BEL V MODEL DEVELOPMENT AND ASSESSMENT WITH MELCOR 2.2

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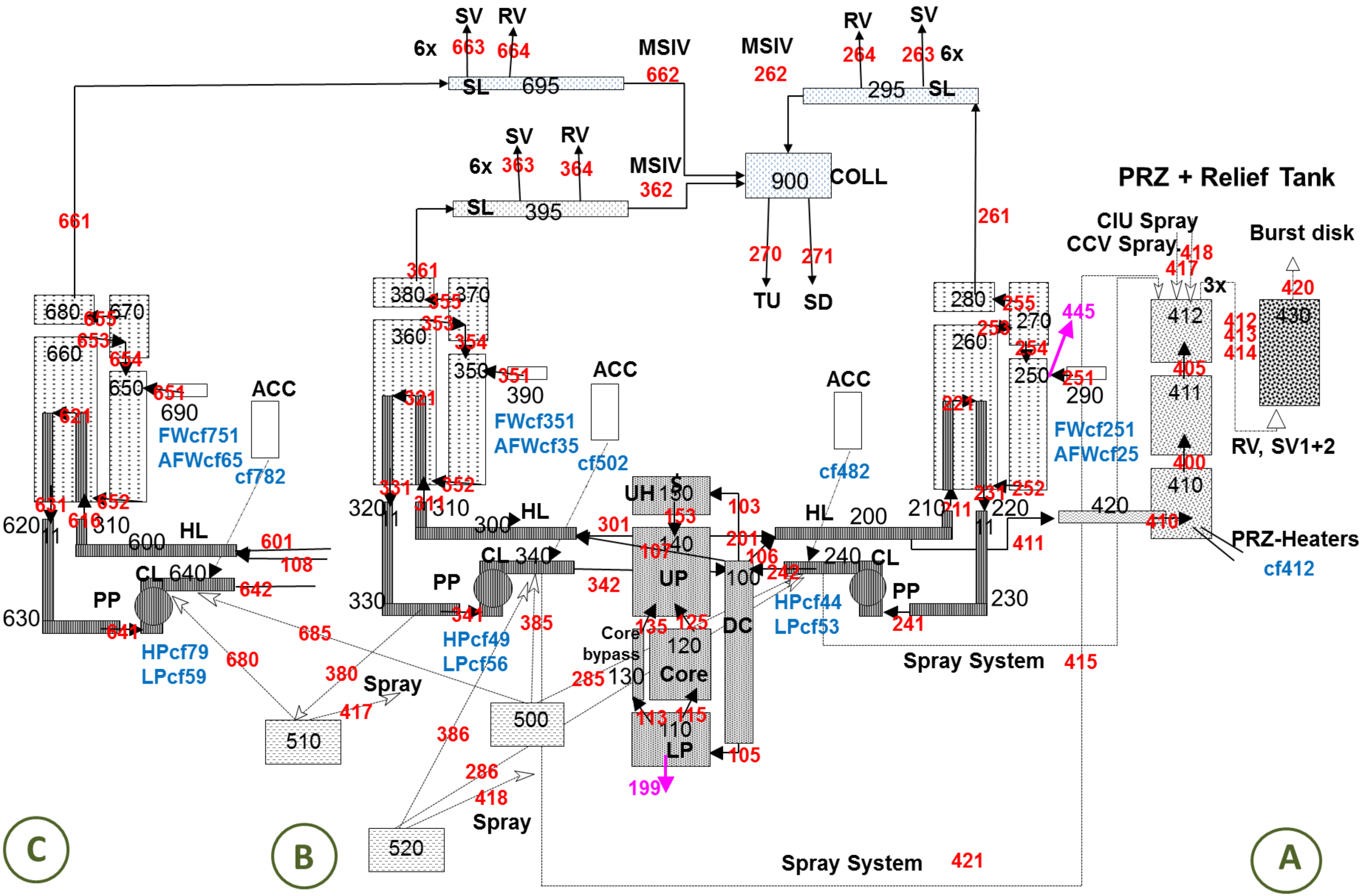
INTRODUCTION

- MELCOR: reference code selected by Bel V for severe accident analysis
- Acquisition of MELCOR code: end 2012
- MELCOR code mainly used in the framework of Bel V R&D program and in support of nuclear safety assessments
- Objectives of the presentation
  - Exchange experience and information about model development and assessment efforts
    - Key messages from model development and open questions
    - Focus on modeling activities, some sample results

Creep rupture modeling

PROGRESS IN MELCOR MODELING



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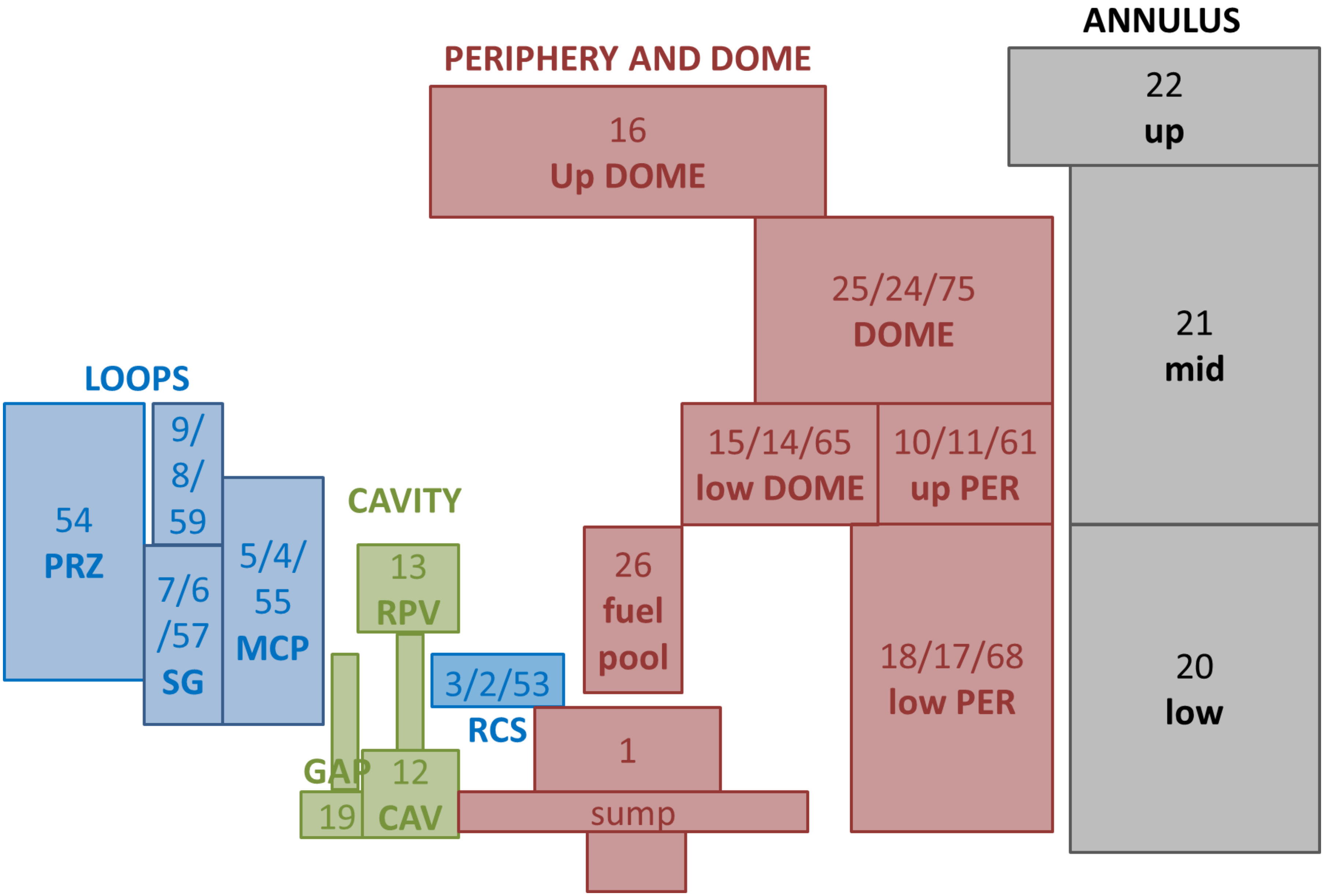
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RCS
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CAV

CREEP RUPTURE MODELING

- PIPE-STR and LM-CREEP CFs can be used to calculate the creep failure of a pipe under pressure-induced stresses
  - Hot leg creep failure MELCOR modeling
  - Problems with the stress function
  - Two-step procedure of calculations
- Focus on the capability of creep failure modeling, no nodalization changes at this stage
- MELCOR input manual contains useful example of modeling

CREEP RUPTURE MODELING

- PIPE-STR: cumulative damage to the pipe, max stress in a thick-walled cylindrical pipe under internal pressure

```
CF_ID Stress 202 PIPE-STR
CF_SAI 1.0 0.0
CF_MSC 0.37 0.46
CF_ARG 2
    1 CVH-P('hot leg_C')  1. 0. ! Inner pressure (hot leg)
    2 CVH-P('RCS C')      1. 0. ! Outer pressure (containment)
```

CREEP RUPTURE MODELING

- LM-CREEP: cumulative damage based on the Larson-Miller creep-rupture failure model

```
CF_ID 'Pipe Creep' 203 LM-CREEP
CF_SAI 1.0 0.0
CF_MSC SS-316 ! default data of 316 Stainless steel
CF_ARG 2
        1 CF-VALU(Stress)                1. 0. ! Stress
        2 HS-TEMP('hl pipe hor_3', 2) 1. 0. ! Temp, node 2
```

CREEP RUPTURE MODELING

- Failure is assumed to occur when LM-CREEP(t) = 1

```
CF_ID   'Pipe Creep=1'    204   L-GT
CF_LIV  FALSE
CF_ARG  2
            1 CF-VALU('Pipe Creep')      1.0
            2 CF-CONST                   1.0
```

CREEP RUPTURE MODELING

- Trip function used to operate valves (open/close)

```
CF_ID    'Pipe Creep_1'    205   TRIP
CF_SAI        1.0               0.0          0.0
CF_ULB        DEFAULT           0.0          0.0
CF_ARG        1
              1 CF-VALU('Pipe Creep=1')
```

CREEP RUPTURE MODELING

- Upon creep failure of the hot leg nozzle, a large hole opens that rapidly depressurizes the RCS
  - FLs & CFs modeling like a large break loss-of-coolant accident
- Alternate failure locations could include
  - pressurizer surge line
  - steam generator tubes
- The most vulnerable location can be calculated

CREEP RUPTURE MODELING

- Problem encountered by modeling as explained in the previous slides
  - @Time ~ hot leg creep failure prediction
  - **Calculation terminated by: CF_CREEP error: Negative or zero value for Stress**

CREEP RUPTURE MODELING

- Two-step calculation procedure
  - **RUN 1**: Activation of creep CFs, without LB-LOCA like features → no rapid depressurization of the RCS at HL failure

    Id of time of HL creep failure
  - **RUN 2**: Disabling of creep CFs, with LB-LOCA like features operating at time id above → rapid depressurization of the RCS resulting from HL failure

    Run with creep failure induced depressurization
- Are there better ways to model it?

The IRSN's DENOPI research program, in which Bel V collaborates, is devoted to spent fuel pool loss-of-cooling and loss-of-coolant accidents (French National Research Agency (ANR) contract reference: ANR 11 - RSNR 006)

Bel V contribution to the IRSN's DENOPI project

STUDY OF THE AERAULICS OF THE SFP-BUILDING BY MEANS OF MELCOR CODE

SFP-BUILDING STUDY

- Objective
  - Analysis of the SFP building aeraulic by means of MELCOR code during accident situations
    - Base calculations of the Kondo et al.* *(current presentation)*
    - Comparisons with the results of ASTEC calculations (*to be confirmed*) and IRSN's DENOPI project experimental results (*when available*)
- Phenomena of interest
  - SFP building atmosphere transient behavior
  - Wall condensation
  - SFP free surface evaporation
  - Impact of: opening to the environment (doors, leaks), surface/volume ratio of the building, spent fuel power

Part of Bel V expected contribution to IRSN's DENOPI project theme 1: large convective structures within the spent fuel pool

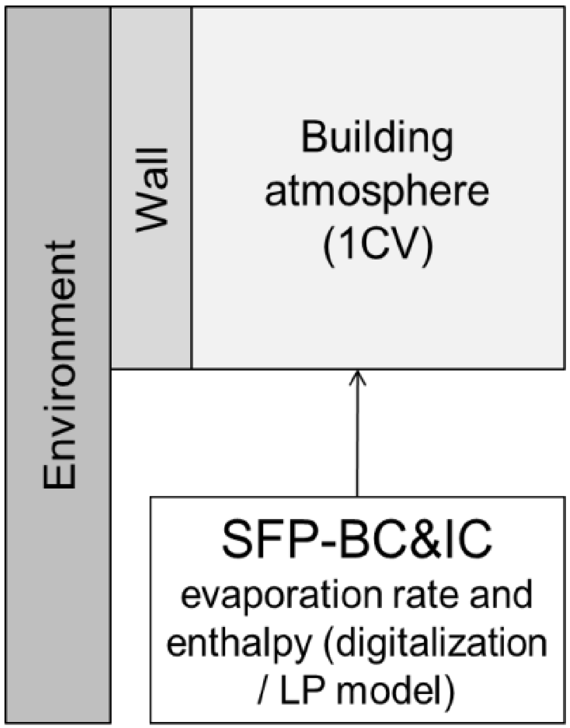
SFP-BUILDING STUDY

- MELCOR version 1.8.6.4073
- SBO accident scenario
  - No power for cooling spent fuel
  - No conditioning of the air
- BWR reactor building
  - SFP located within the reactor building, but outside of the primary containment
- 72h transient calculations

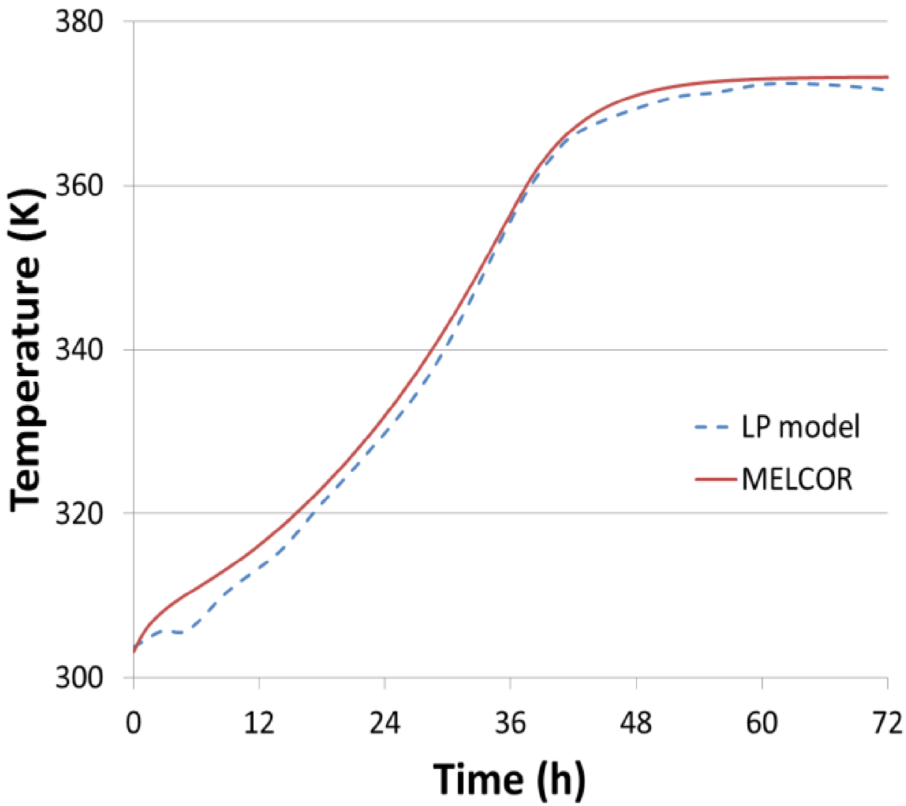
* Kondo M. et al., An evaluation model to predict steam concentration in a BWR reactor building, Nuclear Science and Technology, 2015 Vol. 52, No.11, pp 1369-1382.

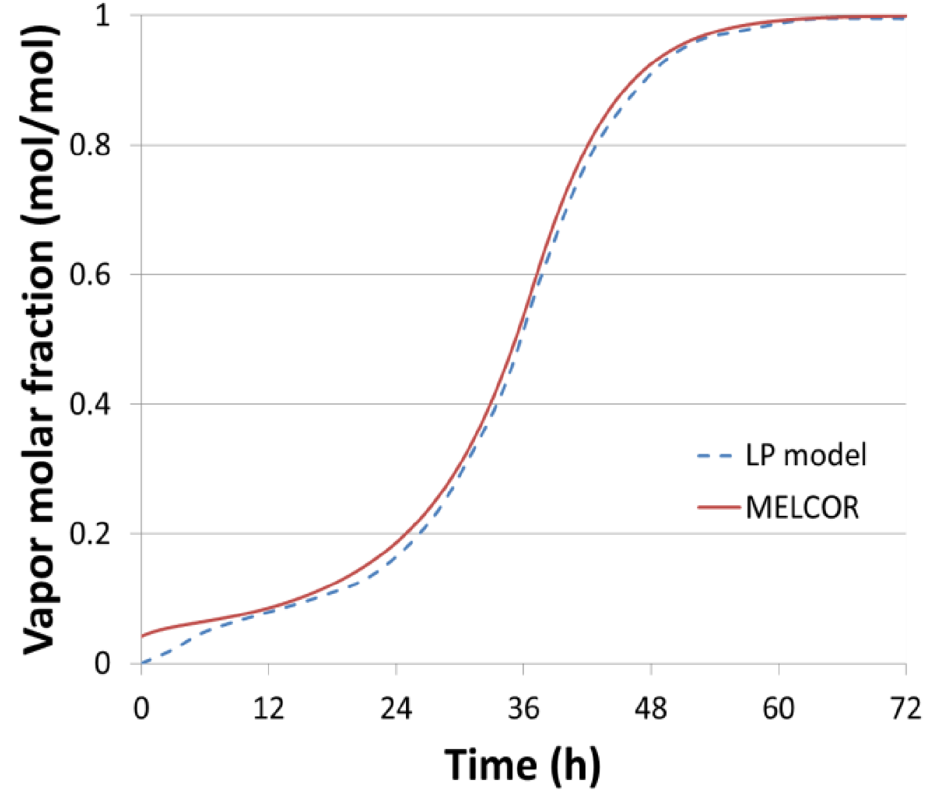
SFP-BUILDING STUDY

- Base input deck created starting from
  - Tills J. et al., Application of the MELCOR Code to Design Basis PWR Large Dry Containment Analysis, SAND2009-2858
- Initial and Boundary conditions from Kondo et al. (2015)
- Simulation domain
  - Operation floor, floor wall, building atmosphere and environment
  - SFP time dependent boundary conditions: evaporation rate and enthalpy



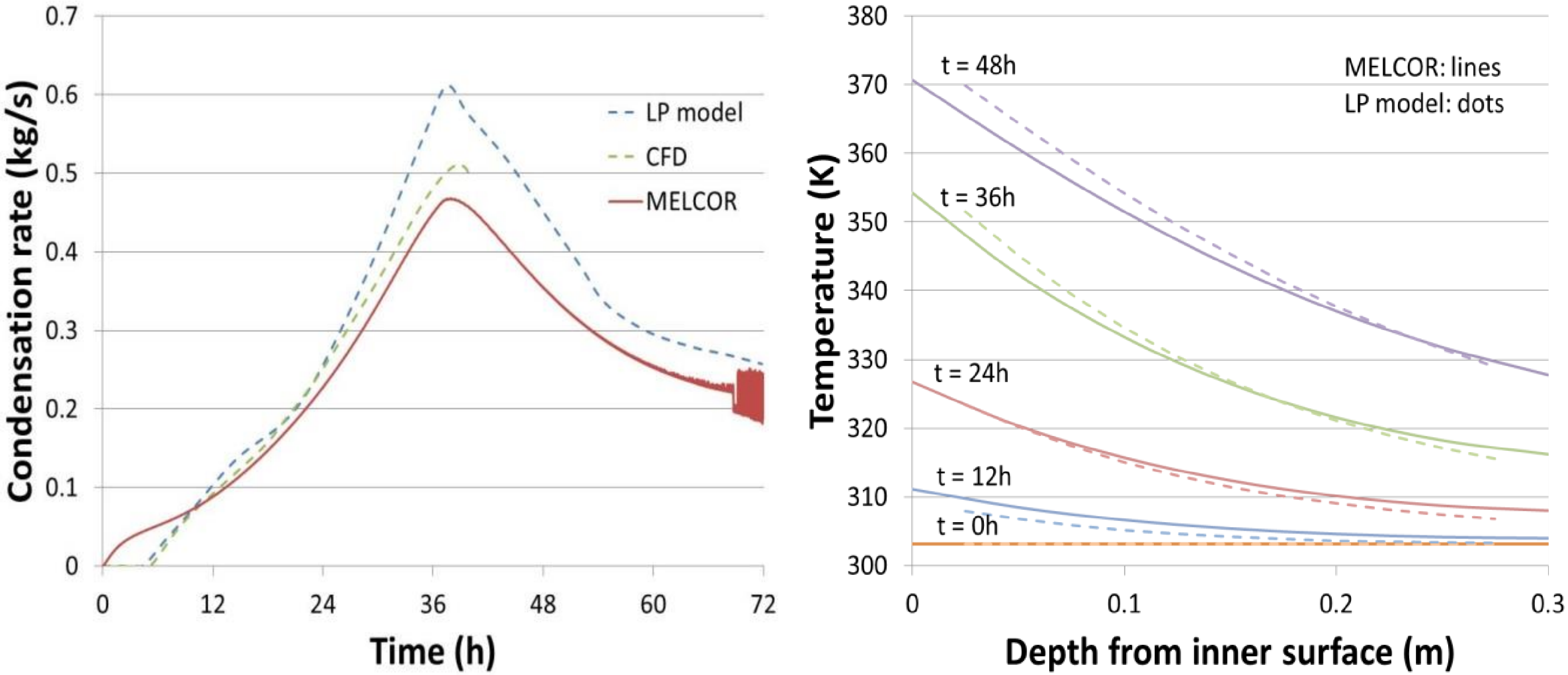
SFP-BUILDING STUDY





Temperature of building atmosphere (left) and vapor concentration in the building (right)

SFP-BUILDING STUDY



SFP condensation rate (left) and temperature distribution in the building wall (right)

FUTURE PLANS

- The activity proceeds as scheduled
  - SFP-building analysis in support of the interpretation of the IRSN's DENOPI project experimental results
- Next steps
  - Conversion of the developed input decks to MELCOR 2.2 version
  - Extension of the simulation to the pool modeling
  - Sensitivity analyses
  - Study of other cases: SFP-LOCA?

Bel V model development and assessment with MELCOR 2.2

CONCLUSIVE REMARKS

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- Exchange experience and information about model development and assessment efforts
  - Bel V is progressing in MELCOR modeling by extending the developed plant input deck with additional modeling capabilities (HL creep failure)
  - Bel V contributes to MELCOR assessment (IRSN's DENOPI project)
- Possible future interest
  - Activity calculations (BONUS): how to use it?
  - Retrieving isotopes composition from MELCOR classes

QUESTIONS?

THANKS FOR YOUR ATTENTION!