RBMK SP-2 Validation Results (KS PH Rupture Simulation)

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RINSC/INSC Code Validation Support

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- Joint Project 6 established to assist with code validation, primarily with the application of western codes like RELAP5
- Standard problems were defined to investigate important phenomena for VVER and RBMK designs
- PNNL provided analysis support to ANL for RBMK problems
- PNNL and KI jointly analyzed SP-2

RBMK Standard Problem 2 (SP-2)

- RBMK SP-2 was defined from a series of stop flow experiments that were performed with the KS facility
- SP-2 was to simulate a pressure header rupture
  - although it was performed at system pressure

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➢ RBMK SP-2 phenomena investigated

- water release (ejection) from the fuel channel (FC) model and fuel simulator surface drying,
- dryout under sharp flow deceleration at the inlet of the RBMK-1000 and RBMK-1500 fuel assembly (FA) models,
- post dryout heat transfer and fuel simulator temperature conditions in the FA model under channel drying,
- steam and water counter current flows in the steam-water piping, and in the FC with the FA model,
- propagation of the reflood and quench front in the FA model under flow resumption at the channel inlet.

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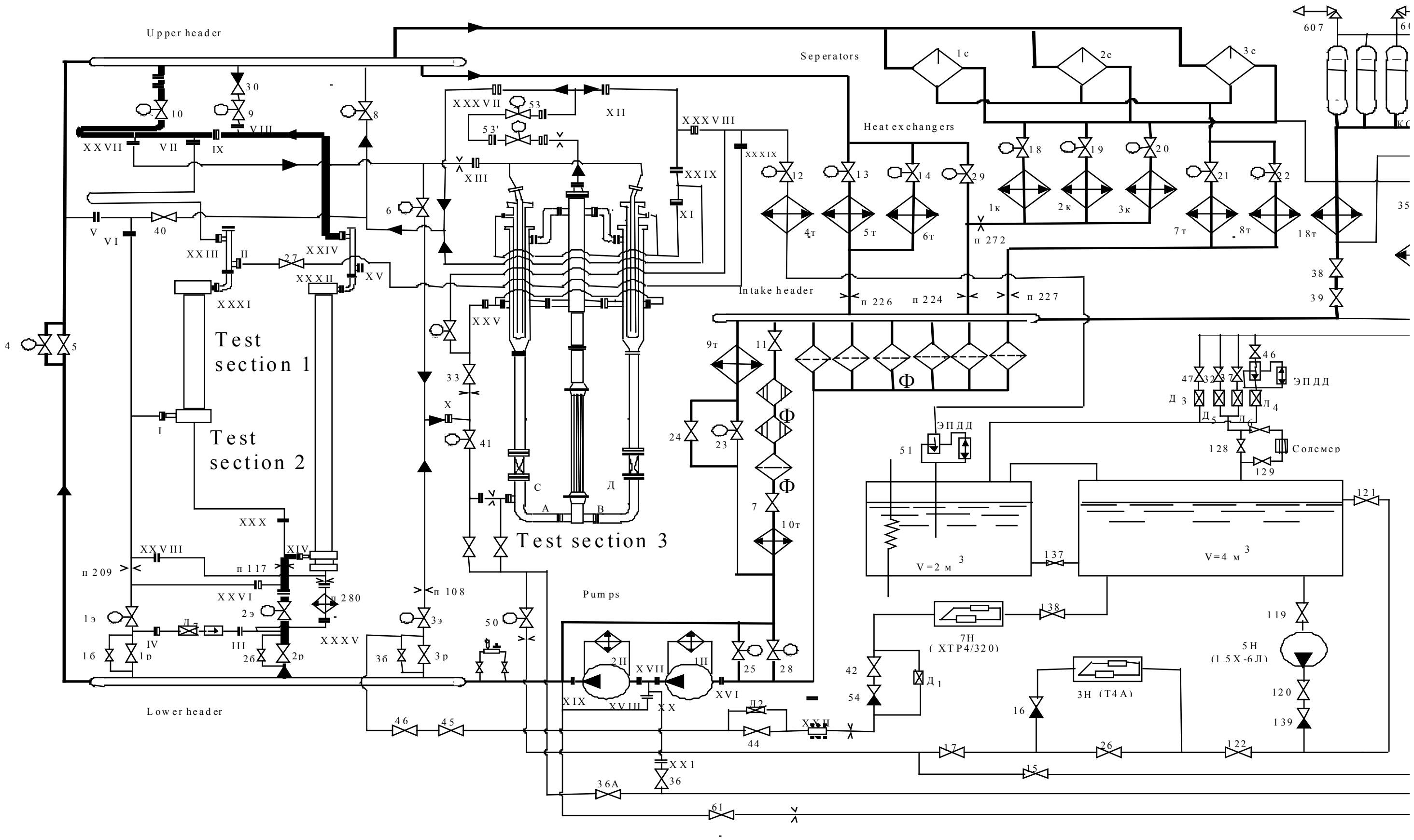

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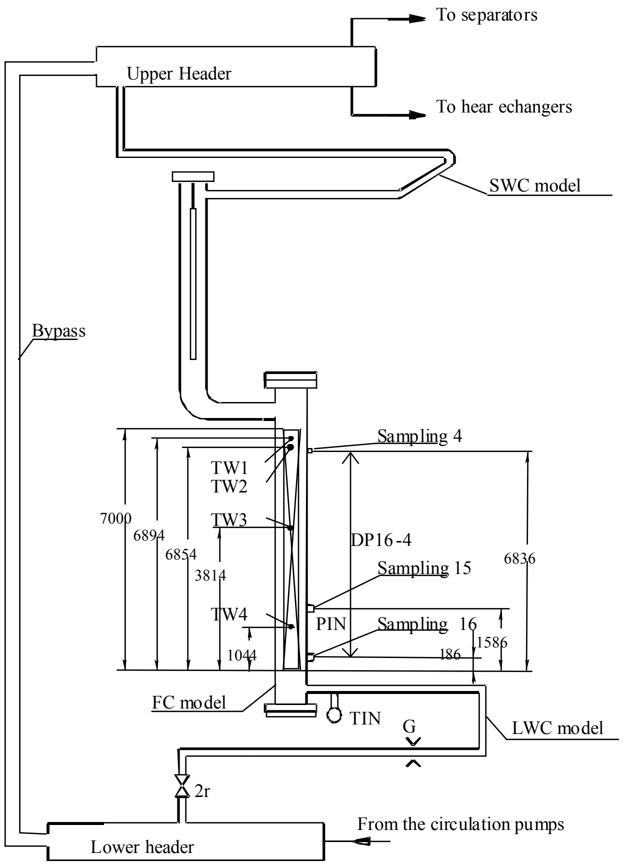

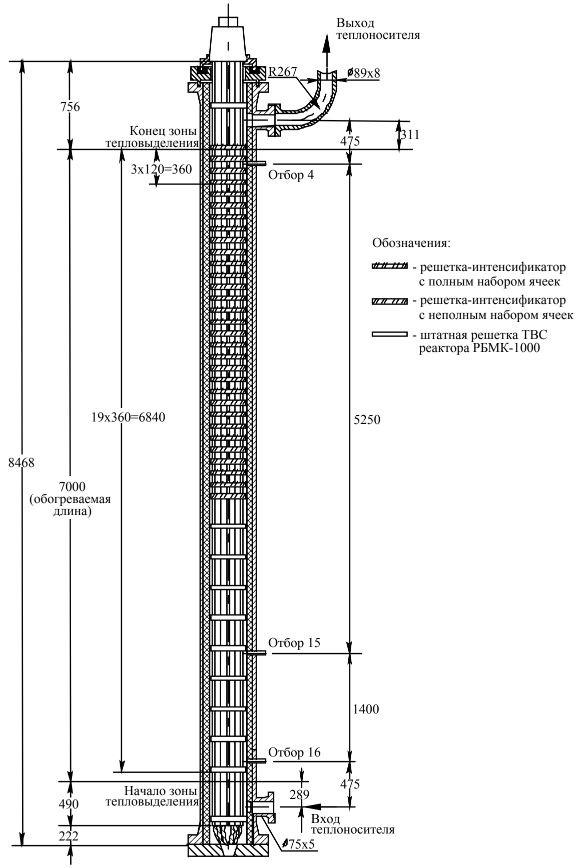

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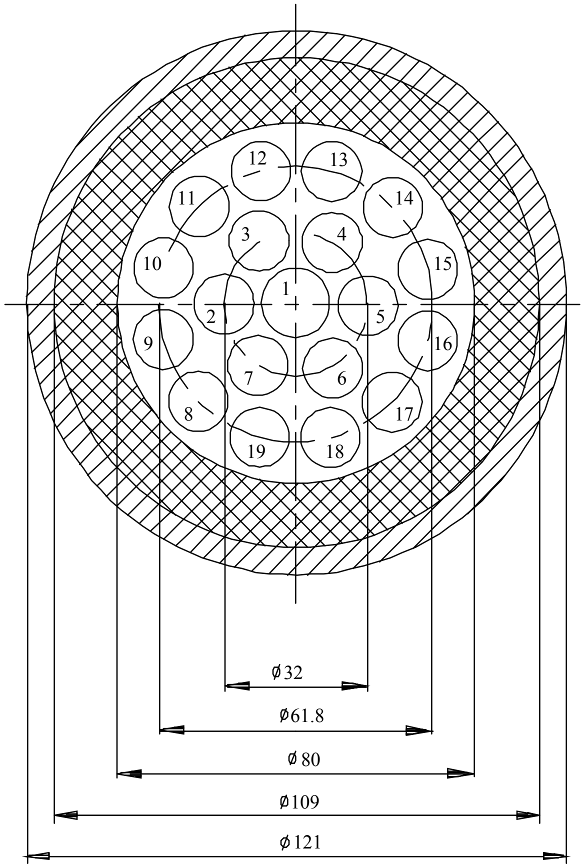

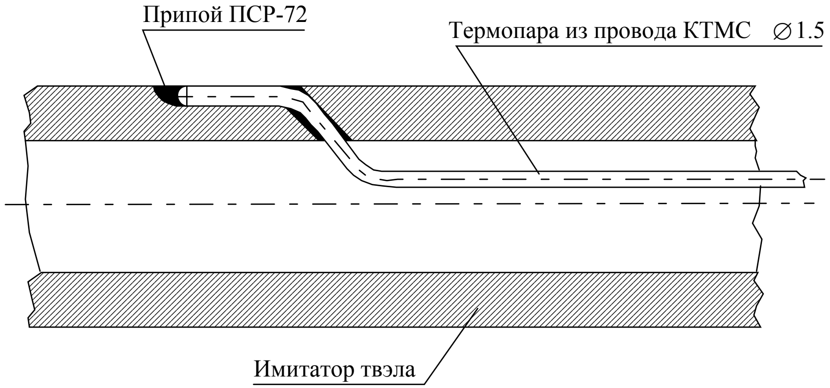

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Figure 6) KS Model Node Diagram

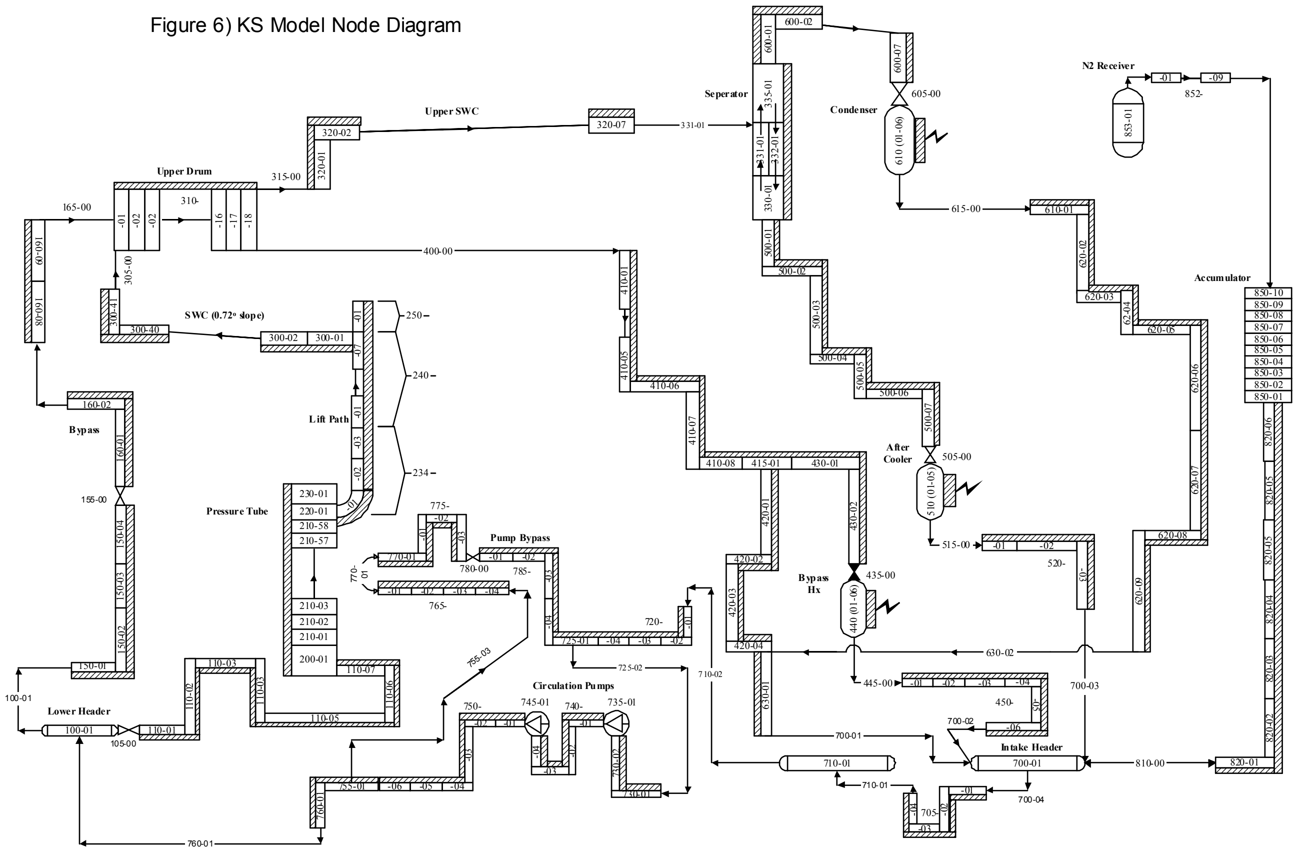

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Table 2) KS Facility Initial Conditions

No.	Experiment	Electrical power of fuel assembly model, MWth	Pressure at inlet of fuel assembly, P16, MPa	Water temperature at inlet of fuel channel, TF1, ºK	Water flow rate at inlet GL, kg/s
1	Test-4	1.691	7.68	516.1	3.90
2	Test-5	2.486	8.40	527.4	4.70
3	Test-5?	2.532	7.95	533.1	4.17
4	Test-6	2.926	8.23	527.3	4.28
5	Test-7	3.488	8.23	529.3	4.13
6	Test-8	4.566	8.74	531.1	6.27

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Table 1) RELAP5 Model Equivalent Data Locations

Data	**RELAP5 Model**	
Thermocouples	**HS**	**Volume**
TW-1	2102-59 mesh 8	210-58
TW-2	2102-58 mesh 8	210-57
TW-3	2101-33 mesh 8	210-32
TW-4	2102-10 mesh 8	210-09
Pressure Taps	**Volume**	
P4	210-57	
P16	210-02	

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Table 3) Calculation Matrix

Test ID	Case Options								
	e	**s**	**m**	**t**	**h**	**vp**	**b**		
4	X	O	X	O	O		O		
5	X		X				O		
5?	X	O	X	O	O		O		
6	X		X				O		
7	X		X				O		
8	X	O	X	O	O	X	O		

Case Option Definitions (x –results presented here, o –results not presented)

e - EPRI bundle friction correlation (this is the 'basecase' model setup)

s - the SWC piping junction diameter is reduced by 1/8, based on SP-1 results [5] for liquid drainback

m - improved CHF multiplier coefficient, based on SP-1 results [5] for dryout prediction

v - valve leakage allowed

p - early power shutdown

t - time step size reduction

h - heat structure radial mesh reduction

b - Bestion bundle friction correlation

Conclusions

- **Overall Performance considered minimal or poor**
- The predicted steady state pressure drop in the heater bundle is not well correlated by RELAP5, and is considered to be minimally acceptable.
  - This suggests that the RBMK bundle requires a more specific correlation than the Lockart-Martinelli correlation used in RELAP5 or that the mass-flux dependent coefficients be defined specific to the RBMK bundle.
- Time to dryout is reasonably predicted for each case. However, this would be expected for even significant errors in the predicted CHF for this evaluation.

Conclusions

- RELAP5 consistently under-predicts rewet for the cases where power is maintained constant and the overall prediction is considered poor.
  - In general this is in the conservative direction. However, for the case of power reduction, Test 5′, early rewet is predicted.
  - Sensitivity studies performed do indicate that an improved CHF correlation (specific to the RBMK fuel assemblies) would likely provide significant improvement.
  - It should also be noted that for RELAP5/MOD3.2, the reflood model is disabled because of incompatibilities. Updated versions of RELAP5 with a reflood model may provide additional improvement as well.

Conclusions

- Post-dryout heat transfer is reasonably predicted (except during rewet), as indicated by the rate of heatup in the cladding after dryout, and the peak cladding temperature is reasonably predicted.
  - However, this is limited to conditions prior to reflood.
- The progression of the quench front is not correctly predicted for all cases.
  - the sequencing of temperature turn-over shows an inversion where the lower elevation cladding remains in post-dryout while the upper cladding is in partial rewet.
  - updated versions of RELAP5 with a reflood model may provide additional improvement.