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International Agreement Report

Transient Analysis of the Research Reactor MARIA MC Fuel Elements Using RELAP5 Mod 3.3

Prepared by:
M. Dabrowski, P. Domitr, E. Staron

Panstwowa Agencja Atomistyki
(National Atomic Energy Agency)
Krucza 36
00-522 Warszawa, POLAND

A. Calvo, NRC Project Manager

Office of Nuclear Regulatory Research
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ABSTRACT

The new fuel type in the Research Reactor 'Maria' is undergoing a test procedure. Thermal-hydraulic calculations using RELAP have been applied in order to cross-check the results obtained using a specialized thermal-hydraulic 'SN' code. Nodalization of the fuel element has been developed and calculations have been performed. LOFA and RIA cases have been analysed and compared showing good agreement between the two codes.

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EXECUTIVE SUMMARY

In accordance with the international agreement on GTRI (Global Threat Reduction Initiative) Poland agreed to change the fuel type in the MARIA research reactor in Świerk from Highly Enriched Uranium (HEU) fuel to Low Enriched Uranium fuel (LEU). The new fuel MC5-485 – in short MC fuel - consists of 19,75% of 235-U. At this stage several new MC elements have been inserted into the reactor core and are under a test procedure.

Prior to this test, thermal-hydraulic effects have been calculated by the operator using a specialized computer code called 'SN'. The SN code is capable of performing thermal-hydraulic calculations of the fuel elements behaviour and has been verified and validated for the research reactor MARIA only.

The Polish National Atomic Energy Agency (PAA) has decided to try to cross-check the results of the analysis using the RELAP5 code although it is aware that the results of the analysis at this stage might need further elaboration and additional calculations. However an important aim is to gain experience in performing analysis using RELAP5 and to judge whether it is applicable and to what extent to the analysis of the research reactor.

The National Centre for Nuclear Research who is the operator of the research reactor MARIA has provided the results of two types of accidents: a Reactivity Initiated Accident (RIA) and Loss of Flow Accident (LOFA). The analysis of RIA was divided into four scenarios: two for reactor low power level operation (possible during start-up of the reactor or during work with low power level – 10 kW) and two for normal operation with maximum allowed power. Both cases were performed for slow and fast reactivity insertion. The SN code models the fuel element only. It does not include the possibility to model the whole reactor together with the safety systems. As a consequence of this limitation no analyses of the Loss Of Coolant Accident (LOCA) have been supplied as yet. Using RELAP should change this and enable the regulatory body to perform a LOCA analysis as well.

The Regulatory Body has cross checked the analyses made and presented by the operator and has provided the comparison of results in this report. Due to other limitations of the SN code, the comparison is rather limited. Only a small number of parameters is included in the SN output. Thus, only those could be compared.

The presented results of calculations do not include errors and sensitivity studies. However the scenario analysed for the purpose of this document was made with conservative assumptions. The model used for this calculation was limited to a model of the fuel element only. Other elements of the reactor systems were not included. As a consequence it was necessary to:

- omit influence of reactivity coefficients of the coolant in reactor pool and beryllium blocks positioned around the analysed fuel channel; the omitted thermal reactivity coefficients are positive but during postulated accidents, the increase of the temperature of the beryllium blocks and water of pool is very low,
- omit heat transfer between the fuel channel and water of the reactor pool; the influence of this factor is very small due to the very small difference in temperatures between

water in the outer part of the fuel channel and the water in the pool (i.e. heated water flows in the internal part of fuel channel).

Following an introduction in chapter 1, the report covers a short description of the Research Reactor 'Maria' including the fuel channel and the fuel element presented in chapter 2. Additional information concerning the RR Maria is supplied in Appendix A.

The nodalization model is presented in chapter 3 and includes a description of the fuel channel and heat structures. The input data file is attached in Appendix B.

The results of the calculations are presented in chapter 4 mostly on figures. They begin with the steady state evaluation which is followed by a loss of flow in the fuel channel analysis. Further analyses cover the slow reactivity insertion accident on low power level, fast reactivity insertion accident on low power level, slow reactivity insertion accident during reactor normal operation and finally fast reactivity insertion accident during reactor normal operation.
In chapter 5 a brief information on run statistics is presented.

Finally a summary of the results is presented in chapter 6.

As already mentioned, initial calculations were performed for steady-state conditions. The newly created model of the reactor with the new fuel elements for RELAP was used and compared with the results of steady state calculations received from the SN code. The limitations of the SN code does not allow to perform detailed comparisons however peak cladding temperatures and heat flux were compared.

The steady state was calculated for the reactor normal operation deviated from full power.

The conditions that were used in the simulation were chosen to simulate work of the fuel channel during normal operation with safety parameters equal to warning signals. In order to have such conditions the mass flow was reduced to 90% of nominal value and thermal power was increased to 110% of the nominal value.

The results received were satisfactory.

Loss of flow in the fuel channel cooling system is possible in case of the loss of power in the pump system. As a result a sudden decrease of pressure occurs in the cooling channel that leads to the initiation of the emergency signal and shutdown of the reactor. Furthermore, after the loss of flow a rapid increase of fuel clad temperature and cooling temperature in gaps between fuel pipes occurs. According to the scenario a few seconds after the loss of power in the pump system, the work of a backup pump should be initiated powered by accumulator batteries however operating at a lower speed – 1500 r/s. After the reactor shutdown and before the flow is stabilized another small temperature jump can be detected.

The highest outer clad temperature calculated with the RELAP5 code was 432K (outer layer temperature – 440K). The temperature calculated with the SN code was 433.4K. Both codes calculated the highest temperature in the same place – on the internal side of pipe number 6.

In case when the operator undertakes incorrect actions or a malfunction of the reactivity regulation system occurs, it is possible that as a result, positive reactivity is inserted into the core with the maximum reactivity speed 0.04$/s. This scenario was checked for low power level conditions. This scenario has the lowest impact on the fuel elements. The temperature peaks of water and clad are very small - smaller than fluctuations of temperature during normal operation of the reactor.

One of the important scenarios addressed in the supplementary document is the fast inflow of cold water into the core resulting in a sudden increase of reactivity. The negative reactivity coefficients lead to the increase of power in the fuel elements. The scenario analysis was performed for low power. The results received were satisfactory.

The slow reactivity insertion accident during normal operation was very similar to the slow reactivity insertion accident on low power. Also here the results were satisfactory.

A break of control rods is another scenario analysed. The break of control rods leads to fast insertion of positive reactivity into the reactor. It is assumed that the maximum insertion of positive reactivity is equal to 1.5$ with the top speed of insertion 4$/s.

The main differences in the results between RELAP and the SN code are due to the different models of reactor kinetics. RELAP5 uses the point kinetic model and this model was applied to the RIA analysis. In case of the SN code a more pessimistic model was used.

Summarizing the analysed cases it can be stated that most of the results of the simulation for the research reactor MARIA obtained using the RELAP5 code, showed that there are no big differences between the results achieved by the validated SN and the RELAP5 codes. Only in one case (RIA with fast reactivity insertion with maximum power level) there is the opportunity to exceed the lowest allowed level of the ONBR parameter. Exceeding this parameter can cause the onset of boiling of the coolant in the gap between the fuel pipes. In the analysed case, the duration of time when ONBR is lower than 1.2 is very short (about 0.35s) and should not cause any damage to the fuel and clad material. In the fast RIA scenario, the power jump during the insertion of positive reactivity was stopped by the negative reactivity coefficients (fuel and coolant) before insertion of the safety and control rods into the core could be initiated.

In other simulated scenarios, no opportunity to exceed the ONBR parameter or temperature limit of clad – 452K occurred.

In the analysed LOFA scenario, the calculations showed that enough cooling capability is provided even when only one pump is working with a lower rotation speed than the normally required two pumps.

The content of this report does not cover all possible accident conditions that should be analysed for the research reactor. Further analysis will be necessary. A comparison of the SN and RELAP5 codes showed that RELAP5 can be used in the safety analysis for the research reactor MARIA.

ABBREVIATIONS

ECEP	external side of clad on the external side of pipe
ECIP	external side of clad on the internal side of pipe
HEU	highly enriched Uranium
ICEP	internal side of clad on the external side of pipe
ICIP	internal side of clad on the internal side of pipe
LEU	Low enriched Uranium
LOFA	Loos of Flow Accident
NCBJ	Narodowe Centrum Badań Jądrowych (National Centre for Nuclear Research)
ONBR	Onset of Nucleate Boiling Ratio
PAA	Państwowa Agencja Atomistyki (National Atomic Energy Agency of Poland)
PAR	automatic regulation rod
PK	control rods
PB	safety rods
REP	moving type fuel elements
RIA	Reactivity Initiated Accident
RR	research reactor
SN	name of computer code used for RR 'Maria' calculations

1 INTRODUCTION

Fulfilling the international agreement on GTRI (Global Threat Reduction Initiative) Poland agreed to change the fuel type in the MARIA research reactor in Świerk from Highly Enriched Uranium (HEU) fuel to Low Enriched Uranium fuel (LEU). The new fuel MC5-485 consists of 19,75% 235-U. At this stage several new MC elements have been inserted into the reactor core and are under a test procedure.

Prior to this test, thermal-hydraulic effects have been calculated by the operator using a specialized computer code called 'SN'. The SN code is capable of performing thermal-hydraulic calculations of the fuel elements behaviour and has been verified and validated for the research reactor MARIA only.

The Polish National Atomic Energy Agency (PAA) has decided to try to cross-check the results of the analysis using the RELAP5 code although it is aware that the results of the analysis at this stage might need further elaboration and additional calculations. However an important aim is to gain experience in performing analysis using RELAP5 and to judge whether it is applicable and to what extent to the analysis of the research reactor.

The National Centre for Nuclear Research who is the operator of the research reactor MARIA has provided the results of two types of accidents: a Reactivity Initiated Accident (RIA) and Loss of Flow Accident (LOFA). The results of the analyses are part of a supplementary document[1] to the Safety Analysis Report. The analysis of RIA was divided into four scenarios: two for reactor low power level operation (possible during start-up of the reactor or during work with low power level – 10 kW) and two for normal operation with maximum allowed power. Both cases were performed for slow and fast reactivity insertion. The SN code models the fuel element only. It does not include the possibility to model the whole reactor together with the safety systems. As a consequence of this limitation no analyses of the Loss Of Coolant Accident (LOCA) have been supplied as yet. Using RELAP should change this and enable the regulatory body to perform a LOCA analysis as well.

The Regulatory Body has cross checked the analyses made and presented by the operator in the supplementary document and has provided the comparison of results in this report. Due to other limitations of the SN code, the comparison is rather limited. Only a small number of parameters is included in the SN output. Thus, only those could be compared.

1 *Aneks 2012/1 do Eksploatacyjnego Raportu Bezpieczeństwa Reaktora MARIA Konwersja rdzenia reaktora MARIA na paliwo MC, July 2012.*

2 FACILITY DESCRIPTION

2.1 MARIA research reactor technical information

The Maria research reactor is a pool type research reactor with 20-25 closed fuel channels in the core, with a beryllium moderator and graphite reflector. The designed maximum thermal power is 30 MW. The reactor is placed about 30 km from Warsaw in Świerk-Otwock and is operated by the National Centre for Nuclear Research (NCBJ). More technical information including a description of the primary safety systems is provided in Appendix A.

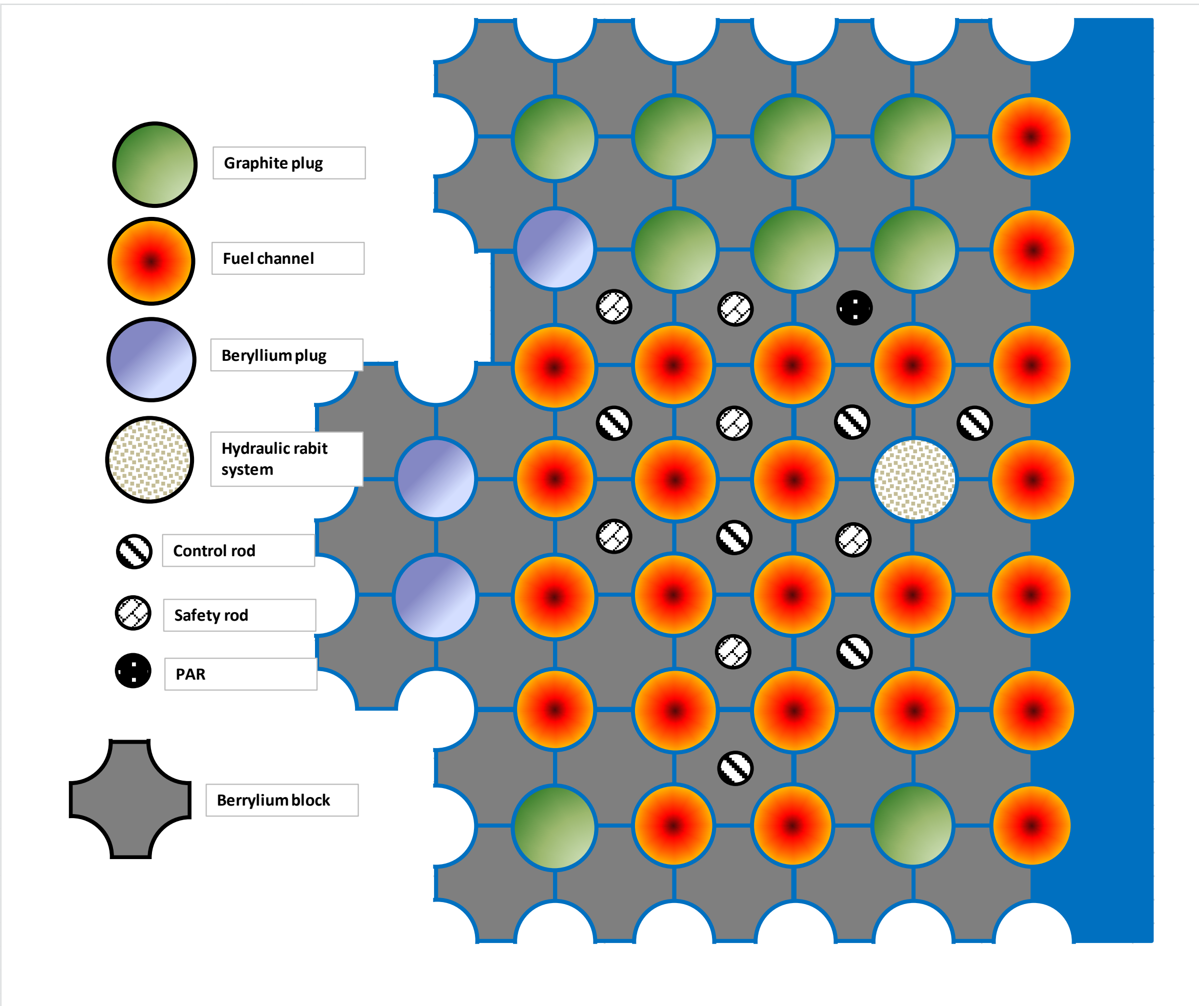

Figure 1. Simplified scheme of the Research Reactor 'MARIA' core configuration

2.2 Fuel channel with fuel element technical information:

This report assumes that only the new type of fuel – the French LEU fuel MC5-485 with 19.75% of 235U is used. The fuel element is a pipe in pipe construction, consisting of 5 pipes with fuel (Fig.2 with numbers from 2 to 6) and filler. The fuel is a dispersion U3Si2-Al with AG3NE alloy as a clad material and SAW alloy (aluminium alloy type) as an outer tube of the fuel channel. Water in the fuel element flows through 6 gaps (numbered from 1 to 6 on the picture) and through a gap in the centre of the fuel element. Fuel elements work with various thermal power levels depending on the position in the core. Usually, fuel elements work in the centre of the core with thermal power at the level of about 1.2-1.6 MW and in the peripheral position of the core with power about 0.3-1.2 MW. The maximum allowed thermal power – the safety limit for this fuel is 1.8 MW and it is forbidden for the reactor to exceed the limit in any conditions.

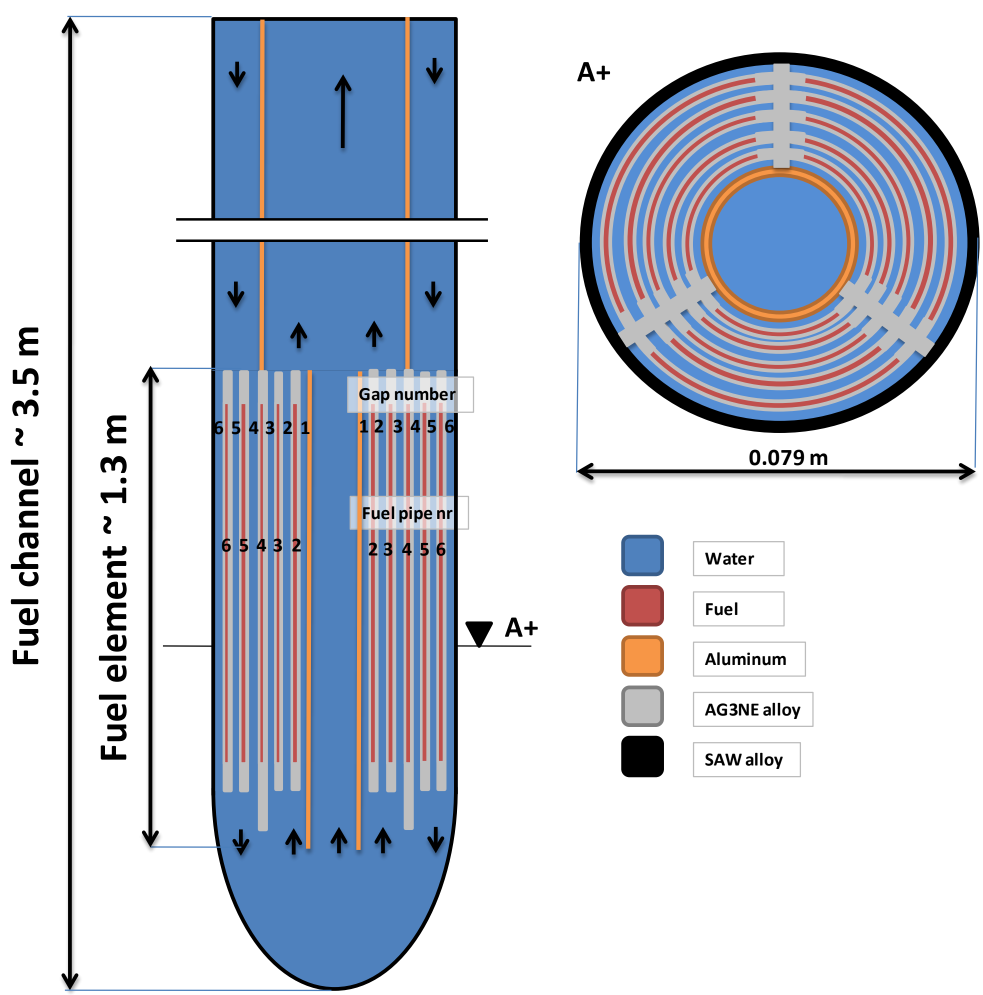

Figure 2. Simplified scheme of the fuel channel with an MC fuel element

3 CODE INPUT AND MODEL DESCRIPTION

3.1 Nodalization

In order to cross-check the analysis it was necessary to prepare a model of the fuel channel with a fuel element consisting of 5 fuel pipes and a bypass in centre. The nodalization is presented on Fig.3. Water flowing in the channel is directed first to the outer part of channel (component 10), then split into three gaps between fuel pipes (components 20, 25 and 30). Next, the water mixes and changes direction of flow (in component 35, 40 and 45) and goes up through the rest of the gaps and bypass (components 50, 55, 60 and 80). Next, the water flows to the exit of the channel through the inner part of the channel (component 70).

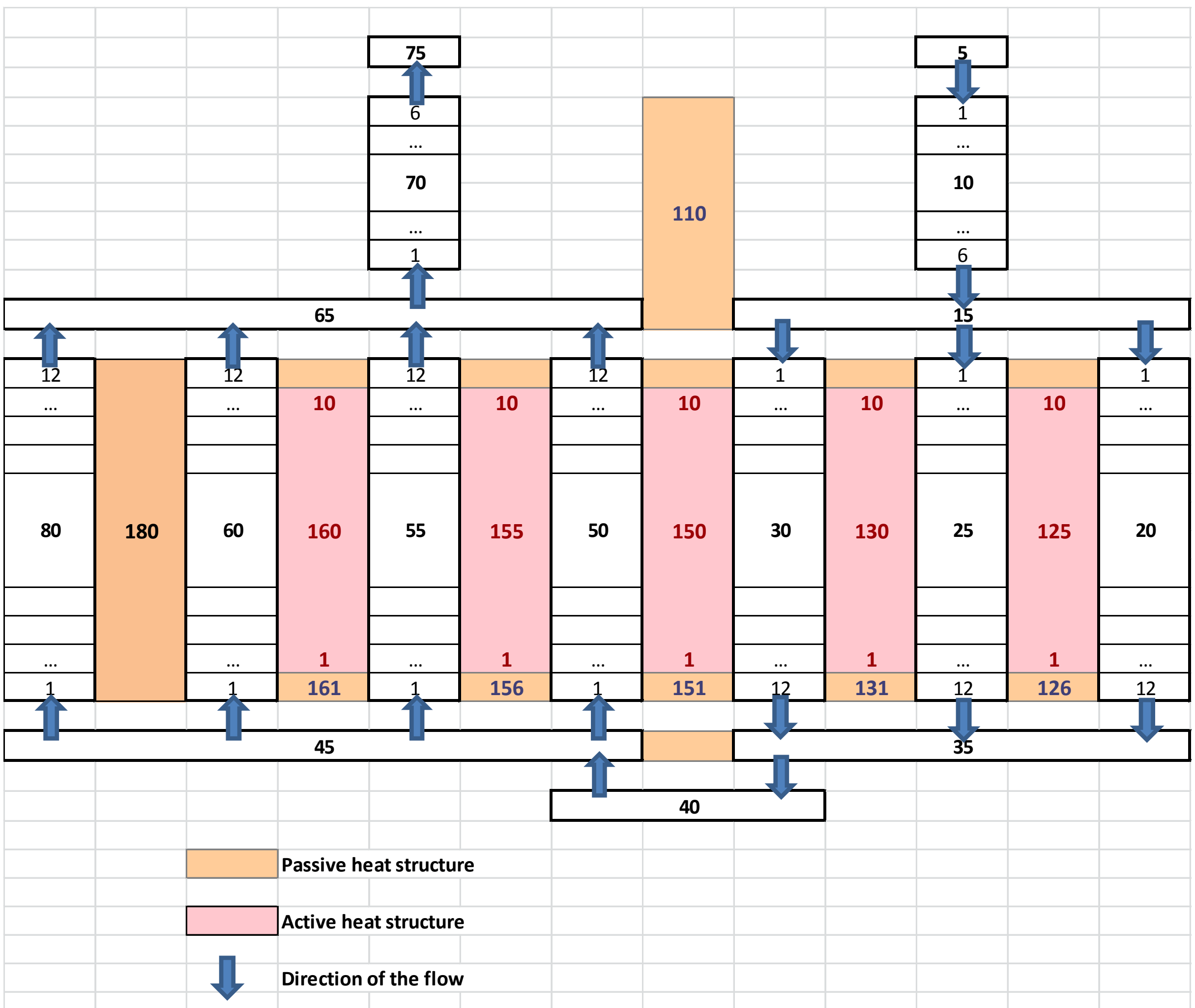

Figure 3. Nodalization scheme of the MC fuel element.

3.2 Heat structures

Two types of heat structures - active and passive were used for modelling heat exchange. Passive heat structures without heat generation are used for modelling heat transfer between the outer and inner part of the fuel channel (node no. 110 on Figure 3), non-filled fuel pipe parts (161, 156, 151, 131, 126) and filler (180). Active heat structures are used for modelling fuel pipes with heat generation (160, 155, 150, 130, 125 consisting of 10 cells). Each cell in the active heat structure was divided into 17 meshes as is visualised on Figure 4. In case of passive structures each cell was divided into less than 10 meshes.

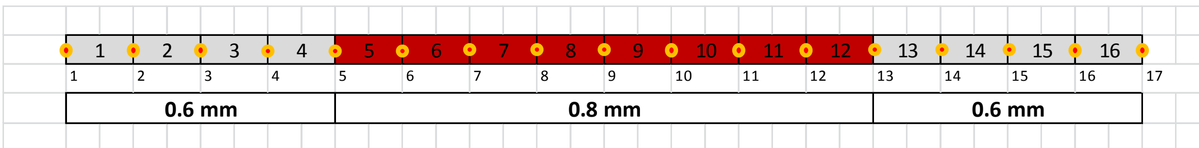

Figure 4. Positioning of mesh points in each fuel pipe – grey colour clad material, red colour - fuel

For the purpose of this document it was required to check the temperature in four points:
External side of Clad on the Internal side of Pipe (ECIP) – mesh nr 1,
Internal side of Clad on the Internal side of Pipe (ICIP) – mesh nr 5,
Internal side of Clad on the External side of Pipe (ICEP) – mesh nr 13,
External side of Clad on the External side of Pipe (ECEP) – mesh nr 17.
The placement of the four points is shown on Figure 5.

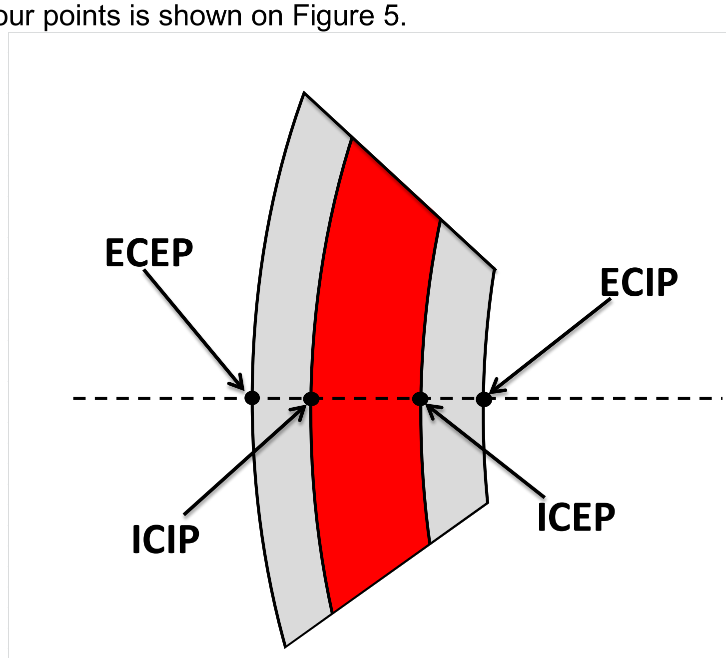

Figure 5. Placement of measurement points

The heat generation distribution model was based on two factors: (1) heat generation in each pipe calculated by the computer code MCNP[2] and (2) axial heat generation based on the cosine model with a slight shift downwards in order to simulate partial insertion of control rods into the core during operation.

Table 1. Distribution of heat generation on fuel pipes and comparison of heat generation with content of uranium

Pipe	Heat generation [%]	Mass of U-235 [%]
2	11.0	11.15
3	14.1	15.58
4	18.1	20.00
5	23.8	24.43
6	33.0	28.84

3.3 Limitation of the model and errors

A model of the analysed objects, as well as data and calculations should always include an errors analysis that influence the final results. However the scenario analysed for the purpose of this document was made with conservative assumptions in the initial condition and did not include the influence of errors and sensitivity studies. The model used for this calculation was limited to a model of the fuel element only. Other elements of the reactor systems were not included. As a consequence it was necessary to:

- omit influence of reactivity coefficients of the coolant in reactor pool and beryllium blocks positioned around the analysed fuel channel; the omitted thermal reactivity coefficients are positive but during postulated accidents, the increase of the temperature of the beryllium blocks and water of pool is very low,
- omit heat transfer between the fuel channel and water of the reactor pool; the influence of this factor is very small due to the very small difference in temperatures between water in the outer part of the fuel channel and the water in the pool (i.e. heated water flows in the internal part of fuel channel).

2 Calculated by NCBJ in document: *Aneks 2009/1 do Eksploatacyjnego Raportu Bezpieczeństwa Reaktora MARIA Badania paliwa MC*

4 RESULTS

4.1 Steady state evaluation

Initial calculations were performed for steady-state conditions. The newly created model of the reactor with the new fuel elements for RELAP was used and compared with the results of steady state calculations received from the SN code. The limitations of the SN code do not allow to perform detailed comparisons, however peak cladding temperatures and heat flux were compared.
The steady state was calculated for the reactor normal operation deviated from full power.

Steady-state conditions

The conditions that were used in the simulation were chosen to simulate work of the fuel channel during normal operation with safety parameters equal to warning signals. In order to have such conditions the mass flow was reduced to 90% of nominal value and thermal power was increased to 110% of the nominal value.
Initial conditions:

- Cooling channel inlet water temperature Tin=318.15K
- Mass flow Q=7.43kg/s (27m^3/h for density of water: 990kg/m^3) (90% of nominal mass flow)
- Pressure at the fuel channel inlet p=1.7MPa
- Fuel channel pressure drop Δp=0.59MPa
- Fuel element thermal power 1.98MW (110% of nominal value)

Results

Temperature distribution on fuel pipes
The results of calculations are presented on the following figures – from Figure 6 to Figure 13.

The temperature distribution on the internal side of the fuel pipe as below:

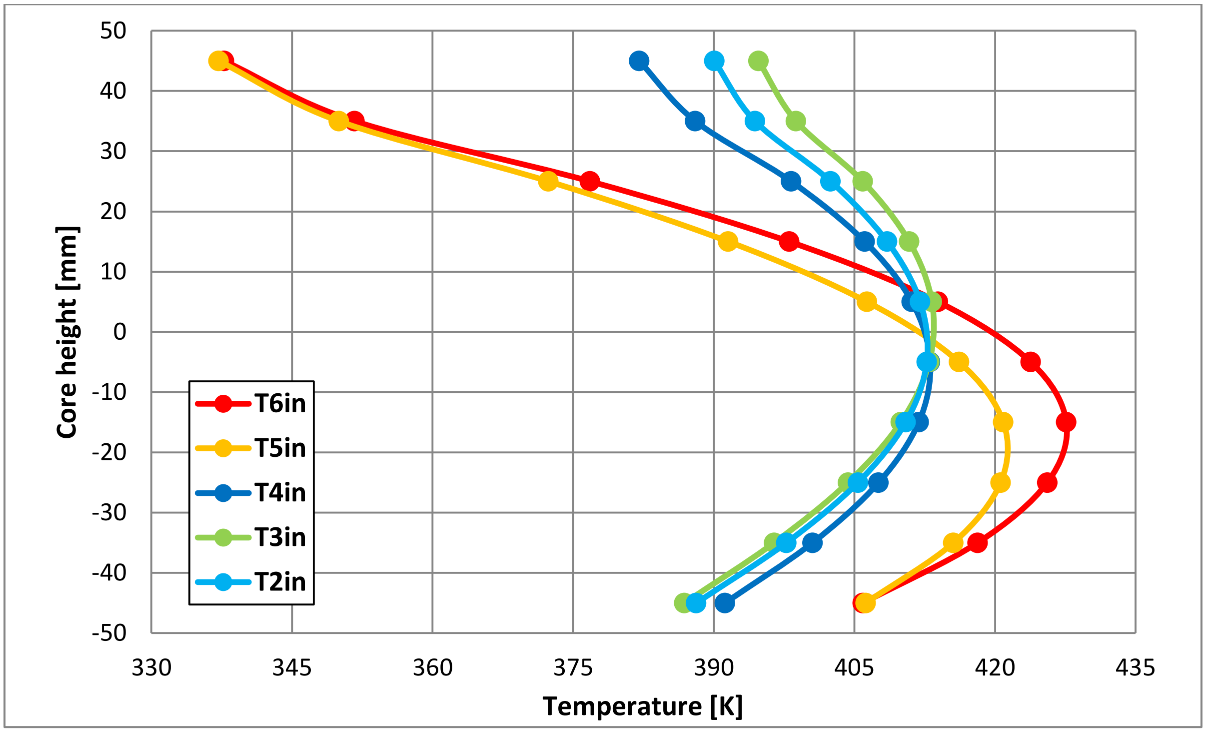

Figure 6. Temperature distribution on ICIP of each fuel pipe

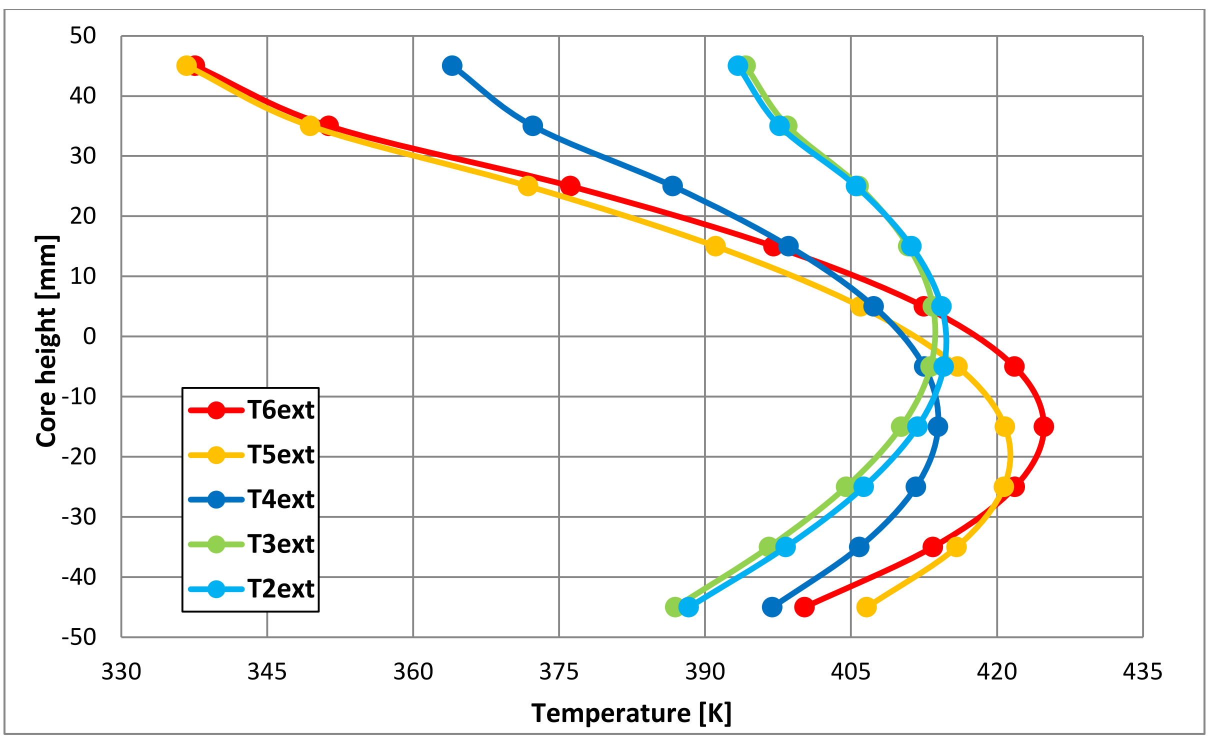

Figure 7. Temperature distribution on ECIP of each fuel pipe

On the outer side of fuel pipe as below:

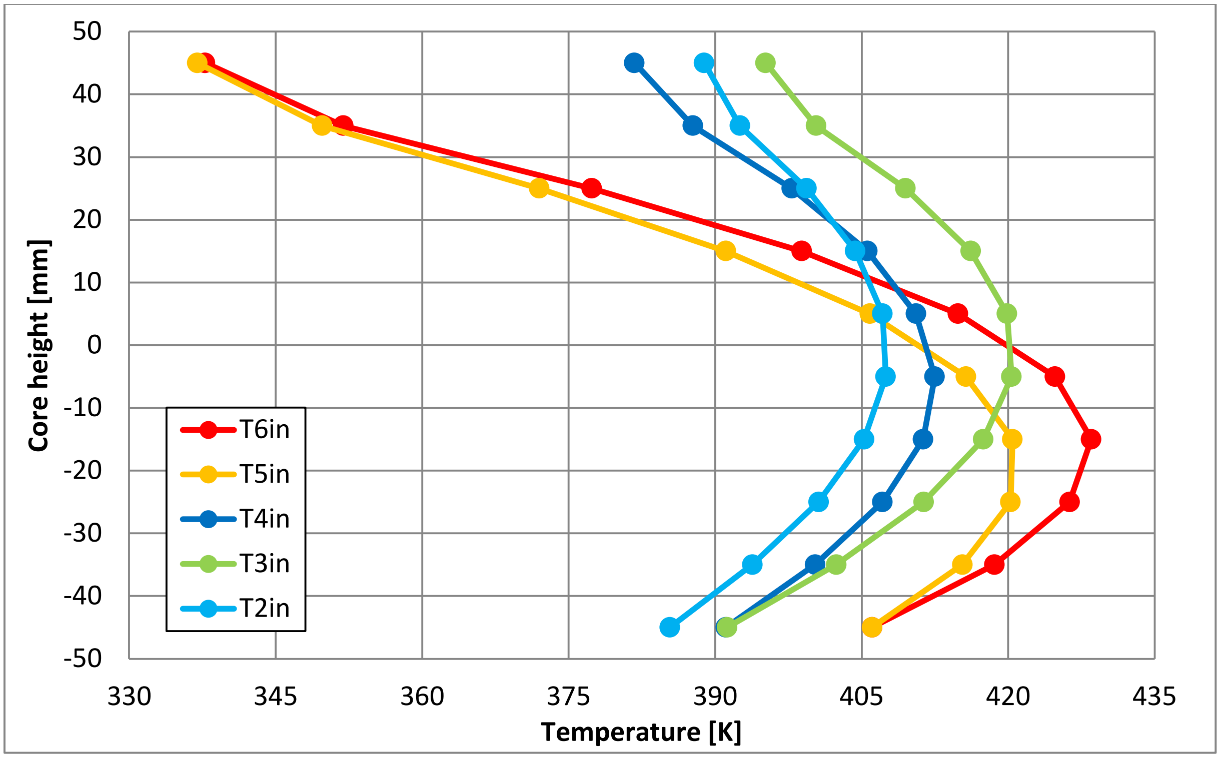

Figure 8. Temperature distribution on ICEP of each fuel pipe

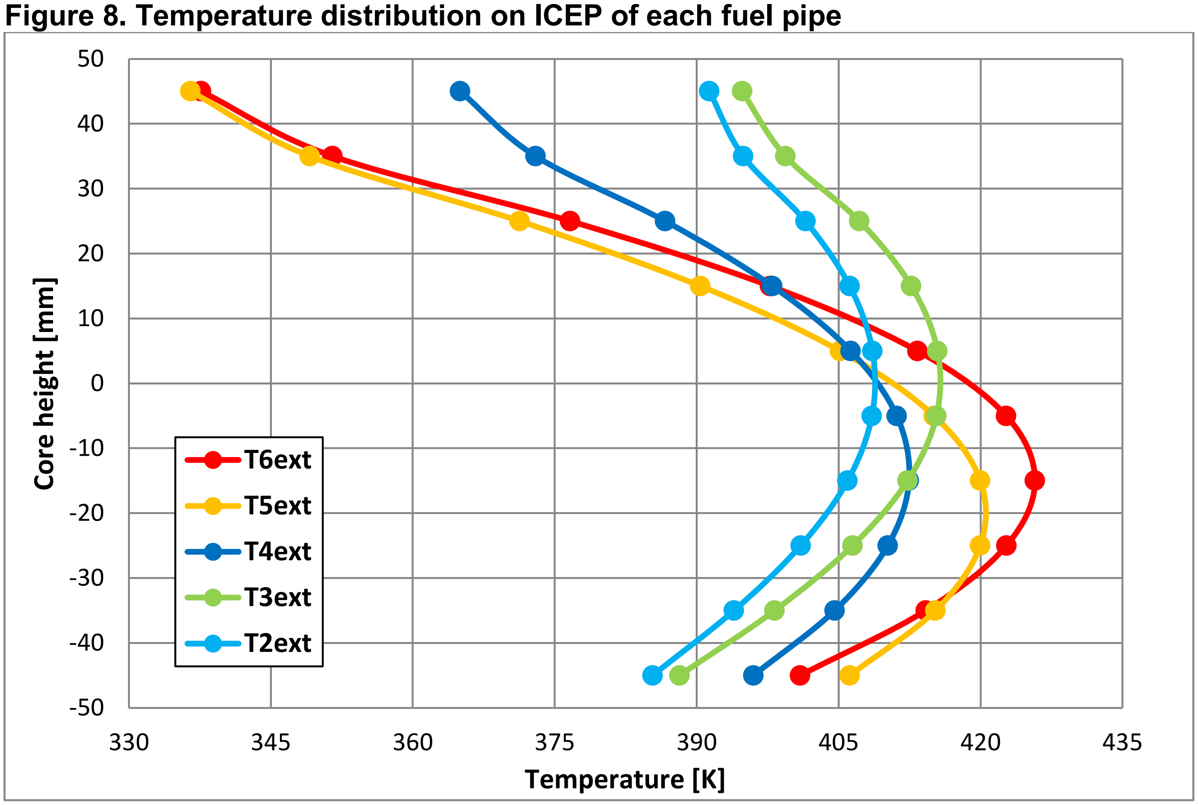

Figure 9. Temperature distribution on ECEP of each fuel pipe

Temperature distribution of water between pipes in gaps as below:

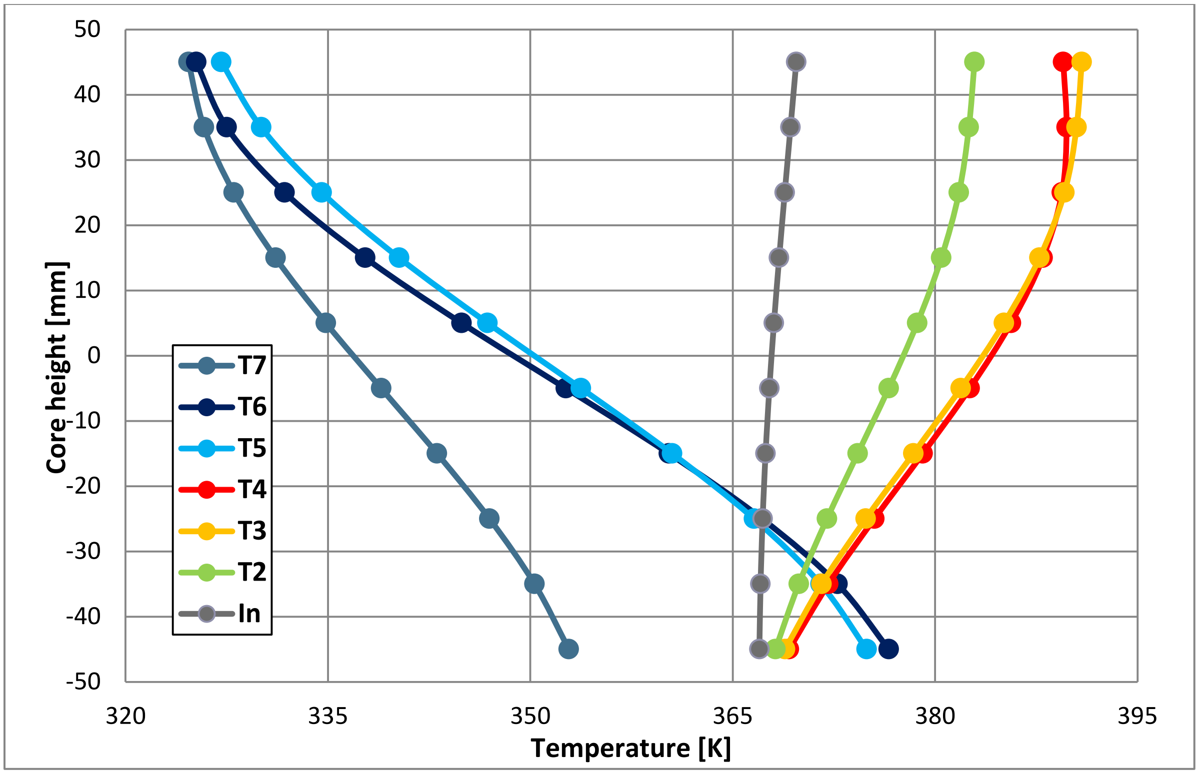

Figure 10. Water temperature distribution in gaps between fuel pipes. In – filler gap

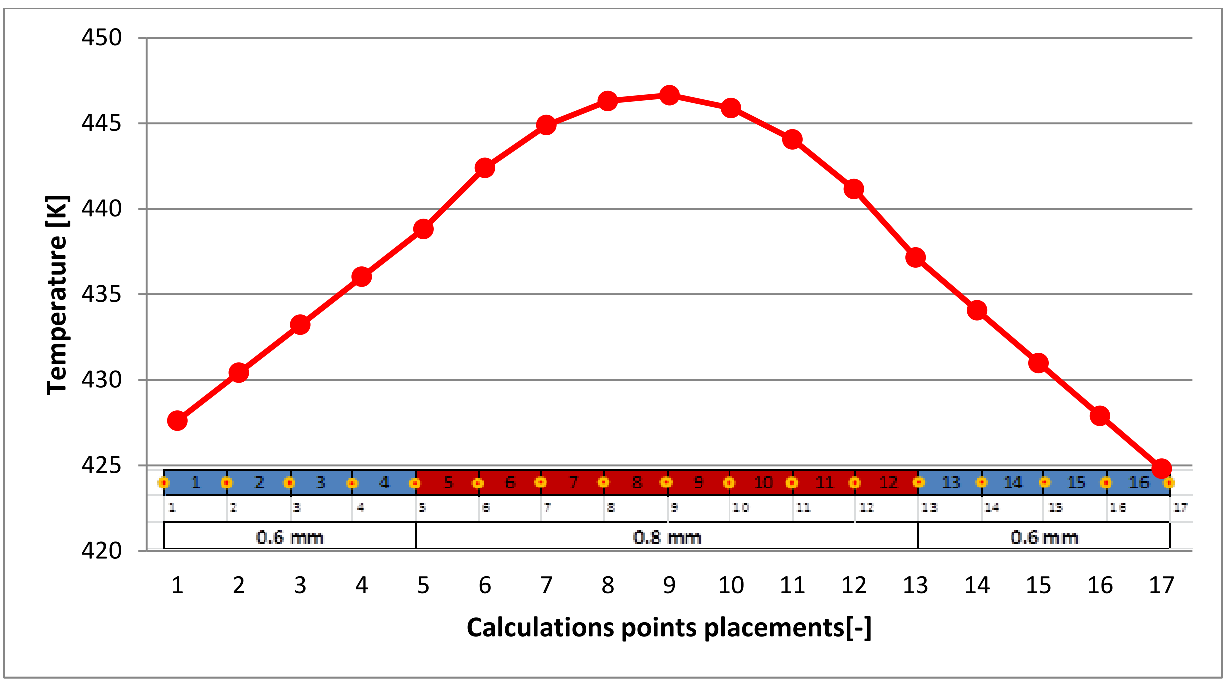

Figure 11. Maximum temperature axial distribution in fuel pipe no. 6. Yellow dots – calculation points in fuel pipe, red – fuel, blue – cladding

Heat flux distribution on outer side of fuel pipes

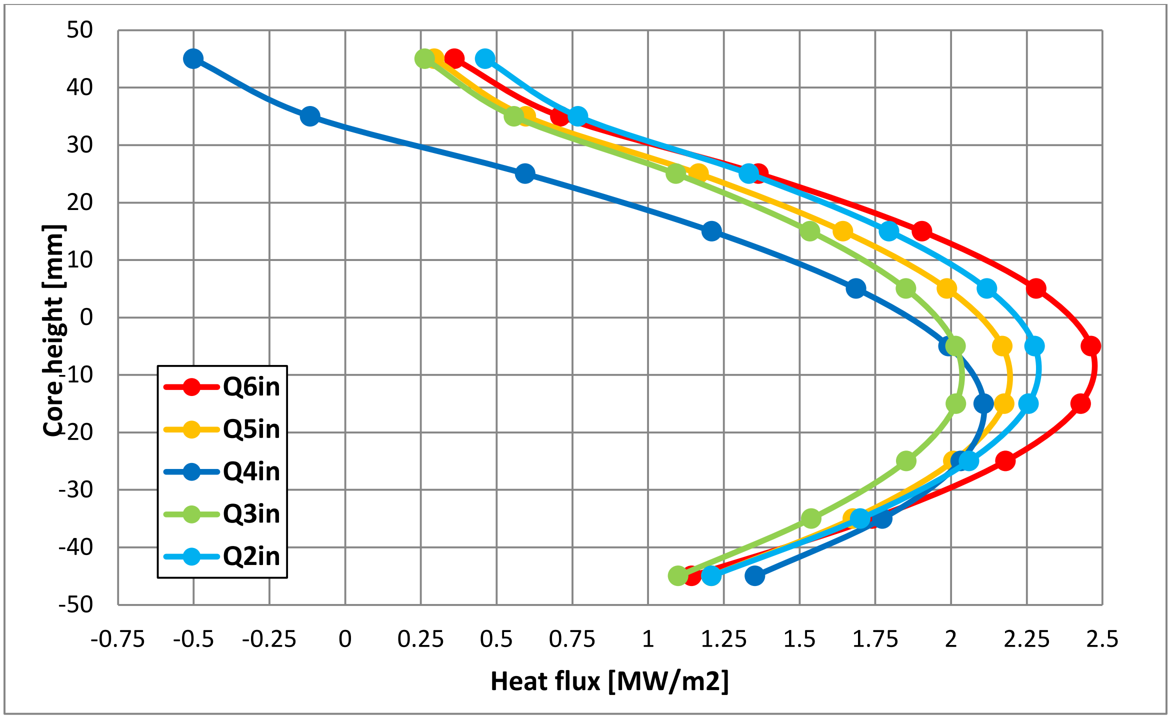

Figure 12. Heat flux distribution on inner side of fuel pipes.

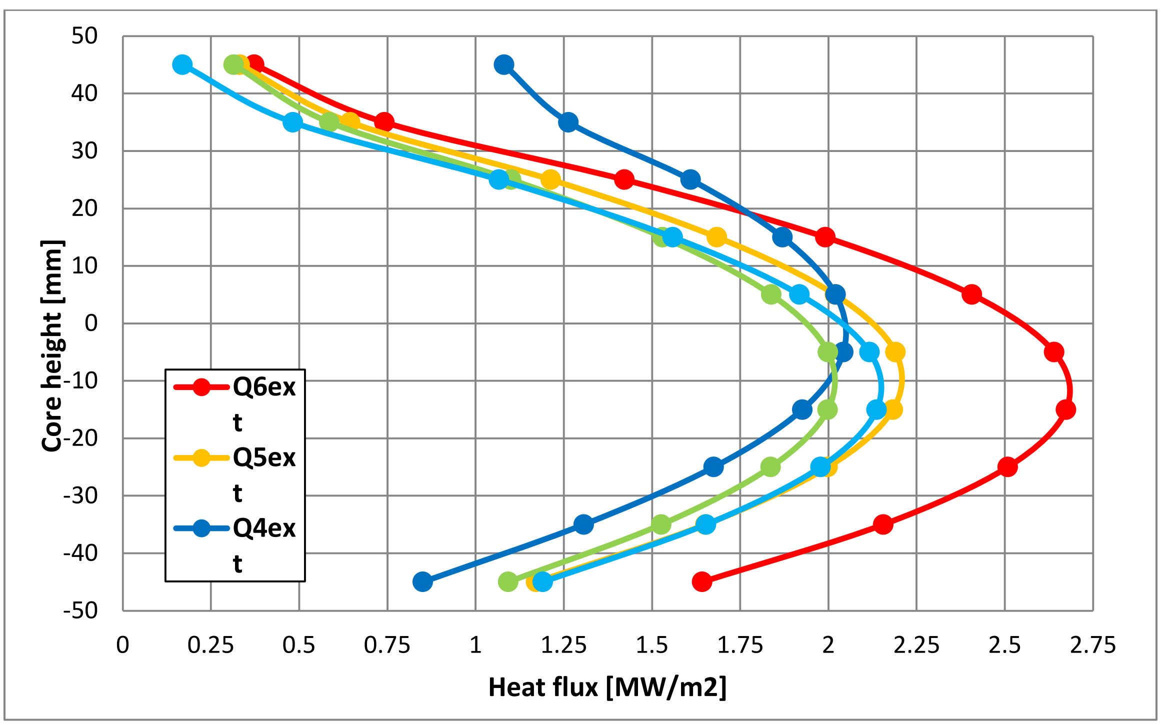

Figure 13. Heat flux distribution on outer side of fuel pipes

Comparison of results

A comparison of two calculations is presented in Table 2. The main results of the RELAP5 calculations with inlet temperature Tin=318.15K presented in the chapter above are compared with the results received using the SN code. Additionally one more calculation using RELAP5 was performed for the same conditions except for the inlet temperature which was changed to Tin=323.15K

Table 2. Comparison of results for two scenarios

	RELAP5	RELAP5 (T_{in}=323.1K)	SN
Maximum peak clad temperature on ECIP of fuel pipe [K]	427.6	431.0	425.6
Maximum peak coolant temperature [K]	390.9	396.2	no data
Maximum heat flux [MW/m^2]	2.67	2.68	2.63
Maximum temperature in the fuel centre point [K]	446.6	450.0	no data

4.2 LOFA - Loss of flow in the fuel channel cooling system

Accident conditions

Loss of flow in the fuel channel cooling system is possible in case of the loss of power in the pump system. As a result a sudden decrease of pressure occurs in the cooling channel that leads to the initiation of the emergency signal and shutdown of the reactor. Furthermore, after the loss of flow a rapid increase of fuel clad temperature and cooling temperature in gaps between fuel pipes occurs. According to the scenario a few seconds after the loss of power in the pump system, the work of a backup pump should be initiated with the power supply from accumulator batteries and with lower speed – 1500 r/s. After the reactor shutdown and before the flow is stabilized another small temperature jump can be detected.

Initial and boundary conditions:

Initial conditions:

- Cooling channel Inlet water temperature Tin=318.15K
- Mass flow Q=8.25kg/s (30m^3/h for density of water:990kg/m^3)
- Pressure at the fuel channel inlet pin=1.7MPa
- Fuel channel pressure drop Δp=0.59MPa
- Fuel element thermal power 1.8MW

Boundary conditions:

- Alarm signal – signal from decrease pressure to 1.4MPa
- Signal delay time t1=0.2s
- Effective time of safety and control rods insertion t2=0.15s
- Inserted negative reactivity (from rods PK and PB) ϱ=-5.5$ (-2$ PK, -3.5$ PB – with the

assumption that the rod with the highest weight failed)

- Loos of flow modelled as in the Supplement[3]
- Temperature reactivity coefficients: αf=-0.25¢/deg, αw=-2.02¢/deg

Results

The sequence of events:

Table 3. Sequence of events for LOFA

Time [s]	
0.00	Pump trip, loos of flow
0.40	Alarm signal p=1.4Mpa
0.75	Beginning of the negative reactivity insertion from PK and PB
0.78	Peak Clad Temperature on ICIP of fuel pipe nr 6 - 440.38 K
0.79	Peak Clad Temperature on ECIP of fuel pipe nr 6 - 432.07 K
0.89	Peak Coolant Temperature in the gap between fuel pipe nr 3 and nr 4 – 394.07 K
6.32	Second Peak Clad Temperature on ECIP of fuel pipe nr 6 with 2 cooling pumps – 381.56 K
13.90	Second Peak Clad Temperature on ECIP of fuel pipe nr 6 with 1 cooling pump – 399 K

Table 4. Distribution of calculated top temperatures on fuel pipes

Pipe nr	2		3		4		5		6	
RELAP5 component	160		155		150		130		125	
Side of pipe	In.	Out.	In.	Out.	In.	Out.	In.	Out.	In.	Out.
Max. temperature on the outer layer of clad	413	415	413	413	416	418	426	426	**432**	430
Max. temperature on the inner layer of clad	421	422	420	420	423	424	433	433	**440**	439

3 *Aneks 2012/1 do Eksploatacyjnego Raportu Bezpieczeństwa Reaktora MARIA Konwersja rdzenia reaktora MARIA na paliwo MC, July 2012.*

Comparison of results

Clad temperature

The highest outer clad temperature calculated with the SN code was 433.4K, and temperature calculated with RELAP5 code was 432K (outer layer temperature – 440K). Both codes calculated the highest temperature in the same place – on the internal side of pipe no 6.

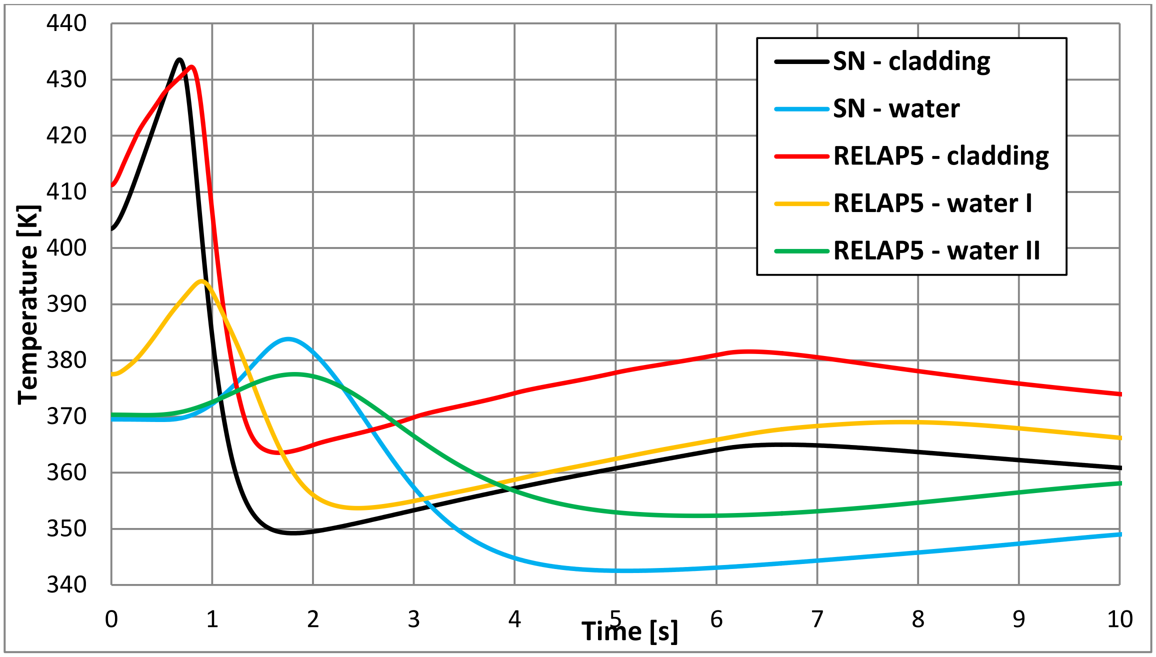

Figure 14. Cladding and water temperature changes. SN code: water and fuel element outlet temperature, RELAP5: water I – fuel element outlet temperature, water II - fuel channel outlet temperature

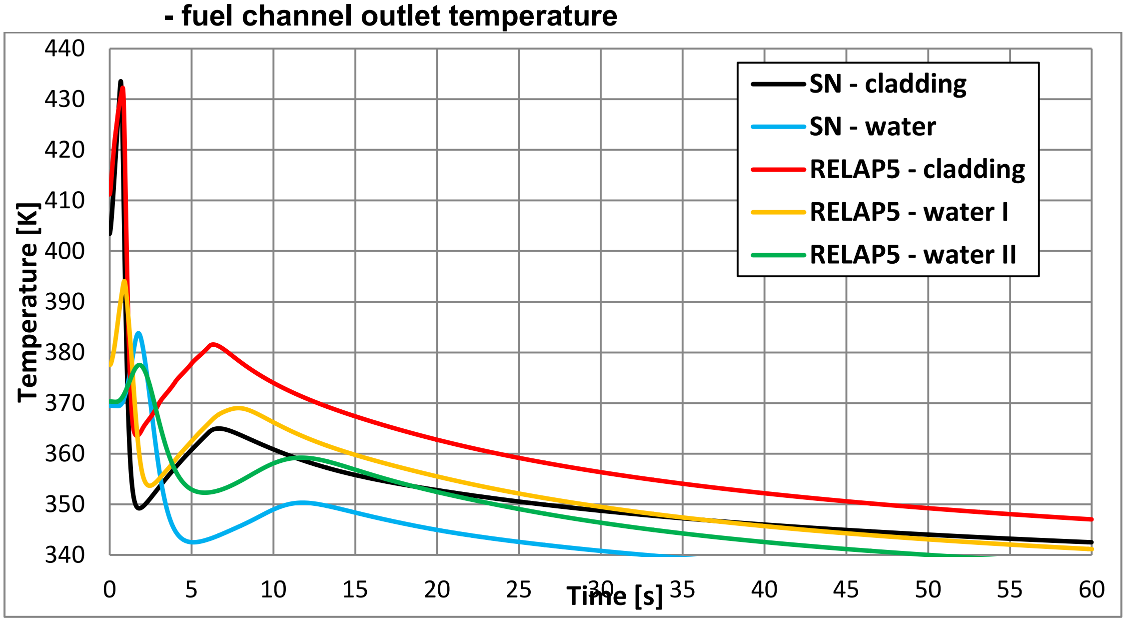

Figure 15. Cladding and water temperature changes. SN code: water and fuel element outlet temperature, RELAP5: water I – fuel element outlet temperature, water II - fuel channel outlet temperature. Wider scale range.

ONBR[4] parameter

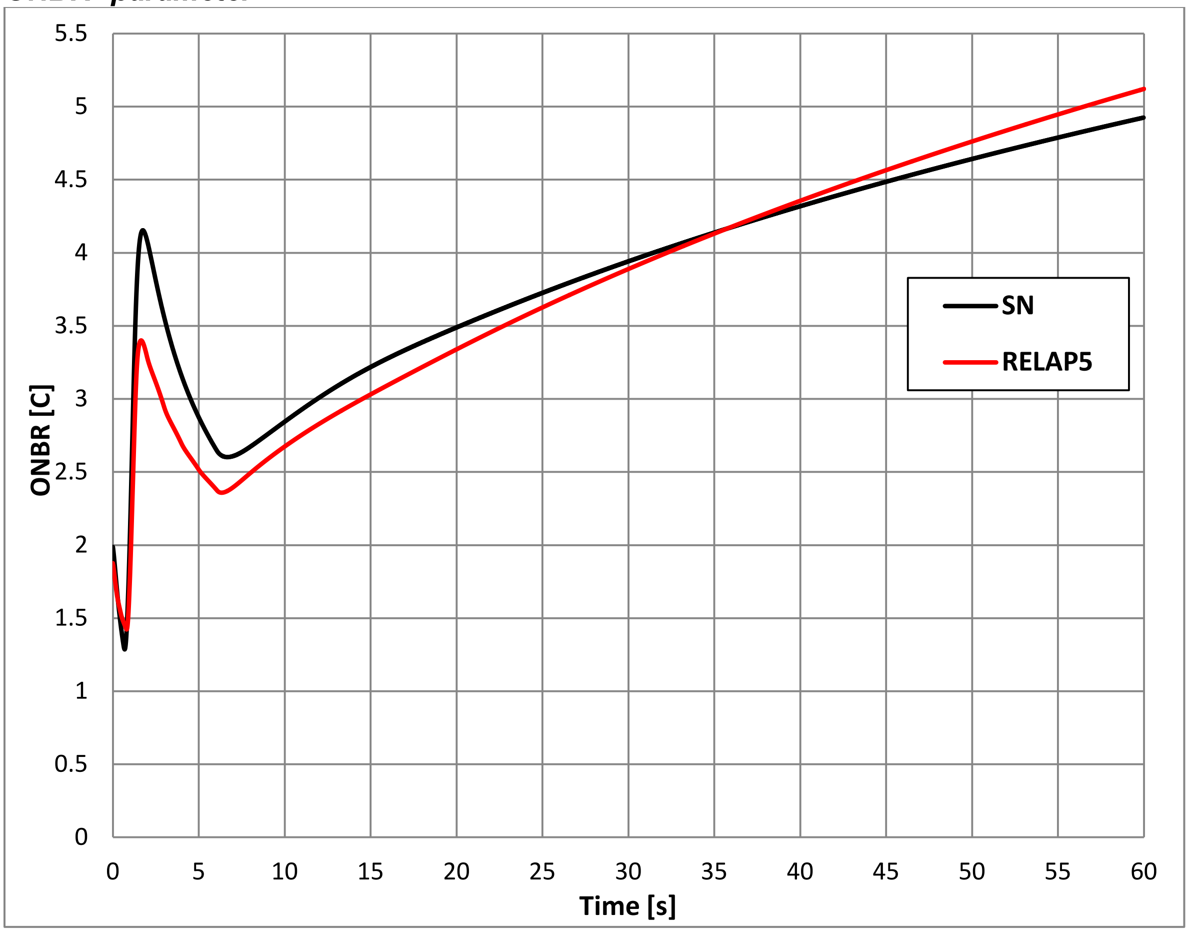

Figure 16. ONBR parameter changes

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4 **ONBR** (**O**nset of **N**uclear **B**oiling **R**atio) should be greater than 1.2, where:

$ONBR=(T_{ONB}-T_{in})/(T_{wall}-T_{in})$

$T_{ONB}=T_{sat}+0.182*q^{0.35}/p^{0.23}$ (Forester-Greif correlations)

T_{in} - inlet coolant temperature,

T_{wall} - the clad surface temperature,

T_{sat} - saturation coolant temperature,

q - heat flux [W/m^2],

p - pressure [bar].

Second clad temperature maximum (depending on the number of cooling pumps)

Table 5. Comparison of results for second temperature peak

Parameter	SN		RELAP5	
	1 pump	2 pumps	1 pump	2 pumps
Maximum outer temperature of clad [K]	**387.25**	364.98	**399.0**	381.56
Minimum ONBR	1.74	2.60	1.84	2.34

Differences in results

Differences in the results calculated by RELAP5 and the SN code arose due to many factors and not necessarily related only to nodalization. One of the factors - is a different flow model. In case of the SN code a more pessimistic method was used – coolant flow from fuel channel occurs at the same time in all gaps between fuel pipes. In case of RELAP5 a more realistic model was used. The water first flows down into the three gaps then gets mixed and next fills the rest of the gaps between the fuel pipes. The second example of differences is another model of decay heat. In case of RELAP5 decay heat was calculated by the code from kinetics and time of operation, whereas in the case of the SN code - decay heat was calculated on the basis of the old type of fuel measurements.

4.3 Slow reactivity insertion accident on low power level

Accident conditions

In case when the operator undertakes incorrect actions or a malfunction of the reactivity regulation system occurs, it is possible that as a result, positive reactivity is inserted into the core with the maximum reactivity speed 0.04$/s. This scenario was checked for low power level conditions.

Initial conditions:

- Cooling channel Inlet water temperature Tin=313.15K
- Mass flow Q=8.268kg/s (30m^3/h for density of water: 992.2kg/m^3)
- Pressure at the fuel channel inlet pin=1.7MPa
- Fuel channel pressure drop Δp=0.59MPa
- Fuel element thermal power 10kW

Boundary conditions:

- Alarm signal – signal from increase of power to 480% - in this case to 48kW
- Signal delay time t1=0.2s
- Effective time of safety and control rods insertion t2=0.15s
- Insertion positive reactivity from accident t=0s ϱ=0.04$/s, ϱmax=1.5$

- Inserted negative reactivity (from rods PK and PB)ϱ=-5.5$ (-2$ PK, -3.5$ PB)
- Temperature reactivity coefficients: αf=-0.23¢/deg, αw=-1.93¢/deg

Comparison of results

Table 6. Comparison of results for SRIA on low power level

Sequence of events	SN		RELAP5	
	Time [s]	Value	Time [s]	Value
Start of positive reactivity insertion	0.0	-	0.0	-
Alarm signal 480% of power	12.3	-	12.48	-
Start of negative reactivity insertion	no data	-	12.83	-
Maximum power	12.7	53kW	12.83	52.7kW
Maximum peak cladding temperature on ECIP of fuel pipe nr 6	no data	316.15K	12.85	316.14K
Maximum peak cladding temperature on ICIP of fuel pipe nr 6	no data	no data	12.85	316.44K
Minimum ONBR	no data	about 50	12.85	53.8
Maximum peak coolant temperature in gap nr 3 between fuel pipe nr 3 and 4	no data	no data	12.9	314.72K

This scenario has the lowest impact on the fuel elements. The temperature peaks of water and clad are very small - smaller than fluctuations of temperature during normal operation of the reactor.

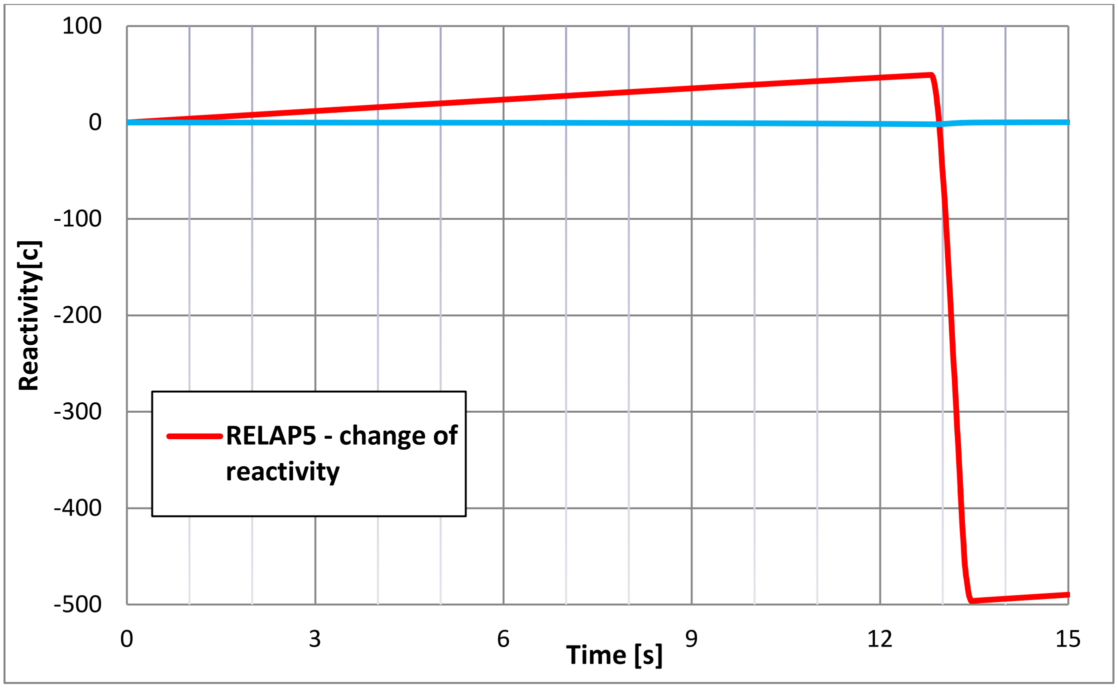

Figure 17. Reactivity changes. RELAP5: total reactivity change; water and fuel: reactivity change due to coolant and fuel temperature reactivity coefficients

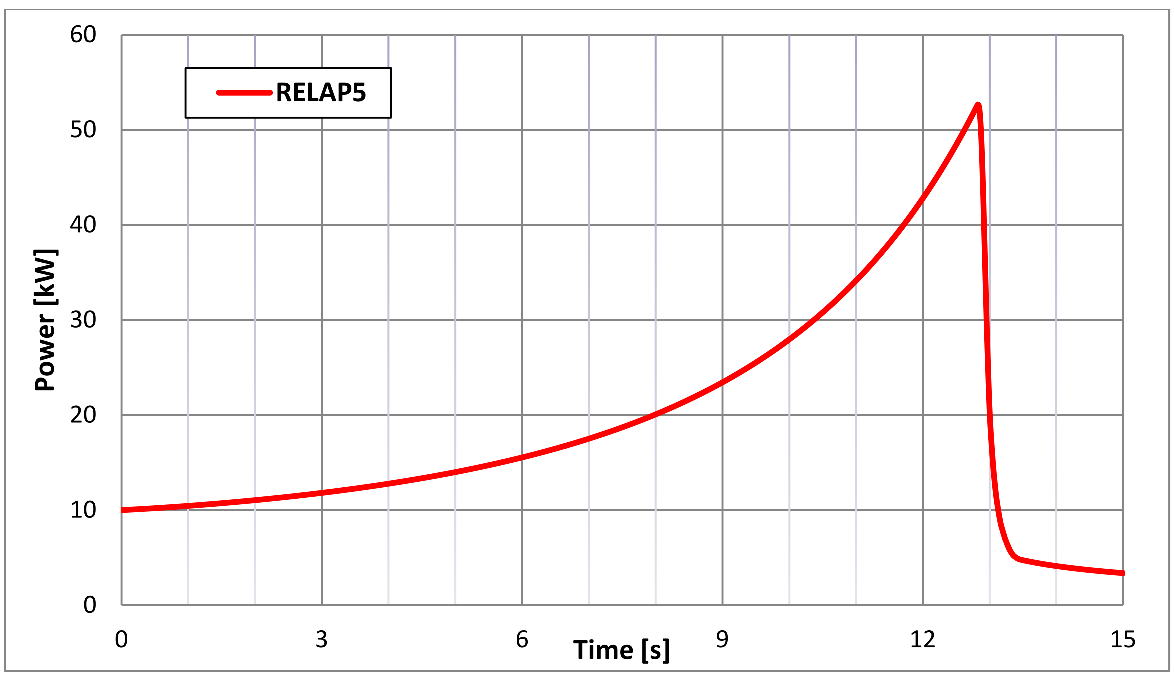

Figure 18. Power changes of fuel element for SRIA on low power level

4.4 Fast reactivity insertion accident on low power level

One of the important scenarios addressed in the supplementary document is the fast inflow of cold water into the core resulting in a sudden increase of reactivity. The negative reactivity coefficients lead to the increase of power in the fuel elements. The cold water is directed first between the first three pipes – pipes no. 4, 5, 6 on Figure 2 and after about 0.2s into the rest of the gaps.

Accident conditions

Initial conditions:

- Cooling channel Inlet water temperature Tin=323.15K, after 1s insertion of cold water T2in=283.15K
- Mass flow Q=8.268kg/s (30m^3/h for density of water: 992.2kg/m^3) T2in=283.15K.
- Pressure at the fuel channel inlet pin=1.7MPa
- Fuel channel pressure drop Δp=0.59MPa
- Fuel element thermal power 10kW

Boundary conditions:

- Alarm signal – increase of power to 480% - in this case to 48kW
- Signal delay time t1=0.2s
- Effective time of safety and control rods insertion t2=0.15s
- Insertion of positive reactivity from accident t=0s ϱ=0.04$/s, ϱmax=1.5$
- Insertion of negative reactivity (from rods PK and PB) ϱ=-5.5$ (-2$ PK, -3.5$ PB)
- Temperature reactivity coefficients: αf=-0.23¢/deg, αw=-1.93¢/deg

Comparison of results

Table 7. Comparison of results for FRIA on low power level

Sequence of events:	SN		RELAP5	
	Time [s]	Value	Time [s]	Value
Start of insertion of cold water to the fuel channel	1.0	-	1.0	-
Minimum ONBR	no data	about 5	1.34	4.95
Cold water In fuel pipes zone	1.59	-	1.67	-
Alarm 480% of power	2.44	-	2.47	-
Start of negative reactivity insertion	2.79	-	2.82	-
Maximum power	2.83	96.3kW	2.85	80.9kW

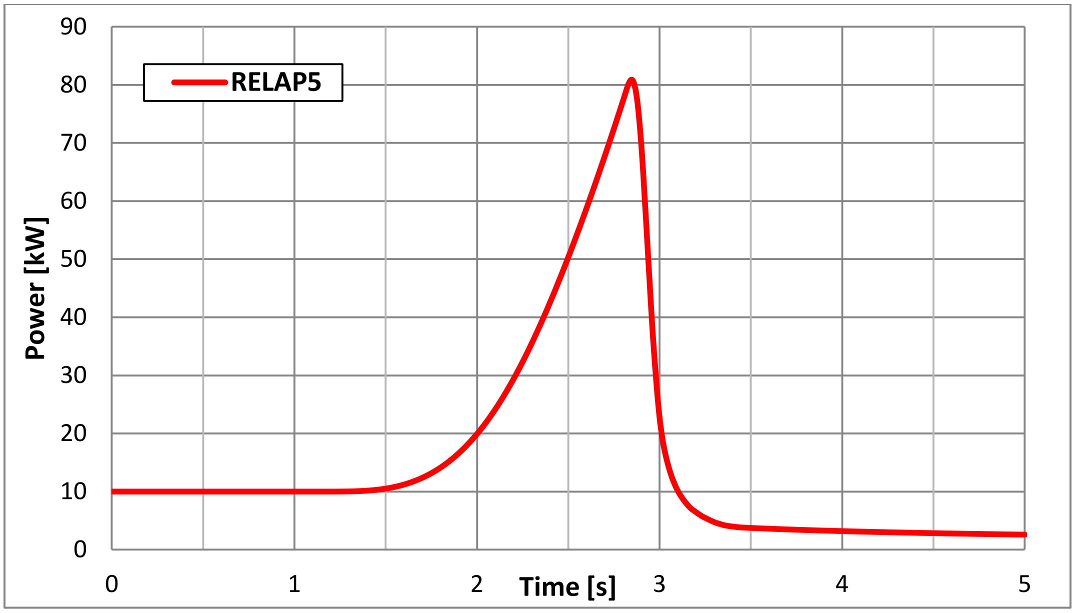

Figure 19. Power changes of fuel element for FRIA on low power level

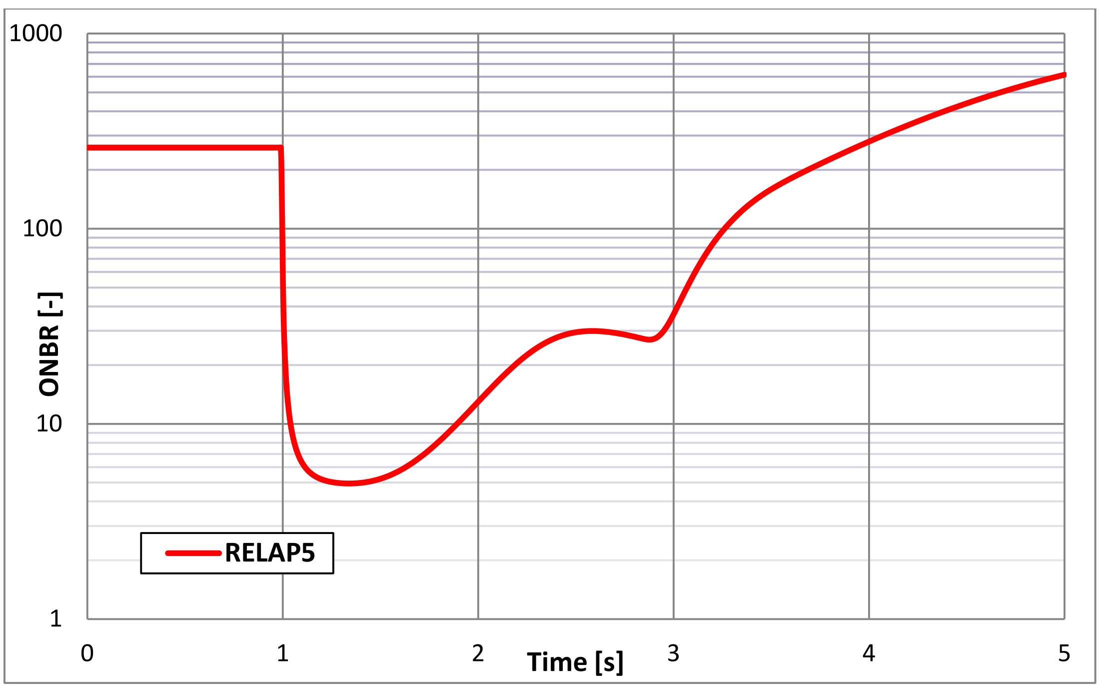

Figure 20. ONBR parameter changes

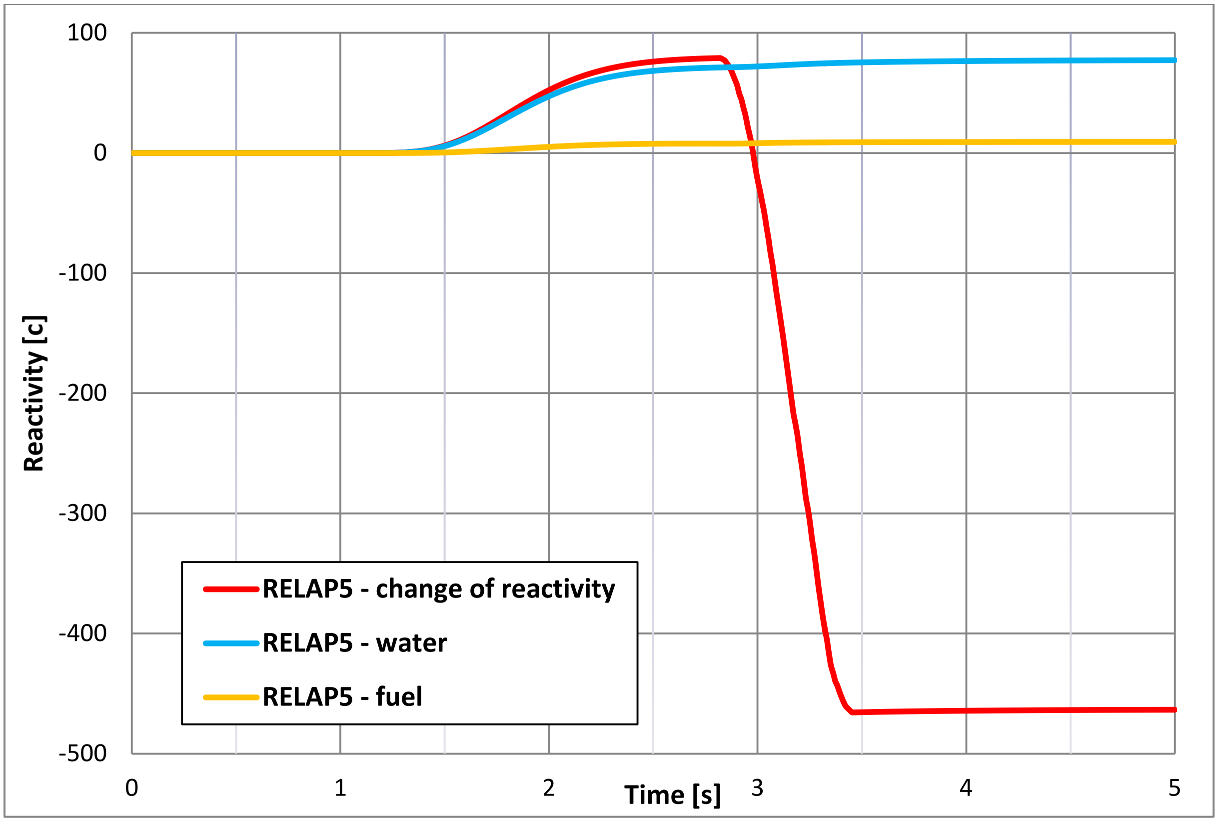

Figure 21. Reactivity changes - RELAP5 calculations: i) change of reactivity: total reactivity change, ii) water: change due to coolant temperature reactivity coefficients, iii) fuel: change due to fuel temperature reactivity coefficient

4.5 Slow reactivity insertion accident during normal operation of reactor

Accident conditions

The scenario analyzed in this transient is very similar to the slow reactivity insertion on low power. The main difference is that the reactor is in the normal operation mode, on full power, with the maximum allowed thermal power generation. In case when the operator undertakes incorrect actions or a malfunction of the reactivity regulation system occurs, it is possible that as a result, positive reactivity is inserted into the core with the maximum reactivity speed 0.04$/s.

Initial conditions:

- Cooling channel Inlet water temperature Tin=318.15K,
- Mass flow Q=8.252kg/s (30m^3/h for density of water: 990.2kg/m^3)
- Pressure at the fuel channel inlet pin=1.7MPa
- Fuel channel pressure drop Δp=0.59MPa
- Fuel element thermal power 1.8MW

Boundary conditions:

- Alarm signal – signal from increase of power to 120% - in this case to 2.16MW
- Signal delayed t1=0.2s
- Effective time of safety and control rods insertion t2=0.15s
- Insertion of positive reactivity from accident t=0s ϱ=0.04$/s, ϱmax=1.5$
- Insertion of negative reactivity (from rods PK and PB) ϱ=-5.5$ (-2$ PK, -3.5$ PB)
- Temperature reactivity coefficients: αf=-0.23¢/deg, αw=-1.93¢/deg

Comparison of results

Table 8. Comparison of results for SRIA during normal operation

Sequence of events:	SN		RELAP5	
	Time [s]	Value	Time [s]	Value
Start of insertion of positive reactivity	0.0	0.04$/s	0.0	0.04$/s
Alarm signal – power 120%	5.37	-	6.44	-
Start of insertion of negative reactivity	no data	-	6.79	-
Maximum power	5.72	2.189MW	6.80	2.183MW
Maximum peak cladding temperature on ECIP of fuel pipe nr 6	5.73	**424.86K**	6.80	**428.16K**
Maximum peak cladding temperature on ICIP of fuel pipe nr 6	no data	-	6.80	440.5K
Minimum ONBR	5.73	about 1.6	6.80	1.60
Maximum peak coolant temperature on exit from fuel element	5.77	381.29K	6.86	386K

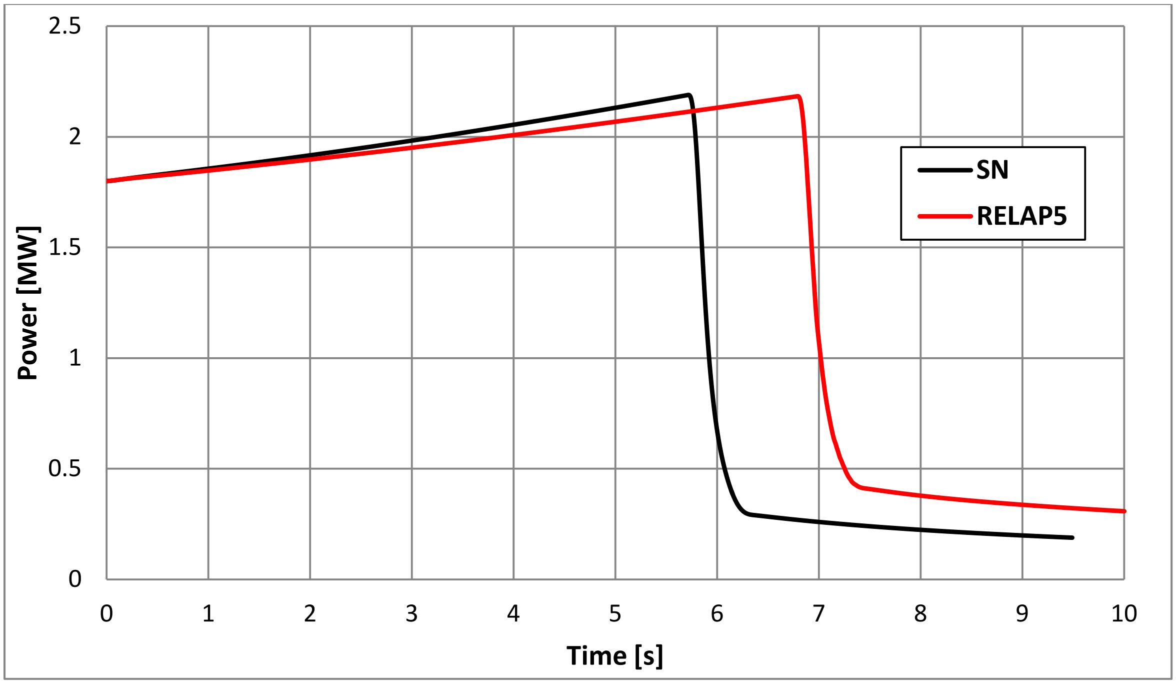

Figure 22. Power changes of fuel element for SRIA on nominal power level

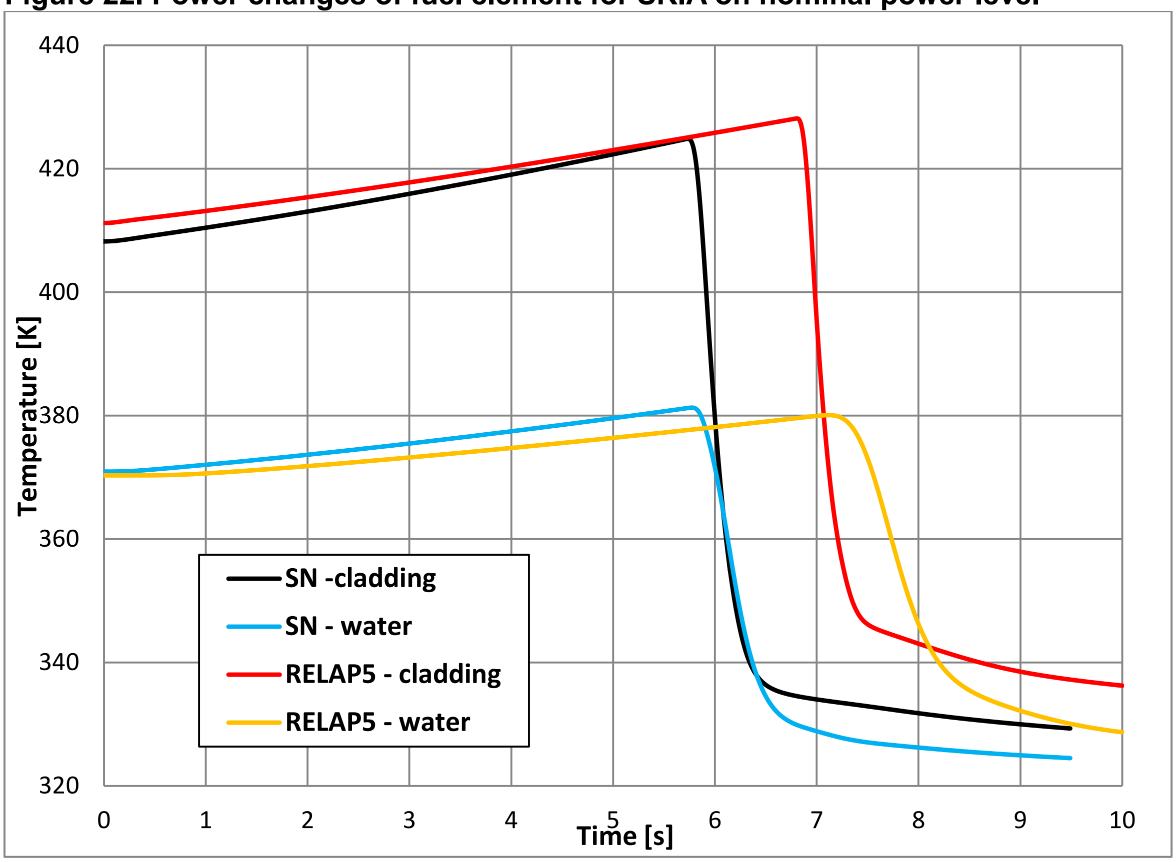

Figure 23. Cladding and water temperature changes. RELAP5 and SN codes: cladding – cladding temperature, water – fuel element outlet temperature

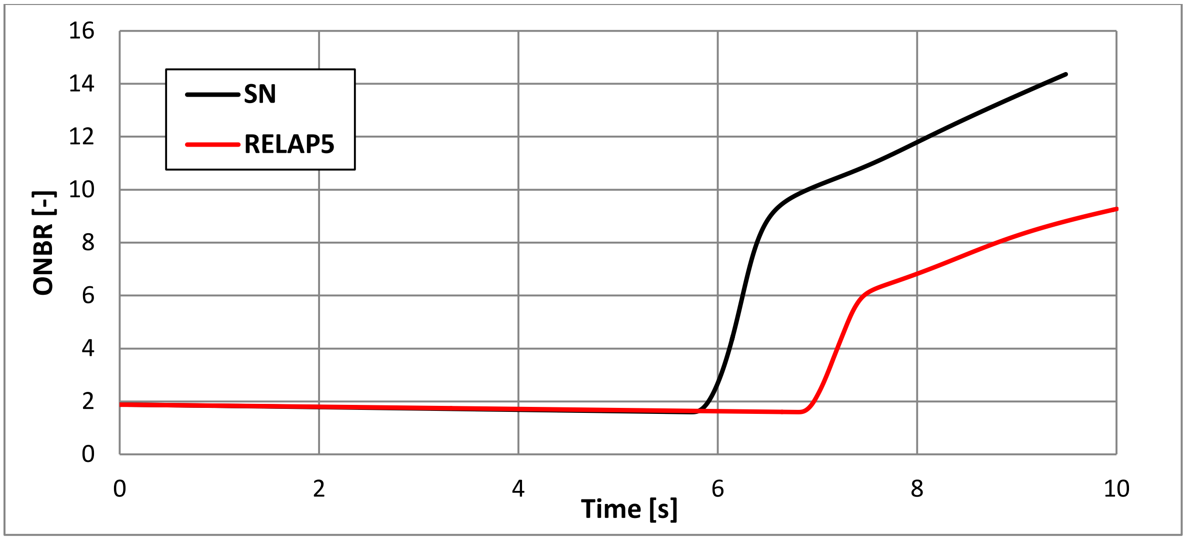

Figure 24. ONBR parameter changes

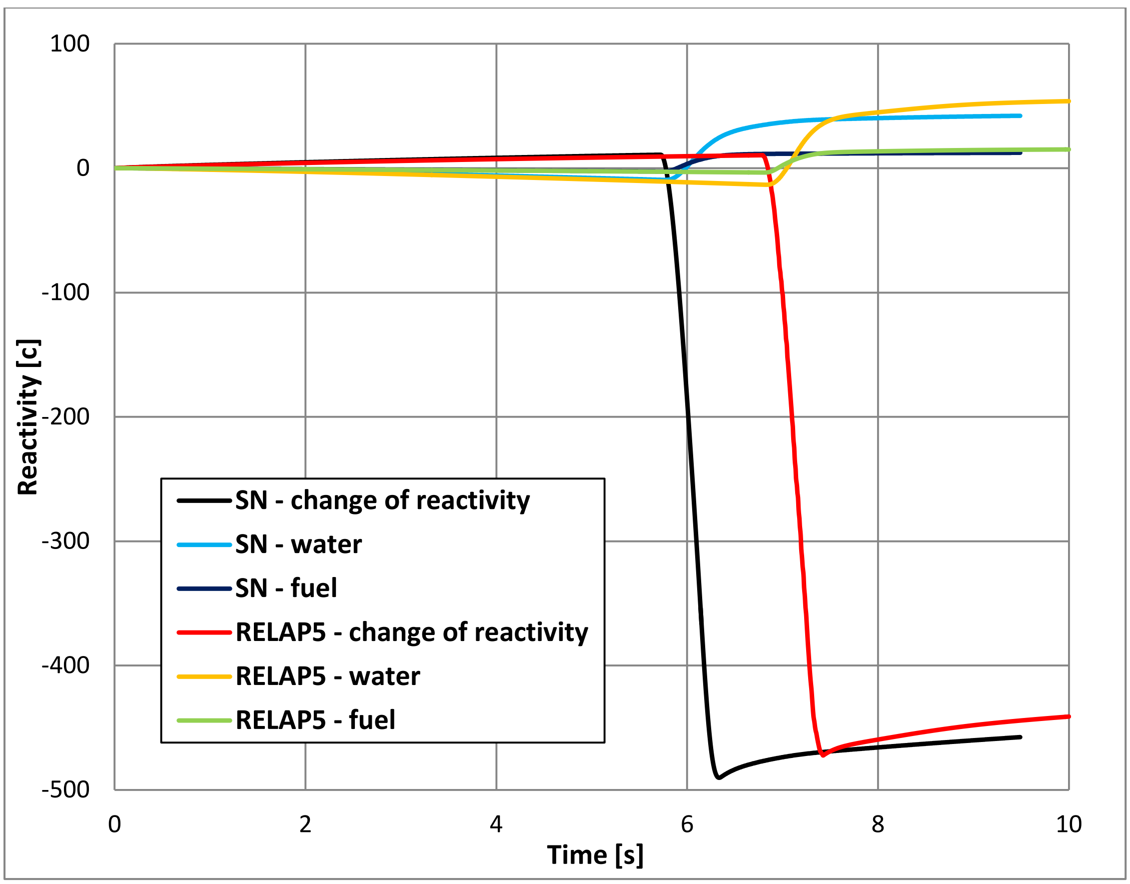

Figure 25. Reactivity changes. RELAP5 and SN codes: change of reactivity - total reactivity change, water - change due to coolant temperature reactivity coefficients, fuel - change due to fuel temperature reactivity coefficients

4.6 Fast reactivity insertion accident during reactor normal operation

Accident Conditions

A break of control rods is another scenario included in the supplementary document. The break of control rods leads to fast insertion of positive reactivity into the reactor. It is assumed that the maximum insertion of positive reactivity is equal to 1.5$ with the top speed of insertion 4$/s. Initial conditions:

- Cooling channel inlet water temperature Tin=318.15K,
- Mass flow Q=8.252kg/s (30m^3/h for density of water: 990.2kg/m^3)
- Pressure at the fuel channel inlet pin=1.7MPa
- Fuel channel pressure drop Δp=0.59MPa
- Fuel element thermal power 1.8MW

Boundary conditions:

- Alarm signal – increase of power to 120% - in this case to 2.16MW
- Signal delay time t1=0.2s
- Effective time of safety and control rods insertion t2=0.15s
- Insertion of positive reactivity from accident t=0s ϱ=0.04$/s, ϱmax=1.5$
- Insertion of negative reactivity (from rods PK and PB) ϱ=-5.5$ (-2$ PK, -3.5$ PB)
- Temperature reactivity coefficients: αf=-0.23¢/deg, αw=-1.93¢/deg

Comparison of results

Table 9. Comparison results for FRIA during normal operation

Sequence of events:	SN		RELAP5	
	Time [s]	Value	Time [s]	Value
Start of	0.0	4$/s	0.0	4$/s
Alarm signal 120%	0.08	-	0.07	-
Maximum thermal power	0.40	8.6MW	0.38	5.62MW
Maximum peak cladding temperature on ECIP of fuel pipe nr 6	no data	**598.88K**	0.40	**515.52K**
Maximum peak cladding temperature on ICIP of fuel pipe no. 6	no data	-	0.40	547.46K
Minimum ONBR	0.45	**0.64**	0.41	**0.928**
Start of insertion of negative reactivity	0.44	-	0.42	-
Max. peak coolant temperature on exit from fuel element	0.58	460.65K	0.55	448.39K

The main differences in the results between RELAP and the SN code are due to the different models of reactor kinetics. RELAP5 uses the point kinetic model and this model was applied to the RIA analysis. In the nodalization model applied, total reactivity was divided into many sections depending on the position in the fuel pipes or in the gap between pipes. The fuel reactivity coefficient was divided in 50 point, 10 points in each cell of the fuel pipe because the values of the divided fuel reactivity coefficients depend on the distribution of heat generation on fuel pipes and axial distribution of heat generation (i.e. shifted cosine model). The coolant reactivity coefficient was divided into 60 points, 10 points in each gap. The values of the divided coolant reactivity coefficient depend on the distribution of the mass flow between gaps and the distribution of heat (shifted cosine model). In case of the SN code a more pessimistic model was used.

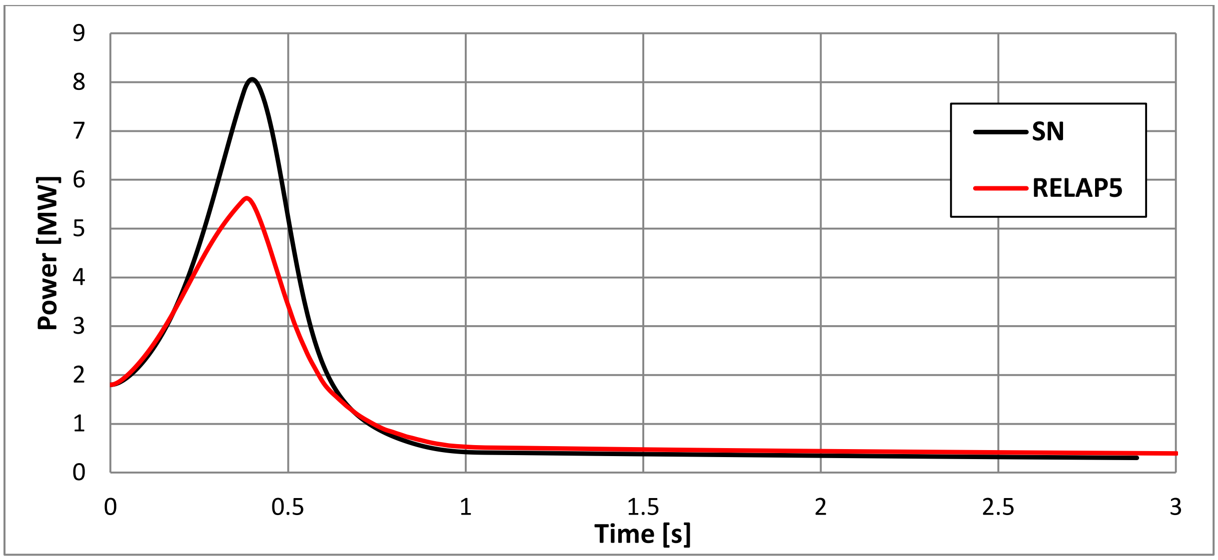

Figure 26. Power changes of fuel element for FRIA on nominal power level

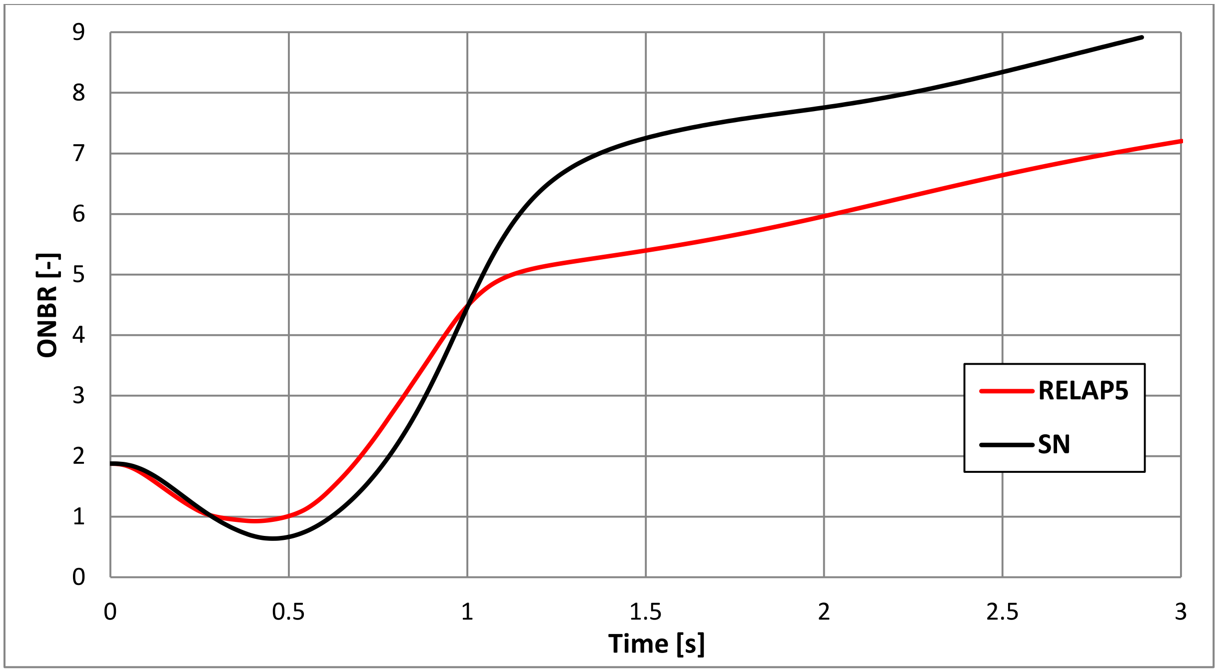

Figure 27. ONBR parameter changes

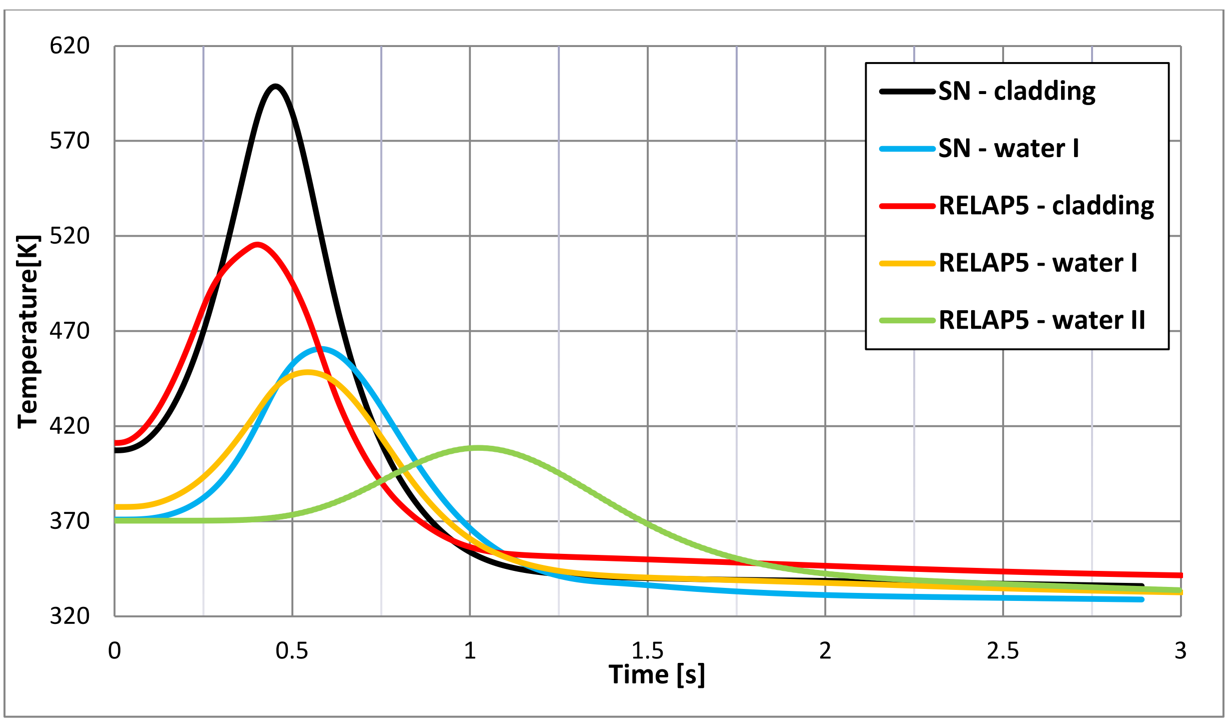

Figure 28. Cladding and water temperature changes. RELAP5 and SN codes: cladding – cladding temperature, water I – fuel element outlet temperature, water II - fuel channel outlet temperature

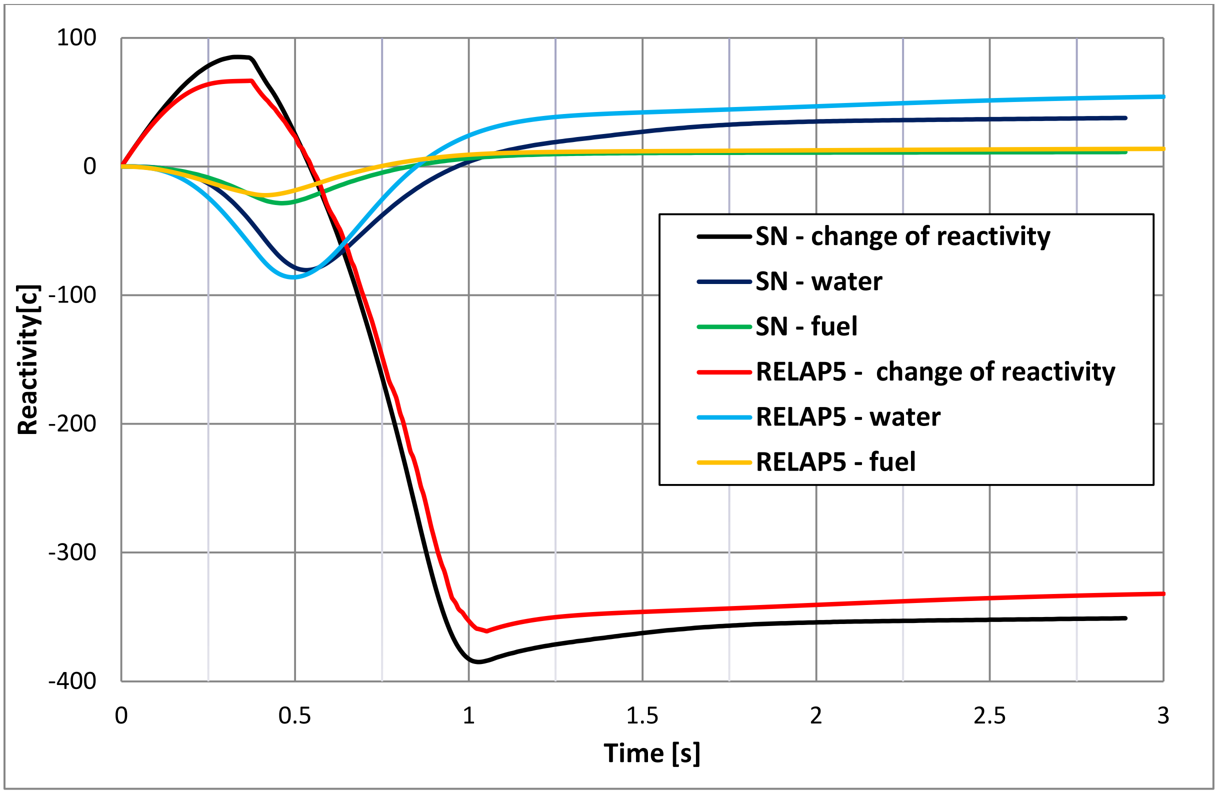

Figure 29. Reactivity changes. RELAP5 and SN codes: change of reactivity - total reactivity change, water - change due to coolant temperature reactivity coefficients, fuel - change due to fuel temperature reactivity coefficients

5 RUN STATISTICS

All analysis were performed on one computer:

Intel(R) Core(TM) i3-2125 CPU @ 3.30 GHz
RAM memory :4.00 GB
Windows 7 Professional – SP1, 64-bit version
IFC (Intel Fortran Compiler) for RELAP5

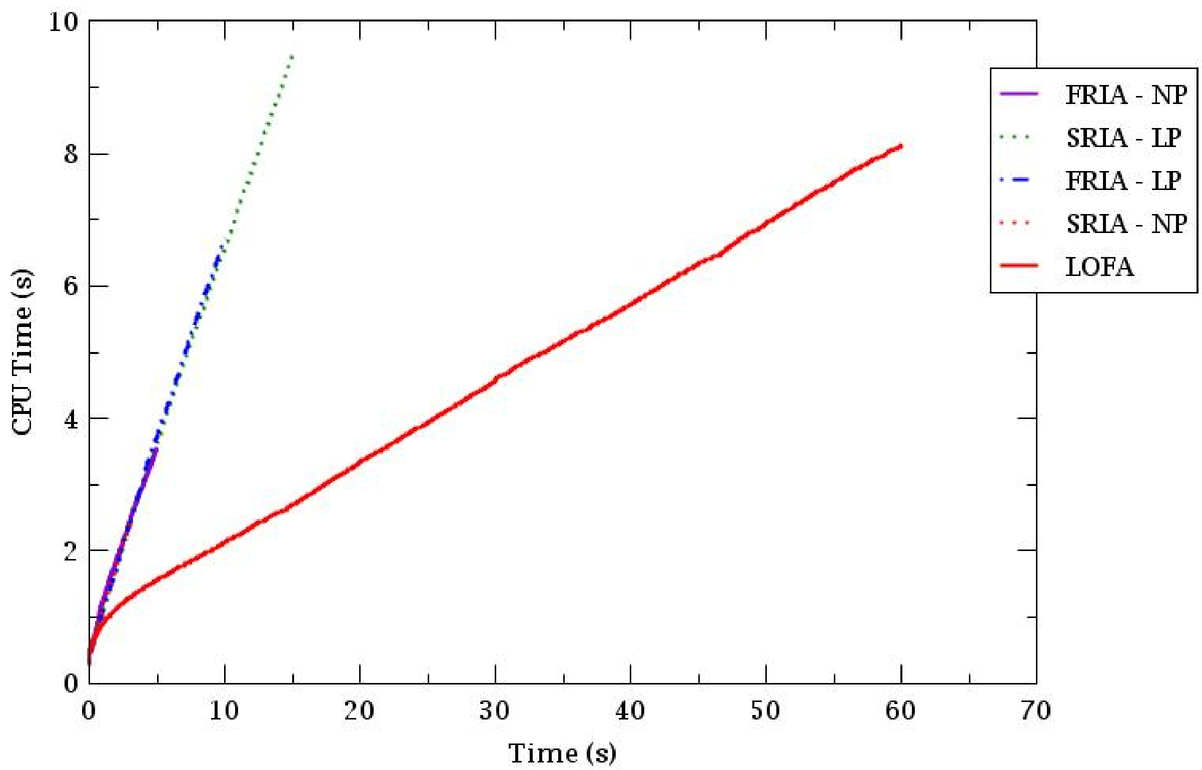

Figure 30. Calculation time for various cases

6 CONCLUSIONS

Most of the results of the simulation for the research reactor MARIA made with RELAP5 code showed that there is no big difference between the results achieved by the validated SN and the RELAP5 codes. Only in one case (RIA with fast reactivity insertion with maximum power level) there is the opportunity to exceed the lowest allowed level of the ONBR parameter. Exceeding this parameter can cause the onset of boiling of the coolant in the gap between the fuel pipes. In the analysed case, the duration of time when ONBR is lower than 1.2 is very short (about 0.35s) and should not cause any damage to the fuel and clad material. In the fast RIA scenario, the power jump during the insertion of positive reactivity was stopped by the negative reactivity coefficients (fuel and coolant) before insertion of the safety and control rods into the core could be initiated.

In other simulated scenarios, no opportunity to exceed the ONBR parameter or temperature limit of clad – 452K occurred.

In the analysed LOFA scenario, the calculations showed that enough cooling capability is provided even when only one pump is working with a lower rotation speed than the normally required two pumps.

The content of this report does not cover all possible accident conditions that should be analysed for the research reactor. Further analysis will be necessary. A comparison of the SN and RELAP5 codes showed that RELAP5 can be used in the safety analysis for the research reactor MARIA.

7 REFERENCES

1. “Aneks 2009/1 do Eksploatacyjnego Raportu Bezpieczeństwa Reaktora MARIA Badania paliwa MC”, 2009 (in Polish).
2. “Aneks 2012/1 do Eksploatacyjnego Raportu Bezpieczeństwa Reaktora MARIA Konwersja rdzenia reaktora MARIA na paliwo MC”, July 2012 (in Polish).
3. (SAR) “Eksploatacyjny Raport Bezpieczeństwa Reaktora MARIA”, 2009 (in Polish).

APPENDIX A – TECHNICAL INFORMATION ON THE RESEARCH REACTOR MARIA

The research reactor 'Maria' was designed by the Institute for Nuclear Studies in Poland and is operated by the National Centre for Nuclear Research that was created on the basis of two older Institutes. The reactor started to work in 1974 and is under operation till now except for the period of 1986 to 1991 when it was undergoing modernization.

It is a pool type reactor with closed fuel channels and closed fuel channel primary cooling circuit, primary pool cooling circuit and secondary cooling circuit. The fuel channel cooling circuit includes also a pressurizer.

At present the reactor is used for the production of isotopes and for performing experiments. The total thermal power is 30 MW. More data that might be of interest is presented below.

Thermo-hydraulic parameters	During a typical cycle of work: Thermal power of a fuel channel: 15-19 MW(th) for 19-23 fuel channels, Inlet temperature to fuel channels: 303-323 K, Temperature increase in the core: 20-30 deg, Hot leg pressure (in outlet collector): about 0.9-1 MPa, Cold leg pressure (in inlet collector): about 1.7-1.8 MPa, Minimum flow in fuel channels 30 m^3/h for channels with maximum thermal power 1.8 MW, Minimum flow is 15 m^3/h for channels with 0.9 MW (in peripheral core position).
Pressurizer	Filled with water and helium gas under high pressure At pressure about 1.7 MPa maintains sufficient water inventory in the circuit.
Safety signals causing reactor scram	1) Decrease of mass flow in the fuel channel in the channel cooling circuit. Each fuel channel is equipped with temperature and mass flow measurements (it is important for calculating the thermal power of the element), a small value of the mass flow in the channel will generate a "low mass flow" signal i.e. a warning signal when the flow drops to 90% of nominal mass flow and an alarm when the flow drops to 80% of nominal mass flow. 2) Kinetics control system. In case of sudden power jump signal is generated through detectors and other systems. It's warning signal when is 110% of nominal reactor power, and alarm signal in case of 120% of nominal power. Additional safety signal for fast reactivity jump it is

	alarm signal from increase of period of the reactor.
Reactivity coefficients	Fuel reactivity coefficient (negative) -0.23¢/deg to -0.25¢/deg Coolant reactivity coefficient in the fuel channel (negative) -1.93¢/deg to -2.09¢/deg Coolant reactivity coefficient of the pool plus moderator reactivity coefficient (positive) +1.9¢/deg Void reactivity coefficient (negative) -9.37 ¢/% of void to -9.71¢/% of void Values of coefficients depend on the beginning or end of the fuel cycle and number of molybdenum channels in the core (none, one or two molybdenum channels).
Control system	The reactor power is controlled through changes of position of the control rods and automatic or manual changes of position of the UAR. The UAR is an automatic regulation system, that through the change of position of one control rod in the reactor core controls the power level and maintains, if it's necessary, the criticality of the reactor.
Shutdown system	The shutdown system is provided through safety rods (insertion reactivity from -7.5$ to -11$ to the core) and control rods (the weights depend on the position of the rods in the core, it can be pessimistically assumed that the injection is -2.5$). Safety rods and control rods work in accordance to the fail-safe rule. In case of loss of the power supply the safety rods will be automatically released from electromagnets into the reactor core. It's also possible to remove two fuel elements from the core. This is done by moving two fuel type elements (REP). This action is slower than the movement of safety rods. Sometimes it's impossible to remove the REP because of temperature stress until several hours after reactor shutdown. The reactivity of two REPs is about 4.2+/-0.5$. The shutdown system does not depend on the boron injection system.
Emergency core cooling system	In case of low water level in the pressurizer, an additional pump (1u6) that is connected to the pressurizer is automatically switched on and pumps water from the tank system (water volume 20-30m^3) into the pressurizer. The solution is good only in case of a small leakage from the channel cooling circuit. The gas discharge system from the pressurizer. In case of very low water level in the pressurizer a discharge of helium

	into the tank system through a system of valves will take place. This will result in a sudden depressurization of the channel cooling circuit. The safety vales 1z100A/B. In case of depressurization the valves automatically open and connect the channel cooling circuit with pool of the reactor (due to the pressure difference between two circuits).
Fuelling	Fuelling is performed when necessary depending on the reactivity supply, however always before a new work cycle. Refuelling, minimum 48 hours after a previous cycle, includes also a possibility of adding fuel elements removed after earlier cycles.
Cooling system	Fuel cooling channels are cooled by two from four pumps. After shut-down is done by two from the four mentioned pumps but with rotation speed changed from 3000r/s to 1500r/s. Hot water from the core passes through the heat exchangers system (four from six) transferring heat to the secondary circuit. The pool is individually cooled by three from four pumps and in shutdown mode - by one from two shutdown pumps. There is one secondary cooling circuit for the fuel cooling circuit and the pool cooling circuit. It pumps water to the outer cooling tower with ventilators. During normal operation two from three pumps and after shutdown one from three shutdown pumps are in operation. During loss of external power after a rapid shutdown, in order to remove decay heat, about 4 hours of cooling with post-shutdown pumps is necessary. The post-shutdown pumps are powered by accumulator batteries or diesel generators.
Moderator	Beryllium blocks are used as a moderator. They are placed between fuel channels.
Reflector	Graphite blocks are used as a reflector. They placed around beryllium blocks and fuel channels.
Operation	The reactor works in cycles lasting from five to ten days with nominal power usually between 16 and 23 MW(th). In some cases the reactor is used for training of students and then it operates for several hours with the power level about 10 kW(th).
Applications	Production of radioactive materials for medicine – mainly

	molybdenum production in special molybdenum channels. Training of students. Research activities.
Safety analysis	Safety Analysis Report [1] updated in 2009. Update of the report is planned till 03.2015.

APPENDIX B – INPUT FILE.

RESEARCH REACTOR 'MARIA'
STEADY STATE CALCULATIONS INPUT
DATE: 26.10.2012

```
=MARIA
*m: SNAP:Symbolic Nuclear Analysis Package,  Version 2.2.0,
September 04, 2012
*m: PLUGIN:RELAP Version 4.3.0
*m: CODE:RELAP5 Version 3.3
*m: DATE:10/26/12
******************************      Model Options
******************************          type       state
100          new      transnt
*      iunits       ounits
102          si          si
*  tend minstep maxstep copt pfreq majed rsrtf
201 10.0  1.0e-8    0.5    3     5   100  1000
20500000        9999
*******************************     Control Blocks
*******************************              name type scale       ival iflag limit
20500010 "dP_15-65"  sum   1.0 5.882538e5     0     0
*              a0        scale     name         param
20500011       0.0           1.0        p       15010000
20500012                     -1.0        p      65010000
*          name type scale       ival iflag limit
20500020 "dT_10-70"  sum   1.0 0.38535583     0     0
*              a0        scale     name         param
20500021       0.0         -1.0    tempf      10010000
20500022                     1.0    tempf      70060000
*         name type scale       ival iflag limit
20500030 "Ent_70" mult   1.0 1.743369e6     0     0
*            input        param         input        param
20500031        hvmix      70060000        mflowj       74000000
*         name type scale       ival iflag limit
20500040 "Power"  sum   1.0 8973.1709     0     0
*              a0        scale     name         param
20500041       0.0         -1.0 cntrlvar            5
20500042                     1.0 cntrlvar            3
*         name type scale       ival iflag limit
20500050 "Ent_10" mult   1.0 1.734396e6     0     0
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20500051        hvmix      10010000        mflowj       6000000
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20500111       0.0           1.0   httemp       6000213
*          name type scale      ival iflag limit
20500120 "unnamed"  sum   1.0 323.52133     0     0
*              a0        scale     name         param
20500121       0.0           1.0   httemp       6000313
*          name type scale      ival iflag limit
20500130 "unnamed"  sum   1.0 323.55933     0     0
*              a0        scale     name         param
20500131       0.0           1.0   httemp       6000413
*          name type scale      ival iflag limit
20500140 "unnamed"  sum   1.0 323.57919     0     0
*              a0        scale     name         param
20500141       0.0           1.0   httemp       6000513
*          name type scale      ival iflag limit
20500150 "unnamed"  sum   1.0 323.57993     0     0
*              a0        scale     name         param
20500151       0.0           1.0   httemp       6000613
*          name type scale      ival iflag limit
20500160 "unnamed"  sum   1.0 323.56198     0     0
*              a0        scale     name         param
20500161       0.0           1.0   httemp       6000713
*          name type scale     ival iflag limit
20500170 "unnamed"  sum   1.0 323.5274     0     0
*              a0        scale     name         param
20500171       0.0           1.0   httemp       6000813
*          name type scale      ival iflag limit
20500180 "unnamed"  sum   1.0 323.47955     0     0
*              a0        scale     name         param
20500181       0.0           1.0   httemp       6000913
*          name type scale      ival iflag limit
20500190 "unnamed"  sum   1.0 323.45679     0     0
*              a0        scale     name         param
20500191       0.0           1.0   httemp       6001013
*          name type scale      ival iflag limit
20500200 "unnamed"  sum   1.0 323.40326     0     0
*              a0        scale     name         param
20500201       0.0           1.0   httemp       6000105
*          name type scale      ival iflag limit
20500210 "unnamed"  sum   1.0 323.46854     0     0
*              a0        scale     name         param
20500211       0.0           1.0   httemp       6000205
*          name type scale     ival iflag limit
20500220 "unnamed"  sum   1.0 323.5217     0     0
*              a0        scale     name         param
20500221       0.0           1.0   httemp       6000305
*          name type scale      ival iflag limit
20500230 "unnamed"  sum   1.0 323.55899     0     0
*              a0        scale     name         param
20500231       0.0           1.0   httemp       6000405
*          name type scale      ival iflag limit
20500240 "unnamed"  sum   1.0 323.57797     0     0
*              a0        scale     name         param
20500241       0.0           1.0   httemp       6000505
*          name type scale      ival iflag limit
20500250 "unnamed"  sum   1.0 323.57767     0     0
*              a0        scale     name         param
20500251       0.0           1.0   httemp       6000605
*          name type scale      ival iflag limit
20500260 "unnamed"  sum   1.0 323.55865     0     0
*              a0        scale     name         param
20500261       0.0           1.0   httemp       6000705
*          name type scale      ival iflag limit
20500270 "unnamed"  sum   1.0 323.52307     0     0
*              a0        scale     name         param
20500271       0.0           1.0   httemp       6000805
*          name type scale      ival iflag limit
20500280 "unnamed"  sum   1.0 323.47437     0     0
*              a0        scale     name         param
20500281       0.0           1.0   httemp       6000905
*          name type scale      ival iflag limit
20500290 "unnamed"  sum   1.0 323.45117     0     0
*              a0        scale     name         param
20500291       0.0           1.0   httemp       6001005
*          name type scale      ival iflag limit
20500300 "unnamed"  sum   1.0 323.42294     0     0
*              a0        scale     name         param
20500301       0.0           1.0   httemp       5500113
*          name type scale      ival iflag limit
20500310 "unnamed"  sum   1.0 323.49878     0     0
*              a0        scale     name         param
20500311       0.0           1.0   httemp       5500213
*          name type scale      ival iflag limit
20500320 "unnamed"  sum   1.0 323.56104     0     0
*              a0        scale     name         param
20500321       0.0           1.0   httemp       5500313
*          name type scale      ival iflag limit
20500330 "unnamed"  sum   1.0 323.60513     0     0
*              a0        scale     name         param
20500331       0.0           1.0   httemp       5500413
*          name type scale      ival iflag limit
20500340 "unnamed"  sum   1.0 323.62796     0     0
*              a0        scale     name         param
20500341       0.0           1.0   httemp       5500513
*          name type scale      ival iflag limit
20500350 "unnamed"  sum   1.0 323.62811     0     0
*              a0        scale     name         param
20500351       0.0           1.0   httemp       5500613
*          name type scale      ival iflag limit
20500360 "unnamed"  sum   1.0 323.60602     0     0
*              a0        scale     name         param
20500361       0.0           1.0   httemp       5500713
*          name type scale     ival iflag limit
20500370 "unnamed"  sum   1.0 323.5639     0     0
*              a0        scale     name         param
20500371       0.0           1.0   httemp       5500813
*          name type scale      ival iflag limit
20500380 "unnamed"  sum   1.0 323.50562     0     0
*              a0        scale     name         param
20500381       0.0           1.0   httemp       5500913
*          name type scale      ival iflag limit
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20500390 "unnamed"  sum   1.0 323.47556    0     0
*              a0       scale     name        param
20500391           0.0          1.0   httemp       5501013
*          name type scale      ival iflag limit
20500400 "unnamed"  sum   1.0 323.43329    0     0
*              a0       scale     name        param
20500401           0.0          1.0   httemp       5500105
*          name type scale      ival iflag limit
20500410 "unnamed"  sum   1.0 323.51294    0     0
*              a0       scale     name        param
20500411           0.0          1.0   httemp       5500205
*          name type scale      ival iflag limit
20500420 "unnamed"  sum   1.0 323.57779    0     0
*              a0       scale     name        param
20500421           0.0          1.0   httemp       5500305
*          name type scale      ival iflag limit
20500430 "unnamed"  sum   1.0 323.62311    0     0
*              a0       scale     name        param
20500431           0.0          1.0   httemp       5500405
*          name type scale      ival iflag limit
20500440 "unnamed"  sum   1.0 323.64563    0     0
*              a0       scale     name        param
20500441           0.0          1.0   httemp       5500505
*          name type scale      ival iflag limit
20500450 "unnamed"  sum   1.0 323.64407    0     0
*              a0       scale     name        param
20500451           0.0          1.0   httemp       5500605
*          name type scale      ival iflag limit
20500460 "unnamed"  sum   1.0 323.61902    0     0
*              a0       scale     name        param
20500461           0.0          1.0   httemp       5500705
*          name type scale      ival iflag limit
20500470 "unnamed"  sum   1.0 323.57294    0     0
*              a0       scale     name        param
20500471           0.0          1.0   httemp       5500805
*          name type scale      ival iflag limit
20500480 "unnamed"  sum   1.0 323.51001    0     0
*              a0       scale     name        param
20500481           0.0          1.0   httemp       5500905
*          name type scale      ival iflag limit
20500490 "unnamed"  sum   1.0 323.47787    0     0
*              a0       scale     name        param
20500491           0.0          1.0   httemp       5501005
*          name type scale      ival iflag limit
20500500 "unnamed"  sum   1.0 323.45538    0     0
*              a0       scale     name        param
20500501           0.0          1.0   httemp       5000113
*          name type scale      ival iflag limit
20500510 "unnamed"  sum   1.0 323.52072    0     0
*              a0       scale     name        param
20500511           0.0          1.0   httemp       5000213
*          name type scale      ival iflag limit
20500520 "unnamed"  sum   1.0 323.56552    0     0
*              a0       scale     name        param
20500521           0.0          1.0   httemp       5000313
*          name type scale      ival iflag limit
20500530 "unnamed"  sum   1.0 323.58615    0     0
*              a0       scale     name        param
20500531           0.0          1.0   httemp       5000413
*          name type scale      ival iflag limit
20500540 "unnamed"  sum   1.0 323.58093    0     0
*              a0       scale     name        param
20500541           0.0          1.0   httemp       5000513
*          name type scale      ival iflag limit
20500550 "unnamed"  sum   1.0 323.55032    0     0
*              a0       scale     name        param
20500551           0.0          1.0   httemp       5000613
*          name type scale      ival iflag limit
20500560 "unnamed"  sum   1.0 323.49677    0     0
*              a0       scale     name        param
20500561           0.0          1.0   httemp       5000713
*          name type scale      ival iflag limit
20500570 "unnamed"  sum   1.0 323.42453    0     0
*              a0       scale     name        param
20500571           0.0          1.0   httemp       5000813
*          name type scale      ival iflag limit
20500580 "unnamed"  sum   1.0 323.33942    0     0
*              a0       scale     name        param
20500581           0.0          1.0   httemp       5000913
*          name type scale      ival iflag limit
20500590 "unnamed"  sum   1.0 323.29184    0     0
*              a0       scale     name        param
20500591           0.0          1.0   httemp       5001013
*          name type scale      ival iflag limit
20500600 "unnamed"  sum   1.0 323.4418     0     0
*              a0       scale     name        param
20500601           0.0          1.0   httemp       5000105
*          name type scale      ival iflag limit
20500610 "unnamed"  sum   1.0 323.50943    0     0
*              a0       scale     name        param
20500611           0.0          1.0   httemp       5000205
*          name type scale      ival iflag limit
20500620 "unnamed"  sum   1.0 323.55914    0     0
*              a0       scale     name        param
20500621           0.0          1.0   httemp       5000305
*          name type scale      ival iflag limit
20500630 "unnamed"  sum   1.0 323.58707    0     0
*              a0       scale     name        param
20500631           0.0          1.0   httemp       5000405
*          name type scale      ival iflag limit
20500640 "unnamed"  sum   1.0 323.59106    0     0
*              a0       scale     name        param
20500641           0.0          1.0   httemp       5000505
*          name type scale      ival iflag limit
20500650 "unnamed"  sum   1.0 323.57092    0     0
*              a0       scale     name        param
20500651           0.0          1.0   httemp       5000605
*          name type scale      ival iflag limit
20500660 "unnamed"  sum   1.0 323.52841    0     0
*              a0       scale     name        param
20500661           0.0          1.0   httemp       5000705
*          name type scale      ival iflag limit
20500670 "unnamed"  sum   1.0 323.46704    0     0
*              a0       scale     name        param
20500671           0.0          1.0   httemp       5000805
*          name type scale      ival iflag limit
20500680 "unnamed"  sum   1.0 323.39188    0     0
*              a0       scale     name        param
20500681           0.0          1.0   httemp       5000905
*          name type scale      ival iflag limit
20500690 "unnamed"  sum   1.0 323.3504     0     0
*              a0       scale     name        param
20500691           0.0          1.0   httemp       5001005
*          name type scale      ival iflag limit
20500700 "unnamed"  sum   1.0 323.52029    0     0
*              a0       scale     name        param
20500701           0.0          1.0   httemp       3000113
*          name type scale      ival iflag limit
20500710 "unnamed"  sum   1.0 323.58707    0     0
*              a0       scale     name        param
20500711           0.0          1.0   httemp       3000213
*          name type scale      ival iflag limit
20500720 "unnamed"  sum   1.0 323.62198    0     0
*              a0       scale     name        param
20500721           0.0          1.0   httemp       3000313
*          name type scale      ival iflag limit
20500730 "unnamed"  sum   1.0 323.62195    0     0
*              a0       scale     name        param
20500731           0.0          1.0   httemp       3000413
*          name type scale      ival iflag limit
20500740 "unnamed"  sum   1.0 323.58676    0     0
*              a0       scale     name        param
20500741           0.0          1.0   httemp       3000513
*          name type scale      ival iflag limit
20500750 "unnamed"  sum   1.0 323.51904    0     0
*              a0       scale     name        param
20500751           0.0          1.0   httemp       3000613
*          name type scale      ival iflag limit
20500760 "unnamed"  sum   1.0 323.42395    0     0
*              a0       scale     name        param
20500761           0.0          1.0   httemp       3000713
*          name type scale      ival iflag limit
20500770 "unnamed"  sum   1.0 323.30902    0     0
*              a0       scale     name        param
20500771           0.0          1.0   httemp       3000813
*          name type scale      ival iflag limit
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20500780 "unnamed"  sum   1.0 323.18326    0     0
*              a0        scale     name         param
20500781          0.0          1.0   httemp       3000913
*         name type scale      ival iflag limit
20500790 "unnamed"  sum   1.0 323.11334    0     0
*              a0        scale     name         param
20500791          0.0          1.0   httemp       3001013
*         name type scale     ival iflag limit
20500800 "unnamed"  sum   1.0 323.5889    0     0
*              a0        scale     name         param
20500801          0.0          1.0   httemp       3000205
*         name type scale      ival iflag limit
20500810 "unnamed"  sum   1.0 323.52145    0     0
*              a0        scale     name         param
20500811          0.0          1.0   httemp       3000105
*         name type scale      ival iflag limit
20500820 "unnamed"  sum   1.0 323.62451    0     0
*              a0        scale     name         param
20500821          0.0          1.0   httemp       3000305
*         name type scale      ival iflag limit
20500830 "unnamed"  sum   1.0 323.62512    0     0
*              a0        scale     name         param
20500831          0.0          1.0   httemp       3000405
*         name type scale      ival iflag limit
20500840 "unnamed"  sum   1.0 323.59042    0     0
*              a0        scale     name         param
20500841          0.0          1.0   httemp       3000505
*         name type scale      ival iflag limit
20500850 "unnamed"  sum   1.0 323.52289    0     0
*              a0        scale     name         param
20500851          0.0          1.0   httemp       3000605
*         name type scale      ival iflag limit
20500860 "unnamed"  sum   1.0 323.42776    0     0
*              a0        scale     name         param
20500861          0.0          1.0   httemp       3000705
*         name type scale      ival iflag limit
20500870 "unnamed"  sum   1.0 323.31241    0     0
*              a0        scale     name         param
20500871          0.0          1.0   httemp       3000805
*         name type scale      ival iflag limit
20500880 "unnamed"  sum   1.0 323.18585    0     0
*              a0        scale     name         param
20500881          0.0          1.0   httemp       3000905
*         name type scale      ival iflag limit
20500890 "unnamed"  sum   1.0 323.11505    0     0
*              a0        scale     name         param
20500891          0.0          1.0   httemp       3001005
*         name type scale      ival iflag limit
20500900 "unnamed"  sum   1.0 323.50284    0     0
*              a0        scale     name         param
20500901          0.0          1.0   httemp       2500113
*         name type scale      ival iflag limit
20500910 "unnamed"  sum   1.0 323.58917    0     0
*              a0        scale     name         param
20500911          0.0          1.0   httemp       2500213
*         name type scale      ival iflag limit
20500920 "unnamed"  sum   1.0 323.64075    0     0
*              a0        scale     name         param
20500921          0.0          1.0   httemp       2500313
*         name type scale      ival iflag limit
20500930 "unnamed"  sum   1.0 323.65314    0     0
*              a0        scale     name         param
20500931          0.0          1.0   httemp       2500413
*         name type scale      ival iflag limit
20500940 "unnamed"  sum   1.0 323.62518    0     0
*              a0        scale     name         param
20500941          0.0          1.0   httemp       2500513
*         name type scale      ival iflag limit
20500950 "unnamed"  sum   1.0 323.55893    0     0
*              a0        scale     name         param
20500951          0.0          1.0   httemp       2500613
*         name type scale      ival iflag limit
20500960 "unnamed"  sum   1.0 323.45953    0     0
*              a0        scale     name         param
20500961          0.0          1.0   httemp       2500713
*         name type scale      ival iflag limit
20500970 "unnamed"  sum   1.0 323.33487    0     0
*              a0        scale     name         param
20500971          0.0          1.0   httemp       2500813
*         name type scale      ival iflag limit
20500980 "unnamed"  sum   1.0 323.19482    0     0
*              a0        scale     name         param
20500981          0.0          1.0   httemp       2500913
*         name type scale      ival iflag limit
20500990 "unnamed"  sum   1.0 323.11862    0     0
*              a0        scale     name         param
20500991          0.0          1.0   httemp       2501013
*         name type scale      ival iflag limit
20501000 "unnamed"  sum   1.0 323.51813    0     0
*              a0        scale     name         param
20501001          0.0          1.0   httemp       2500105
*         name type scale      ival iflag limit
20501010 "unnamed"  sum   1.0 323.60406    0     0
*              a0        scale     name         param
20501011          0.0          1.0   httemp       2500205
*         name type scale      ival iflag limit
20501020 "unnamed"  sum   1.0 323.65451    0     0
*              a0        scale     name         param
20501021          0.0          1.0   httemp       2500305
*         name type scale      ival iflag limit
20501030 "unnamed"  sum   1.0 323.66528    0     0
*              a0        scale     name         param
20501031          0.0          1.0   httemp       2500405
*         name type scale      ival iflag limit
20501040 "unnamed"  sum   1.0 323.63525    0     0
*              a0        scale     name         param
20501041          0.0          1.0   httemp       2500505
*         name type scale      ival iflag limit
20501050 "unnamed"  sum   1.0 323.56671    0     0
*              a0        scale     name         param
20501051          0.0          1.0   httemp       2500605
*         name type scale    ival iflag limit
20501060 "unnamed"  sum   1.0 323.465    0     0
*              a0        scale     name         param
20501061          0.0          1.0   httemp       2500705
*         name type scale     ival iflag limit
20501070 "unnamed"  sum   1.0 323.3382    0     0
*              a0        scale     name         param
20501071          0.0          1.0   httemp       2500805
*         name type scale      ival iflag limit
20501080 "unnamed"  sum   1.0 323.19641    0     0
*              a0        scale     name         param
20501081          0.0          1.0   httemp       2500905
*         name type scale      ival iflag limit
20501090 "unnamed"  sum   1.0 323.11926    0     0
*              a0        scale     name         param
20501091          0.0          1.0   httemp       2501005
*         name type scale     ival iflag limit
20501100 "unnamed"  sum   1.0 323.6972    0     0
*              a0        scale     name         param
20501101          0.0          1.0   httemp       2500409
*         name   type scale      ival iflag limit
20501110 "unnamed" powerr   1.0 0.52376056    0     0
*           input         param          power
20501111     cntrlvar          114         -0.23
*         name   type scale      ival iflag limit
20501120 "unnamed" powerr   1.0 25.589294    0     0
*           input         param          power
20501121        htrnr        2500400        0.35
*        name type scale      ival iflag limit
20501130 "T_ONBR"  sum   1.0 478.85593    0     0
*              a0        scale     name         param
20501131          0.0          1.0  sattemp      25040000
20501132                  0.182 cntrlvar          115
*         name type scale      ival iflag limit
20501140 "unnamed"  sum   1.0 16.640322    0     0
*              a0        scale     name         param
20501141          0.0       1.0e-5        p      25040000
*         name type scale      ival iflag limit
20501150 "unnamed" mult   1.0 13.402663    0     0
*           input         param          input         param
20501151     cntrlvar          111      cntrlvar          112
*         name type scale       ival iflag limit
20501160 "unnamed"  sum   1.0 0.60251117    0     0
*              a0        scale     name         param
20501161          0.0          1.0   httemp       2500401
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20501162              -1.0   tempf     10010000
*         name type scale     ival iflag limit
20501170 "unnamed"  sum   1.0 155.84138    0    0
*             a0       scale    name       param
20501171        0.0       1.0 cntrlvar         113
20501172              -1.0   tempf     10010000
*         name   type scale     ival iflag limit
20501180 "unnamed" powerr   1.0 1.6597203    0    0
*           input        param        power
20501181     cntrlvar         116        -1.0
*        name type scale     ival iflag limit
20501190 "ONBR" mult   1.0 258.65311    0    0
*           input        param        input        param
20501191     cntrlvar         117     cntrlvar          118
20600000     expanded
*******************************      Variable Trips
*******************************n: Pressure_signal
*     var    param  r  var param acon l timeo
20600010   p 10010000 le null     0  9.0 l  -1.0
*n: Scram_delay
*       var param  r    var param acon l timeo
20600020 time     0 gt timeof  1001 0.35 l  -1.0
*n: A120 Power_signal
*         var param  r  var param   acon l timeo
20600030 rktpow     0 ge null     0 2.16e6 l  -1.0
*n: LOOS OF COOLANT FLOW
*       var param  r  var param  acon l timeo
20600040 time     0 ge null     0 160.0 l  -1.0
*n: RIA_FAST
*       var param  r  var param  acon l timeo
20600050 time     0 ge null     0 160.0 l  -1.0
*n: RIA_SLOW
*       var param  r  var param  acon l timeo
20600060 time     0 ge null     0 160.0 l  -1.0
******************************      Logical Trips
*******************************n: SCRAM
*           trip1        oper        trip2          l        timeo
20610010          3          or          1          l          -1.0
*******************************      General Tables
*******************************n: ENVI
*         type         trip
20200100    temp         0
*             Time   Temperature
20200101        0.0       300.0
*n: PK + PAR
*         type         trip      factor1      factor2
20200200   reac-t          2          1.0         -2.0
*             Time    Reactivity
20200201        0.0         0.0
20200202        0.01       5.0e-3
20200203        0.02        0.01
20200204        0.03        0.022
20200205        0.04        0.035
20200206        0.05        0.05
20200207        0.06        0.07
20200208        0.07        0.09
20200209        0.08        0.11
20200210        0.09        0.145
20200211        0.1         0.165
20200212        0.11        0.2
20200213        0.12        0.23
20200214        0.13        0.275
20200215        0.14        0.31
20200216        0.15        0.35
20200217        0.16        0.4
20200218        0.17        0.45
20200219        0.18        0.49
20200220        0.19        0.525
20200221        0.2         0.565
20200222        0.21        0.6
20200223        0.22        0.64
20200224        0.23        0.675
20200225        0.24        0.72
20200226        0.25        0.75
20200227        0.26        0.79
20200228        0.27        0.825
20200229        0.28        0.85
20200230        0.29        0.88
20200231        0.3         0.9
20200232        0.35        0.975
20200233        0.36        0.983
20200234        0.37        0.99
20200235        0.38        0.999
20200236        0.39        1.0
*n: PB
*         type         trip      factor1      factor2
20200300   reac-t          2          1.0         -3.5
*             Time    Reactivity
20200301        0.0         0.0
20200302        0.01        0.0
20200303        0.02        0.0
20200304        0.03        0.0
20200305        0.04        0.0
20200306        0.05        0.0
20200307        0.06       1.0e-3
20200308        0.07       2.0e-3
20200309        0.08       3.0e-3
20200310        0.09       4.0e-3
20200311        0.1        5.0e-3
20200312        0.11       6.0e-3
20200313        0.12       7.0e-3
20200314        0.13       8.0e-3
20200315        0.14       9.0e-3
20200316        0.15        0.01
20200317        0.16        0.013
20200318        0.17        0.016
20200319        0.18        0.019
20200320        0.19        0.022
20200321        0.2         0.025
20200322        0.21        0.03
20200323        0.22        0.04
20200324        0.23        0.05
20200325        0.24        0.06
20200326        0.25        0.07
20200327        0.26        0.085
20200328        0.27        0.1
20200329        0.28        0.118
20200330        0.29        0.135
20200331        0.3         0.157
20200332        0.35        0.3
20200333        0.36        0.32
20200334        0.37        0.345
20200335        0.38        0.38
20200336        0.39        0.41
20200337        0.4         0.45
20200338        0.41        0.49
20200339        0.42        0.515
20200340        0.43        0.55
20200341        0.44        0.59
20200342        0.45        0.62
20200343        0.46        0.66
20200344        0.47        0.7
20200345        0.48        0.735
20200346        0.49        0.77
20200347        0.5         0.8
20200348        0.51        0.825
20200349        0.52        0.86
20200350        0.53        0.89
20200351        0.54        0.905
20200352        0.55        0.925
20200353        0.56        0.935
20200354        0.57        0.95
20200355        0.58        0.963
20200356        0.59        0.975
20200357        0.6         0.985
20200358        0.63        1.0
*n: Reactivity_Slow
*         type         trip
20200400   reac-t          6
*             Time    Reactivity
20200401       -1.0         0.0
20200402        0.0         0.0
20200403        1.0         0.04
20200404        2.0         0.08
20200405        3.0         0.12
20200406        4.0         0.16
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20200407    5.0    0.2
20200408    6.0    0.24
20200409    7.0    0.28
20200410    8.0    0.32
20200411    9.0    0.36
20200412    10.0   0.4
20200413    11.0   0.44
20200414    12.0   0.48
20200415    13.0   0.52
20200416    14.0   0.56
20200417    15.0   0.6
20200418    16.0   0.64
20200419    17.0   0.68
20200420    18.0   0.72
20200421    19.0   0.76
20200422    20.0   0.8
20200423    21.0   0.84
20200424    22.0   0.88
20200425    23.0   0.92
20200426    24.0   0.96
20200427    25.0   1.0
20200428    26.0   1.04
20200429    27.0   1.08
20200430    28.0   1.12
20200431    29.0   1.16
20200432    30.0   1.2
20200433    31.0   1.24
20200434    32.0   1.28
20200435    33.0   1.32
20200436    34.0   1.36
20200437    35.0   1.4
20200438    36.0   1.44
20200439    37.0   1.48
20200440    38.0   1.52
20200441    39.0   1.56
20200442    40.0   1.6
20200443    41.0   1.64
20200444    42.0   1.68
20200445    43.0   1.72
20200446    44.0   1.76
20200447    45.0   1.8
20200448    46.0   1.84
20200449    47.0   1.88
20200450    48.0   1.92
20200451    49.0   1.96
20200452    50.0   2.0
*n: Reactivity_Fast
*        type      trip
20200500  reac-t      5
*          Time   Reactivity
20200501    -1.0   0.0
20200502    0.0    0.0
20200503    0.01   0.04
20200504    0.02   0.08
20200505    0.03   0.12
20200506    0.04   0.16
20200507    0.05   0.2
20200508    0.06   0.24
20200509    0.07   0.28
20200510    0.08   0.32
20200511    0.09   0.36
20200512    0.1    0.4
20200513    0.11   0.44
20200514    0.12   0.48
20200515    0.13   0.52
20200516    0.14   0.56
20200517    0.15   0.6
20200518    0.16   0.64
20200519    0.17   0.68
20200520    0.18   0.72
20200521    0.19   0.76
20200522    0.2    0.8
20200523    0.21   0.84
20200524    0.22   0.88
20200525    0.23   0.92
20200526    0.24   0.96
20200527    0.25   1.0
20200528    0.26   1.04
20200529    0.27   1.08
20200530    0.28   1.12
20200531    0.29   1.16
20200532    0.3    1.2
20200533    0.31   1.24
20200534    0.32   1.28
20200535    0.33   1.32
20200536    0.34   1.36
20200537    0.35   1.4
20200538    0.36   1.44
20200539    0.37   1.48
20200540    0.375  1.5
*n: Power_for_SS
*        type      trip
20200600  power       0
*           Time     Power
20200601    -1.0    1.8e6
20200602    0.0     1.8e6
20200603    1.0     1.8e6
20200604    1.0e6   1.8e6
**************************    Materials    **************************n:
Fuel
*           type     tflag    vflag
20100100    tbl/fctn    1        1
*         thcond
20100101    59.0
*           temp     capacity
20100151    273.0   0.35837293
20100152    303.0   0.35837293
20100153    313.0   0.37012693
20100154    323.0   0.38188093
20100155    333.0   0.39363493
20100156    343.0   0.40538893
20100157    353.0   0.41714293
20100158    363.0   0.42889693
20100159    373.0   0.44065093
20100160    383.0   0.45240493
20100161    393.0   0.46415893
20100162    403.0   0.47591293
20100163    413.0   0.48766693
20100164    423.0   0.49942093
20100165    433.0   0.51117493
20100166    443.0   0.52292893
20100167    453.0   0.53468293
20100168    463.0   0.54643693
20100169    473.0   0.55819093
20100170    523.0   0.61696093
20100171    573.0   0.67573093
20100172    623.0   0.73450093
20100173    673.0   0.79327093
20100174    723.0   0.85204093
20100175    773.0   0.91081093
20100176    823.0   0.96958093
20100177    873.0   1.0283509
20100178    923.0   1.0871209
20100179    973.0   1.1458909
20100180    2000.0  1.1458909
*n: AGN cladding
*           type     tflag    vflag
20100200    tbl/fctn    1        1
*         thcond
20100201    130.0
*     heat Capacity
20100251    2.3496e6
*n: Aluminium
*           type     tflag    vflag
20100300    tbl/fctn    1        1
*           temp     thcond
20100301    273.0    237.0
20100302    300.0    237.0
20100303    350.0    240.0
20100304    400.0    240.0
20100305    500.0    236.0
20100306    600.0    231.0
20100307    800.0    218.0
20100308    1200.0   218.0
*           temp     capacity
20100351    273.0    2.4219e6
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20100352        298.0     2.4219e6
20100353        350.0     2.51262e6
20100354        400.0     2.57985e6
20100355        500.0     2.68596e6
20100356        600.0     2.7918e6
20100357       1000.0     2.7918e6
*n: SAW
*          type      tflag      vflag
20100400     tbl/fctn        1          1
*          temp      thcond
20100401        273.0       170.0
20100402        900.0       170.0
*          temp      capacity
20100451        273.0     2.4192e6
20100452        900.0     2.4192e6
*************************************     Hydraulic Components
*************************************          name         type
0050000    "unnamed"     tmdpvol
*          area      length        vol
0050101        20.0        20.0        0.0
*        az-angle    inc-angle        dz
0050102        0.0        90.0        20.0
*        x-rough       x-hd       flags
0050103        0.0        0.0         0
*        cword
0050200          3
*          srch       press       temp
0050201        0.0       1.4e6      323.15
0050202        0.99      1.4e6      323.15
0050203        1.0       1.4e6      323.15
*          name         type
0060000    "unnamed"     tmdpjun
*          from          to        area      jefvcahs
0060101     5010002     10010001     2.294e-3          0
*        control
0060200          1
*          srch        mfl         mfv       unused
0060201        0.0        7.41         0.0         0.0
*          name         type
0100000    "unnamed"        pipe
*        ncells
0100001          6
*        x-area       volid
0100101     2.294e-3          6
*        x-length       volid
0100301        0.3          1
0100302        0.5          4
0100303        0.4          5
0100304        0.2          6
*        volume       volid
0100401        0.0          6
*      azim-angle       volid
0100501        0.0          6
*      vert-angle       volid
0100601       -90.0          6
*        x-wall         xhd        volid
0100801      1.0e-5      0.027          6
*        x-flags       volid
0101001          0          6
*     ebt     press   water-ie   steam-ie void none id
0101201 000 1.698744e6 2.085118e5 2.596097e6  0.0  0.0  1
0101202 000 1.700844e6 2.085396e5 2.596122e6  0.0  0.0  2
0101203 000 1.703468e6 2.085674e5 2.596154e6  0.0  0.0  3
0101204 000 1.706092e6 2.085951e5 2.596185e6  0.0  0.0  4
0101205 000 1.708454e6 2.086174e5 2.596214e6  0.0  0.0  5
0101206 000 1.710028e6 2.086285e5 2.596232e6  0.0  0.0  6
*        jefvcahs       jun num
0101101     00000000          5
*            vl           vv        unused        junid
0101301    3.6371021    3.6371021         0.0          1
0101302     3.63711      3.63711         0.0          2
0101303    3.6371169    3.6371169         0.0          3
0101304    3.6371241    3.6371241         0.0          4
0101305    3.6371293    3.6371293         0.0          5
*            hd         corr         gas        slope        junid
0101401       0.027         0.0         1.0         1.0          5
*          name         type
0150000    "unnamed"      branch
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```
*          njuns
0150001          4
*          area       length         vol
0150101     2.294e-3         0.1         0.0
*        az-angle    inc-angle          dz
0150102        0.0        -90.0        -0.1
*        x-rough       x-hd       flags
0150103        0.0        0.0          0
*          ebt        press     water-ie     steam-ie        void
0150200        000    1.710953e6   2.086334e5   2.596243e6
0.0
*          from          to         area
0151101     15010001     10060002     2.294e-3
*        fwd. loss     rev. loss      efvcahs
0151102        0.0         0.0          0
*        hyd diam     ccfl wght     ccfl gas    ccfl slope
0151110       0.027         0.0         1.0         1.0
*            vl          vv        unused
0151201    -3.6371312    -3.6371312         0.0
*          from          to         area
0152101     15010002     20010001     5.24e-4
*        fwd. loss     rev. loss      efvcahs
0152102        0.4         0.4          0
*            vl          vv        unused
0152201     6.1487789    6.1487789         0.0
*          from          to         area
0153101     15010002     25010001     4.54e-4
*        fwd. loss     rev. loss      efvcahs
0153102        0.4         0.4          0
*            vl          vv        unused
0153201     6.1307321    6.1307321         0.0
*          from          to         area
0154101     15010002     30010001     3.83e-4
*        fwd. loss     rev. loss      efvcahs
0154102        0.4         0.4          0
*            vl          vv        unused
0154201     6.1051373    6.1051373         0.0
*          name         type
0200000    "unnamed"       pipe
*        ncells
0200001         12
*        x-area       volid
0200101      5.24e-4         12
*        x-length       volid
0200301        0.05          1
0200302        0.1          11
0200303        0.05         12
*        volume       volid
0200401        0.0         12
*      azim-angle       volid
0200501        0.0         12
*      vert-angle       volid
0200601       -90.0         12
*        x-wall        xhd        volid
0200801      1.0e-5     4.827e-3         12
*        x-flags       volid
0201001          0         12
*     ebt     press     temp none none none id
0201201 003 1.689443e6 323.045  0.0  0.0  0.0  1
*     ebt     press   water-ie   steam-ie void none id
0201202 000 1.682478e6 2.086602e5 2.595899e6  0.0  0.0  2
*     ebt     press   water-ie   steam-ie void none id
0201203 000 1.673191e6 2.086929e5 2.595784e6  0.0  0.0  3
*     ebt     press   water-ie   steam-ie void none id
0201204 000 1.663904e6 2.087463e5 2.595668e6  0.0  0.0  4
*     ebt     press   water-ie   steam-ie void none id
0201205 000 1.654618e6 2.088172e5 2.595551e6  0.0  0.0  5
*     ebt     press   water-ie   steam-ie void none id
0201206 000 1.645331e6 2.089011e5 2.595432e6  0.0  0.0  6
*     ebt     press   water-ie   steam-ie void none id
0201207 000 1.636045e6 2.089922e5 2.595312e6  0.0  0.0  7
*     ebt     press   water-ie   steam-ie void none id
0201208 000 1.626759e6 2.090844e5 2.595191e6  0.0  0.0  8
*     ebt     press   water-ie   steam-ie void none id
0201209 000 1.617473e6 2.091712e5 2.595068e6  0.0  0.0  9
*     ebt     press   water-ie   steam-ie void none id
0201210 000 1.608187e6 2.092468e5 2.594944e6  0.0  0.0 10
*     ebt     press   water-ie   steam-ie void none id
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0201211 000 1.598902e6 2.093061e5 2.594818e6  0.0  0.0 11
*      ebt      press   water-ie   steam-ie void none id
0201212 000 1.591937e6 2.093155e5 2.594723e6  0.0  0.0 12
*            area          jun
0200201      5.24e-4           11
*          jefvcahs       jun num
0201101      00000000           11
*                vl           vv       unused        junid
0201301    6.1488385    6.1488385         0.0           1
0201302    6.1488714    6.1488714         0.0           2
0201303    6.1489172    6.1489172         0.0           3
0201304    6.1489778    6.1489778         0.0           4
0201305    6.1490493    6.1490493         0.0           5
0201306    6.1491299    6.1491299         0.0           6
0201307    6.1492157    6.1492157         0.0           7
0201308     6.149302     6.149302         0.0           8
0201309    6.1493845    6.1493845         0.0           9
0201310    6.1494598    6.1494598         0.0          10
0201311    6.1495237    6.1495237         0.0          11
*                hd          corr          gas         slope        junid
0201401     4.827e-3          0.0          1.0          1.0           11
*            name          type
0250000    "unnamed"         pipe
*           ncells
0250001           12
*           x-area         volid
0250101      4.54e-4           12
*          x-length         volid
0250301         0.05            1
0250302          0.1           11
0250303         0.05           12
*           volume         volid
0250401          0.0           12
*        azim-angle         volid
0250501          0.0           12
*        vert-angle         volid
0250601        -90.0           12
*           x-wall          xhd         volid
0250801       1.0e-5     4.802e-3           12
*           x-flags         volid
0251001            0           12
*      ebt      press   water-ie   steam-ie void none id
0251201 000 1.689598e6 2.086388e5 2.595986e6  0.0  0.0  1
0251202 000 1.682626e6 2.086712e5 2.595901e6  0.0  0.0  2
0251203 000 1.673329e6 2.087246e5 2.595786e6  0.0  0.0  3
0251204 000 1.664032e6 2.088165e5  2.59567e6  0.0  0.0  4
0251205 000 1.654736e6   2.0894e5 2.595552e6  0.0  0.0  5
0251206 000 1.645439e6 2.090854e5 2.595434e6  0.0  0.0  6
0251207 000 1.636143e6 2.092415e5 2.595314e6  0.0  0.0  7
0251208 000 1.626848e6 2.093963e5 2.595192e6  0.0  0.0  8
0251209 000 1.617552e6 2.095376e5 2.595069e6  0.0  0.0  9
0251210 000 1.608257e6 2.096547e5 2.594945e6  0.0  0.0 10
0251211 000 1.598962e6 2.097386e5 2.594819e6  0.0  0.0 11
0251212 000 1.591991e6  2.09739e5 2.594724e6  0.0  0.0 12
*            area          jun
0250201      4.54e-4           11
*          jefvcahs       jun num
0251101      00000000           11
*                vl           vv       unused        junid
0251301    6.1307912    6.1307912         0.0           1
0251302    6.1308308    6.1308308         0.0           2
0251303    6.1308908    6.1308908         0.0           3
0251304    6.1309767    6.1309767         0.0           4
0251305    6.1310835    6.1310835         0.0           5
0251306    6.1312056    6.1312056         0.0           6
0251307    6.1313348    6.1313348         0.0           7
0251308    6.1314626    6.1314626         0.0           8
0251309    6.1315818    6.1315818         0.0           9
0251310    6.1316848    6.1316848         0.0          10
0251311    6.1317654    6.1317654         0.0          11
*                hd          corr          gas         slope        junid
0251401     4.802e-3          0.0          1.0          1.0           11
*            name          type
0300000    "unnamed"         pipe
*           ncells
0300001           12
*           x-area         volid
0300101      3.83e-4           12
*          x-length         volid
0300301         0.05            1
0300302          0.1           11
0300303         0.05           12
*           volume         volid
0300401          0.0           12
*        azim-angle         volid
0300501          0.0           12
*        vert-angle         volid
0300601        -90.0           12
*           x-wall          xhd         volid
0300801       1.0e-5     4.767e-3           12
*           x-flags         volid
0301001            0           12
*      ebt      press   water-ie   steam-ie void none id
0301201 000 1.689816e6 2.086581e5 2.595989e6  0.0  0.0  1
0301202 000 1.682834e6 2.087158e5 2.595904e6  0.0  0.0  2
0301203 000 1.673524e6 2.087883e5 2.595789e6  0.0  0.0  3
0301204 000 1.664214e6 2.088898e5 2.595672e6  0.0  0.0  4
0301205 000 1.654904e6 2.090142e5 2.595555e6  0.0  0.0  5
0301206 000 1.645594e6 2.091535e5 2.595436e6  0.0  0.0  6
0301207 000 1.636285e6 2.092983e5 2.595316e6  0.0  0.0  7
0301208 000 1.626976e6 2.094388e5 2.595194e6  0.0  0.0  8
0301209 000 1.617667e6 2.095653e5 2.595071e6  0.0  0.0  9
0301210 000 1.608359e6 2.096694e5 2.594946e6  0.0  0.0 10
0301211 000 1.599051e6 2.097441e5  2.59482e6  0.0  0.0 11
0301212 000  1.59207e6 2.097471e5 2.594725e6  0.0  0.0 12
*            area          jun
0300201      3.83e-4           11
*          jefvcahs       jun num
0301101      00000000           11
*                vl           vv       unused        junid
0301301    6.1052089    6.1052089         0.0           1
0301302    6.1052651    6.1052651         0.0           2
0301303    6.1053376    6.1053376         0.0           3
0301304    6.1054296    6.1054296         0.0           4
0301305    6.1055369    6.1055369         0.0           5
0301306    6.1056542    6.1056542         0.0           6
0301307    6.1057749    6.1057749         0.0           7
0301308    6.1058931    6.1058931         0.0           8
0301309    6.1060019    6.1060019         0.0           9
0301310    6.1060958    6.1060958         0.0          10
0301311    6.1061702    6.1061702         0.0          11
*                hd          corr          gas         slope        junid
0301401     4.767e-3          0.0          1.0          1.0           11
*            name          type
0350000    "unnamed"       branch
*           njuns
0350001            4
*            area        length          vol
0350101     2.294e-3         0.05          0.0
*         az-angle     inc-angle           dz
0350102          0.0        -90.0        -0.05
*          x-rough          x-hd        flags
0350103          0.0          0.0            0
*             ebt         press      water-ie      steam-ie          void
0350200          000    1.592632e6    2.095778e5    2.594733e6
0.0
*            from            to          area
0351101     35010002     40010001     2.294e-3
*        fwd. loss     rev. loss       efvcahs
0351102          1.5          1.5            0
*                vl           vv       unused
0351201    3.6376903    3.6376903         0.0
*            from            to          area
0352101     35010001     20120002      5.24e-4
*        fwd. loss     rev. loss       efvcahs
0352102          0.5          0.5            0
*                vl           vv       unused
0352201   -6.1495485   -6.1495485         0.0
*            from            to          area
0353101     35010001     25120002      4.54e-4
*        fwd. loss     rev. loss       efvcahs
0353102          0.5          0.5            0
*                vl           vv       unused
0353201    -6.131784    -6.131784         0.0
*            from            to          area
0354101     35010001     30120002      3.83e-4
```

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*        fwd. loss    rev. loss     efvcahs
0354102        0.5        0.5          0
*           vl         vv      unused
0354201    -6.1061902   -6.1061902        0.0
*          name        type
0400000    "unnamed"      branch
*          njuns
0400001         0
*          area       length        vol
0400101    4.418e-3      0.05        0.0
*       az-angle    inc-angle         dz
0400102        0.0        -90.0      -0.05
*        x-rough        x-hd       flags
0400103        0.0         0.0         0
*           ebt       press     water-ie      steam-ie         void
0400200         000    1.589762e6    2.095778e5    2.594694e6
0.0
*          name        type
0450000    "unnamed"      branch
*          njuns
0450001         5
*          area       length        vol
0450101      1.81e-3      0.05        0.0
*       az-angle    inc-angle         dz
0450102        0.0        90.0       0.05
*        x-rough        x-hd       flags
0450103        0.0         0.0         0
*           ebt       press     water-ie      steam-ie         void
0450200         000    1.562884e6    2.095779e5    2.594318e6
0.0
*          from          to        area
0451101    45010001    40010001      1.81e-3
*        fwd. loss    rev. loss     efvcahs
0451102        1.5        1.5          0
*           vl         vv      unused
0451201    -4.6104264   -4.6104264        0.0
*          from          to        area
0452101    45010002    50010001      3.12e-4
*        fwd. loss    rev. loss     efvcahs
0452102        0.5        0.5          0
*           vl         vv      unused
0452201    11.260211    11.260211        0.0
*          from          to        area
0453101    45010002    55010001      2.42e-4
*        fwd. loss    rev. loss     efvcahs
0453102        0.5        0.5          0
*           vl         vv      unused
0453201    11.155989    11.155989        0.0
*          from          to        area
0454101    45010002    60010001      1.71e-4
*        fwd. loss    rev. loss     efvcahs
0454102        0.5        0.5          0
*           vl         vv      unused
0454201    10.971682    10.971682        0.0
*          from          to        area
0455101    45010002    80010001       1.1e-5
*        fwd. loss    rev. loss     efvcahs
0455102        0.5        0.5          0
*           vl         vv      unused
0455201     23.26129     23.26129        0.0
*          name        type
0500000    "unnamed"       pipe
*         ncells
0500001         12
*        x-area       volid
0500101     3.12e-4        12
*       x-length       volid
0500301       0.05         1
0500302        0.1        11
0500303       0.05        12
*        volume       volid
0500401        0.0        12
*      azim-angle      volid
0500501        0.0        12
*      vert-angle      volid
0500601       90.0        12
*         x-wall        xhd       volid
0500801      1.0e-5     4.717e-3        12
*          x-flags        volid
0501001          0           12
*     ebt     press   water-ie   steam-ie void none id
0501201 000 1.470377e6 2.095963e5 2.592927e6  0.0  0.0  1
0501202 000 1.444268e6 2.096746e5 2.592505e6  0.0  0.0  2
0501203 000 1.409458e6 2.097678e5 2.591922e6  0.0  0.0  3
0501204 000 1.374648e6 2.098706e5 2.591312e6  0.0  0.0  4
0501205 000 1.339838e6 2.099767e5 2.590677e6  0.0  0.0  5
0501206 000 1.305028e6 2.100796e5 2.590014e6  0.0  0.0  6
0501207 000 1.270217e6 2.101732e5 2.589321e6  0.0  0.0  7
0501208 000 1.235407e6 2.102518e5 2.588597e6  0.0  0.0  8
0501209 000 1.200597e6  2.10311e5 2.587841e6  0.0  0.0  9
0501210 000 1.165786e6 2.103481e5  2.58705e6  0.0  0.0 10
0501211 000 1.130976e6 2.103731e5 2.586223e6  0.0  0.0 11
0501212 000 1.104867e6  2.10377e5 2.585578e6  0.0  0.0 12
*          area         jun
0500201      3.12e-4          11
*        jefvcahs      jun num
0501101      00000000          11
*             vl          vv       unused       junid
0501301     11.260675    11.260675        0.0          1
0501302     11.260897    11.260897        0.0          2
0501303     11.261178    11.261178        0.0          3
0501304     11.261471    11.261471        0.0          4
0501305     11.261768    11.261768        0.0          5
0501306     11.262062    11.262062        0.0          6
0501307     11.262344    11.262344        0.0          7
0501308     11.262608    11.262608        0.0          8
0501309     11.262847    11.262847        0.0          9
0501310      11.26306     11.26306        0.0         10
0501311     11.263257    11.263257        0.0         11
*             hd        corr        gas       slope       junid
0501401     4.717e-3        0.0         1.0         1.0          11
*          name        type
0550000    "unnamed"        pipe
*         ncells
0550001         12
*        x-area       volid
0550101     2.42e-4        12
*       x-length       volid
0550301       0.05         1
0550302        0.1        11
0550303       0.05        12
*        volume       volid
0550401        0.0        12
*      azim-angle      volid
0550501        0.0        12
*      vert-angle      volid
0550601       90.0        12
*         x-wall        xhd       volid
0550801      1.0e-5     4.64e-3        12
*          x-flags        volid
0551001          0           12
*     ebt     press   water-ie   steam-ie void none id
0551201 000 1.472093e6  2.09595e5 2.592954e6  0.0  0.0  1
0551202 000 1.445911e6 2.096632e5 2.592532e6  0.0  0.0  2
0551203 000 1.411005e6 2.097448e5 2.591948e6  0.0  0.0  3
0551204 000 1.376099e6  2.09836e5 2.591338e6  0.0  0.0  4
0551205 000 1.341192e6 2.099321e5 2.590702e6  0.0  0.0  5
0551206 000 1.306286e6  2.10028e5 2.590038e6  0.0  0.0  6
0551207 000 1.271379e6 2.101188e5 2.589344e6  0.0  0.0  7
0551208 000 1.236472e6 2.101997e5  2.58862e6  0.0  0.0  8
0551209 000 1.201565e6 2.102668e5 2.587862e6  0.0  0.0  9
0551210 000 1.166658e6 2.103176e5  2.58707e6  0.0  0.0 10
0551211 000 1.131751e6 2.103593e5 2.586242e6  0.0  0.0 11
0551212 000  1.10557e6 2.103754e5 2.585596e6  0.0  0.0 12
*          area         jun
0550201      2.42e-4          11
*        jefvcahs      jun num
0551101      00000000          11
*             vl          vv       unused       junid
0551301     11.156439    11.156439        0.0          1
0551302     11.156647    11.156647        0.0          2
0551303     11.156912    11.156912        0.0          3
0551304     11.157188    11.157188        0.0          4
0551305     11.157471    11.157471        0.0          5
0551306     11.157754    11.157754        0.0          6
0551307     11.158031    11.158031        0.0          7
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0551308     11.158295     11.158295          0.0            8
0551309     11.158542     11.158542          0.0            9
0551310      11.15877      11.15877          0.0           10
0551311     11.158986     11.158986          0.0           11
*               hd          corr         gas        slope        junid
0551401      4.64e-3           0.0           1.0           1.0           11
*             name          type
0600000     "unnamed"          pipe
*            ncells
0600001           12
*            x-area         volid
0600101       1.71e-4            12
*          x-length         volid
0600301          0.05            1
0600302           0.1           11
0600303          0.05           12
*            volume         volid
0600401           0.0           12
*        azim-angle         volid
0600501           0.0           12
*        vert-angle         volid
0600601          90.0           12
*            x-wall           xhd         volid
0600801       1.0e-5     4.506e-3           12
*           x-flags         volid
0601001             0           12
*      ebt      press   water-ie   steam-ie void none id
0601201 000 1.475083e6 2.095953e5 2.593001e6  0.0  0.0  1
0601202 000 1.448776e6 2.096526e5 2.592579e6  0.0  0.0  2
0601203 000 1.413704e6 2.097188e5 2.591994e6  0.0  0.0  3
0601204 000  1.37863e6 2.097916e5 2.591384e6  0.0  0.0  4
0601205 000 1.343557e6 2.098679e5 2.590746e6  0.0  0.0  5
0601206 000 1.308484e6 2.099442e5 2.590081e6  0.0  0.0  6
0601207 000  1.27341e6 2.100174e5 2.589386e6  0.0  0.0  7
0601208 000 1.238336e6 2.100842e5 2.588659e6  0.0  0.0  8
0601209 000 1.203262e6  2.10142e5   2.5879e6  0.0  0.0  9
0601210 000 1.168188e6  2.10189e5 2.587106e6  0.0  0.0 10
0601211 000 1.133113e6 2.102301e5 2.586275e6  0.0  0.0 11
0601212 000 1.106807e6 2.102442e5 2.585627e6  0.0  0.0 12
*              area           jun
0600201       1.71e-4            11
*          jefvcahs       jun num
0601101      00000000            11
*                vl            vv        unused        junid
0601301     10.972111     10.972111          0.0            1
0601302     10.972301     10.972301          0.0            2
0601303     10.972545     10.972545          0.0            3
0601304     10.972795     10.972795          0.0            4
0601305      10.97305      10.97305          0.0            5
0601306     10.973306     10.973306          0.0            6
0601307     10.973557     10.973557          0.0            7
0601308     10.973801     10.973801          0.0            8
0601309     10.974033     10.974033          0.0            9
0601310     10.974254     10.974254          0.0           10
0601311     10.974466     10.974466          0.0           11
*               hd          corr         gas        slope        junid
0601401      4.506e-3           0.0           1.0           1.0           11
*             name          type
0650000     "unnamed"        branch
*             njuns
0650001            5
*              area        length           vol
0650101       1.81e-3           0.1           0.0
*          az-angle     inc-angle            dz
0650102           0.0          90.0           0.1
*           x-rough          x-hd         flags
0650103           0.0           0.0            0
*               ebt         press      water-ie      steam-ie          void
0650200           000    1.122699e6    2.103265e5    2.586021e6
0.0
*              from            to          area
0651101      65010002      70010001       1.81e-3
*         fwd. loss     rev. loss      efvcahs
0651102           0.0           0.0            0
*                vl            vv        unused
0651201     4.6117187     4.6117187           0.0
*              from            to          area
0652101      65010001      50120002       3.12e-4
*         fwd. loss     rev. loss      efvcahs
0652102           0.4           0.4            0
*                vl            vv        unused
0652201    -11.263387    -11.263387           0.0
*              from            to          area
0653101      65010001      55120002       2.42e-4
*         fwd. loss     rev. loss      efvcahs
0653102           0.4           0.4            0
*                vl            vv        unused
0653201    -11.159129    -11.159129           0.0
*              from            to          area
0654101      65010001      60120002       1.71e-4
*         fwd. loss     rev. loss      efvcahs
0654102           0.4           0.4            0
*                vl            vv        unused
0654201    -10.974606    -10.974606           0.0
*              from            to          area
0655101      65010001      80120002        1.1e-5
*         fwd. loss     rev. loss      efvcahs
0655102           0.4           0.4            0
*                vl            vv        unused
0655201    -23.267387    -23.267387           0.0
*             name          type
0700000     "unnamed"          pipe
*            ncells
0700001            6
*            x-area         volid
0700101       1.81e-3            6
*          x-length         volid
0700301           0.2            1
0700302           0.4            2
0700303           0.5            5
0700304           0.3            6
*            volume         volid
0700401           0.0            6
*        azim-angle         volid
0700501           0.0            6
*        vert-angle         volid
0700601          90.0            6
*            x-wall           xhd         volid
0700801        1.0e-5           0.0            6
*           x-flags         volid
0701001             0            6
*      ebt      press   water-ie   steam-ie void none id
0701201 000 1.120749e6 2.103169e5 2.585973e6  0.0  0.0  1
0701202 000 1.116802e6 2.102979e5 2.585876e6  0.0  0.0  2
0701203 000 1.110882e6 2.102742e5 2.585728e6  0.0  0.0  3
0701204 000 1.104304e6 2.102504e5 2.585564e6  0.0  0.0  4
0701205 000 1.097726e6 2.102265e5 2.585398e6  0.0  0.0  5
0701206 000 1.092463e6 2.102121e5 2.585264e6  0.0  0.0  6
*          jefvcahs       jun num
0701101      00000000             5
*                vl            vv        unused        junid
0701301     4.6117172     4.6117172           0.0            1
0701302     4.6117153     4.6117153           0.0            2
0701303     4.6117148     4.6117148           0.0            3
0701304     4.6117158     4.6117158           0.0            4
0701305     4.6117167     4.6117167           0.0            5
*             name          type
0740000     "unnamed"       sngljun
*              from            to          area
0740101      70060002      75010001           0.0
*         fwd. loss     rev. loss      efvcahs
0740102           0.0           0.0            0
*         discharge       thermal
0740103           1.0          0.14
*              flow            vl            vv        unused
0740201             0     4.6117196     4.6117196           0.0
*             name          type
0750000     "unnamed"       tmdpvol
*              area        length           vol
0750101          20.0          20.0           0.0
*          az-angle     inc-angle            dz
0750102           0.0          90.0          20.0
*           x-rough          x-hd         flags
0750103           0.0           0.0            0
*             cword
0750200             3
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*              srch         press         temp
0750201         0.0       1.101e6        300.0
*              name         type
0800000    "unnamed"         pipe
*             ncells
0800001           12
*             x-area        volid
0800101       1.1e-5           1
0800102      3.46e-4          11
0800103       1.1e-5          12
*           x-length        volid
0800301         0.05           1
0800302          0.1          11
0800303         0.05          12
*             volume        volid
0800401          0.0          12
*          azim-angle       volid
0800501          0.0          12
*          vert-angle       volid
0800601         90.0          12
*             x-wall        xhd        volid
0800801       1.0e-5        0.0           12
*            x-flags        volid
0801001            0          12
*      ebt      press   water-ie   steam-ie void none id
0801201 000  1.12475e6 2.096705e5 2.586072e6  0.0  0.0  1
0801202 000  1.34429e6 2.096706e5  2.59076e6  0.0  0.0  2
0801203 000 1.343289e6 2.096722e5 2.590741e6  0.0  0.0  3
0801204 000 1.342287e6 2.096755e5 2.590723e6  0.0  0.0  4
0801205 000 1.341286e6 2.096807e5 2.590704e6  0.0  0.0  5
0801206 000 1.340284e6 2.096875e5 2.590686e6  0.0  0.0  6
0801207 000 1.339282e6  2.09696e5 2.590667e6  0.0  0.0  7
0801208 000 1.338281e6  2.09706e5 2.590648e6  0.0  0.0  8
0801209 000 1.337279e6  2.09717e5 2.590629e6  0.0  0.0  9
0801210 000 1.336277e6 2.097289e5  2.59061e6  0.0  0.0 10
0801211 000 1.335276e6 2.097414e5 2.590592e6  0.0  0.0 11
0801212 000 1.020448e6 2.098705e5 2.583331e6  0.0  0.0 12
*              area          jun
0800201      3.46e-4          11
*           jefvcahs       jun num
0801101     00000000          11
*              vl            vv       unused        junid
0801301    0.73966569    0.73966569        0.0           1
0801302    0.73959684    0.73959684        0.0           2
0801303    0.73959726    0.73959726        0.0           3
0801304    0.73959786    0.73959786        0.0           4
0801305    0.73959857    0.73959857        0.0           5
0801306    0.73959947    0.73959947        0.0           6
0801307    0.73960048    0.73960048        0.0           7
0801308    0.73960161    0.73960161        0.0           8
0801309     0.7396028     0.7396028        0.0           9
0801310    0.73960406    0.73960406        0.0          10
0801311    0.73960543    0.73960543        0.0          11
*******************************     Heat Structures
*******************************       nh   np     geom     ssif     leftcoord
reflood
10010000    8    7        2        1        0.024       0
*              mesh       format
10010100           0           1
*            intervals       radius
10010101           6        0.026
*             material     interval
10010201           3           6
*              rpkf      interval
10010301          0.0          6
*              temp      interval
10010401        300.0          7
*  Left Boundary Condition Data
*          bound      incr     type     code       factor     node
10010501  70060000       0      101       1         0.3       1
10010502  70050000       0      101       1         0.5       2
10010503  70040000       0      101       1         0.5       3
10010504  70030000       0      101       1         0.5       4
10010505  70020000       0      101       1         0.4       5
10010506  70010000       0      101       1         0.2       6
10010507  65010000       0      101       1         0.1       7
10010508  45010000       0      101       1        0.05       8
*  Right Boundary Condition Data
*          bound      incr     type     code       factor     node
10010601  10010000       0      101       1         0.3       1
10010602  10020000       0      101       1         0.5       2
10010603  10030000       0      101       1         0.5       3
10010604  10040000       0      101       1         0.5       4
10010605  10050000       0      101       1         0.4       5
10010606  10060000       0      101       1         0.2       6
10010607  15010000       0      101       1         0.1       7
10010608  35010000       0      101       1        0.05       8
*             source        mult        dmhl        dmhr         num
10010701           0         0.0         0.0         0.0           8
*  Left Additional Boundary Condition Data
10010800           0
*       hthd  hlf  hlr gslf gslr glcf glcr lbf node
10010801  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    8
*  Right Additional Boundary Condition Data
10010900           0
*       hthd  hlf  hlr gslf gslr glcf glcr lbf node
10010901  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    8
*n: 5
*        nh   np     geom    ssif    leftcoord reflood
10025000   10   17       2       1        0.033      0
*              mesh       format
10025100           0           1
*          intervals       radius
10025101           4       0.0336
10025102           8       0.0344
10025103           4        0.035
*           material     interval
10025201           2           4
10025202           1          12
10025203           2          16
*              rpkf      interval
10025301          0.0          4
10025302          1.0         12
10025303          0.0         16
*              temp      interval
10025401        300.0         17
*  Left Boundary Condition Data
*          bound      incr     type     code       factor     node
10025501  25110000       0      101       1         0.1       1
10025502  25100000       0      101       1         0.1       2
10025503  25090000       0      101       1         0.1       3
10025504  25080000       0      101       1         0.1       4
10025505  25070000       0      101       1         0.1       5
10025506  25060000       0      101       1         0.1       6
10025507  25050000       0      101       1         0.1       7
10025508  25040000       0      101       1         0.1       8
10025509  25030000       0      101       1         0.1       9
10025510  25020000       0      101       1         0.1      10
*  Right Boundary Condition Data
*          bound      incr     type     code       factor     node
10025601  20110000       0      101       1         0.1       1
10025602  20100000       0      101       1         0.1       2
10025603  20090000       0      101       1         0.1       3
10025604  20080000       0      101       1         0.1       4
10025605  20070000       0      101       1         0.1       5
10025606  20060000       0      101       1         0.1       6
10025607  20050000       0      101       1         0.1       7
10025608  20040000       0      101       1         0.1       8
10025609  20030000       0      101       1         0.1       9
10025610  20020000       0      101       1         0.1      10
*             source        mult        dmhl        dmhr         num
10025701        1000   0.026176409       0.0         0.0           1
10025702        1000   0.036591412       0.0         0.0           2
10025703        1000   0.044041994       0.0         0.0           3
10025704        1000   0.047924554       0.0         0.0           5
10025705        1000   0.044041994       0.0         0.0           6
10025706        1000   0.036591412       0.0         0.0           7
10025707        1000   0.026176409       0.0         0.0           8
10025708        1000   0.013640753       0.0         0.0           9
10025709        1000   6.890509e-3       0.0         0.0          10
*  Left Additional Boundary Condition Data
10025800           0
*          hthd  hlf  hlr gslf gslr glcf glcr lbf node
10025801 9.816e-3 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
*  Right Additional Boundary Condition Data
10025900           0
```

```
*          hthd  hlf  hlr gslf gslr glcf glcr lbf node
10025901 0.010697 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
*       nh   np     geom     ssif    leftcoord reflood
10026000   2   7       2        1       0.033      0
*            mesh       format
10026100          0          1
*        intervals       radius
10026101          6       0.035
*         material     interval
10026201          2          6
*            rpkf     interval
10026301        0.0          6
*            temp     interval
10026401       300.0          7
*  Left Boundary Condition Data
*        bound     incr     type     code       factor     node
10026501  25010000      0      101        1         0.05        1
10026502  25120000      0      101        1         0.05        2
*  Right Boundary Condition Data
*        bound     incr     type     code       factor     node
10026601  20010000      0      101        1         0.05        1
10026602  20120000      0      101        1         0.05        2
*          source         mult        dmhl         dmhr         num
10026701          0         0.0          0.0          0.0          2
*  Left Additional Boundary Condition Data
10026800          0
*      hthd  hlf  hlr gslf gslr glcf glcr lbf node
10026801  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    2
*  Right Additional Boundary Condition Data
10026900          0
*      hthd  hlf  hlr gslf gslr glcf glcr lbf node
10026901  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    2
*n: 4
*       nh   np     geom     ssif    leftcoord reflood
10030000   10   17       2        1       0.0285      0
*            mesh       format
10030100          0          1
*        intervals       radius
10030101          4       0.0291
10030102          8       0.0299
10030103          4       0.0305
*         material     interval
10030201          2          4
10030202          1          12
10030203          2          16
*            rpkf     interval
10030301        0.0          4
10030302        1.0          12
10030303        0.0          16
*            temp     interval
10030401       300.0          17
*  Left Boundary Condition Data
*        bound     incr     type     code       factor     node
10030501  30110000      0      101        1         0.1        1
10030502  30100000      0      101        1         0.1        2
10030503  30090000      0      101        1         0.1        3
10030504  30080000      0      101        1         0.1        4
10030505  30070000      0      101        1         0.1        5
10030506  30060000      0      101        1         0.1        6
10030507  30050000      0      101        1         0.1        7
10030508  30040000      0      101        1         0.1        8
10030509  30030000      0      101        1         0.1        9
10030510  30020000      0      101        1         0.1        10
*  Right Boundary Condition Data
*        bound     incr     type     code       factor     node
10030601  25110000      0      101        1         0.1        1
10030602  25100000      0      101        1         0.1        2
10030603  25090000      0      101        1         0.1        3
10030604  25080000      0      101        1         0.1        4
10030605  25070000      0      101        1         0.1        5
10030606  25060000      0      101        1         0.1        6
10030607  25050000      0      101        1         0.1        7
10030608  25040000      0      101        1         0.1        8
10030609  25030000      0      101        1         0.1        9
10030610  25020000      0      101        1         0.1        10
*          source         mult        dmhl         dmhr         num
10030701        1000   0.018878743        0.0          0.0          1
10030702        1000    0.02639017        0.0          0.0          2
10030703        1000    0.03176362        0.0          0.0          3
10030704        1000   0.034563769        0.0          0.0          5
10030705        1000    0.03176362        0.0          0.0          6
10030706        1000    0.02639017        0.0          0.0          7
10030707        1000   0.018878743        0.0          0.0          8
10030708        1000   9.837876e-3        0.0          0.0          9
10030709        1000   4.969519e-3        0.0          0.0          10
*  Left Additional Boundary Condition Data
10030800          0
*          hthd  hlf  hlr gslf gslr glcf glcr lbf node
10030801 9.784e-3 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
*  Right Additional Boundary Condition Data
10030900          0
*          hthd  hlf  hlr gslf gslr glcf glcr lbf node
10030901 0.01083 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
*       nh   np     geom     ssif    leftcoord reflood
10031000   2   7       2        1       0.0285      0
*            mesh       format
10031100          0          1
*        intervals       radius
10031101          6       0.0305
*         material     interval
10031201          2          6
*            rpkf     interval
10031301        0.0          6
*            temp     interval
10031401       300.0          7
*  Left Boundary Condition Data
*        bound     incr     type     code       factor     node
10031501  30010000      0      101        1         0.05        1
10031502  30120000      0      101        1         0.05        2
*  Right Boundary Condition Data
*        bound     incr     type     code       factor     node
10031601  25010000      0      101        1         0.05        1
10031602  25120000      0      101        1         0.05        2
*          source         mult        dmhl         dmhr         num
10031701          0         0.0          0.0          0.0          2
*  Left Additional Boundary Condition Data
10031800          0
*      hthd  hlf  hlr gslf gslr glcf glcr lbf node
10031801  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    2
*  Right Additional Boundary Condition Data
10031900          0
*      hthd  hlf  hlr gslf gslr glcf glcr lbf node
10031901  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    2
*n: 3
*       nh   np     geom     ssif    leftcoord reflood
10050000   10   17       2        1       0.024      0
*            mesh       format
10050100          0          1
*        intervals       radius
10050101          4       0.0246
10050102          8       0.0254
10050103          4       0.026
*         material     interval
10050201          2          4
10050202          1          12
10050203          2          16
*            rpkf     interval
10050301        0.0          4
10050302        1.0          12
10050303        0.0          16
*            temp     interval
10050401       300.0          17
*  Left Boundary Condition Data
*        bound     incr     type     code       factor     node
10050501  50020000      0      101        1         0.1        1
10050502  50030000      0      101        1         0.1        2
10050503  50040000      0      101        1         0.1        3
10050504  50050000      0      101        1         0.1        4
10050505  50060000      0      101        1         0.1        5
10050506  50070000      0      101        1         0.1        6
10050507  50080000      0      101        1         0.1        7
10050508  50090000      0      101        1         0.1        8
10050509  50100000      0      101        1         0.1        9
10050510  50110000      0      101        1         0.1        10
*  Right Boundary Condition Data
*        bound     incr     type     code       factor     node
```

```
10050601  30110000        0      101        1          0.1        1
10050602  30100000        0      101        1          0.1        2
10050603  30090000        0      101        1          0.1        3
10050604  30080000        0      101        1          0.1        4
10050605  30070000        0      101        1          0.1        5
10050606  30060000        0      101        1          0.1        6
10050607  30050000        0      101        1          0.1        7
10050608  30040000        0      101        1          0.1        8
10050609  30030000        0      101        1          0.1        9
10050610  30020000        0      101        1          0.1        10
*            source        mult        dmhl         dmhr          num
10050701         1000  0.014357363         0.0          0.0           1
10050702         1000  0.020069835         0.0          0.0           2
10050703         1000  0.024156366         0.0          0.0           3
10050704         1000  0.026285892         0.0          0.0           5
10050705         1000  0.024156366         0.0          0.0           6
10050706         1000  0.020069835         0.0          0.0           7
10050707         1000  0.014357363         0.0          0.0           8
10050708         1000  7.481746e-3         0.0          0.0           9
10050709         1000   3.77934e-3         0.0          0.0          10
*  Left Additional Boundary Condition Data
10050800           0
*          hthd  hlf  hlr gslf gslr glcf glcr lbf node
10050801 9.742e-3 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
*  Right Additional Boundary Condition Data
10050900           0
*          hthd  hlf  hlr gslf gslr glcf glcr lbf node
10050901 0.011028 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
*        nh   np     geom      ssif     leftcoord reflood
10051000    2    7         2         1         0.024       0
*              mesh       format
10051100           0           1
*          intervals       radius
10051101           6        0.026
*            material      interval
10051201           2            6
*               rpkf      interval
10051301         0.0            6
*               temp      interval
10051401       300.0            7
*  Left Boundary Condition Data
*          bound      incr      type      code       factor      node
10051501  50010000        0      101        1          0.05        1
10051502  50120000        0      101        1          0.05        2
*  Right Boundary Condition Data
*          bound      incr      type      code       factor      node
10051601  30120000        0      101        1          0.05        1
10051602  30010000        0      101        1          0.05        2
*            source        mult        dmhl         dmhr          num
10051701           0          0.0          0.0          0.0           2
*  Left Additional Boundary Condition Data
10051800           0
*      hthd  hlf  hlr gslf gslr glcf glcr lbf node
10051801  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    2
*  Right Additional Boundary Condition Data
10051900           0
*      hthd  hlf  hlr gslf gslr glcf glcr lbf node
10051901  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    2
*n: 2
*        nh   np     geom      ssif     leftcoord reflood
10055000   10   17         2         1        0.0195       0
*              mesh       format
10055100           0           1
*          intervals       radius
10055101           4       0.0201
10055102           8       0.0209
10055103           4       0.0215
*            material      interval
10055201           2            4
10055202           1           12
10055203           2           16
*               rpkf      interval
10055301         0.0            4
10055302         1.0           12
10055303         0.0           16
*               temp      interval
10055401       300.0           17
*  Left Boundary Condition Data
*          bound      incr      type      code       factor      node
10055501  55020000        0      101        1          0.1        1
10055502  55030000        0      101        1          0.1        2
10055503  55040000        0      101        1          0.1        3
10055504  55050000        0      101        1          0.1        4
10055505  55060000        0      101        1          0.1        5
10055506  55070000        0      101        1          0.1        6
10055507  55080000        0      101        1          0.1        7
10055508  55090000        0      101        1          0.1        8
10055509  55100000        0      101        1          0.1        9
10055510  55110000        0      101        1          0.1        10
*  Right Boundary Condition Data
*          bound      incr      type      code       factor      node
10055601  50020000        0      101        1          0.1        1
10055602  50030000        0      101        1          0.1        2
10055603  50040000        0      101        1          0.1        3
10055604  50050000        0      101        1          0.1        4
10055605  50060000        0      101        1          0.1        5
10055606  50070000        0      101        1          0.1        6
10055607  50080000        0      101        1          0.1        7
10055608  50090000        0      101        1          0.1        8
10055609  50100000        0      101        1          0.1        9
10055610  50110000        0      101        1          0.1        10
*            source        mult        dmhl         dmhr          num
10055701         1000  0.011184465         0.0          0.0           1
10055702         1000  0.015634512         0.0          0.0           2
10055703         1000  0.018817943         0.0          0.0           3
10055704         1000  0.020476855         0.0          0.0           5
10055705         1000  0.018817943         0.0          0.0           6
10055706         1000  0.015634512         0.0          0.0           7
10055707         1000  0.011184465         0.0          0.0           8
10055708         1000  5.828322e-3         0.0          0.0           9
10055709         1000  2.944127e-3         0.0          0.0          10
*  Left Additional Boundary Condition Data
10055800           0
*          hthd  hlf  hlr gslf gslr glcf glcr lbf node
10055801 0.09676 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
*  Right Additional Boundary Condition Data
10055900           0
*          hthd  hlf  hlr gslf gslr glcf glcr lbf node
10055901 0.011343 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
*        nh   np     geom      ssif     leftcoord reflood
10056000    2    7         2         1        0.0195       0
*              mesh       format
10056100           0           1
*          intervals       radius
10056101           6       0.0215
*            material      interval
10056201           2            6
*               rpkf      interval
10056301         0.0            6
*               temp      interval
10056401       300.0            7
*  Left Boundary Condition Data
*          bound      incr      type      code       factor      node
10056501  55120000        0      101        1          0.05        1
10056502  55010000        0      101        1          0.05        2
*  Right Boundary Condition Data
*          bound      incr      type      code       factor      node
10056601  50120000        0      101        1          0.05        1
10056602  50010000        0      101        1          0.05        2
*            source        mult        dmhl         dmhr          num
10056701           0          0.0          0.0          0.0           2
*  Left Additional Boundary Condition Data
10056800           0
*      hthd  hlf  hlr gslf gslr glcf glcr lbf node
10056801  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    2
*  Right Additional Boundary Condition Data
10056900           0
*      hthd  hlf  hlr gslf gslr glcf glcr lbf node
10056901  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    2
*n: 1
*        nh   np     geom      ssif     leftcoord reflood
10060000   10   17         2         1         0.015       0
*              mesh       format
10060100           0           1
*          intervals       radius
10060101           4       0.0156
```

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10060102           8       0.0164
10060103           4        0.017
*          material      interval
10060201           2           4
10060202           1          12
10060203           2          16
*             rpkf      interval
10060301         0.0           4
10060302         1.0          12
10060303         0.0          16
*             temp      interval
10060401       300.0          17
*  Left Boundary Condition Data
*         bound     incr    type    code     factor    node
10060501  60020000     0     101     1       0.1      1
10060502  60030000     0     101     1       0.1      2
10060503  60040000     0     101     1       0.1      3
10060504  60050000     0     101     1       0.1      4
10060505  60060000     0     101     1       0.1      5
10060506  60070000     0     101     1       0.1      6
10060507  60080000     0     101     1       0.1      7
10060508  60090000     0     101     1       0.1      8
10060509  60100000     0     101     1       0.1      9
10060510  60110000     0     101     1       0.1     10
*  Right Boundary Condition Data
*         bound     incr    type    code     factor    node
10060601  55020000     0     101     1       0.1      1
10060602  55030000     0     101     1       0.1      2
10060603  55040000     0     101     1       0.1      3
10060604  55050000     0     101     1       0.1      4
10060605  55060000     0     101     1       0.1      5
10060606  55070000     0     101     1       0.1      6
10060607  55080000     0     101     1       0.1      7
10060608  55090000     0     101     1       0.1      8
10060609  55100000     0     101     1       0.1      9
10060610  55110000     0     101     1       0.1     10
*          source       mult        dmhl       dmhr        num
10060701       1000   8.72547e-3       0.0        0.0         1
10060702       1000  0.012197137       0.0        0.0         2
10060703       1000  0.014680665       0.0        0.0         3
10060704       1000  0.015974851       0.0        0.0         5
10060705       1000  0.014680665       0.0        0.0         6
10060706       1000  0.012197137       0.0        0.0         7
10060707       1000   8.72547e-3       0.0        0.0         8
10060708       1000  4.546918e-3       0.0        0.0         9
10060709       1000  2.296836e-3       0.0        0.0        10
*  Left Additional Boundary Condition Data
10060800           0
*         hthd  hlf  hlr gslf gslr glcf glcr lbf node
10060801 9.563e-3 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
*  Right Additional Boundary Condition Data
10060900           0
*         hthd  hlf  hlr gslf gslr glcf glcr lbf node
10060901 0.011926 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
*        nh   np     geom      ssif     leftcoord reflood
10061000    2   7       2        1        0.015       0
*             mesh       format
10061100           0           1
*         intervals       radius
10061101           6        0.017
*          material      interval
10061201           2           6
*             rpkf      interval
10061301         0.0           6
*             temp      interval
10061401       300.0           7
*  Left Boundary Condition Data
*         bound     incr    type    code     factor    node
10061501  60120000     0     101     1       0.05     1
10061502  60010000     0     101     1       0.05     2
*  Right Boundary Condition Data
*         bound     incr    type    code     factor    node
10061601  55120000     0     101     1       0.05     1
10061602  55010000     0     101     1       0.05     2
*          source       mult        dmhl       dmhr        num
10061701          0        0.0        0.0        0.0         2
*  Left Additional Boundary Condition Data
10061800           0
*         hthd  hlf  hlr gslf gslr glcf glcr lbf node
10061801  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    2
*  Right Additional Boundary Condition Data
10061900           0
*         hthd  hlf  hlr gslf gslr glcf glcr lbf node
10061901  0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0    2
*n: 0
*        nh   np     geom      ssif     leftcoord reflood
10080000   12   17       2        1       0.0105       0
*             mesh       format
10080100           0           1
*         intervals       radius
10080101          16       0.0125
*          material      interval
10080201           3          16
*             rpkf      interval
10080301         0.0          16
*             temp      interval
10080401       300.0          17
*  Left Boundary Condition Data
*         bound     incr    type    code     factor    node
10080501  80020000     0     101     1       0.1      1
10080502  80030000     0     101     1       0.1      2
10080503  80040000     0     101     1       0.1      3
10080504  80050000     0     101     1       0.1      4
10080505  80060000     0     101     1       0.1      5
10080506  80070000     0     101     1       0.1      6
10080507  80080000     0     101     1       0.1      7
10080508  80090000     0     101     1       0.1      8
10080509  80100000     0     101     1       0.1      9
10080510  80110000     0     101     1       0.1     10
10080511  80010000     0     101     1       0.05    11
10080512  80120000     0     101     1       0.05    12
*  Right Boundary Condition Data
*         bound     incr    type    code     factor    node
10080601  60020000     0     101     1       0.1      1
10080602  60030000     0     101     1       0.1      2
10080603  60040000     0     101     1       0.1      3
10080604  60050000     0     101     1       0.1      4
10080605  60060000     0     101     1       0.1      5
10080606  60070000     0     101     1       0.1      6
10080607  60080000     0     101     1       0.1      7
10080608  60090000     0     101     1       0.1      8
10080609  60100000     0     101     1       0.1      9
10080610  60110000     0     101     1       0.1     10
10080611  60010000     0     101     1       0.05    11
10080612  60120000     0     101     1       0.05    12
*          source       mult        dmhl       dmhr        num
10080701          0        0.0        0.0        0.0        12
*  Left Additional Boundary Condition Data
10080800           0
*         hthd  hlf  hlr gslf gslr glcf glcr lbf node
10080801 9.563e-3 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
10080802      0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0   12
*  Right Additional Boundary Condition Data
10080900           0
*         hthd  hlf  hlr gslf gslr glcf glcr lbf node
10080901 0.011926 10.0 10.0  0.0  0.0  0.0  0.0 1.0   10
10080902      0.0 10.0 10.0  0.0  0.0  0.0  0.0 1.0   12
*******************************        Point Kinetics
*******************************                  type      feedback
30000000        point      separabl
*           decay        power        react        dnf
30000001     gamma-ac       1.98e6         0.0     45.03311
*           control
30000011           2 * General Table 2 (PK + PAR)
30000012           3 * General Table 3 (PB)
30000013           4 * General Table 4 (Reactivity_Slow)
30000014           5 * General Table 5 (Reactivity_Fast)
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Krucza 36
00-522 Warszawa
Poland

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Division of Systems Analysis
Office of Nuclear Regulatory Research
U.S. Nuclear Regulatory Commission
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10. SUPPLEMENTARY NOTES
A. Calvo, NRC Project Manager

11. ABSTRACT *(200 words or less)*
The new fuel type in the Research Reactor 'Maria' is undergoing a test procedure. Thermal-hydraulic calculations using RELAP have been applied in order to cross-check the results obtained using a specialized thermal-hydraulic 'SN' code. Nodalization of the fuel element has been developed and calculations have been performed. LOFA and RIA cases have been analysed and compared showing good agreement between the two codes.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*
Polish National Atomic Energy Agency (PAA)
Research Reactor 'Maria'
RELAP5
GTRI (Global Threat Reduction Initiative)
National Centre for Nuclear Research
Reactivity Initiated Accident (RIA)
Loss of Flow Accident (LOFA)
Loss Of Coolant Accident (LOCA)
Highly Enriched Uranium (HEU)
Low Enriched Uranium fuel (LEU)

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