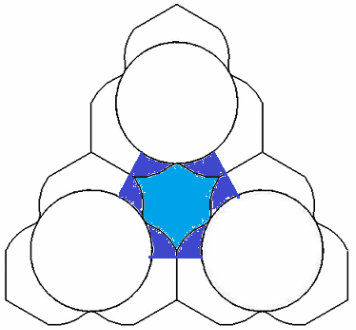
Nuclear Safety Center (INST/VINATOM): National project "VVER technology comparison between AES-91, AES-92 and AES-2006" (2011-2014) T/H multi-scale analysis



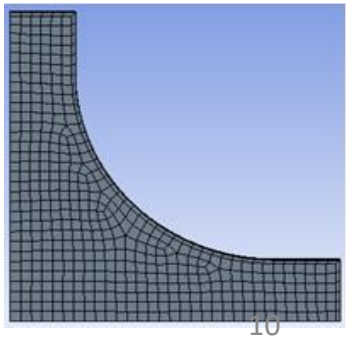
VVER-1000 (AES-92) nodalization scheme

Bundle of sub-channel analysis (COBRA)





Single subchannel analysis (CFD)



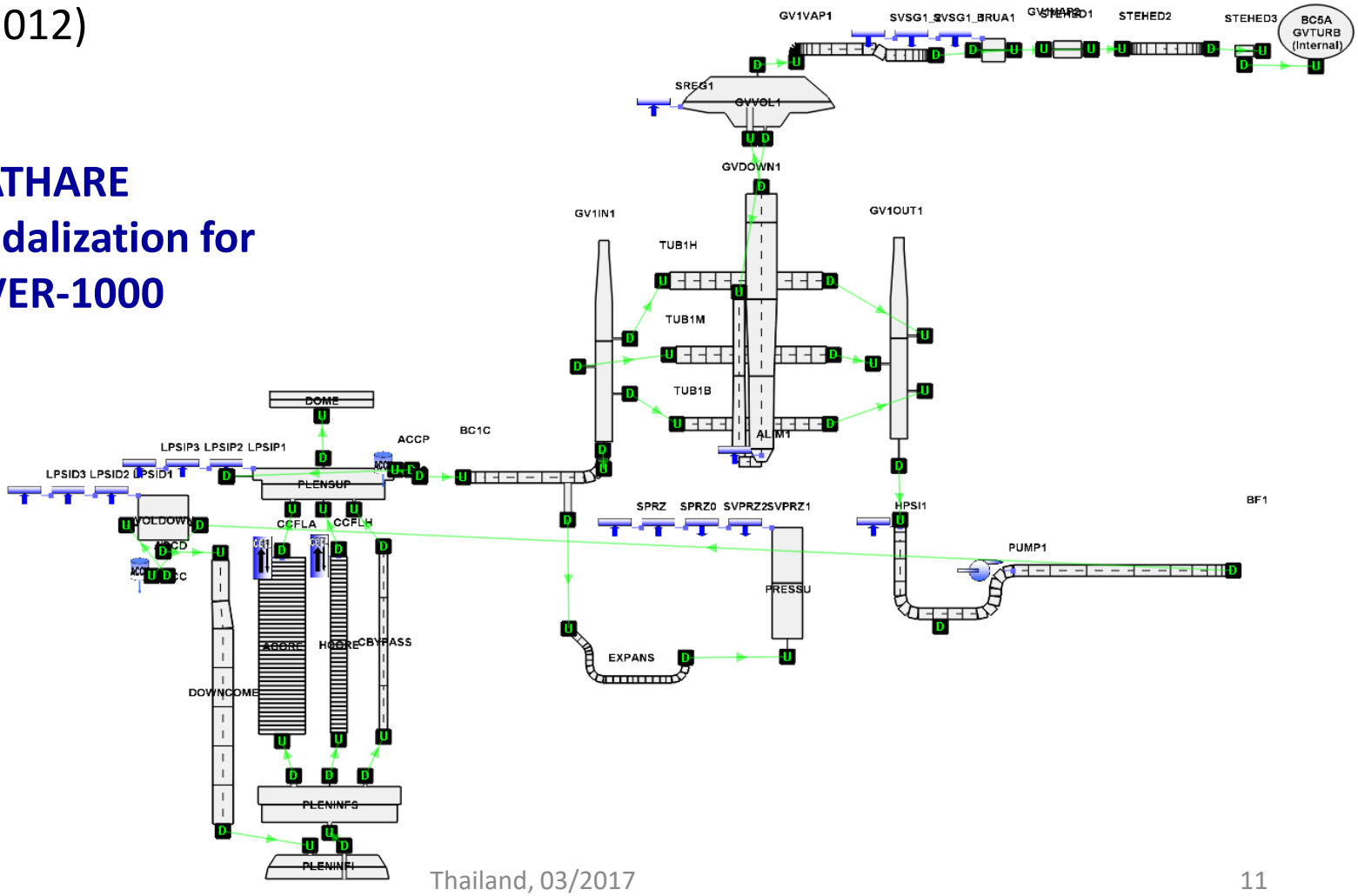
Current research activities

Reactor analysis:

Vietnam Agency for Radiation and Nuclear Safety (VARANS):

Analytical study of Surge Line Break LOCA in VVER-1000 with CATHARE and RELAP (2012)

CATHARE nodalization for VVER-1000



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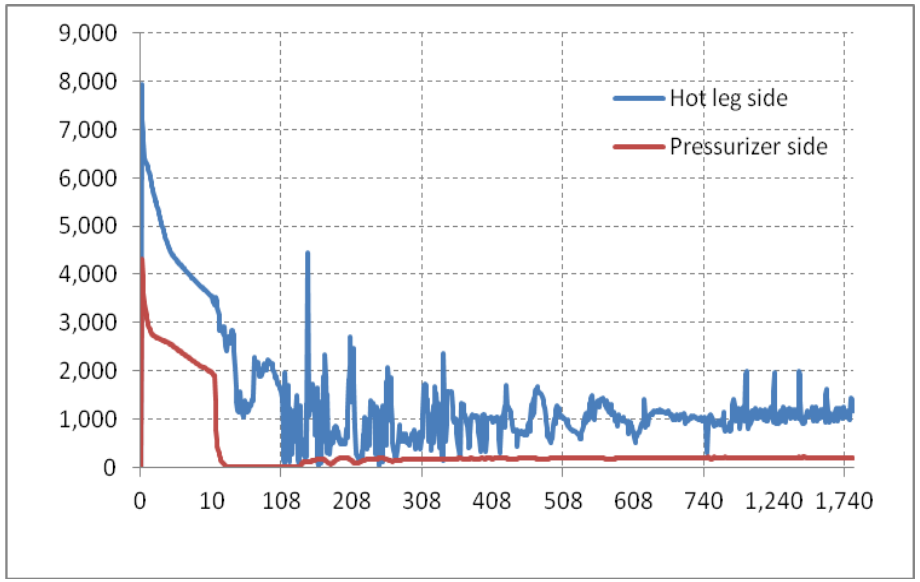
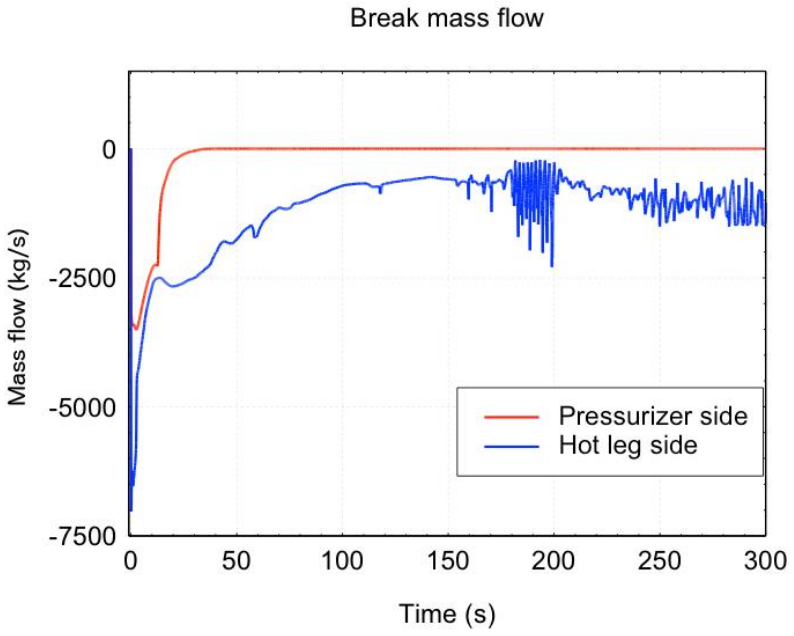


RELAP calculation



CATHARE calculation

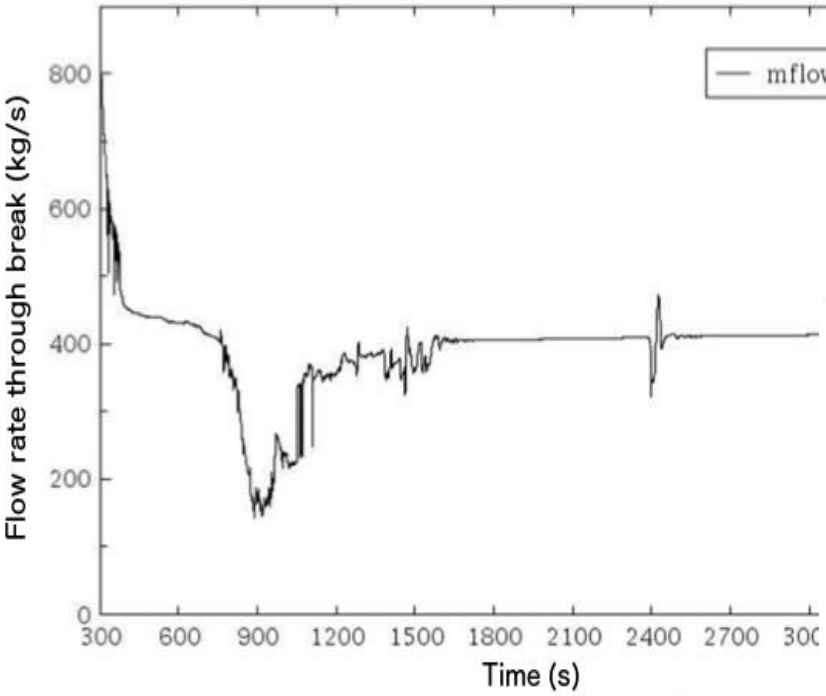
One of reasons for the difference may be direction of surge line in modeling. In CATHARE model, surge line has direction of -45^0 while it is -90^0 in RELAP.

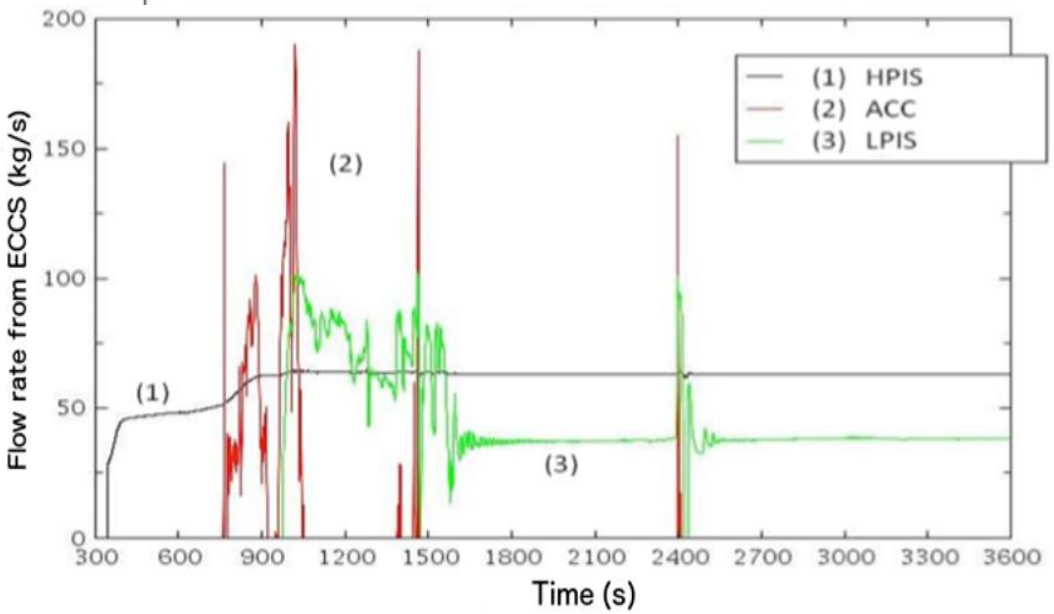
Current research activities

Reactor analysis:

Vietnam Agency for Radiation and Nuclear Safety (VARANS):

Analytical study of T/H simulation for VVER-1000 with RELAP5 code (2014)





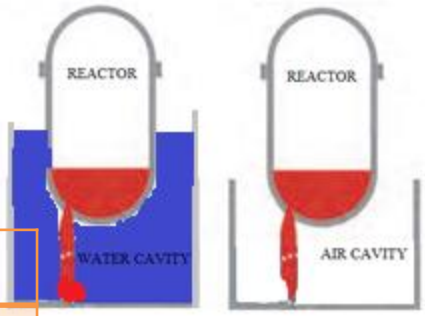
In an investigation with SBLOCA on cold leg.

Current research activities

Severe accident:

Nuclear Safety Center (INST/VINATOM), Joint supported by KAERI (2012-2013)

- **SA study:** MCCI study in case of SBO + LBLOCA for Westinghouse 4-loop PWR



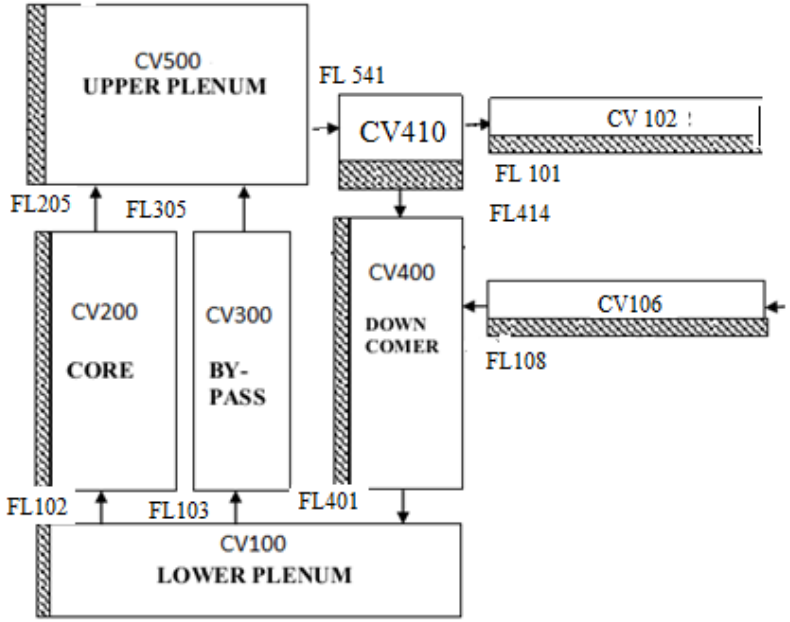
	Wet cavity	Dry cavity
Main events	Time(s)	Time (s)
LOCA	300	300
Core uncovered	396s	418s
Zr oxidation begins	3138 (0.87h)	3066 (0.85h)
Vessel failure	80010 (22.22h)	35746 (9.93h)
MCCI begins	80029 (22.23h)	35746 (9.93)
Containment pressure over the design limit (0.43 MPa)	185610 (51.55h)	138090 (38.36h)
Cavity rupture	2.0064E+05 (55.73h)	177401(49.27h)

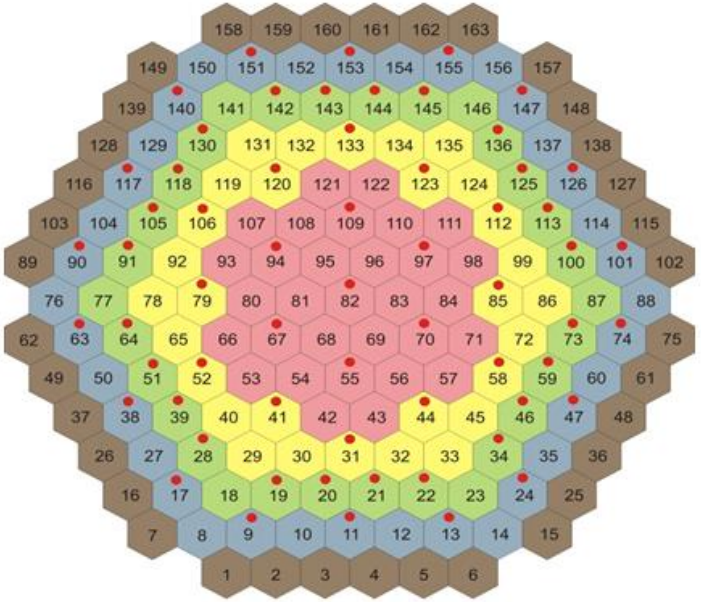
Current research activities

Severe accident:

Nuclear Safety Center (INST/VINATOM), National project for "Study the NPP technologies proposed for NT1 and NT2 in support for Basic Design Review"

- SA works: VVER-1200/V491 Design Extension Condition Investigation by MELCOR
- LBLOCA + SBO Scenario





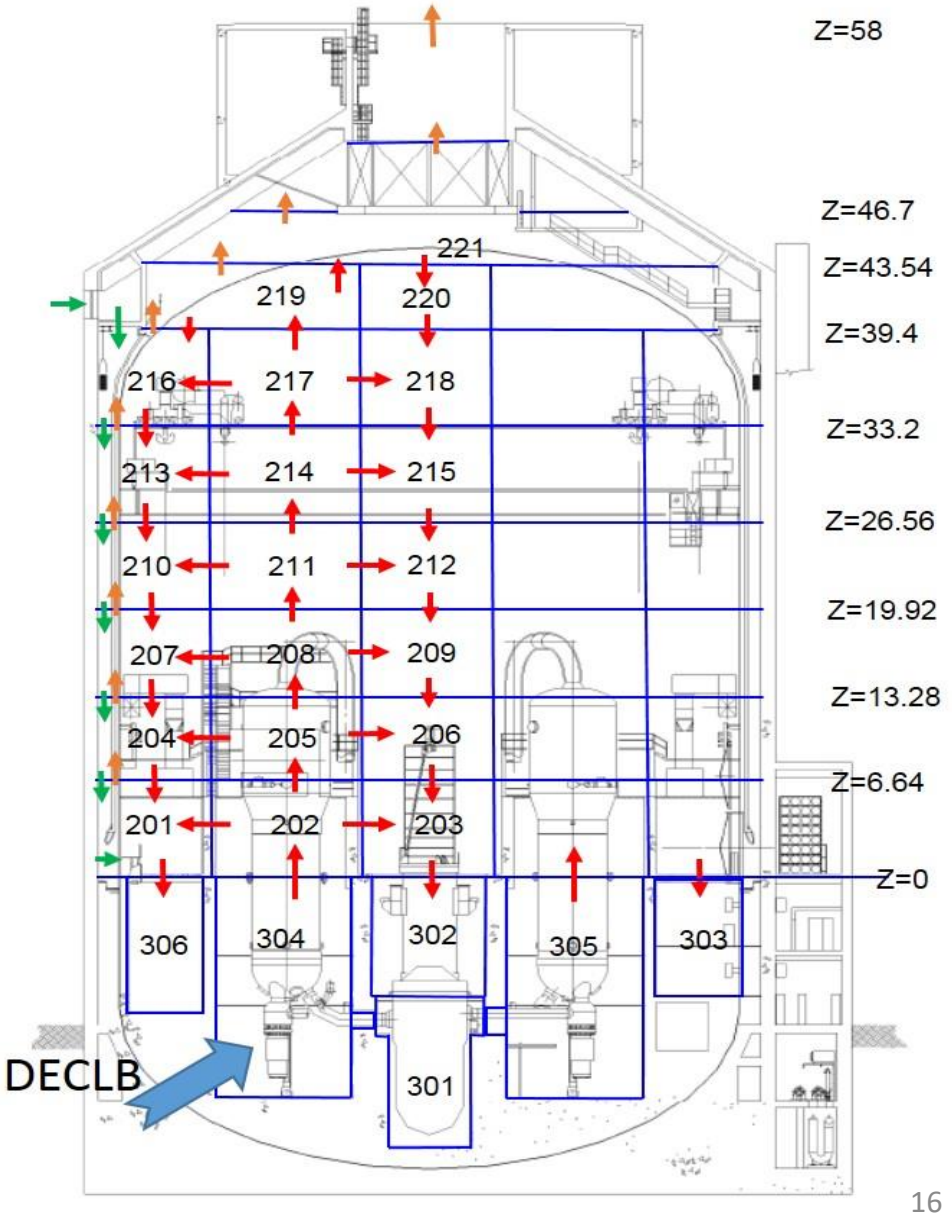
Current research activities

Severe accident:

Hanoi University of Science and Technology (HUST)

Analysis of containment pressure and temperature changes following LOCA (2015)

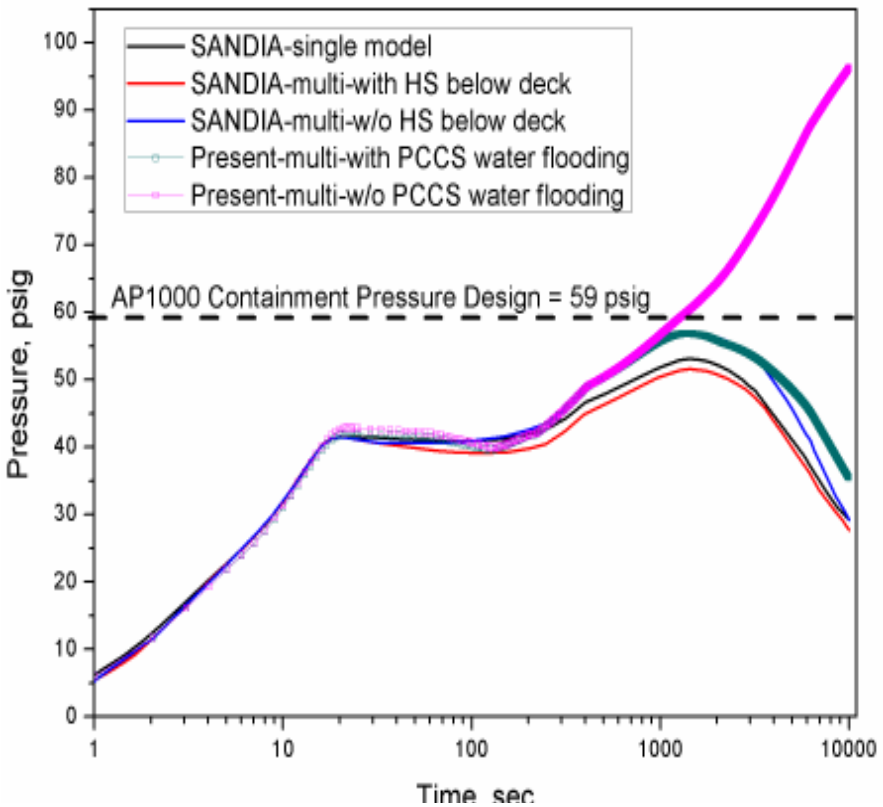
Nodalization scheme of AP1000



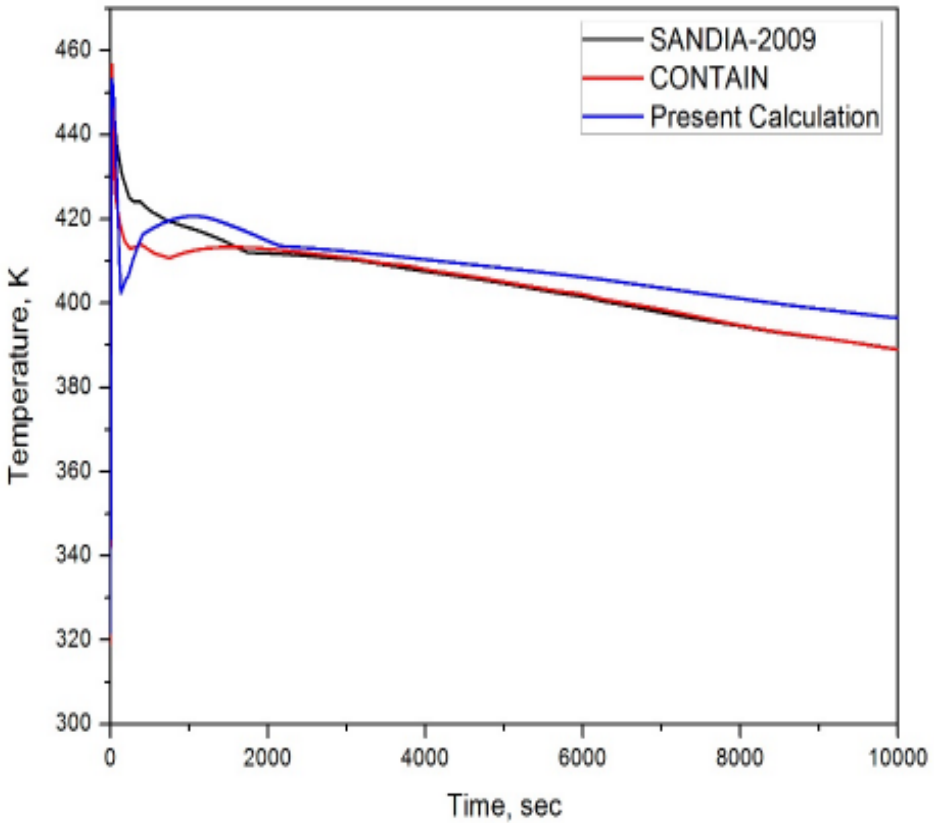
Current research activities

Severe accident:

Hanoi University of Science and Technology (HUST)



Comparison of MELCOR-calculated long-term pressure profiles during AP1000 LOCA event

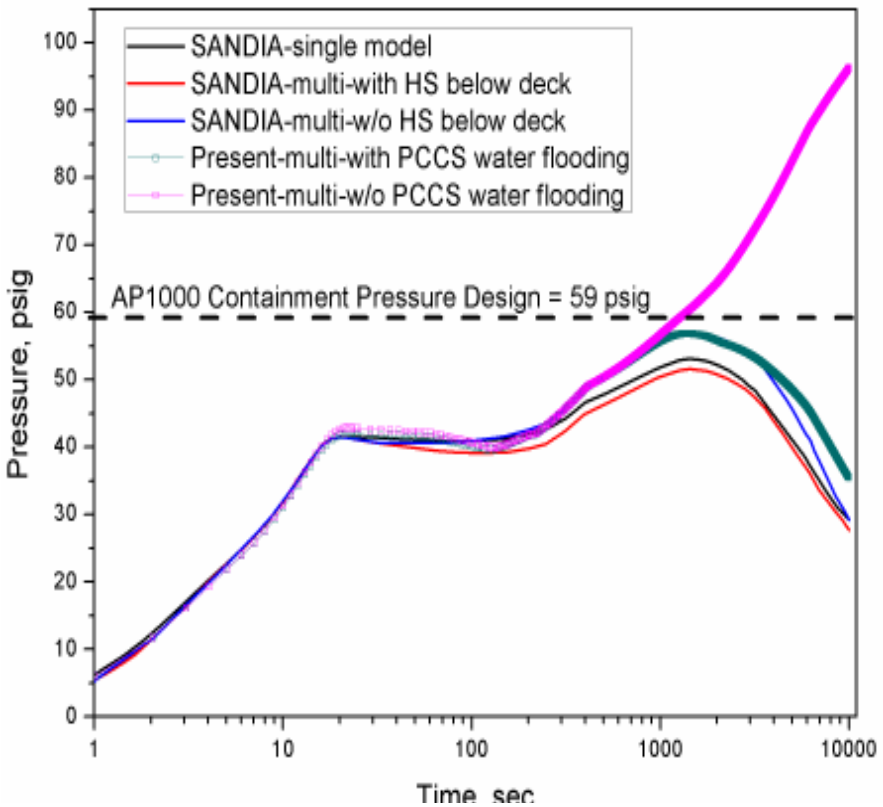


Comparison of MELCOR-calculated long-term gas temperature in the region above the deck

Current research activities

Severe accident:

Hanoi University of Science and Technology (HUST)



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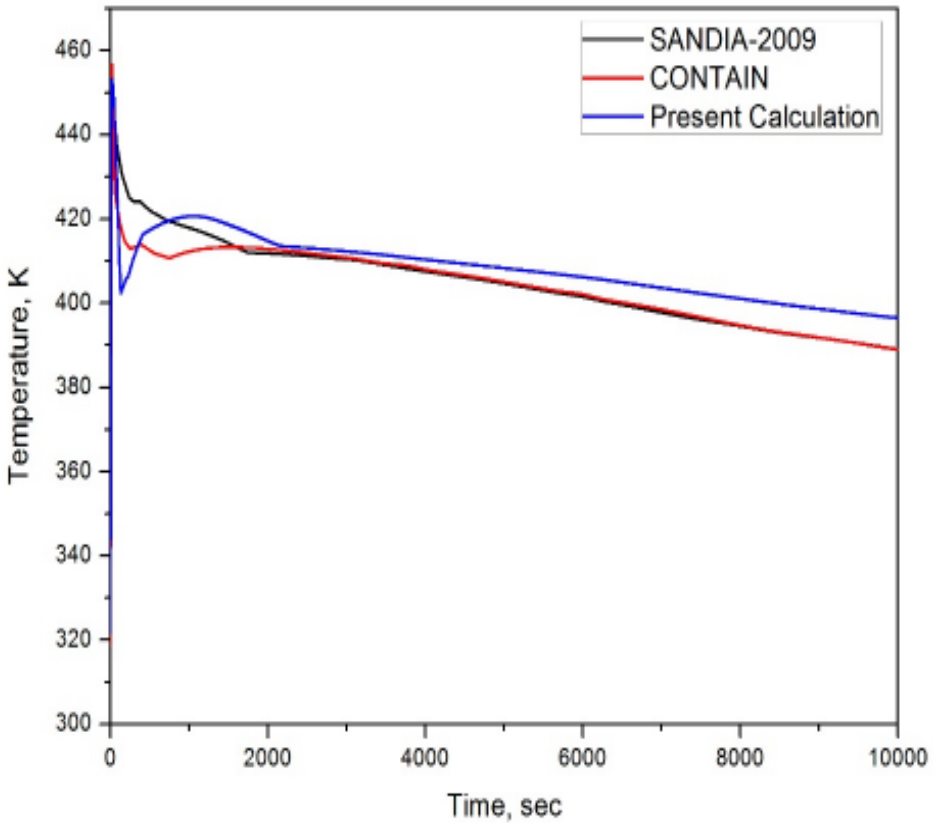
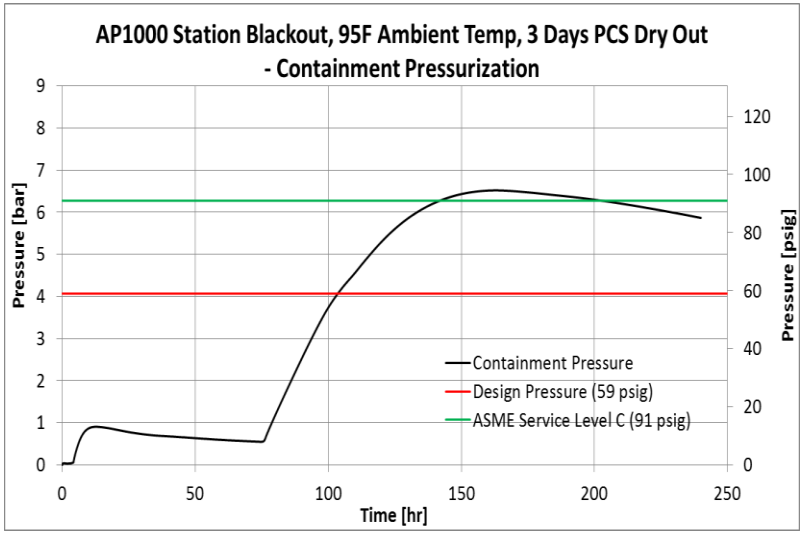


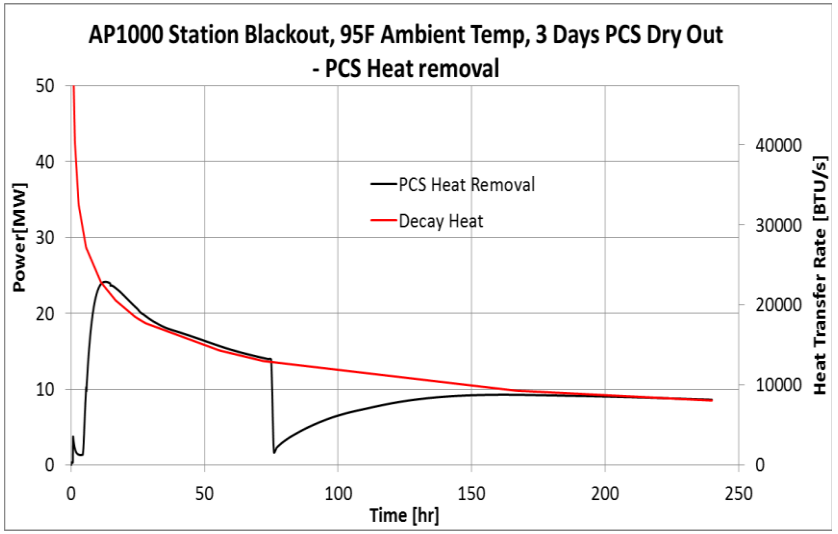
Comparison of MELCOR-calculated long-term gas temperature in the region above the deck

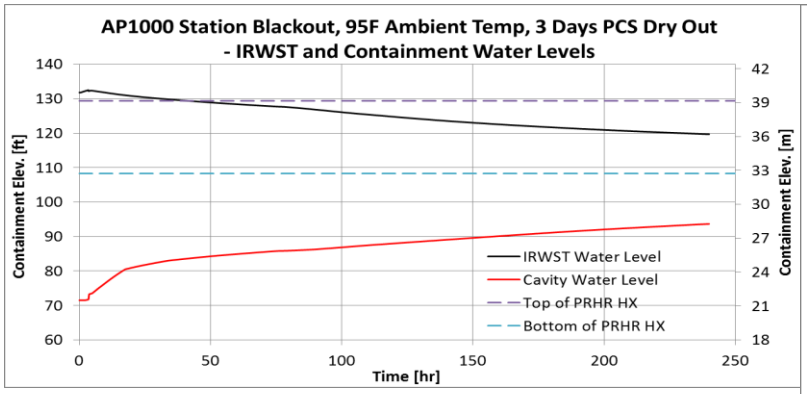
Current research activities

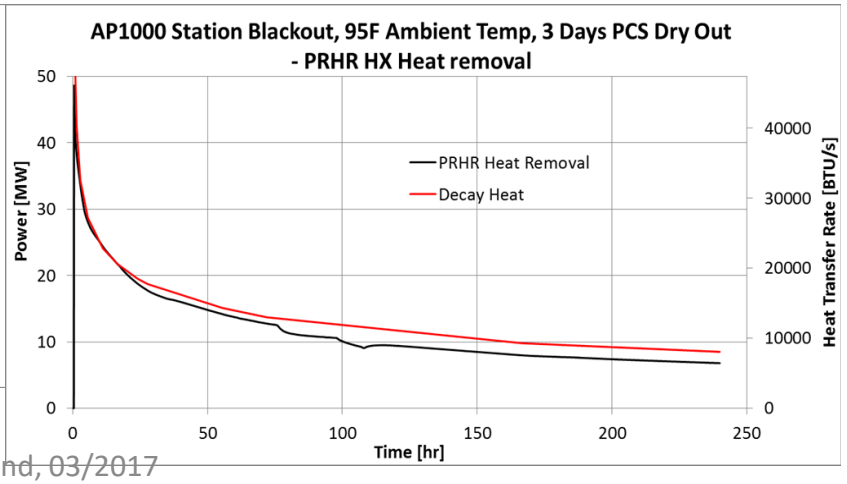
Severe accident:

VINATOM: Calculation with MAAP4 code - AP1000 Containment Pressurization Transients following PCS Cooling Water Depletion









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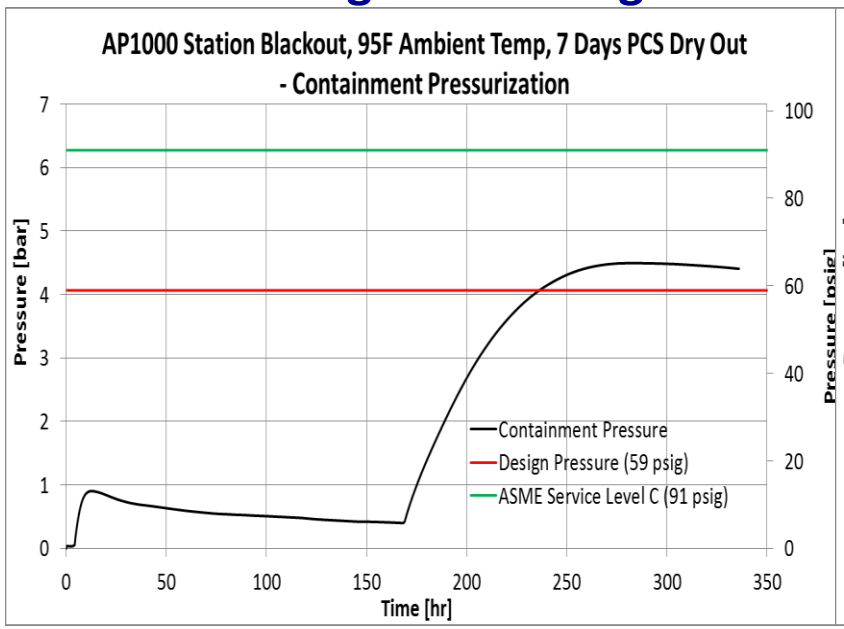
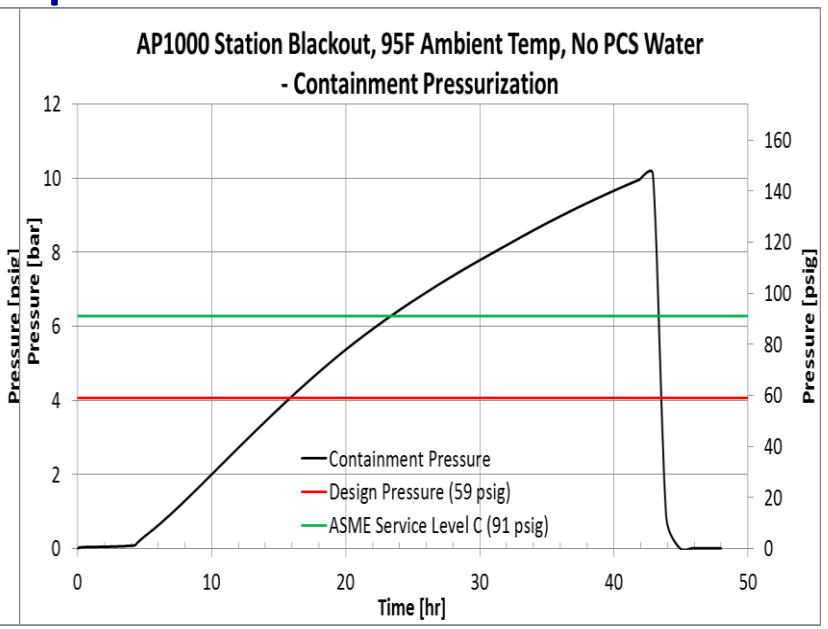




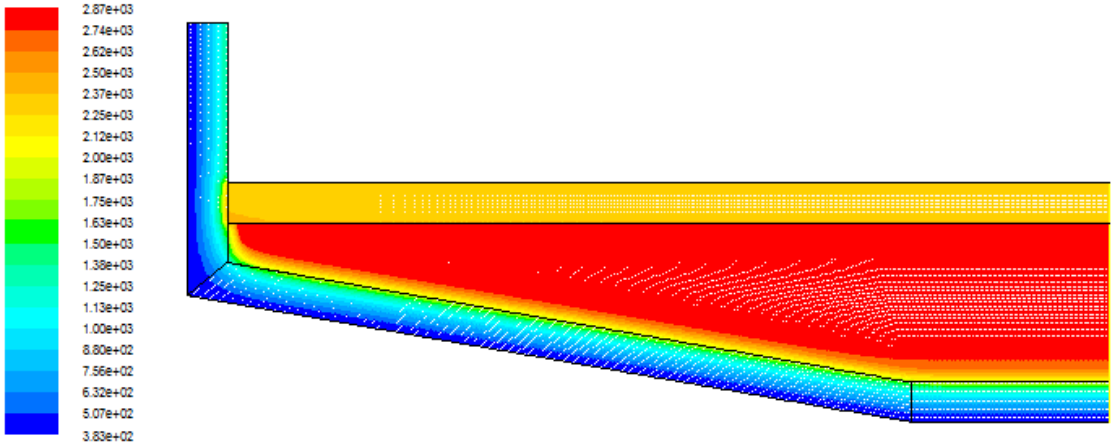
Criterion	Pressure	Time	Time after dryout	Failure Prob
Design Pressure	59 psig / 4.1 bar	16 hrs	16 hrs	0
Service Level C	91 psig / 6.3 bar	23.4 hrs	23.4 hrs	~1.4E-3
24 Hours	93 psig / 6.4 bar	24 hrs	24 hrs	4.1E-3

Current research activities

Severe accident:

VINATOM: A Study on Transient Heat Transfer of The EU-ABWR External Core Catcher using The Phase-Change Effective Convectivity Model

(Chi-Thanh Tran, Viet-Hung Nguyen, M. Tahara, Y. Kojima, R. Hamazaki and P. Kudinov, NURETH16, August 30 September , 2015, Chicago, USA)



Temperature contour of the melt pool and core catcher in 9000 sec in case of accident scenario without water cooing from the top surface of melt pool (only water cooling from the outside walls of the core catcher, case 1B)

Current research activities

Severe accident:

VINATOM: A Study on Transient Heat Transfer of The EU-ABWR External Core Catcher using The Phase-Change Effective Convectivity Model

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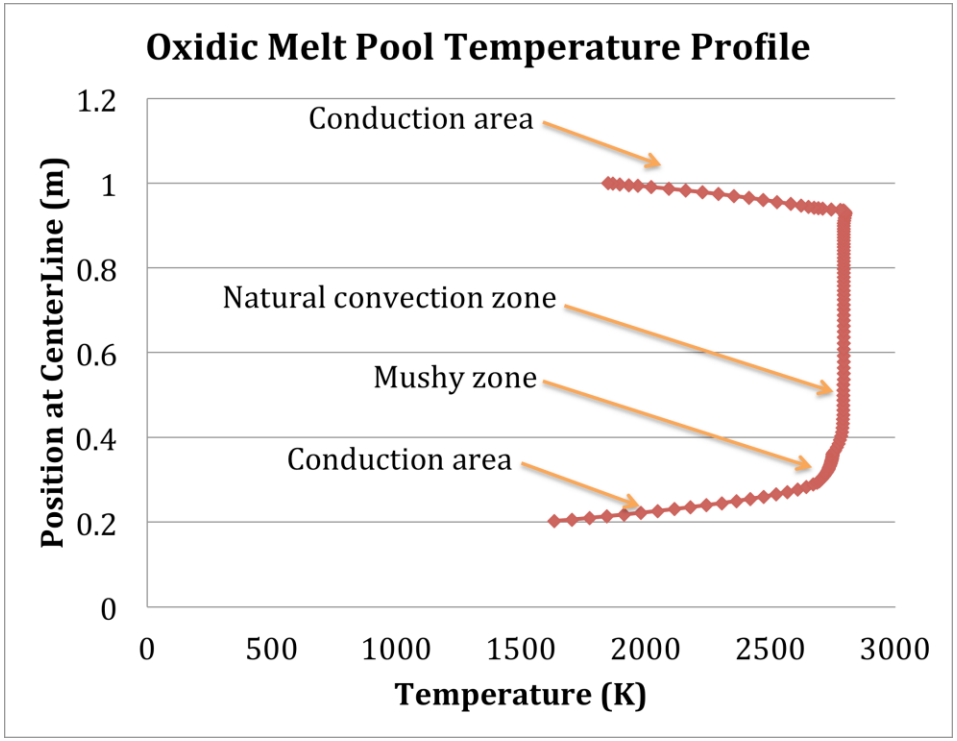

Temperature distribution at centerline of oxidic melt pool at 6000 sec (case 1B)

Current research activities

Difficulties & challenging:

- Lack of experiment data (benchmark experimental data)
- License for computer codes
- Collaboration with foreign research institutes is still limited
- Strongly needs higher qualified researches, better directions

Future:

- Strengthening the capacity of working groups
- Promoting international cooperation
- Training key person for working groups

Proposals for research collaborations

VINATOM is ready for cooperation in:

- ✓ Reactor analysis: Reactor physics and Thermal-hydraulic (including design, implementation and operation of the new research reactor)
- ✓ Severe accident
- ✓ NPP designs and nuclear safety
- ✓ Fission Product (FP) transport and environment monitoring
- ✓ Marine Environmental Studies
- ✓ Information exchange, technical collaboration, sharing the data of monitoring

Our Proposals:

- ✓ Research on design and safety of Chinese nuclear power plant (nuclear reactor technology and safety, severe accident)
- ✓ Research on design and safety of Chinese SMRs (floating nuclear power plant)
- ✓ Benchmark problem on Dispersion of radioactive material from nuclear power plants

CONCLUSIONS

- Broad scale research activities performed in last 5 years but more activities relating to experimental areas are strongly needed.
- Working groups on different research topics already established with 1-2 key persons for each but needs more qualified researches and better directions.
- Continue research activities on nuclear power safety
- In Future, continue to: strengthen capacity of working group; promote international cooperation; training key person for working groups
- Ready and willing for international cooperation on nuclear power safety and related topics

Thank you

Backup

4. Safety Research Organizational Structure

Relevant Nuclear Safety Research Institutions

- Vietnam Atomic Energy Institute (VINATOM):
  - *Nuclear Physics Center (NPC)/Institute for Nuclear Science and Technology (INST)*
  - *Nuclear Safety Center (NSC); Nuclear Energy Center (NEC)/INST*
  - *Nuclear Reactor Center (NRC)/Dalat Nuclear Research Institute (DNRI)*
  - *Nuclear Fuel Group (NFG)/Institute for Technology of Radioactive and Rare Elements (ITRRE)*
  - *Reactor Materials Group (RMG)/Non-Destructive Evaluation (NDE)*
- Hanoi University of Science and Technology (HUST):
  - *School of Nuclear Eng. and Environmental Physics (SNEEP)*
  - *Fluid Mechanics and CFD (FMC)*
  - *Int. Institute for Computational Science and Engineering (IICSE) + DASI (ANSYS Representative)*
- Vietnam Academy of Science and Technology (VAST):
  - *Mechanical Institute (MI); Institute of Physics (IP)*
  - *Material Science Institute (MSI)*

4. Safety Research Organizational Structure

Relevant Universities

- Hanoi University of Science and Technology (HUST):
  - *School of Nuclear Eng. and Environmental Physics (SNEEP)*
  - *Fluid Mechanics and CFD (FMC)*
  - *Int. Institute for Computational Science and Engineering (IICSE) + DASI (ANSYS Representative)*
- Hanoi National University of Natural Sciences:
  - *Faculty of Nuclear Physics*
  - *Faculty of Radiochemistry*
- HCM City National University of Natural Sciences:
  - *Faculty of Nuclear Physics*
  - *Faculty of Material Sciences*
- Dalat University in Dalat (close to Nuclear Research Institute – NRI/ under VINATOM:
  - *Faculty of Nuclear Physics*
  - *Faculty of Nuclear Engineering*

Our proposal

is to establish

ASEAN network on nuclear power safety research (ASEAN2NPSR)

Why we need to establish the network?

- **Do not have joint-researches on NPS between ASEAN member states**
  - Realize “horizontal interaction” between ASEAN member states via NPS joint-research programs
- **Promote research and collaboration on NPS between ASEAN member states**
- Share knowledge and experience on NPS research between ASEAN member states

How to establish the network?

- Get financial support to establish and maintain the network (from the member states)
- MOUs/protocols signed between ASEAN member states to establish the network
- Establish the steering committee
- Plan and perform joint-research projects on NPS
- Hold workshops periodically to discuss on the joint-research results
- Publish technical reports of the joint-researches
- Make newsletters and progress reports periodically

Outputs for ASEAN2NPSR

1. ASEAN2NPSR network
2. Steering committee (SC)
3. **TG 1: NPP technology safety research**
4. **TG 2: Atmospheric dispersion assessment**
5. **TG 3: Oceanic dispersal assessment**
6. **TG 4: Regulatory and safety issues (RSI)**
7. Trainings and workshops (T&W)
8. Newsletters and progress reports (NPR)

Activities for Output 1

1. ASEAN2NPSR network

- Activity 1: MOUs/protocols to be signed by at least 4 ASEAN member states (≥ 1 institutions in each nation required) to establish ASEAN2NPSR with presence of IAEA representatives
- Activity 2: establish the website for ASEAN2NPSR (e.g., https://asean2npsr-iaea.org/)

Activities for Output 2

2. Steering committee (SC)

- Activity 1: establish SC (each ASEAN member state provides 2 committee members)
- Activity 2: SC decides the overall structure, communication rules, and detailed action plan for the network.

Activities for Output 3

3. TG 1: NPP technology safety research

- Activity 1: plan joint-research projects (bilateral or multilateral) on NPP technology safety
- Activity 2: perform the joint-research projects
- Activity 3: make technical reports and have them peer-reviewed by international experts.
- Activity 4: publish technical reports internationally and online as well.

Activities for Output 4

4. TG 2: Atmospheric dispersion assessment

- Activity 1: plan joint-research projects (bilateral or multilateral) to assess atmospheric dispersion of radionuclides
- Activity 2: perform the joint-research projects
- Activity 3: make technical reports and have them peer-reviewed by international experts.
- Activity 4: publish technical reports internationally and online as well.

Activities for Output 5

5. TG 3: Oceanic dispersal assessment

- Activity 1: plan joint-research projects (bilateral or multilateral) to assess on oceanic dispersal of radionuclides
- Activity 2: perform the joint-research projects
- Activity 3: make technical reports and have them peer-reviewed by international experts.
- Activity 4: publish technical reports internationally and online as well.

Activities for Output 6

6. TG 4: Regulatory and safety issues (RSI)

- Activity 1: Each ASEAN member state identifies its own current RSI.
- Activity 2: Each member state proposes solutions to the identified RSI.
- Activity 3: Each member state consults other nations as well as international experts for solving its own current RSI.
- Activity 4: Each member state solves its current RSI, and then draws and shares the lessons learned from experiences with its past/current RSI.

Activities for Output 7

7. Trainings & workshops (T&W)

- Activity 1: plan T&W or fellowship which are relevant to the TGs 1-4
- Activity 2: hold T&W or fellowship periodically with support from IAEA and advanced nuclear industry countries
- Activity 3: store T&W materials and related data online

Activities for Output 8

8. Newsletters & progress reports (NPR)

- Activity 1: SC makes the Editor Board (EB) for NPR (each nation provides 2 persons to join EB).
- Activity 2: EB gathers information from member states to make newsletters every two months and quarterly/half-yearly progress reports.
- Activity 3: EB publishes periodic NPR online.