NUREG/IA-0207

International Agreement Report

RELAP5/MOD3.2.2 Gamma Assessment For Down To Top Reflooding Process At VVER Like 37-Rod Bundle

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Washington, DC 20555-0001

July 2002

Prepared as part of
The Agreement on Research Participation and Technical Exchange
under the International Code Application and Maintenance Program (CAMP)

Published by
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ABSTRACT

The assessment of RELAP5/MOD3.2.2 Gamma for down to top reflooding at VVER like 37-rod bundle is presented. The experiment have been performed at IPPE test facility at the following parameters: upper plenum pressure- 0,246 MPa, cooling water temperature- 51°C, water velocity- 4.91 sm/s, average linear heat flux density at maximal heat production zone before water supply-1,77 kWt/m. RELAP5/MOD3.2.2Gamma assessment showed that code gives satisfactory results for all parameters behavior. The main discrepancies were get for cladding temperature behavior at level H-2.7m, where the calculated cladding temperatures exceed experimental data approximately on 75 K. Computed quenching time for this level are much higher experimental ones. For other levels accordance between experimental and RELAP data is rather good.

EXECUTIVE SUMMARY

This report presents the of RELAP5/MOD3.2.2 Gamma assessment in the prediction of reflooding process in VVER like 37-rod assembly with bottom to top water supply. The results of base case calculations showed that code gives satisfactory results for all parameters behavior. The main discrepancies were get for cladding temperature behavior at elevation 2.7m, where the calculated value exceeded the measured datum by about 75K. Computed quenching time for this elevation is much higher than experimental ones. For other levels accordance between experimental and RELAP data is rather good. Sensitivity analysis of results of calculations to input data showed that radial bundle nodding was inexpedient and it leads to less realistic results than at modeling of the bundle by one channel.

1. INTRODUCTION

One of the main processes determining the behavior of fuel element during the accidents is the reflooding process, at which one they are cooling at the expense of water supplied to reactor from emergency core cooling (ECC) system. VVER type reactors against PWR ones have ECC system, which supplies the water not only from the bottom of the core, but also from the upper plenum.
This process is very difficult for mathematical modeling, so it seems reasonable to investigate it by separate ways: firstly down-to-top reflooding, then top-to-down one and then combined process.
Such researches are carried out now in EPPE at assemblies modeling an active zone of VVER reactors. Results of these investigations could be used for thermohydraulic codes assessment. Presented work such assessment have been done for RELAP5/MOD3 (version 3.2.2 Gamma), which consist an improved reflooding process model developed at Paul Scherer Institute using the experiment carried out at 37-rod VVER like assembly with down-to-top reflooding at IPPE in 2000.

2. TEST FACILITY DESCRIPTION

2.1 Circulation loop

Principal scheme of experimental loop is shown at Fig.1A of Appendix A, which contents all necessary data for carrying out the calculations.
Water from tank (1) is supplied by centrifugal pumps (2) through the block of regulate valves with electric drive (B4) and B4(r) into electric heater (19) where water heats until the given temperature. Flowrate value is measured by set of two orifices, which are established sequentially on line of water supply to the test section (10). In automatic monitoring mode the given water flowrate is supported with the help of a valve electric drive B4(r). Distribution valves (4) established after a preheater (19) allows at an opened valve A and closed valves Б and B and ball plug to route the flow to the test section (10), or to return into the tank (1) through the bypass line, which has the cooler (11) and stop valves (B6). Before the inlet of test section (10) is placed the throttle flowmeter (6), which is the indicator of switching of bang-bang valve (4) and beginning of water supply into the test section.
Separated in the upper plenum of the test section liquid collects in the tank of entrained water (7), connected by pipe with the bottom of the upper plenum. Vapor from the upper plenum passes through the special device with a developed surface, electric heater (15) where the remained non separated water evaporates, flowmeter orifice (6) and trough the vapor pressurizer (13) goes to condenser (16) and tank (1). The pressure in a system is established with the help of a steam compensator (13). Its regulation implements with the help of a valve (B9) and (B9r). If pressure exceeds given value, relief valve at compensator (13) opens.

2.2 Test section

Test section (TS) scheme is shown at Fig. 2A. It consists of vessel, upper and lower plenum. Vessel is made of hexahedral tube with inner described diameter equal 91.4 mm and wall thickness 3.3 mm.
Vessel wall temperature is measured by 12 thermocouples at outer surface in four levels (692, 2038, 2732, 3500 mm from heater zone beginning) three thermocouples in level. There are three rings along the vessel for pressure tapoff.
Upper plenum intended for inertial phase separation of two phase flow coming out from the test section represents the cylindrical vessel (V=30000sm^3). Gills arranged at the top of the plenum before an assigning nipple serve for additional phase separation. Separated water collects in the circular slot at the bottom of upper plenum and through the inclined opening flow off into the tank of entrained liquid. The bottom of upper plenum consists of two flanges lower of which serves for electric current supply to rod bundle and simultaneously for upper rod bundle grid modeling. Thickness of this grid is 20mm and

cross section area is near the grid area value. The nipple by an altitude of 100 mms and inner diameter 84-87mm fastens to the same flange. It models an upper part of reference VVER assembly. At the outlet of this nipple arranged the perforated plate 20mm thickness with 121 holes (109 and 12 hole 5.5mm and 3.5 mm diameter accordingly), which models the plate arranged at the outlet of the core of reference reactor. Cross section area of plate holes per one rod is near the reference reactor one.
There are pipe connections in upper plenum and outlet nipple (fairlead) for thermocouples lead- in and pressure measurement.
Lower plenum represents a cylindrical vessel by inner diameter of 120 mm and altitude of 185 mm. For heat losses reducing vessel and plenums are isolated 20mm thickness high-temperature isolator (heat conduction coefficient equals to 0.05 Wt/(m K), heat capacity - 992 Kj/(kg K), density – 144 kg/m^3 at temperatures 123÷1523 K). There are four thermocouples at the outer surface of the isolator at different locations along the vessel for heat losses control.

2.3 Rod bundle

Rod bundle models the VVER assembly and consists of rod bundle of 37 rod imitators with indirect heating with heated zone length 3530mm.
Rod imitator (Fig. 4A) consists of stainless steel cladding with outer diameter 9.1mm and inner diameter 7.9mm inside, which are placed nichrome heater and six chromel-alumel thermocouples with isolated junction.
There are three types of rod imitators: in imitators of A type thermocouples placed at six locations along the length (one thermocouple for one level), in imitators of B and C type they are located in pairs at three locations (Fig.5A). Electric isolation used in all imitators is oxide magnium.
Heater is made from nichcrome rod of variable cross section at the ends of that are welded copper current supplyes. Average along al 37 rods length axial nonuniformity is equal Kz=1.60.
Main characteristics of imitator are presented at tables A1, A2, A3 of Appendix A. Rod bundle was maked up from imitators, which has identical characteristics. Relative scatter of rod power for 37 rods is less than 10%.
Besides upper grid there are 15 grids along the rod bundle, distance between which is 225mm. The rods in bundle replaced at triangular spasing with pitch equal to 12.75mm.
Cross sectional area in the narrowest part is 3328 mm^2. There are thermocouples in the cells and at the grids .
Table 1 shows the main geometrical characteristics of the test section
The initial geometrical conditions for the test are the following:

- inner circumscribed diameter of the vessel – 91.4mm,
- inner vessel width across fields – 81.8mm,
- average for 37 rods rod diameter – 9.14mm.

Table 1

Cross section area					D hydralics	D heated
Support grid A-A	Rod bundle B-B	Grid C-C	Grid-current supply Д-Д	Perforated plate E-E	B-B	B-B
mm^2	mm^2	mm^2	mm^2	mm^2	mm	mm
2719	3328	2719	2438	2695 (121 holes)	9,95	12,53

2.3 Measurement system

Test loop and assembly model are arranged by necessary amount of sensors and control system to measure the following parameters: inlet and outlet test section pressures and temperatures, water temperature and massflow at test section inlet, vapor temperature and massflow at its outlet, rod cladding and vessel wall temperatures, pressure drops at heated part of test section and tank of entrained liquid. Measurement scheme is presented at Fig.7A of Appendix A.
The Total parameters measurement error in the test was compounded as: pressure - 0,5 %; flowrate - 2,0 %; pressure drop - 1,0 %; power - 1,0 %; temperature - 1,0 %.

2.5 Test procedure

- Loop for reflooding investigation is filled with water from tank (1) with use of centrifugal pumps (2) and blowed out to reduce air.
- Using block of regulation valves (12) necessary flowrate through the test section established. Water heating at the inlet of test section realized by switching on electrical heater (19). Nominal pressure in the loop is supported by valve B9(r). Then power stepwise increased. At different power levels parameters required for pressure drop measurement and verifying mass and energy balance were registered.
- Electrical power reduced to zero. With using bang-bang valve water flow trough the test section stopped and water flow directs to tank (1).
- Drainage valves opened and water flows out from the test section, tang of entrained liquid and vapor compensator (13). The remained liquid level was near the beginning of heater zone of rod bundle.
- Heater (15) switched on for heating-up pipeline before vapor flowmeters.
- Temperature at the inlet of test section checked.
- Information gathering computer system and power control system switched on.
- Test section power increased until ~40÷50% of nominal value.
- Test section power increased until nominal value in automatic mode.
- After reaching of specified temperature (any rod cladding temperature) began water supply to the test section and power decreased according to specified curve. Valve B14 closed.
- Switching on of water flowrate trough the test section (beginning of reflooding process) is controlled by flowmeter indication at line of water supply.
- Parameters supporting during the process in given limits carried out in automatic (power) and manual mode (flowrate, pressure, inlet temperature).
- Test stopped when all thermocouples fixed the rewetting of all rods and power switched out.

3. TEST SCENARIO AND INITIAL CONDITIONS

Second Russian Standart Reflooding Problem is the reflooding experiment from down to top of 37-rods bundle of full length scale VVER like rod assembly with fixed cooling water supply.

3.1 Test scenario

The initial conditions of test section was the following: lower plenum and lower rods (unheated part) part were filled with water 50°C and other part and upper plenum - with saturated vapor.

- Power increasing for given value and rods heating to start temperature.

- After reaching of starting temperature power decreasing began and switched on water supply to the test section.
- Test stopped at rod temperatures reached saturation temperature.

3.2 Starting values of main parameters

- Upper plenum pressure - 0,246 MPa;
- Cooling water temperature - 51°C;
- Water velocity - 4.91 sm/s;
- Average linear heat flux density at maximal heat production zone before water supply -1,77 kWt/m.

Reproducibility of such characteristics as maximal cladding temperature and quenching time in identical tests was near 1%.

Heat losses defined in special steady-state tests describes by formula: $Q_{loss}=4,7\cdot10^{3}(\overline{T}_{\kappa}-T_{o})$ kWt, where $(\overline{T}_{\kappa}-T_{o})$ – difference between average along the vessel length temperature and air one.

4. NODALIZATION SCHEME DESCRIPTION

Heat production in different rod simulators reviewing (Table A1) allows to come to conclusion, that despite of some scatter of axial distribution for different rods it seems quite reasonable to model all 37-rod bundle as the set of identical rods with average on all 37 rods axial heat distribution. Thus test section was modeled as one channel of "pipe" type devided into 15 parts along the length. Two heat structures connected with this channel modeled 37 heated rods (heat production equals zero at upper subvolume) and vessel wall. Upper plenum was modeled by two volumes "branch" type, which modeled upper perforated plate and upper volume where phase separation occurred. Down volume was connected with heat structure, modeled perforated plate. Inlet water temperature and its flowrate were set in the elements "tmdpjun" and "tmdpvol", connected with lower plenum modeled with element "branch" type.

5. Results of calculations

Calculations have been performed by RELAP5/MOD3.2 Gamma, which contents PSI reflooding model. At initial conditions there were established fixed distribution of vapor and heat structures temperatures – 2.46Mpa and 400K. The power bringed to test section began to increase and at time 139s inlet flowrate increased from zero up to 0.16kg/s. Power was changed according to experimental curve. Figs. 2-7 shows the results of calculations for three "A" type rods : №№ 19,22 and 27, for which were made the detailed cladding temperature measurements along the length .Table 2 shows the coordinates of thermocouples location.

Table 2

	Thermocouple location, mm		
Section/ Rod	19	22	27
H=1	57	117	184
H=2	513	690	698
H=3	1100	1215	1222
H=4	-	2212	2203
H=5	2704	2734	2722
H=6	3505	3501	3477

It is clear that the coordinates of thermocouples location some differed for on section and naturally their indications would be different too. But this difference is too small, as thermocouples locates near the end of plate zone of heat distribution. For more larger difference could play role their radial position. So the rod 19 is placed in the middle of bundle, rod 22 in the outer row near the vessel wall and rod 27 is placed in the second row from the center.

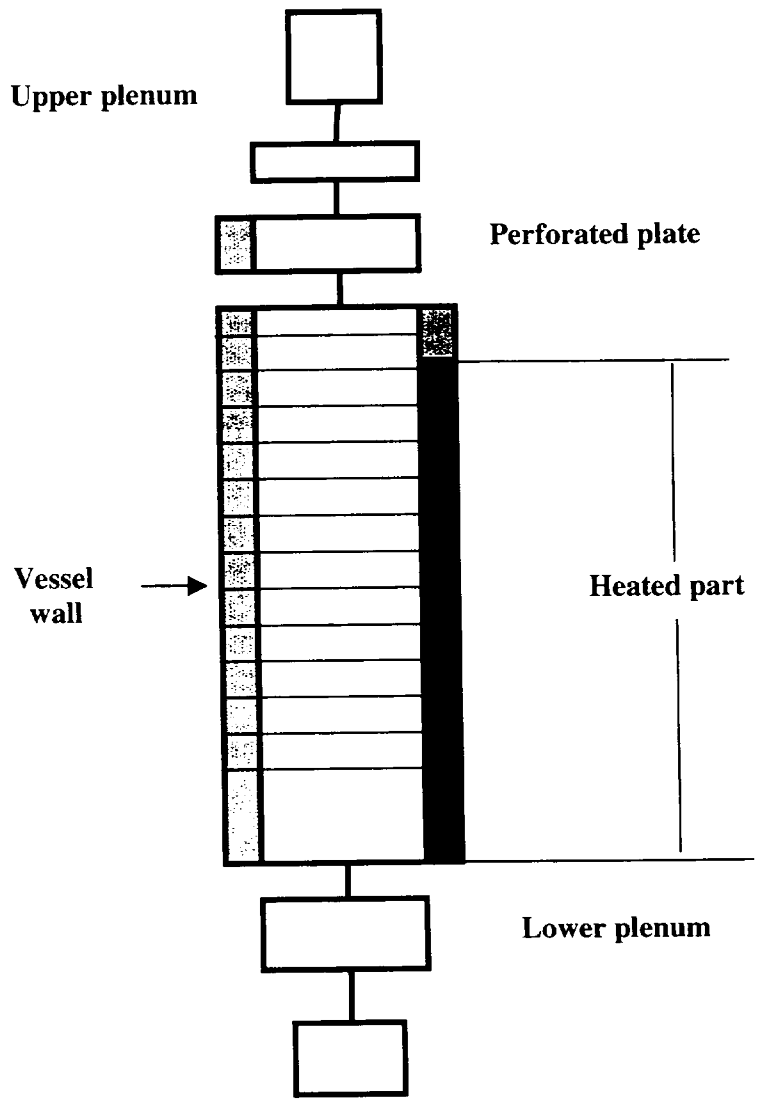


Fig.1 Nodalization scheme of test section

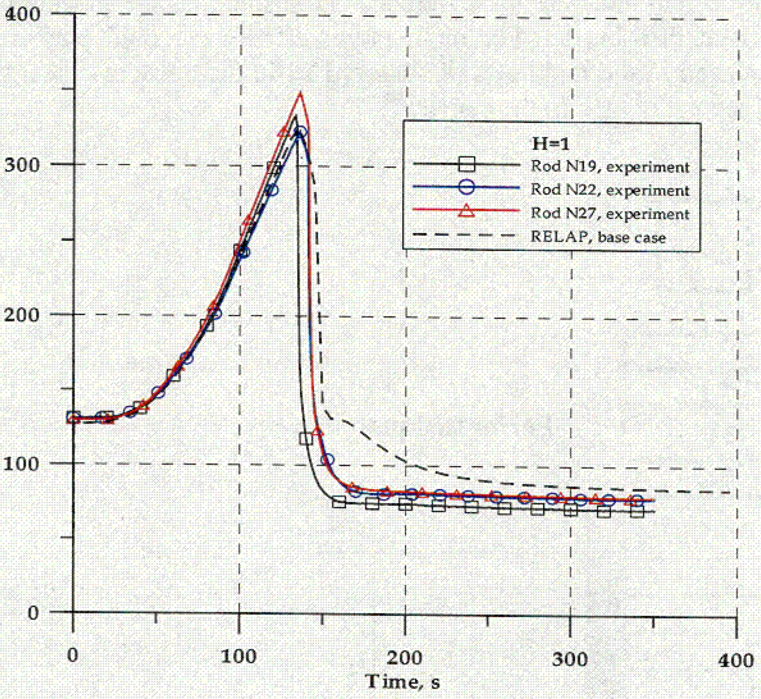


Fig. 2 Rods cladding temperature behavior at H=1. Base case calculation and experimental data

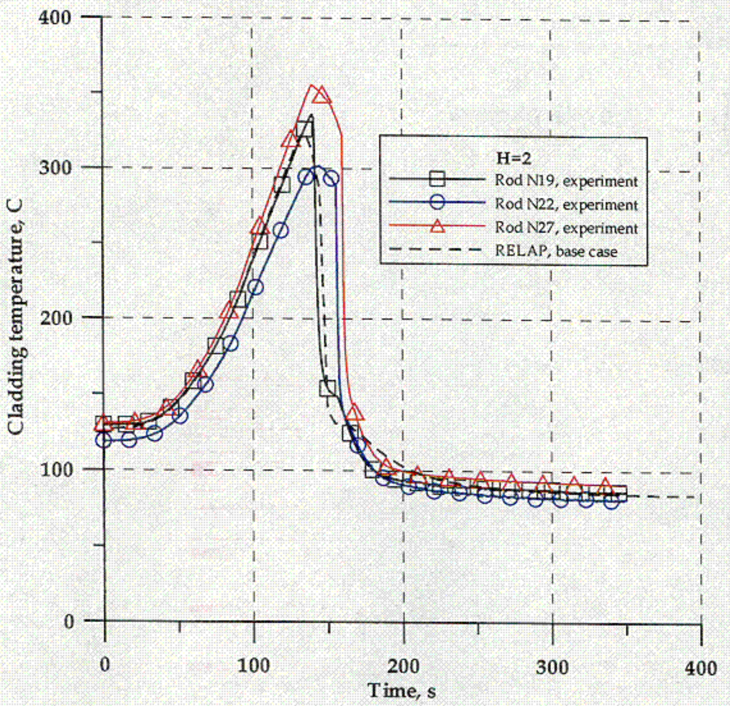


Fig. 3 Rods cladding temperature behavior at H=2. Base case calculation and experimental data

C01

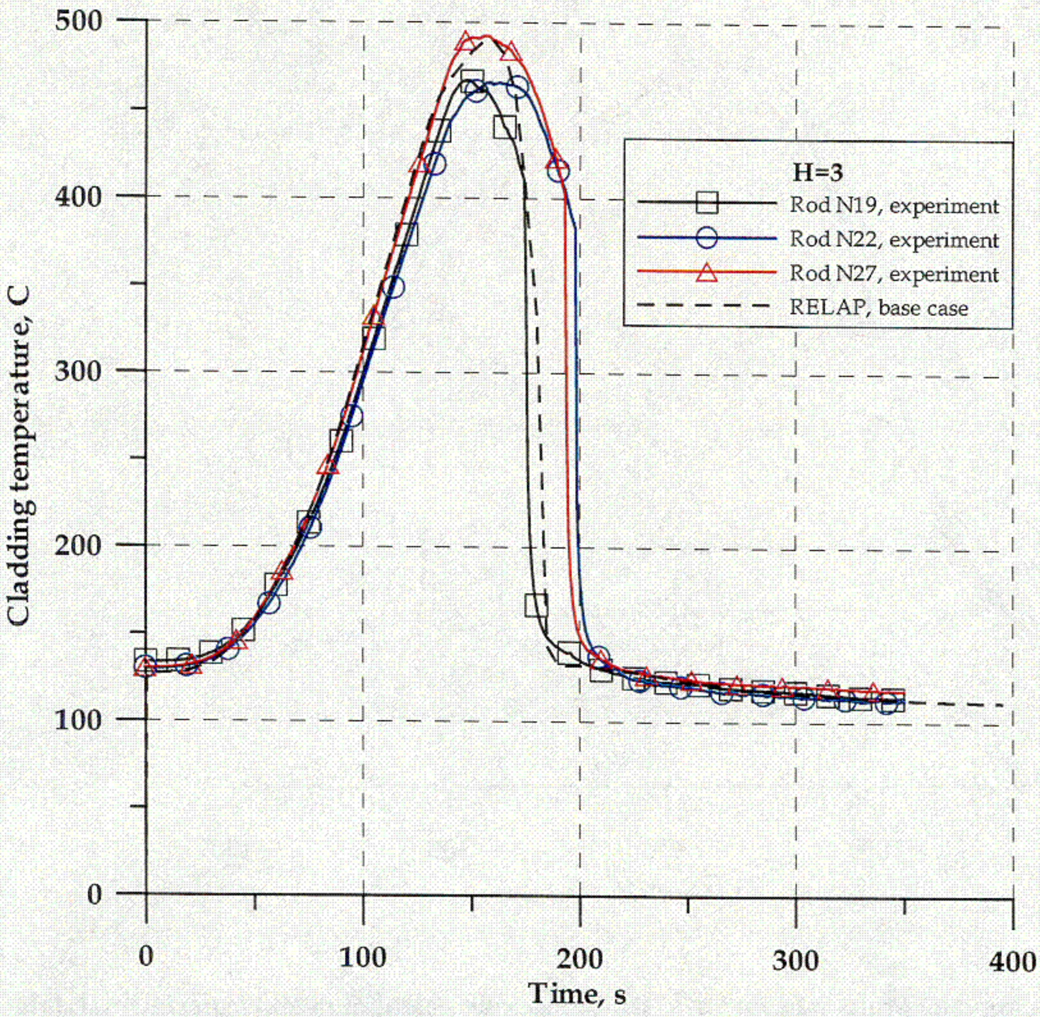


Fig. 4 Rods cladding temperature behavior at H=3. Base case calculation and experimental data

C02

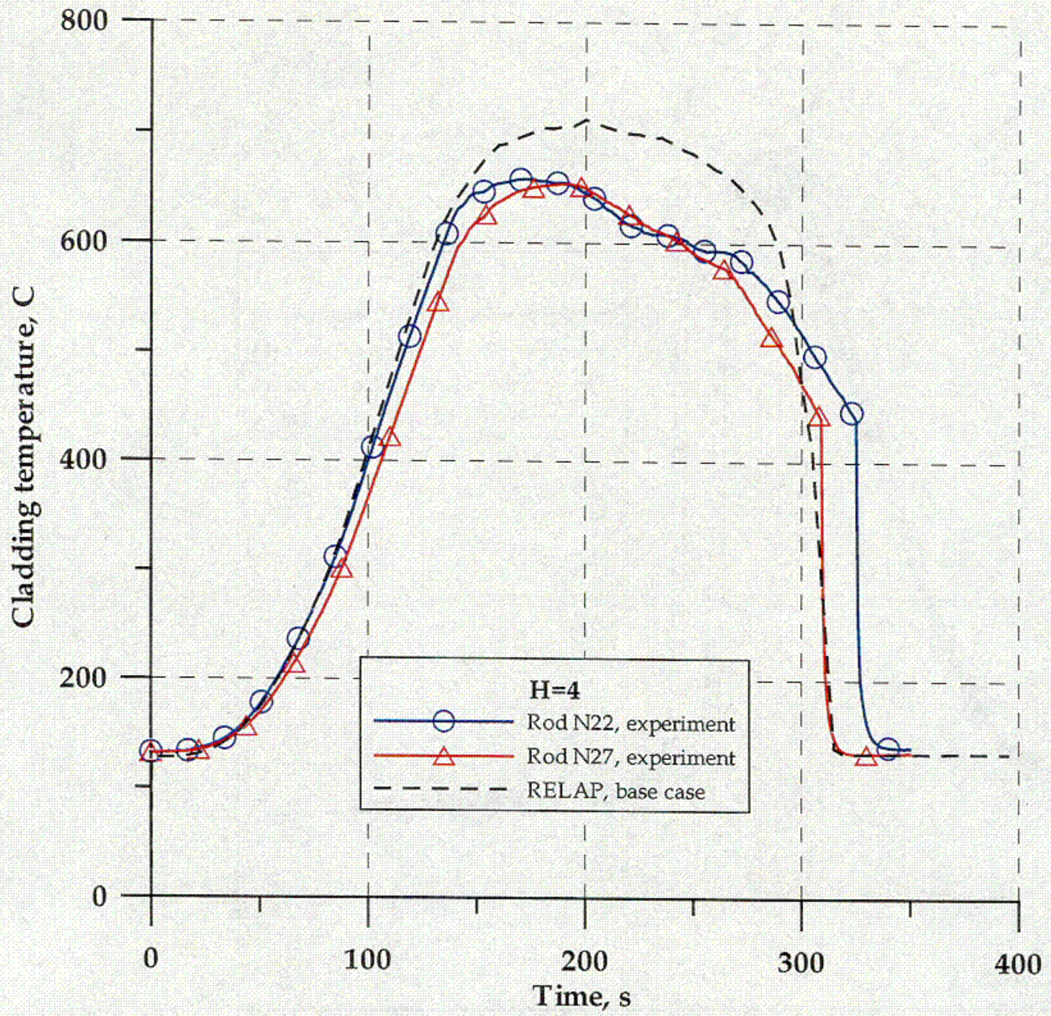


Fig. 5 Rods cladding temperature behavior at H=4. Base case calculation and experimental data

C03

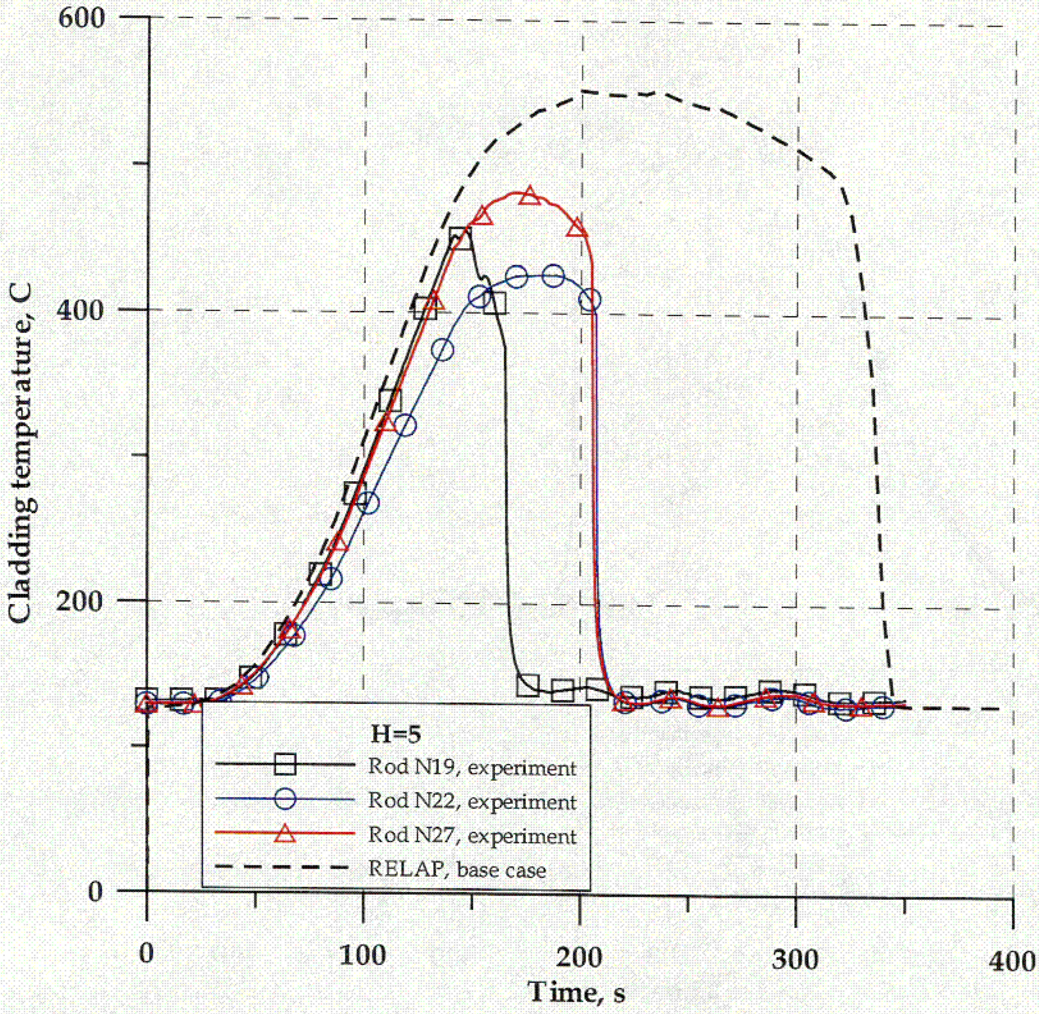


Fig. 6 Rods cladding temperature behavior at H=5. Base case calculation and experimental data

C04

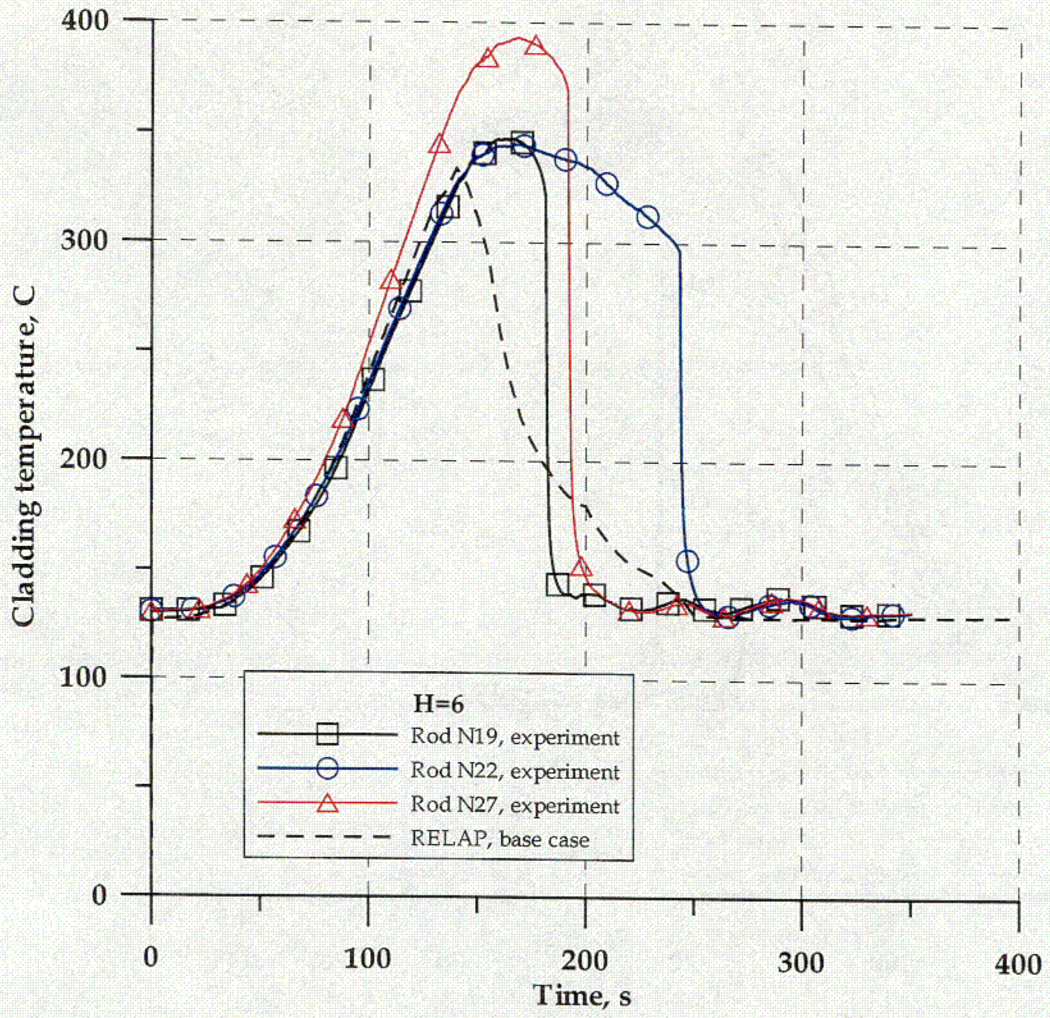


Fig. 7 Rods cladding temperature behavior at H=6. Base case calculation and experimental data

Fig. 8-11 shows the same data but separately for each rod. The analysis of these data shows that accordance between them is rather good especially for down and middle part of rod bundle (until H=4). For upper section especially for H=5 code gives lower temperatures, but more longer duration of reflooding process. Specially clear it is visible at Fig. 11, at which quenching front position during the test is presented. It is clear that front velocity propagation is very well predicted for lower part of the bundle, but for upper part the descripancies between calculated and experimental values becomes larger. It must be noted that the experimental data for this part have significant scatter from 30s to 150s.

Fig. 11-13 shows pressure drop data along the test section: for down part of heated zone, upper part and total pressure drop for heated zone. One can see that total pressure drop predicted well enough, and for lower part calculated values are some lower experimental ones after 180s. Upper part pressure drops at first 300 s have different signs with closed rates of pressure drop increasing. Apparently the experimental data for this parameter is not correct and it is lowered approximately at 4kPa.

C05

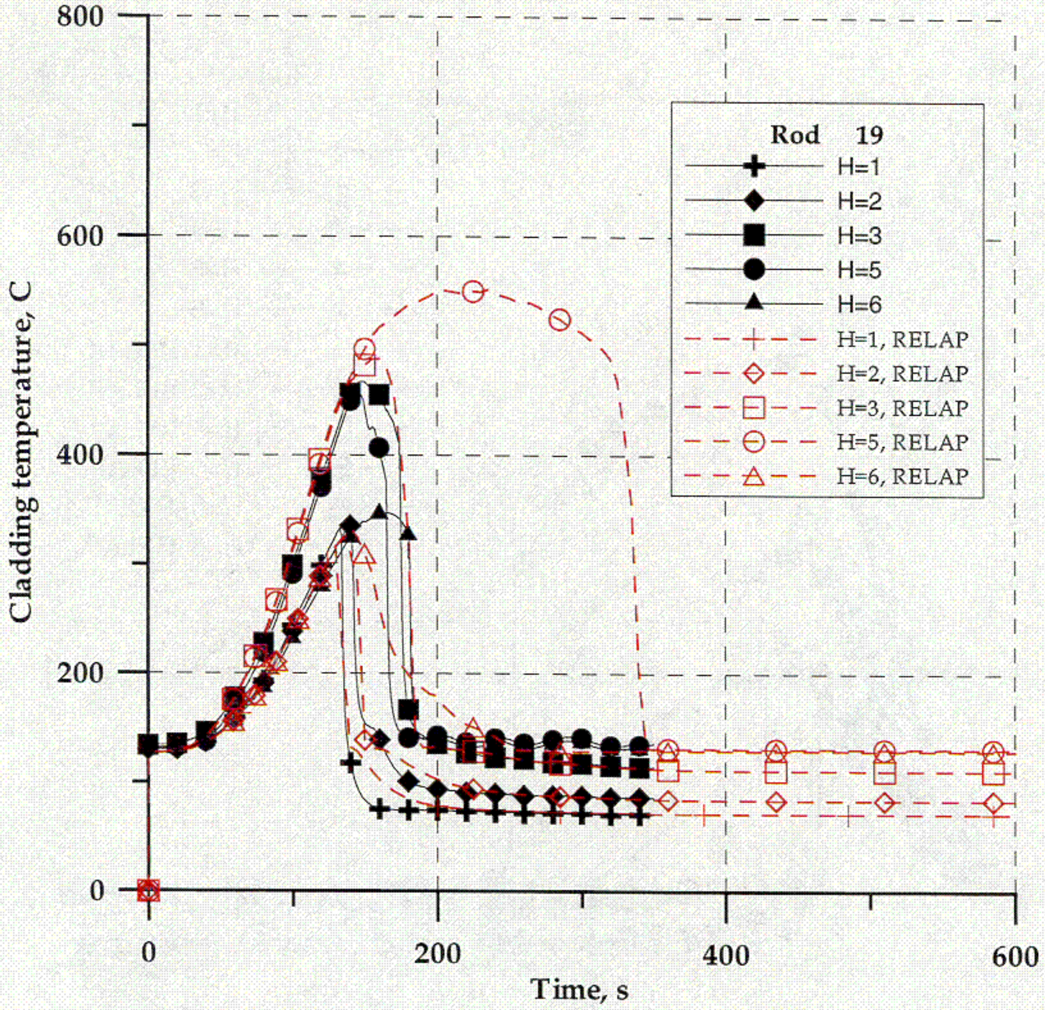


Fig. 8 Cladding temperature of rod N19. Base case calculation and experimental data

C06

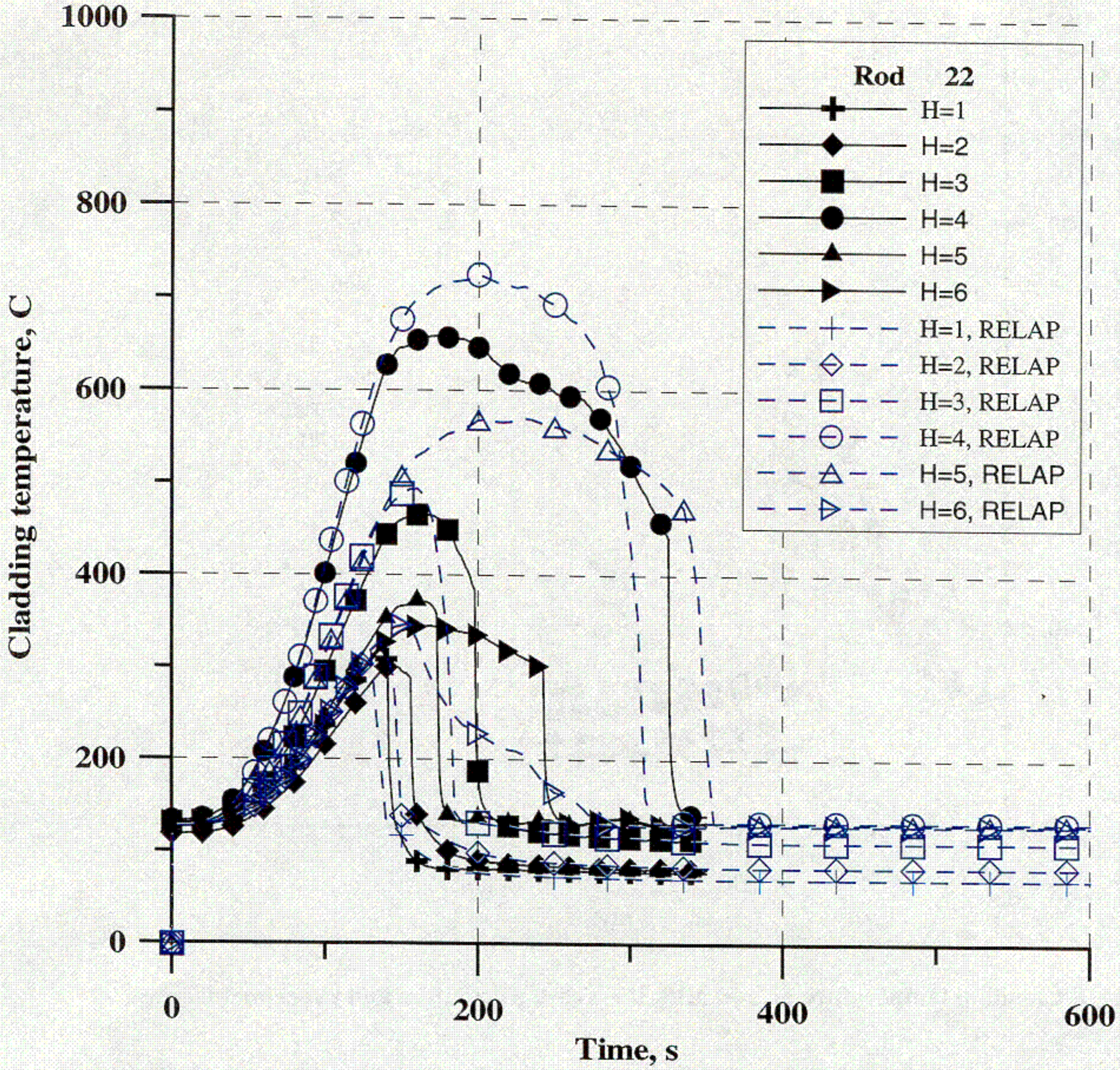


Fig. 9 Cladding temperature of rod N22. Base case calculation and experimental data

C07

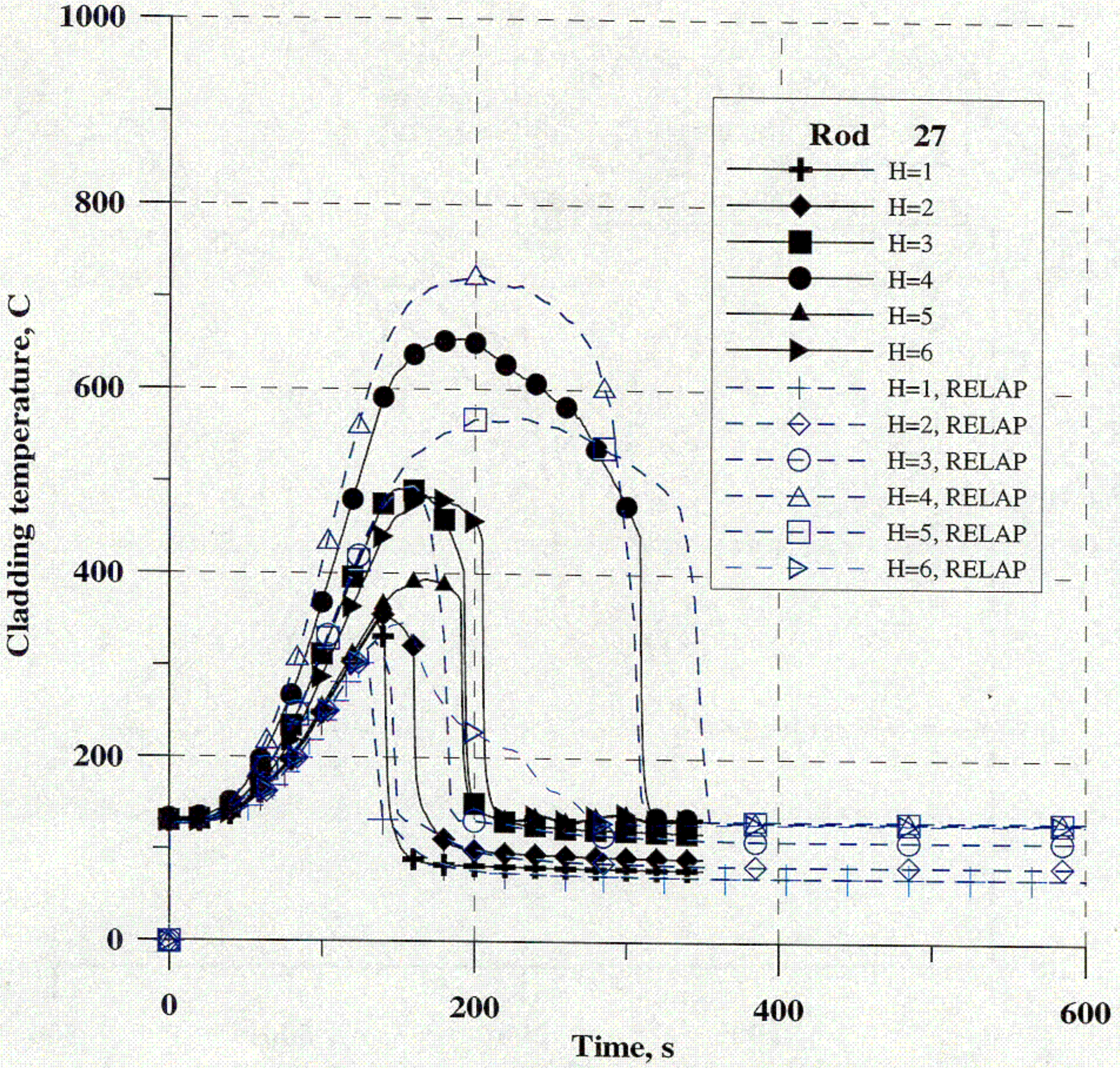


Fig. 10 Cladding temperature of rod N27. Base case calculation and experimental data.

C08

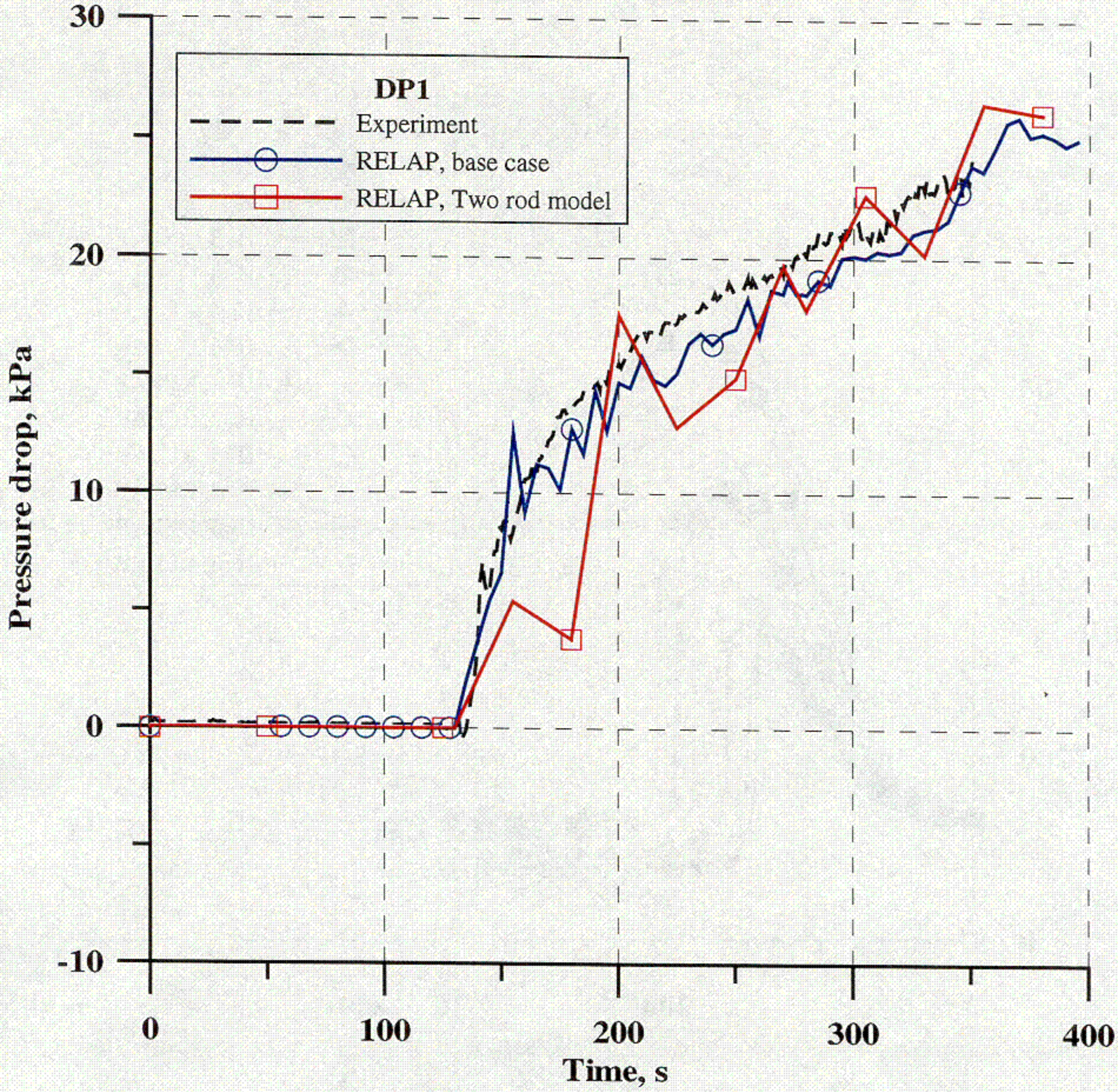


Fig. 11 Full pressure drop at heated zone

C09

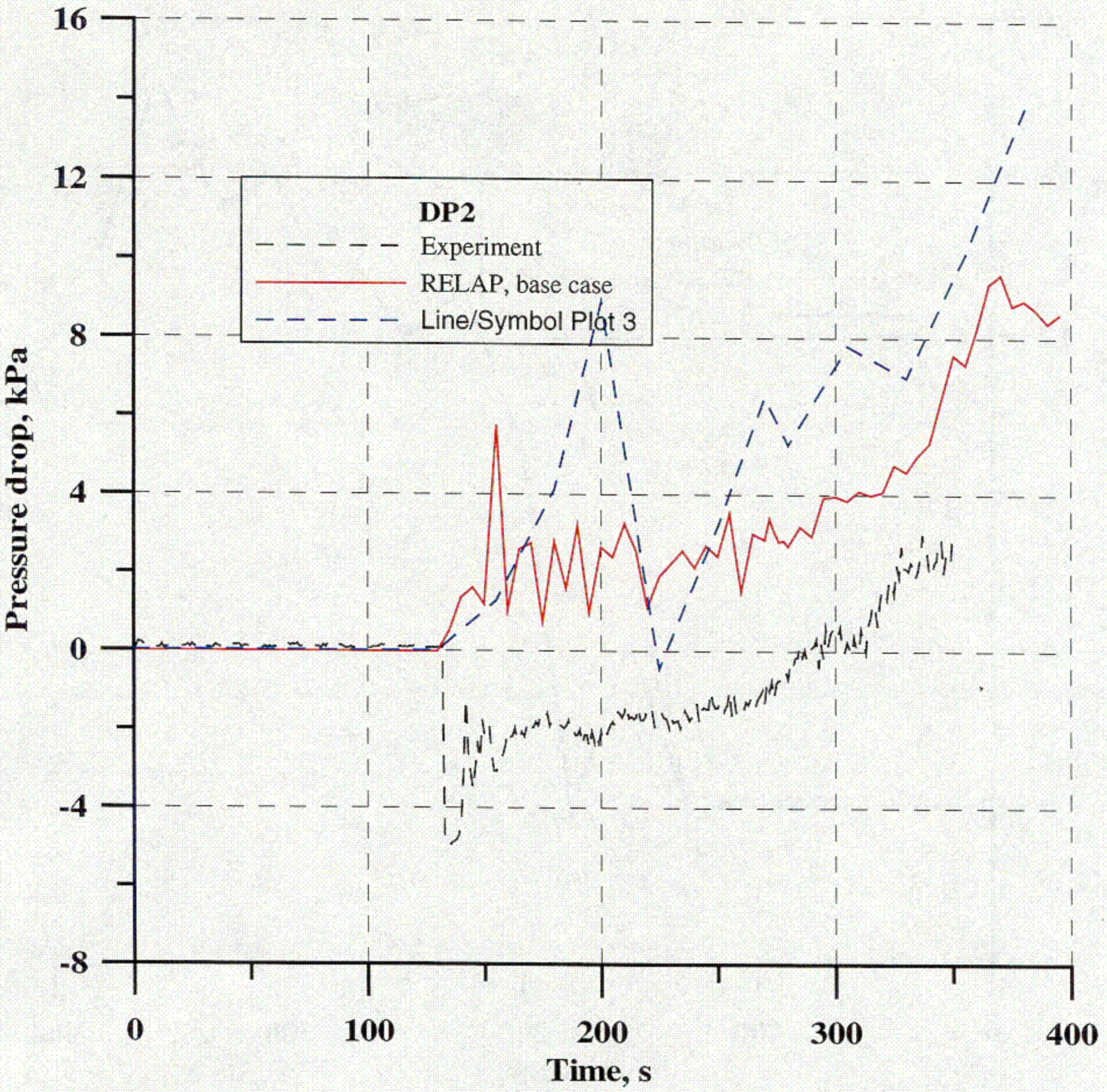


Fig. 12 Pressure drop at upper part of the bundle

C10

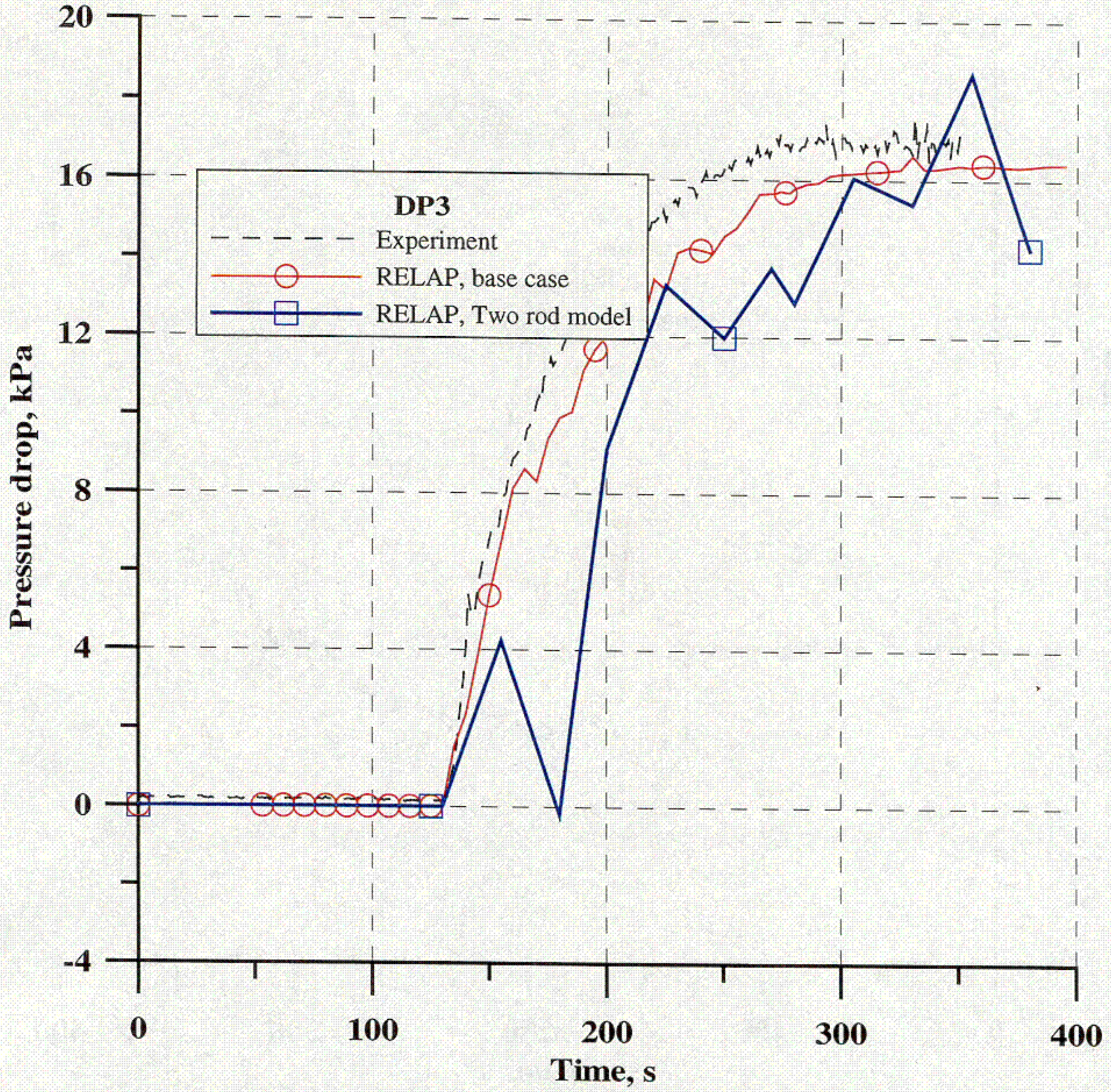


Fig. 13 Pressure drop at lower part of the bundle

C11

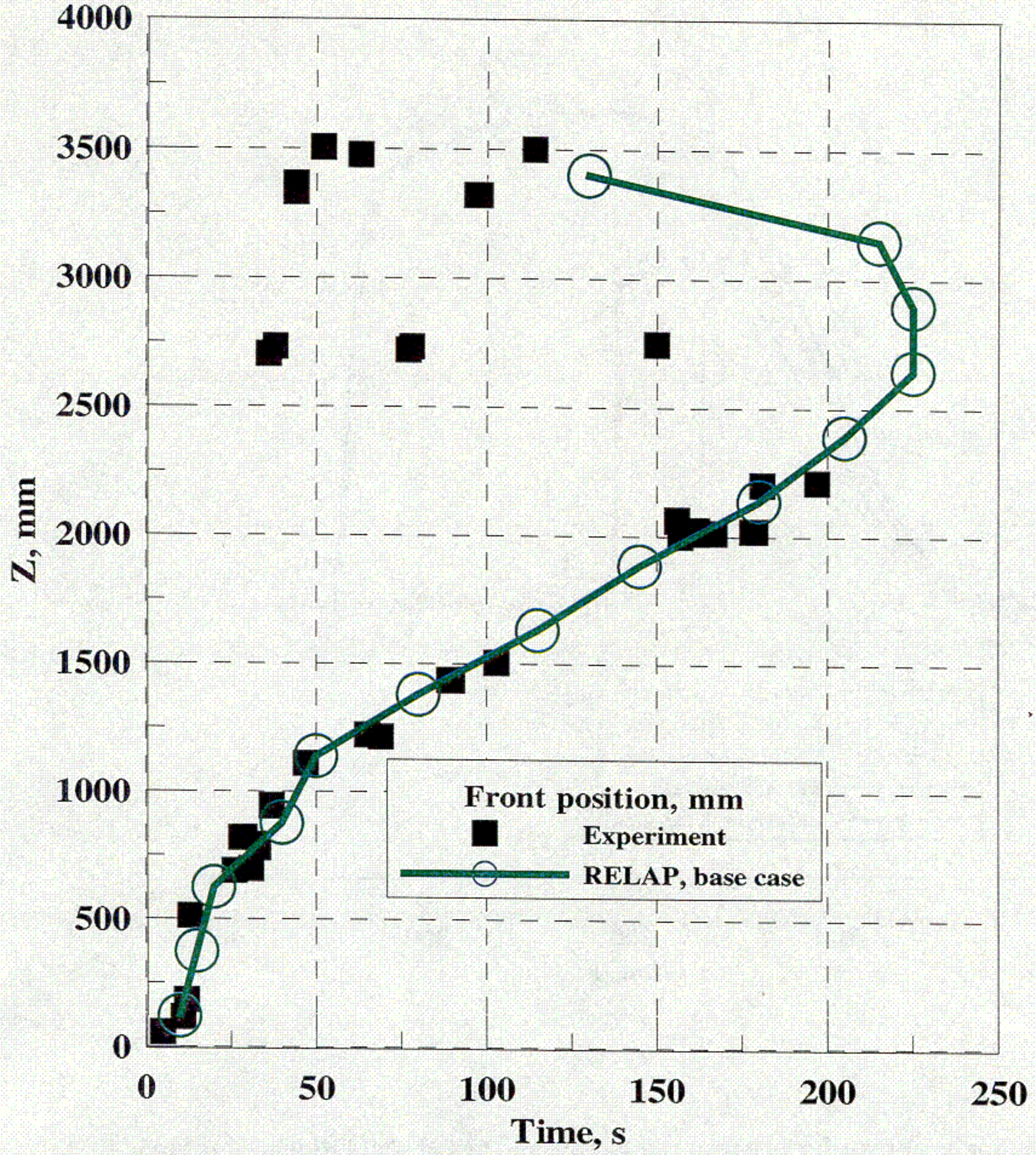


Fig. 14. Quenching front position. Base case and experimental data

6. SENSITIVITY ANALYSIS

6.1. Radiation heat transfer influence

It seems reasonable that radiation heat transfer between different rod is inessential, as their temperatures differ from each other too small during the process. However radiation could play role in outer rods row and vessel wall. For checking such influence the calculations have been performed with taking into consideration the radiation heat transfer. Rod bundle in this calculation was modeled as for base case by one channel multiplicity 37 and heat structure, which changed with radiation heat with vessel wall. The results of this calculations are presented at Fig. 15-16.

C12

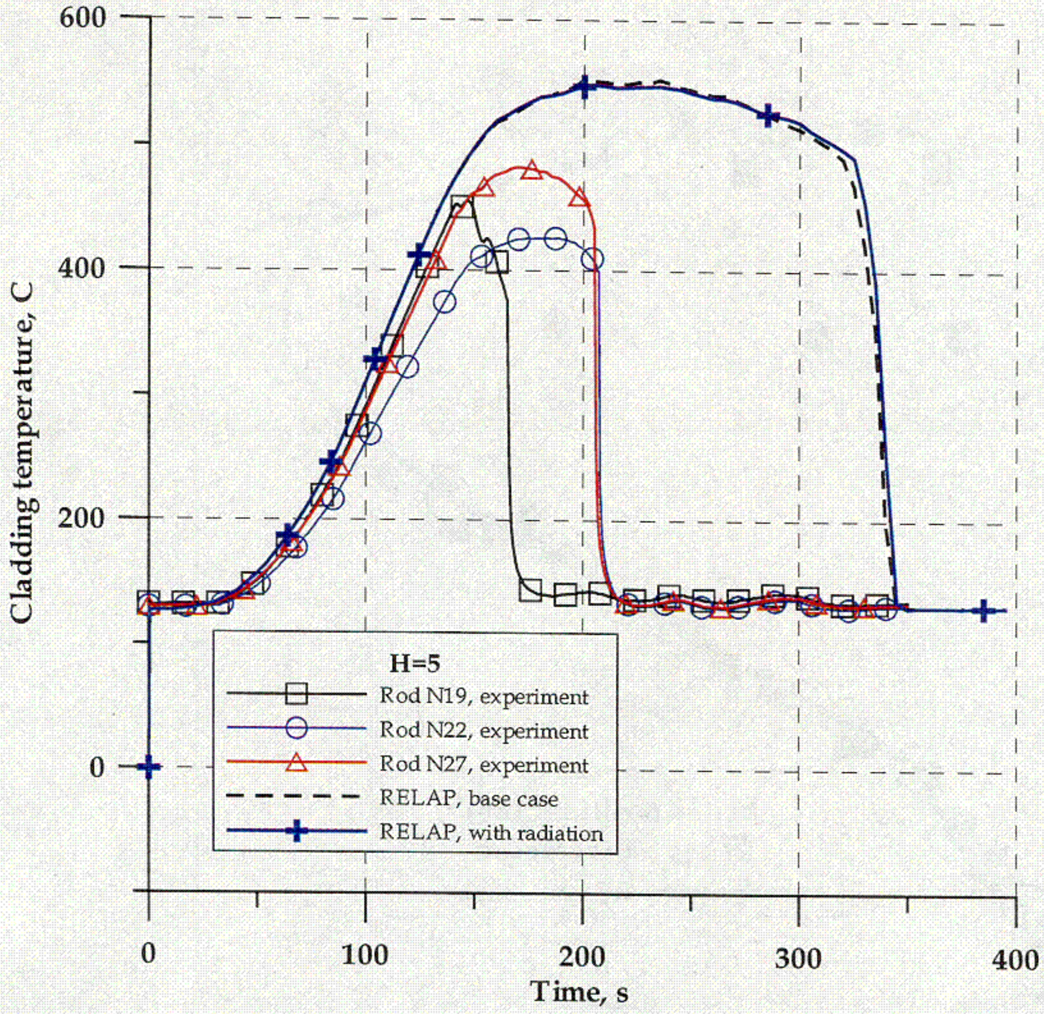


Fig. 15. Radiation heat transfer between rod bundle and vessel wall influence for H=5.

C13

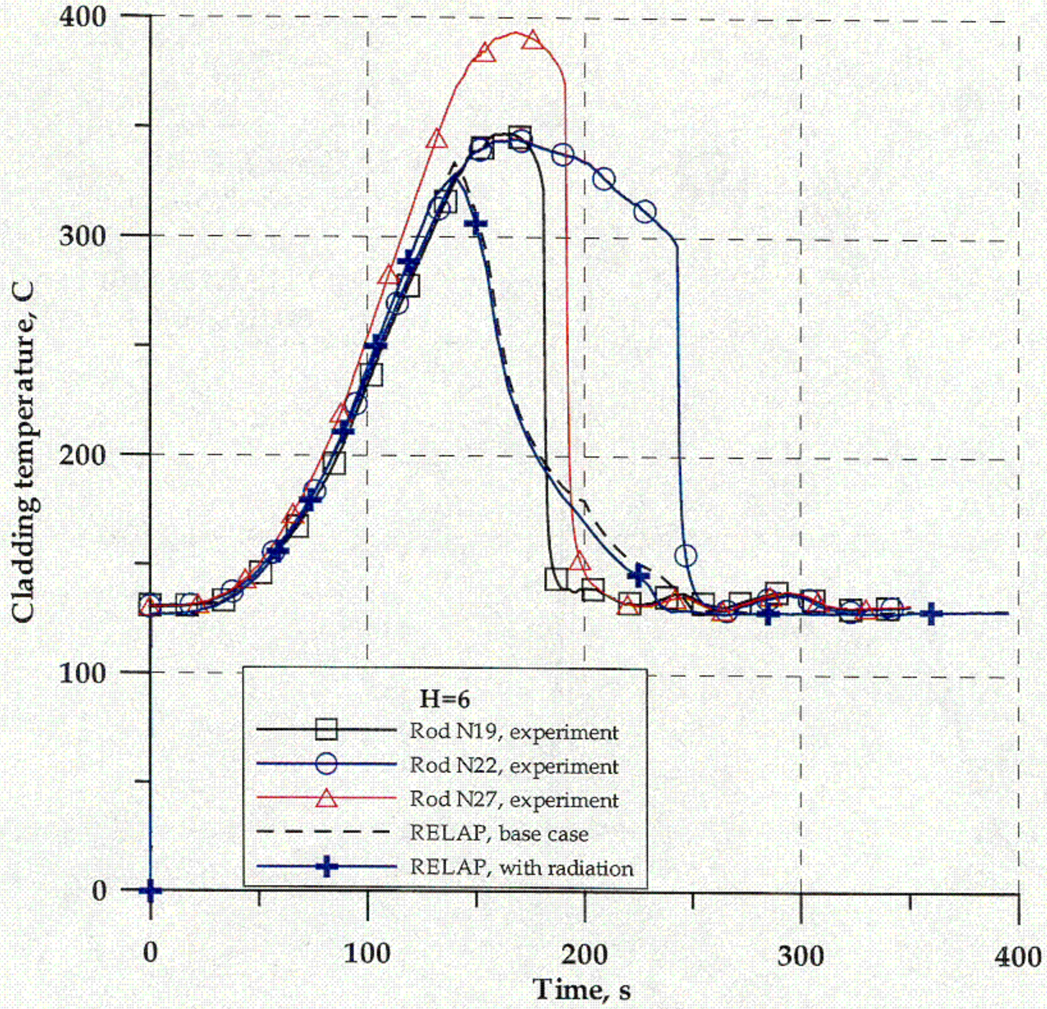


Fig. 16. Radiation heat transfer between rod bundle and vessel wall influence for H=6

6.2 Axial power distribution influence

Fig. 17-18 show the results of calculations, performed with different variation factor along the bundle for H=4 and H=6. For these calculations were chosen such variations factors, which corresponded to rods with its maximal and minimal values of all bundle rods. Maximal difference was got for H=4, but as one could see from Fig. 17-18 this difference is too small and discrepancies between experimental data and computed couldn't be explained by this factor.

C14

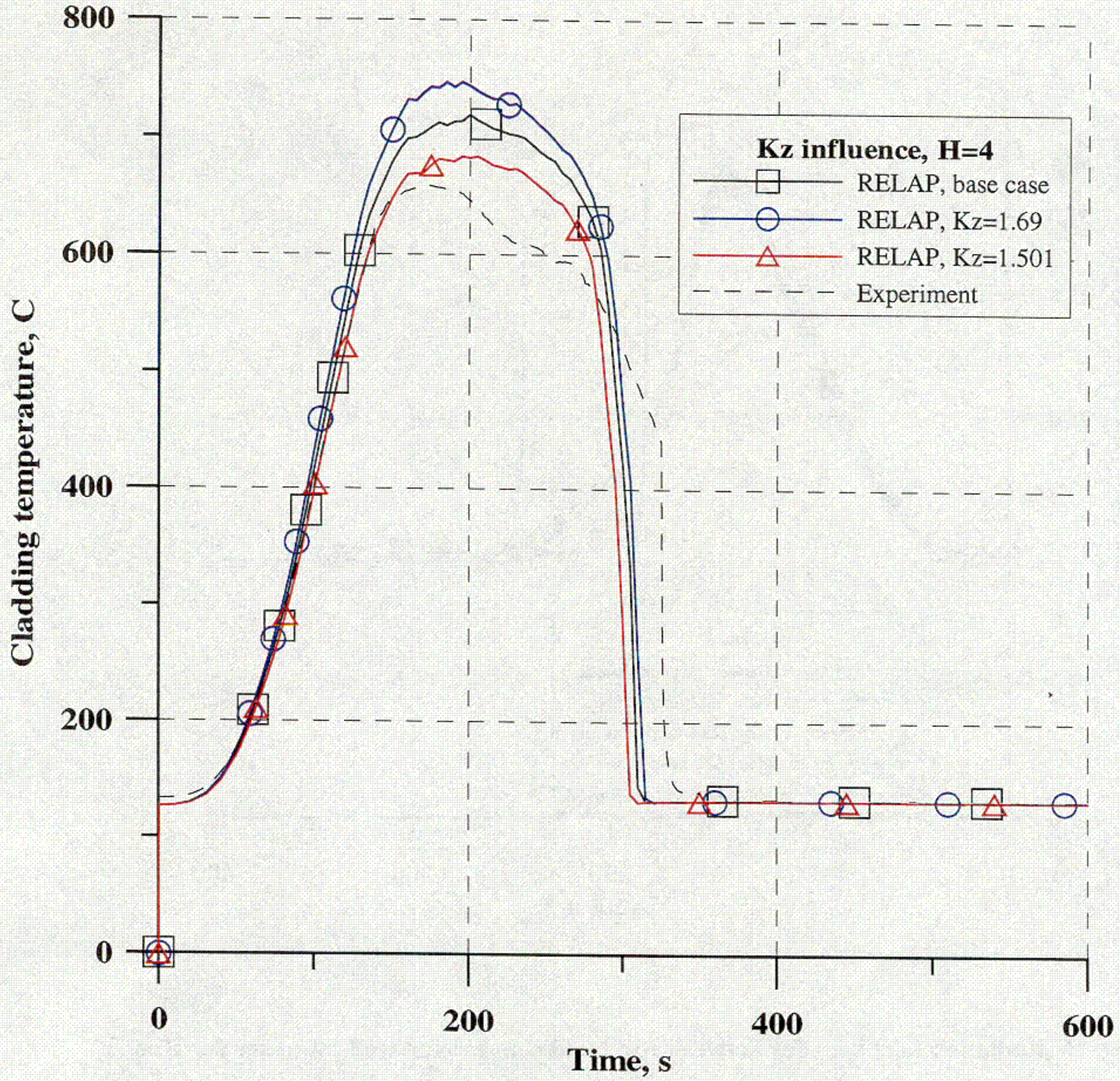


Fig. 17. Axial distribution influence on cladding temperature behavior for H=4

C15

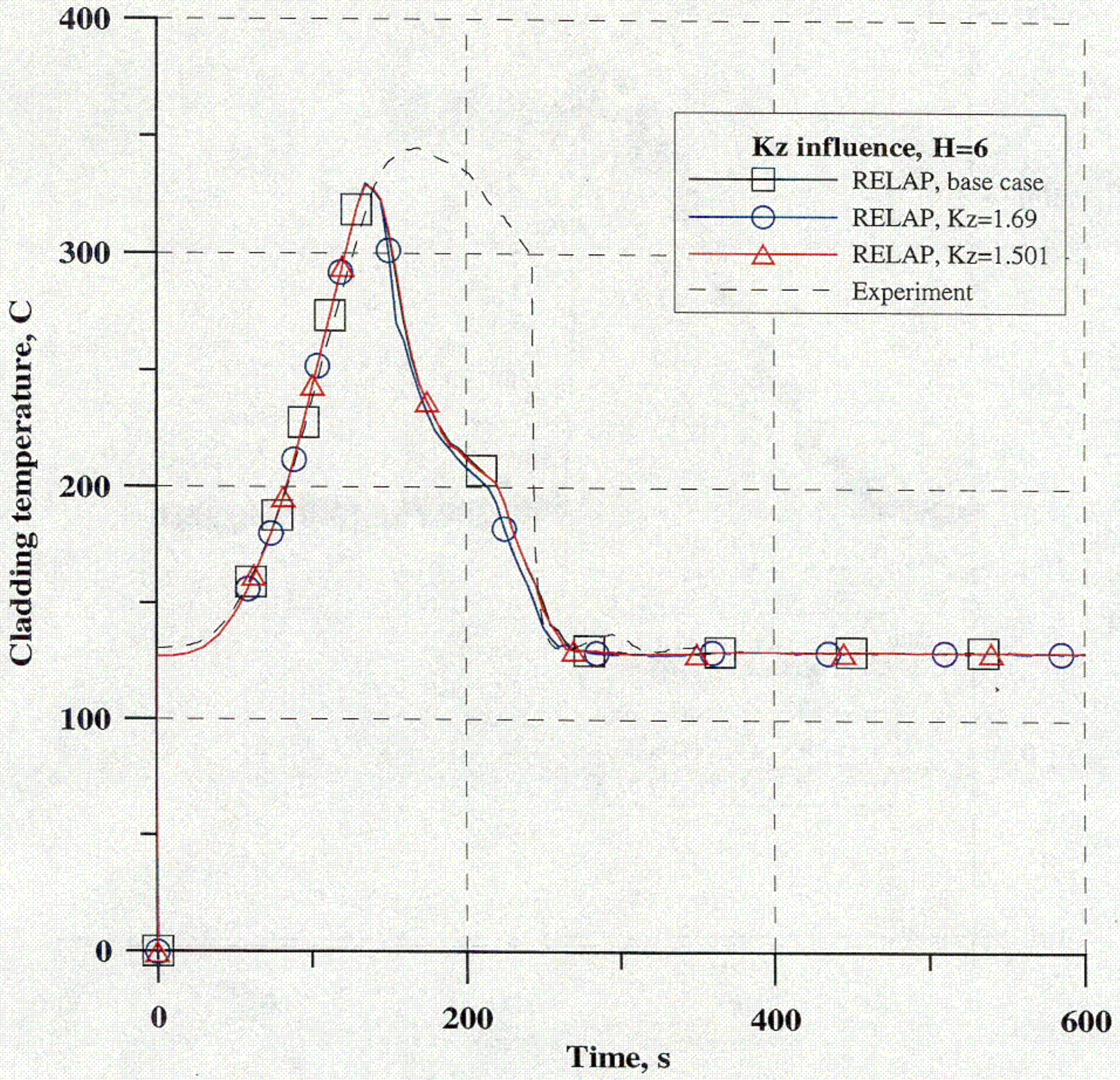


Fig. 18. Axial distribution influence on cladding temperature behavior for H=6

6.3 Radial power distribution influence

Analysis of experimental data presented for example at fig. 7, shows that for upper bundle part radial position of the rod plays significant role. For example the earliest quenching takes place at the rods placed at the outer rod row. Quenching of the rods placed in the second from the vessel wall row occurred some later. The analogous results for type "B" rod presented at fig. 19.

C16

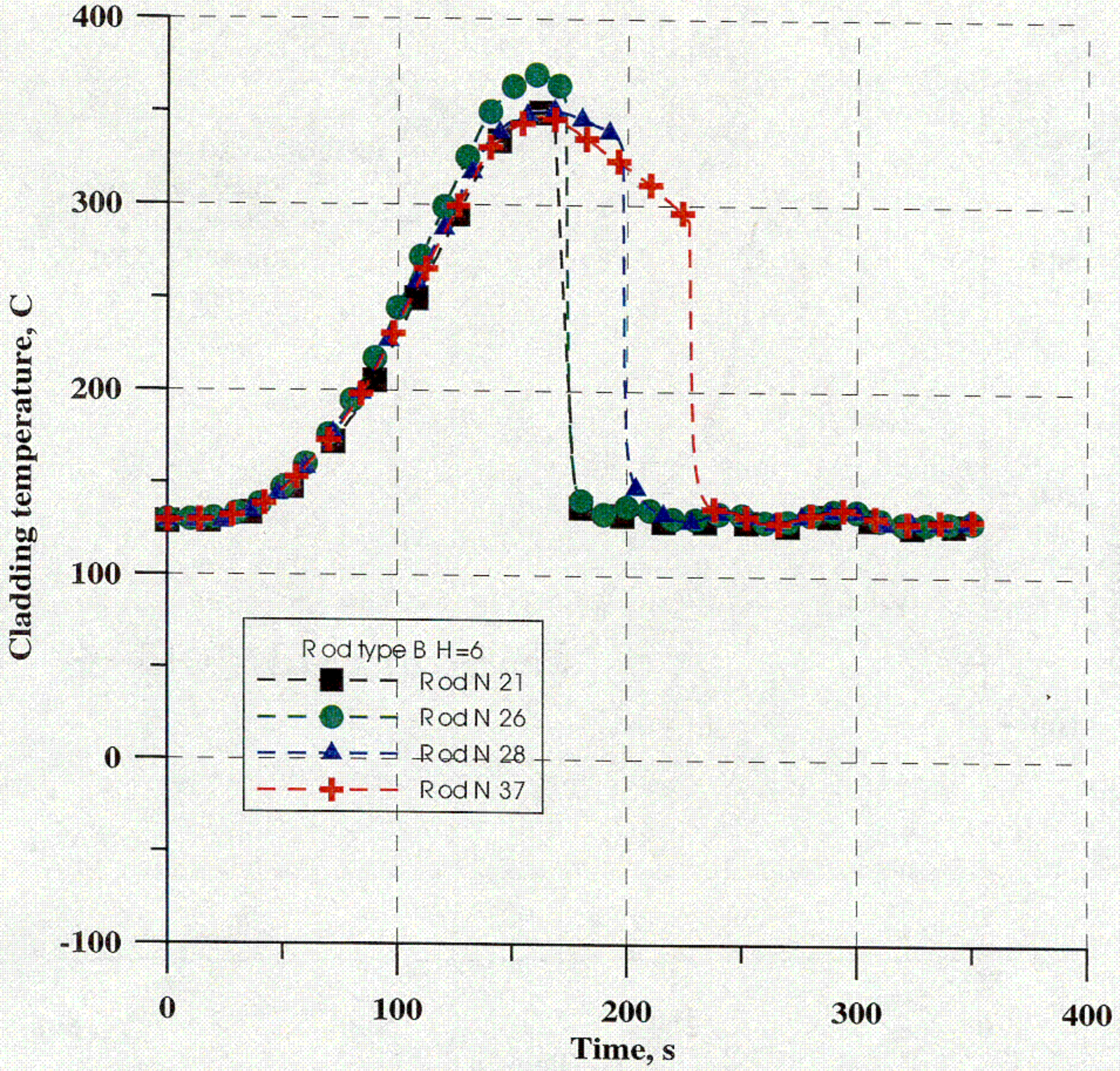


Fig. 19. Rod of type "B" temperature behavior. Experimental data for H=4

For taking into account radial parameter the calculations have been performed with using modified nodalization scheme, in which whole rod bundle was divided into two parts: zone with all rods of outer row and the zone with the rest rods. Radiation heat transfer was taken into account for transfer between outer rods row and vessel wall, and radiation between outer rods and inner was neglected. Fig. 20 shows the results of these calculations for upper section type "B" rods.

C17

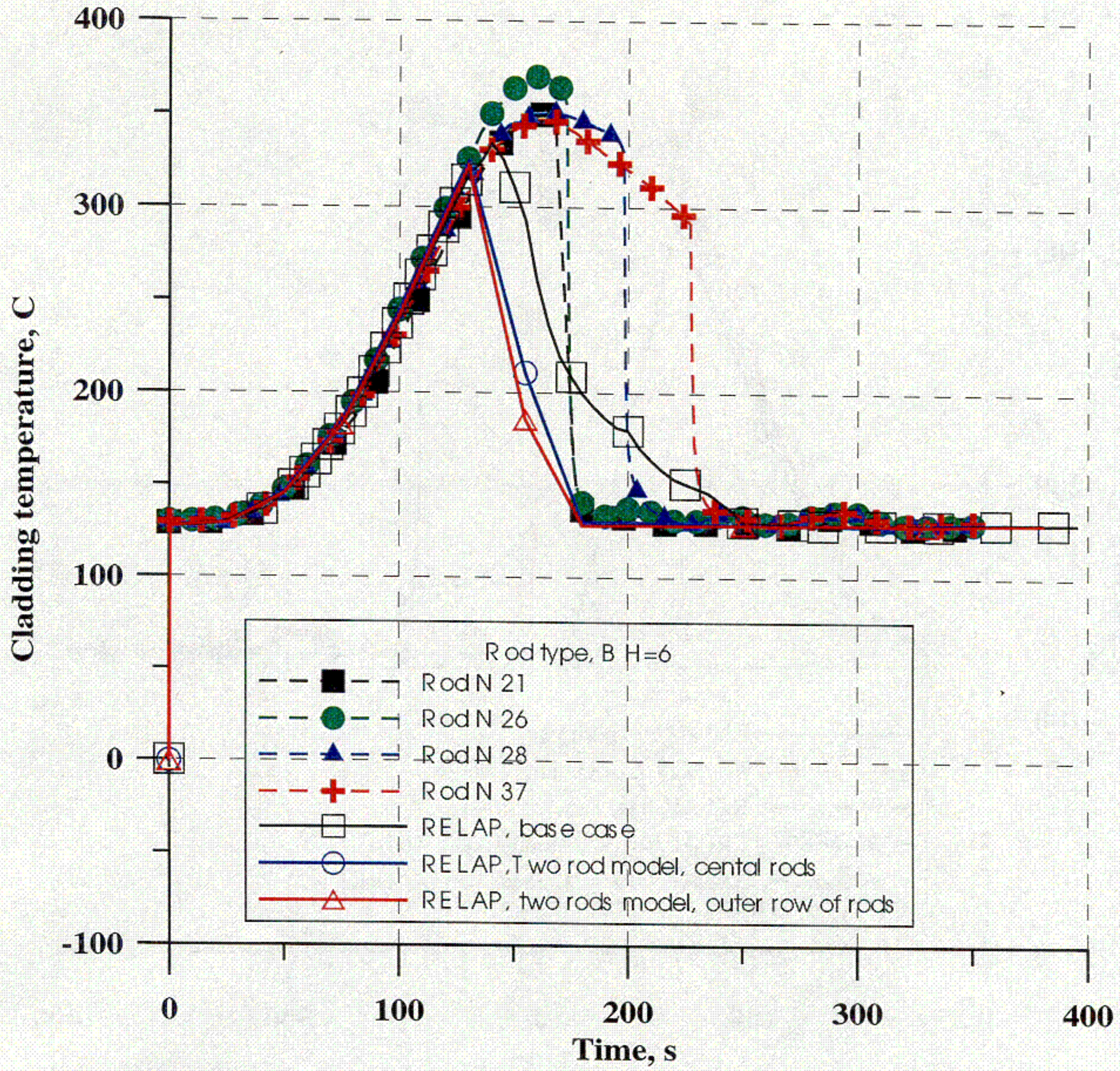


Fig. 20. Rod of type "B" temperature behavior. Experimental and calculated data for H=6

Fig. 21 shows the analogous data for type "A" rods. One can see that though two groups cladding behavior are practically coincided, in a general way their behavior some change and quenching of upper part of the rods occurs some earlier than for case of bundle modeling with one channel. Fig. 22-23 shows the results for "A" group rods at H=5 and H=4.

C18

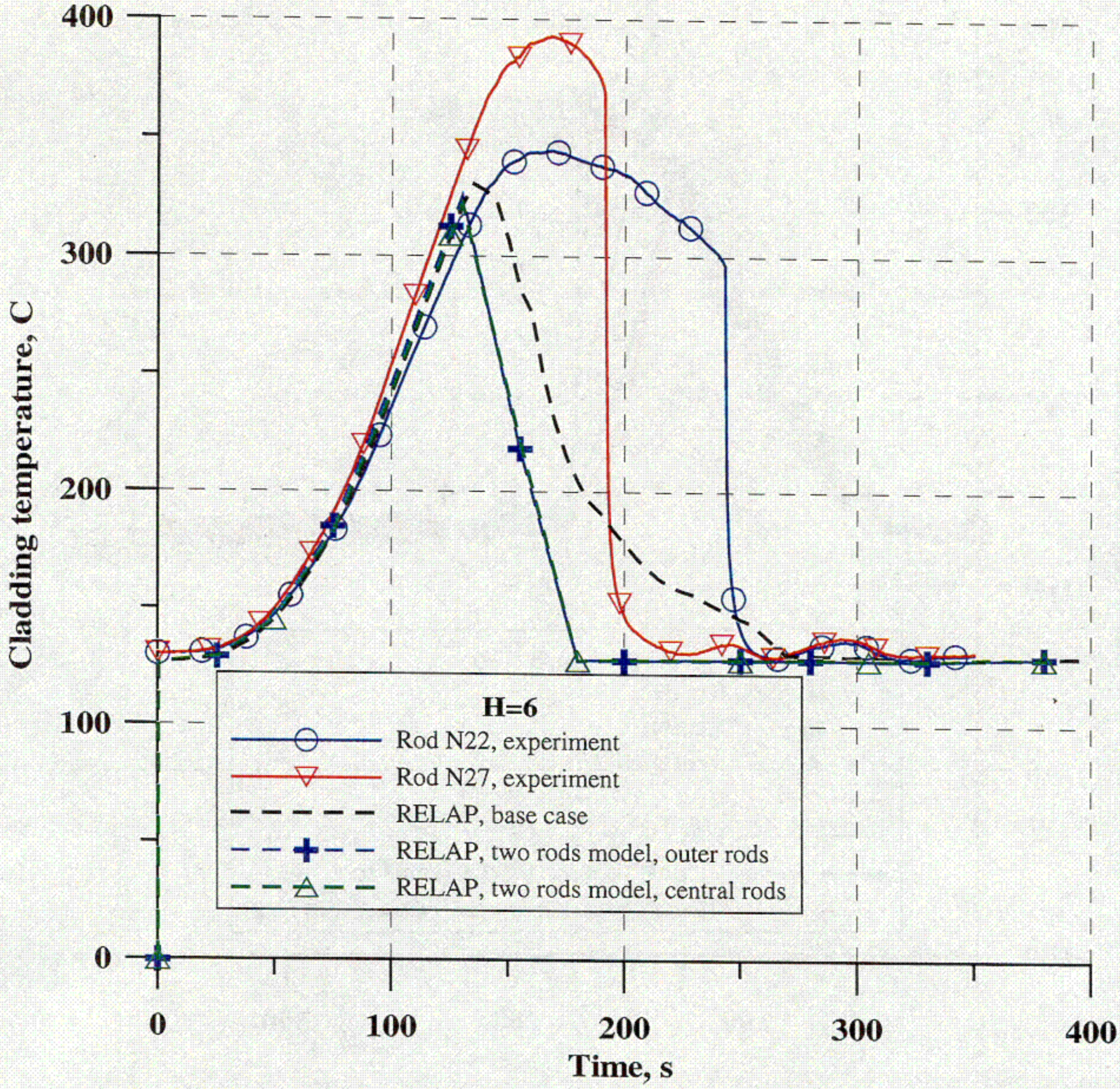


Fig. 21. Rod of type "A" temperature behavior. Experimental and calculated data for H=6

C19

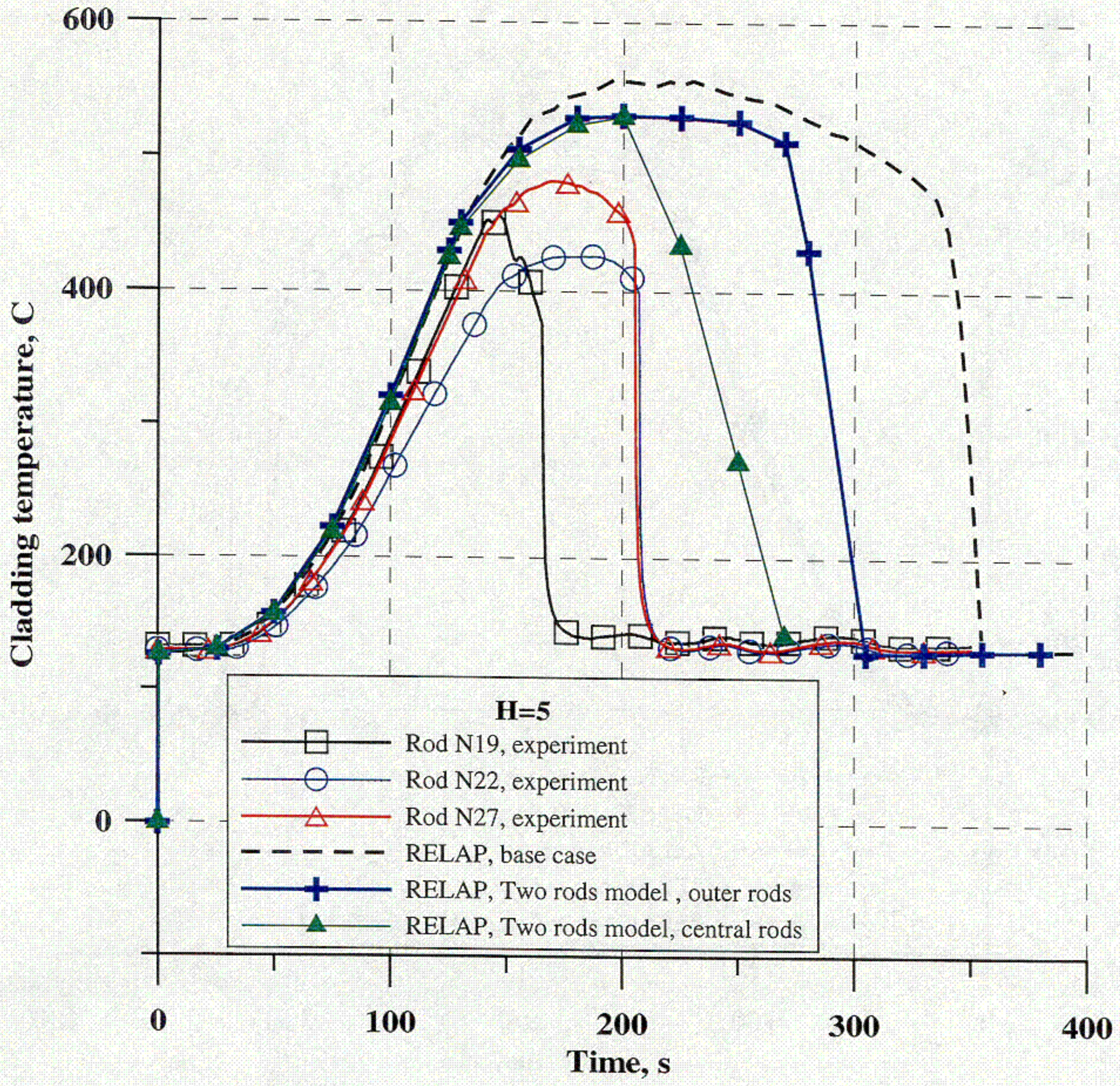


Fig. 22. Rod of type "B" temperature behavior. Experimental and calculated data for H=5

C20

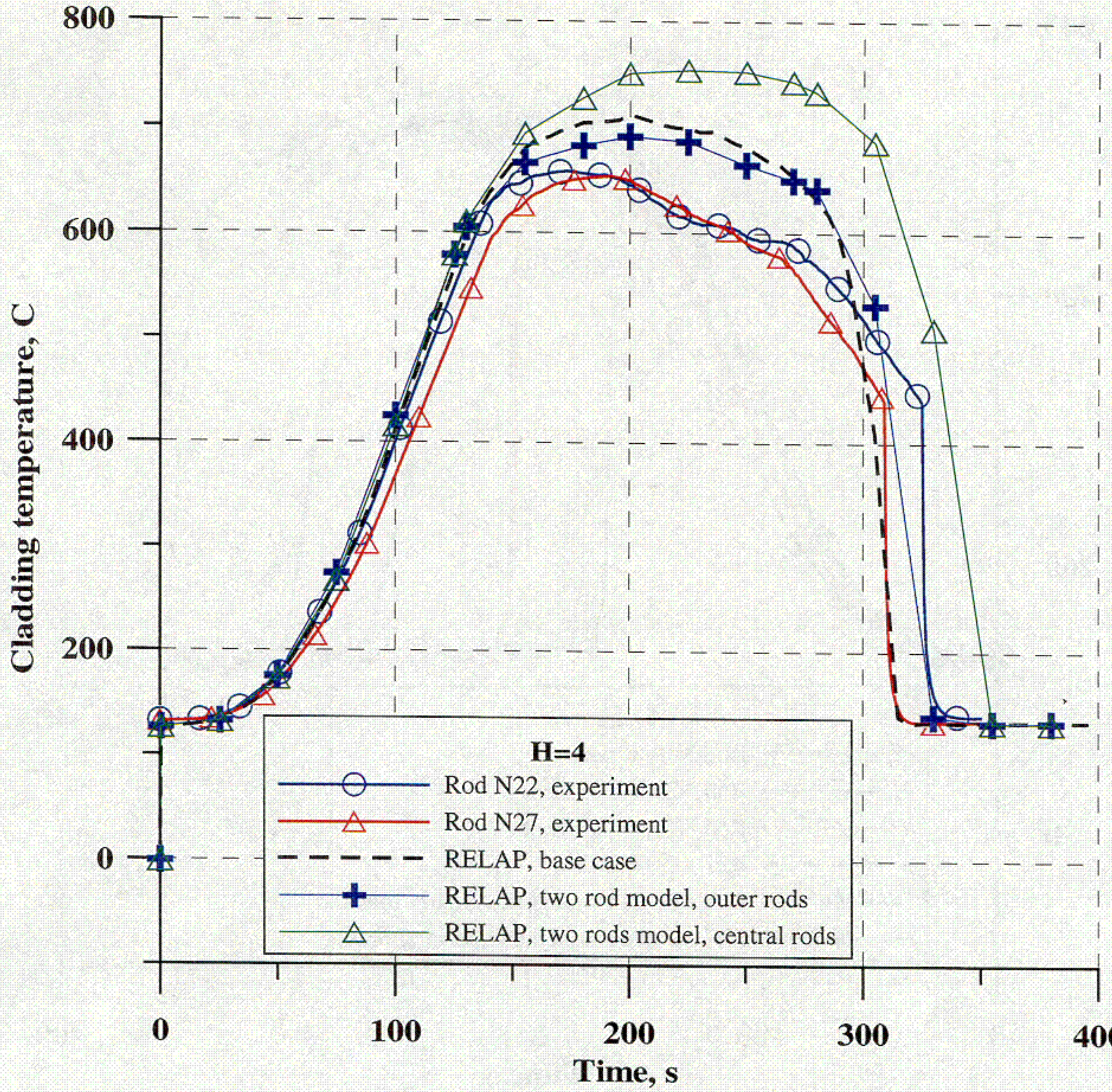


Fig. 23. Rod of type "B" temperature behavior. Experimental and calculated data for H=4

One can see from Fig. 21 radial dividing reduces quenching time for upper section (H=6), difference between temperatures behavior being practically neglecting. Difference from experimental and calculated data remained essential.

For section H=5 was obtained qualitatively incorrect behavior cladding temperature for both rod rows: more earlier quenching of inner rods. For both rows was obtained earlier quenching than for base case calculation. And for this case quenching times were obtained larger than experimental ones also.

For H=4 (Fig. 23) using two-channel model changed the results insignificant.

Fig. 24 shows the results of quenching front propagation with two-cannel model using. Apparently from this figure quenching of bundle lower part occurred some later, than in experiment and in base case calculation. For upper part calculations wit two-channel model gave earlier quenching, than for base case and as a rule inner part quenching occurred earlier than quenching of outer part.

C21

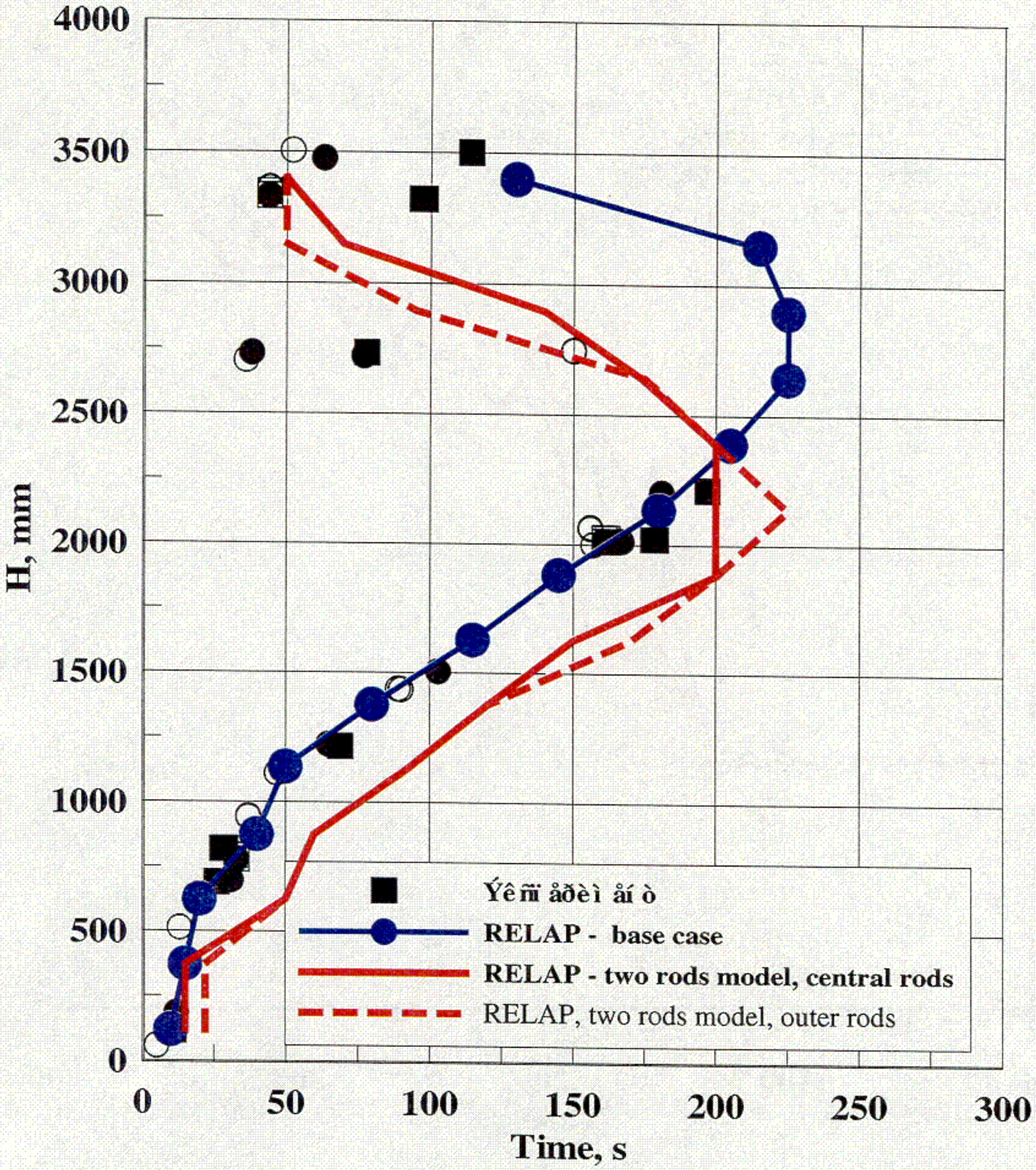


Fig. 24. Quenching front position. Two-channel model results and experimental data

Fig. 25-26 shows the results of calculations of pressure drop on the bundle for base case and two-channel model. One can see pressure drop behavior for two-channel model characterized considerable oscillations not fixed in the experiment and accordance between calculated results and experimental data are less than for base case.

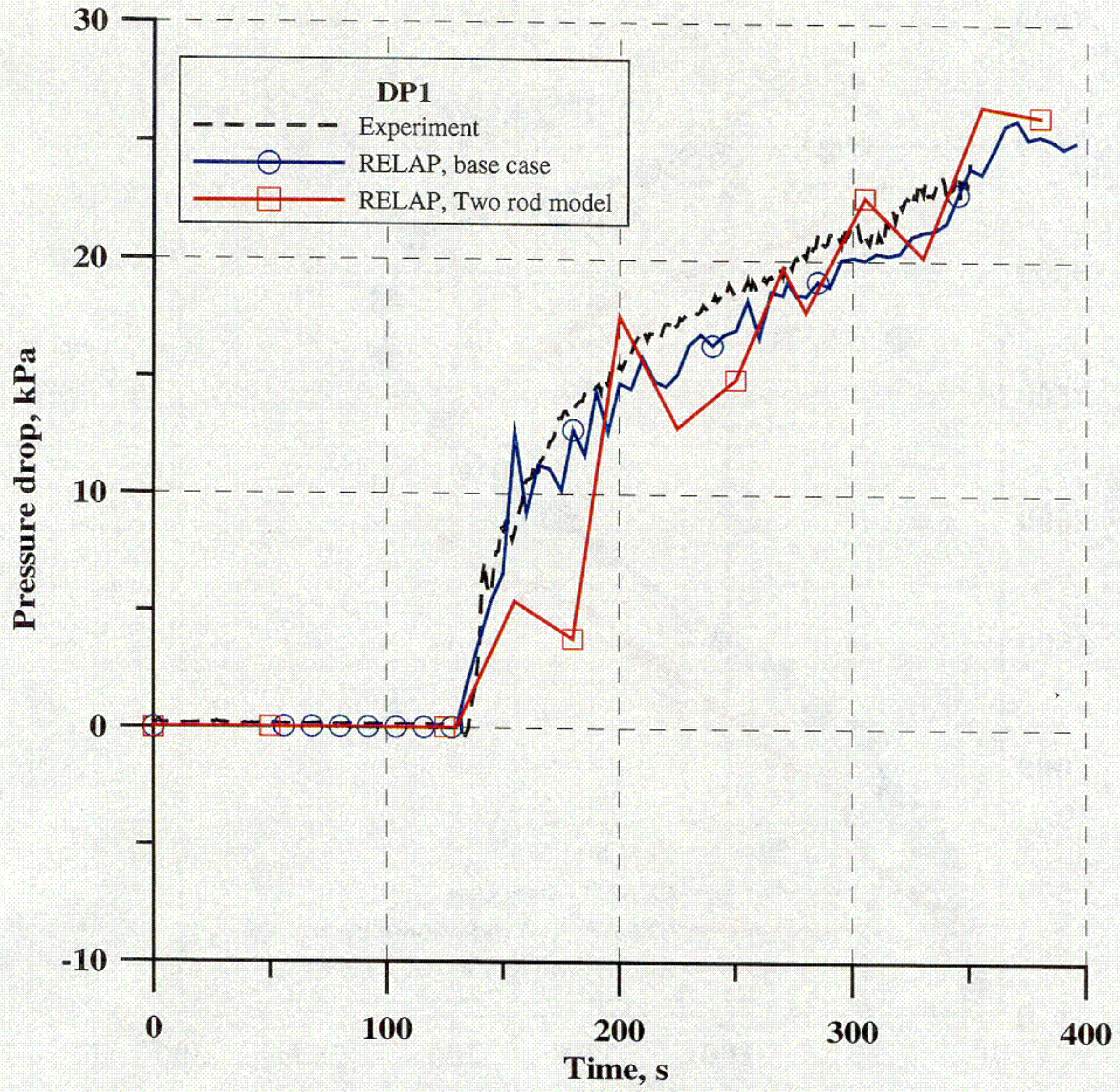


Fig. 25. Pressure drop at the heated zone. Experimental data and results of calculations with two-channel scheme

CZ3

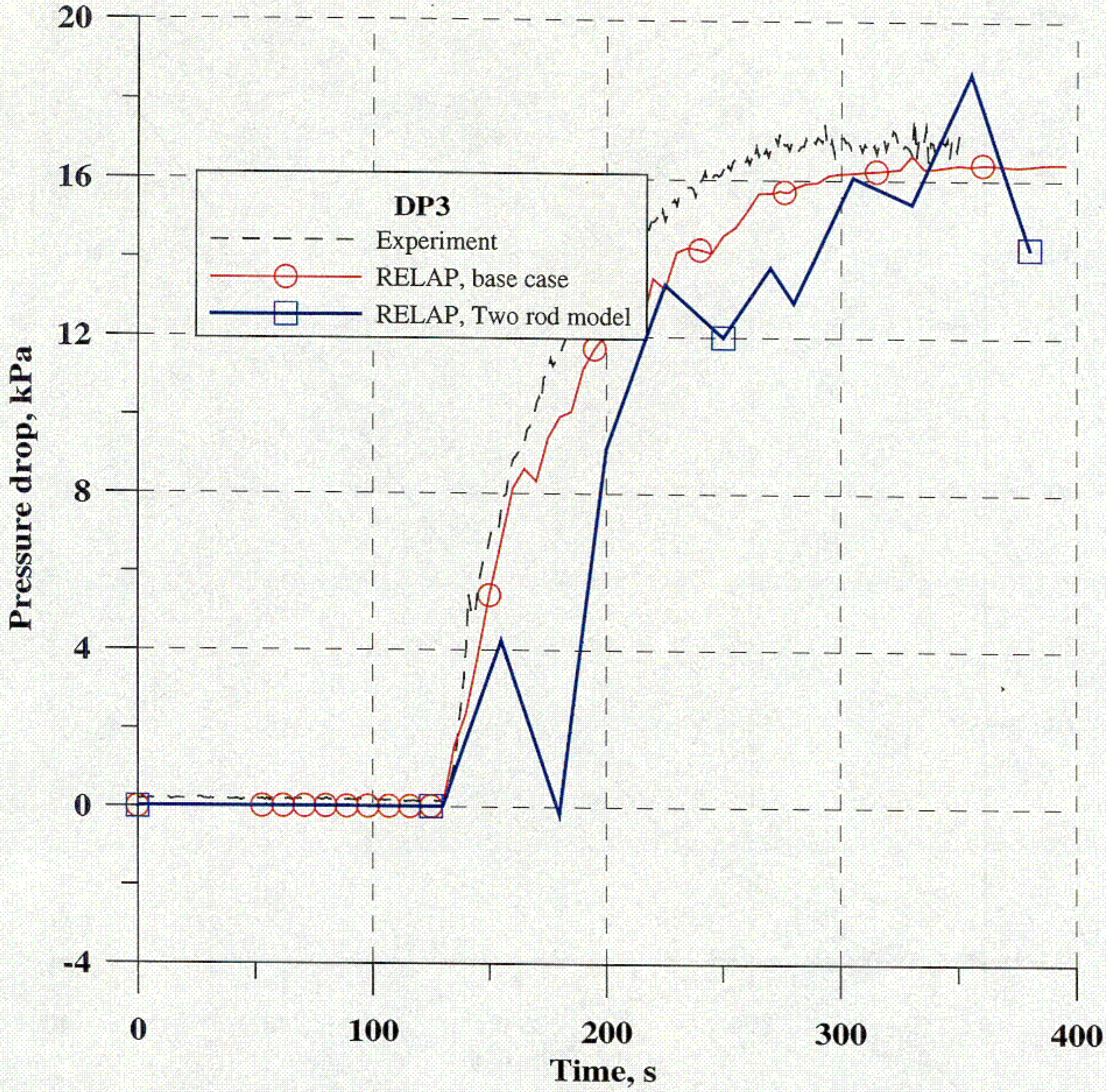


Fig. 26. Pressure drop at lower part of heated zone. Experimental data and results of calculations with two-channel scheme

7. RUN STATISTICS

Fig. 27-28 illustrate code efficiency where time step variation and CPU time during the calculation are presented. Grind time is evaluated as
:

CPU/(C*DT)= 0,000228, where
C= 18 – volumes number,
DT = 95992 – time steps number,
CPU = 395 s – CPU time.

C24

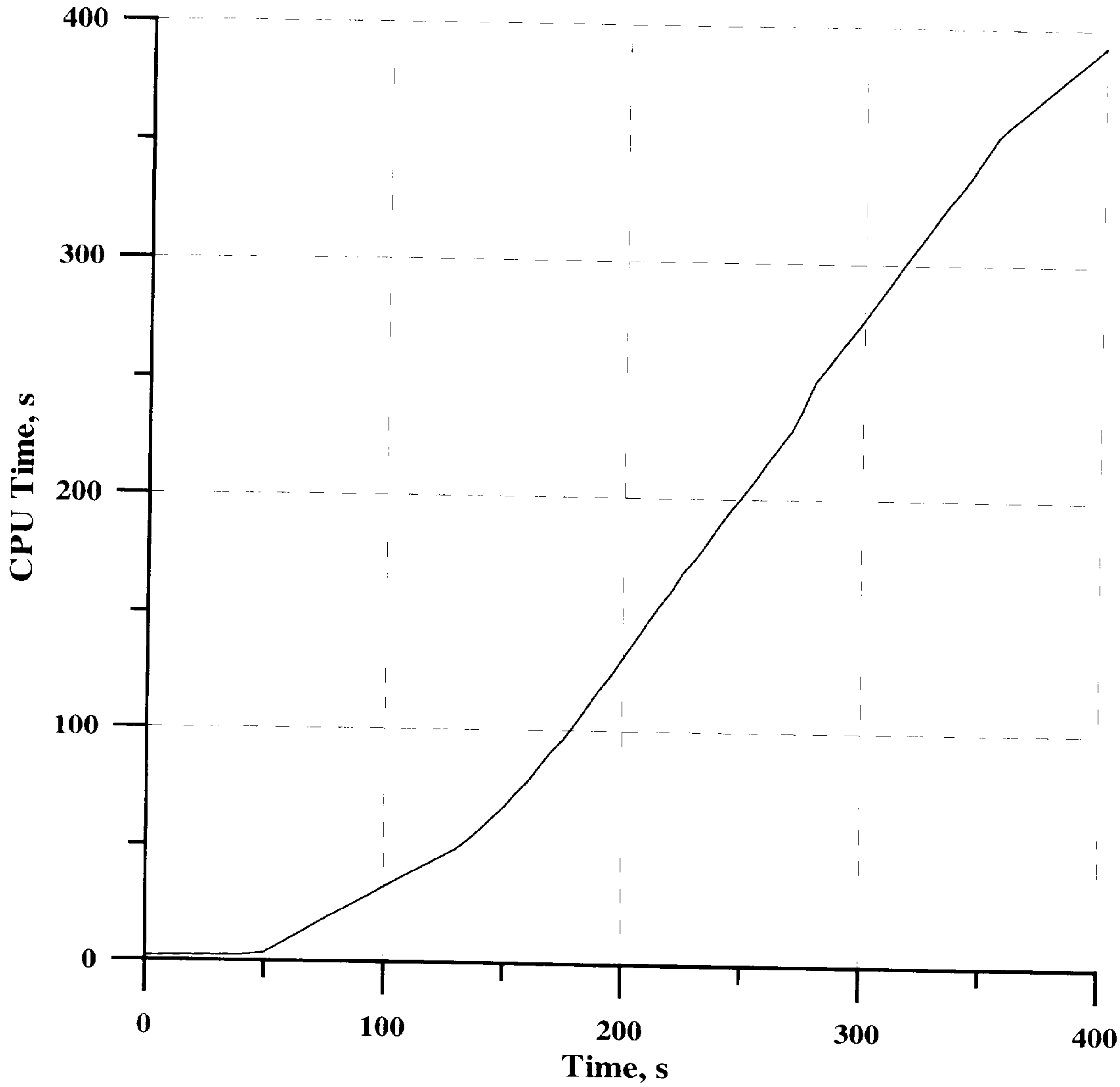


Fig. 27 CPU time during the test calculation

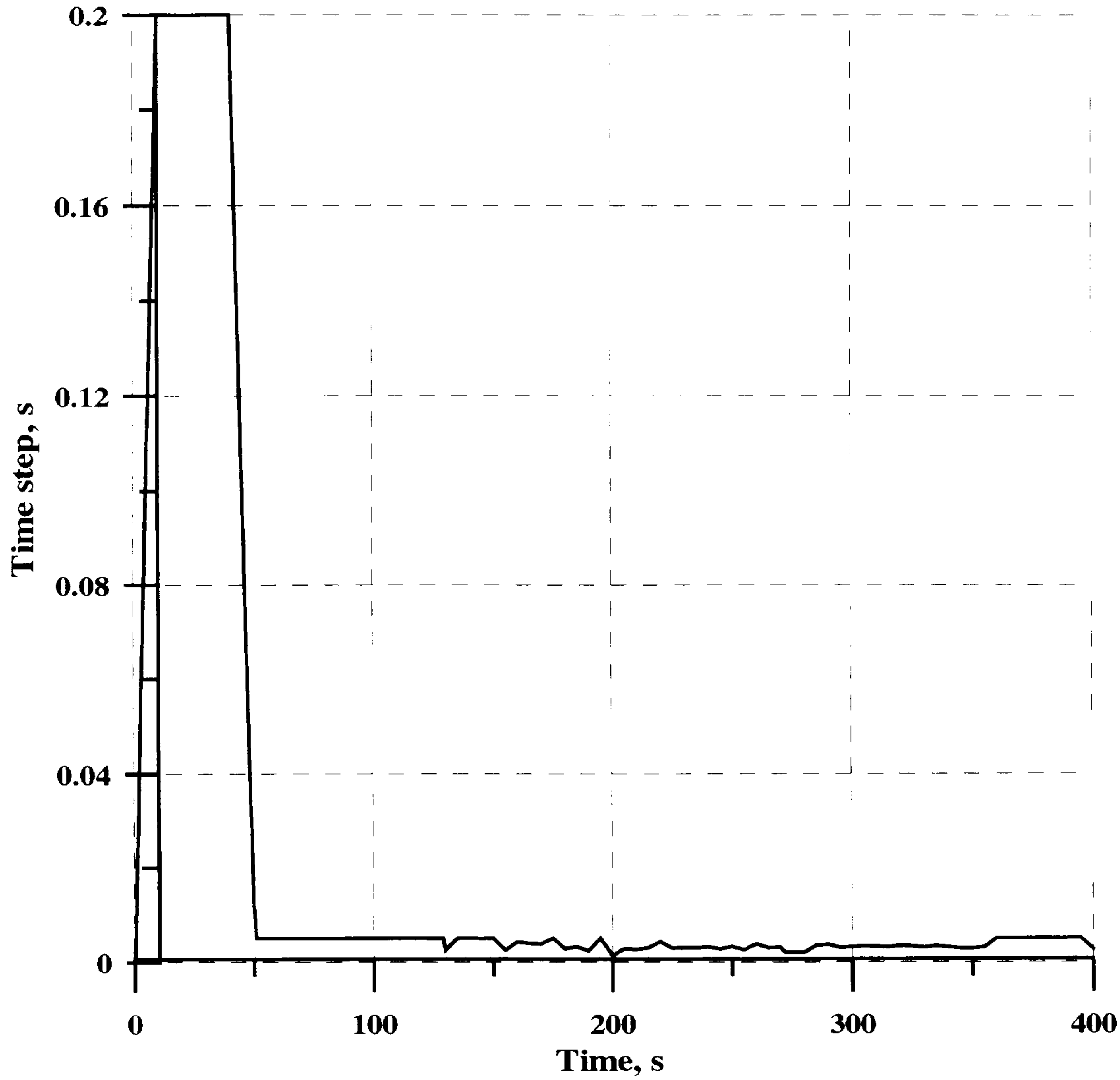


Fig. 28 Time step behavior during the test

8. CONCLUSIONS

The calculations down to top reflooding process at 37-rod bundle with code RELAP5/MOD3 (version 3.2.2 Gamma) showed that code gives satisfactory results for all parameters behavior. The main discrepancies were get for cladding temperature behavior at elevation 2.7m, where the calculated value exceeded the measured datum by about 75K. Computed quenching time for this elevation is much higher than experimental ones. For other levels accordance between experimental and RELAP data is rather good.
Sensitivity analysis of results of calculations to input data showed that radial bundle nodding was inexpedient and it leads to less realistic results than at modeling of the bundle by one channel.

REFERENCES

1. Lozhkin V.V., Sudnitzyn O.A., Kulikov B.I., etc. Experimental and Theoretical Investigation of heat transfer at simulating of loss of coolant accidents with bottom-up reflooding on 37-rod assembly model of VVER. IPPE Report / N 9648, 1998.

Appendix A. TEST FACILITY SCHEMES

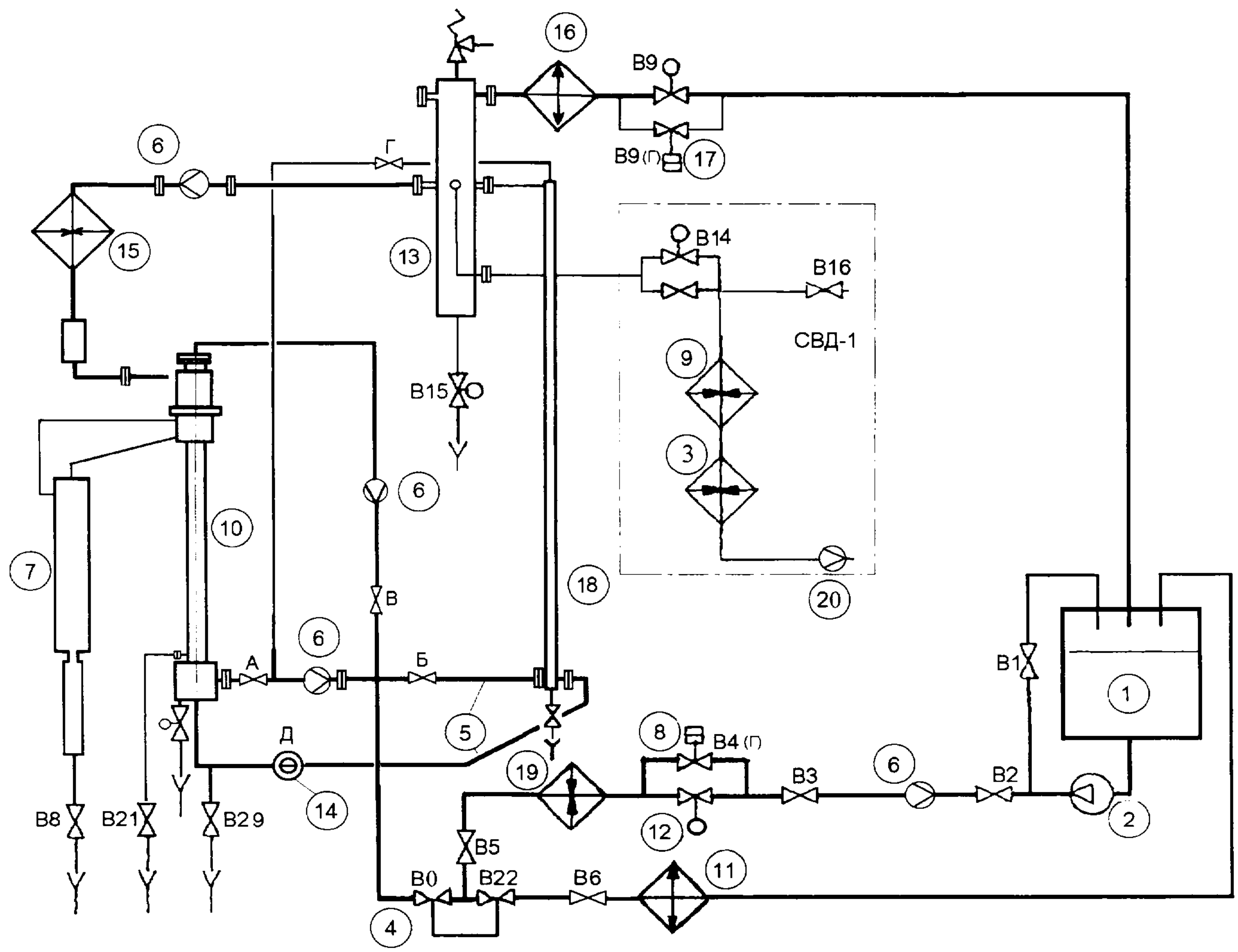


Fig. 1A. Loop scheme

1- tank, 2 – pumps, 3,9 –steam generators , 4 –toggle valve, 5 - connectors, 6 – flowmeter orifices, 7 – entrained liquid tank, 10 – test section, 11- cooler, 13 – steam pressurizer, 15 – electric heater, 18 – downcomer model, 19 - preheater.

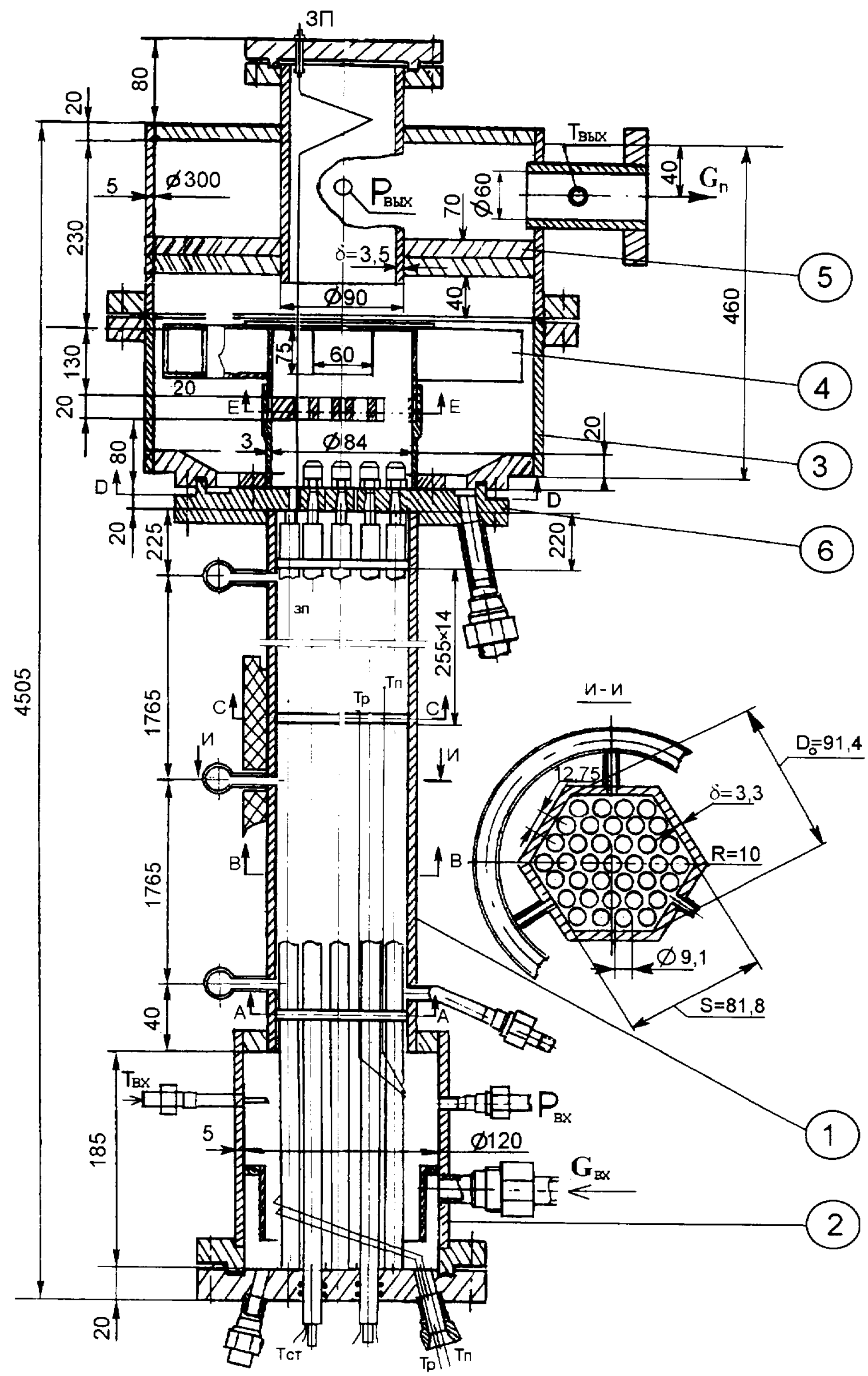


Fig. 2A. Test section scheme

1- vessel; 2 – lower plenum; 3 – upper plenum; 4 – separator; 5 – louver; 6 – plate connected with current lead.; 5 – louver; 6 – plate connected with current lead.

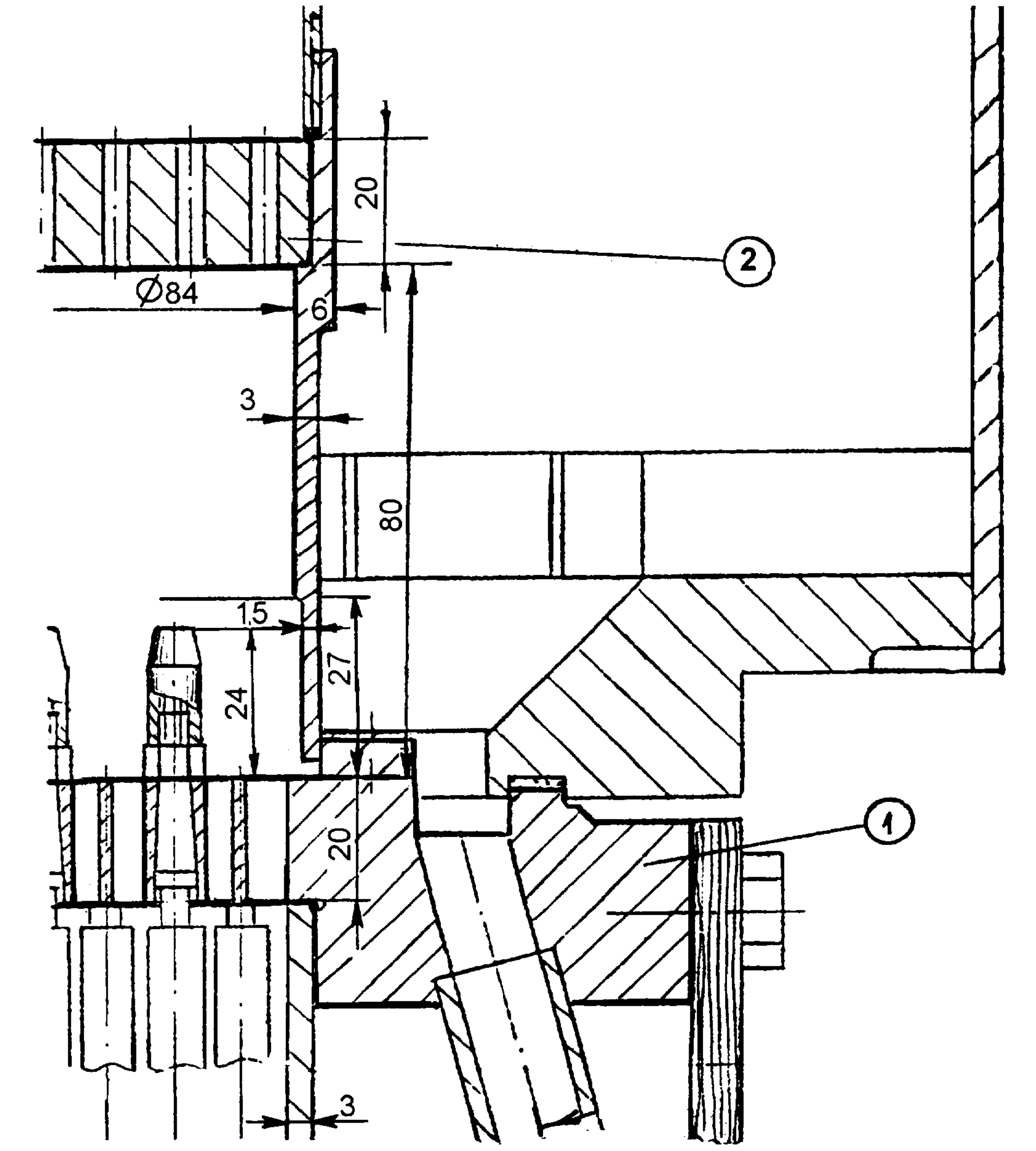


Fig 3A. Upper plenum with current lead plate (1) and perforated plate (2)

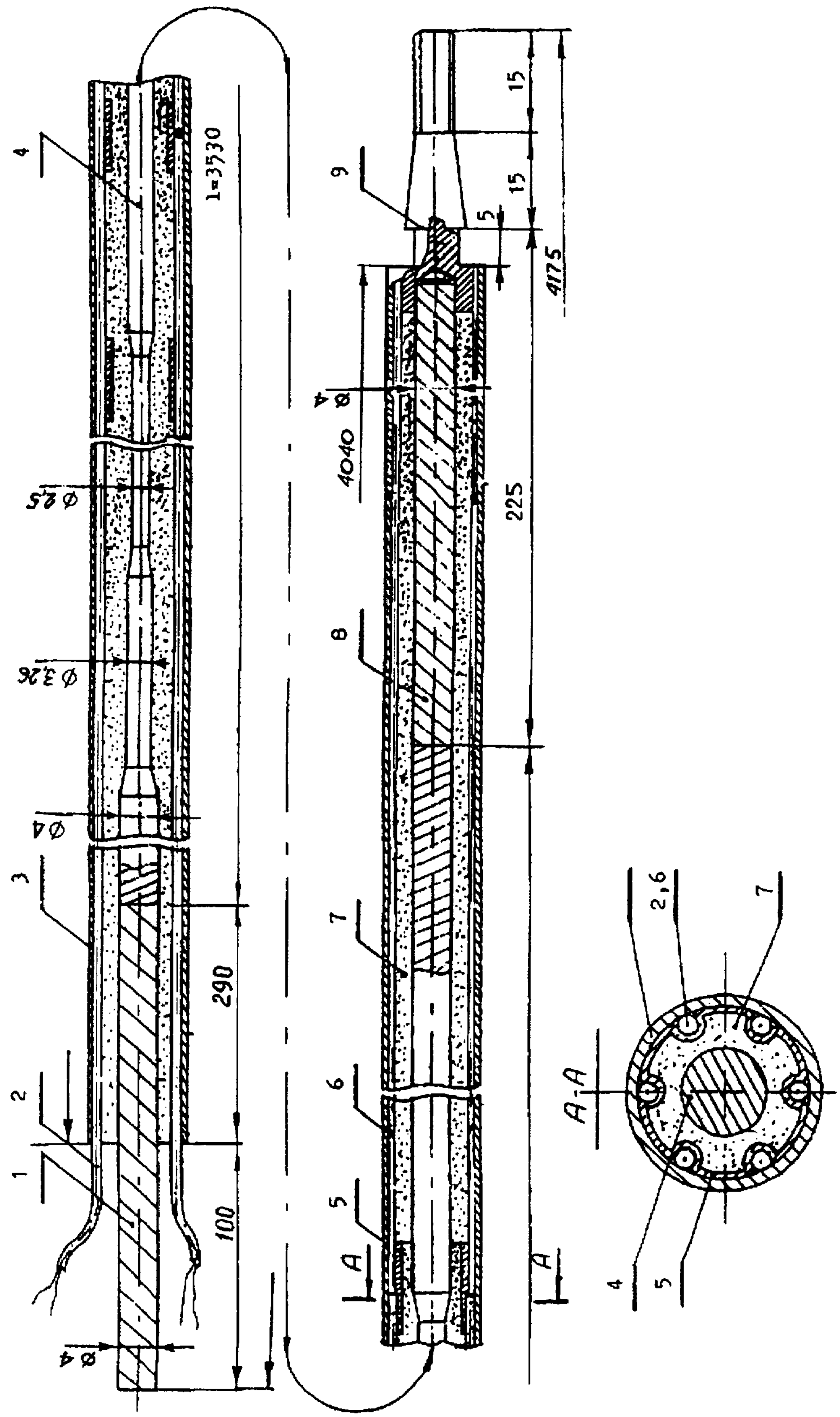


Fig. 4A. Rod imitator with indirect heating. 1, 8 – copper rods, 2 – thermocouples, 3 – cladding, 4 – NI, Cr heater, 5 – pinch barrel, 6 – pulling wire, 7 – MgO, 8 - 9 – cone current lead.

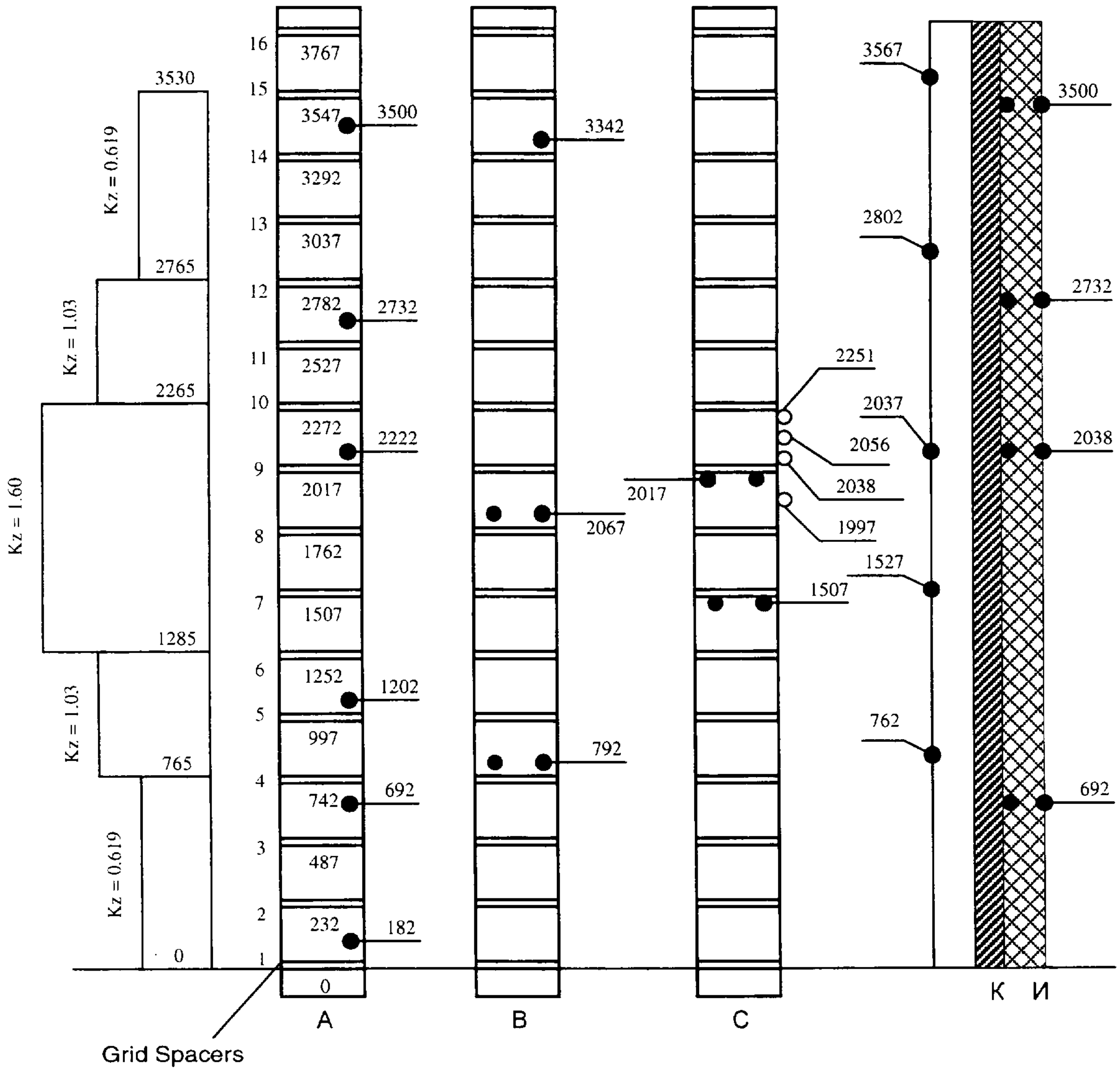


Fig. 5A. Axial power profile and thermocouple arrangement along the height for the test section KB-37.1

A, B, C, - imitator types; K - vessel; И - insulation;

• - wall mounting thermocouples;

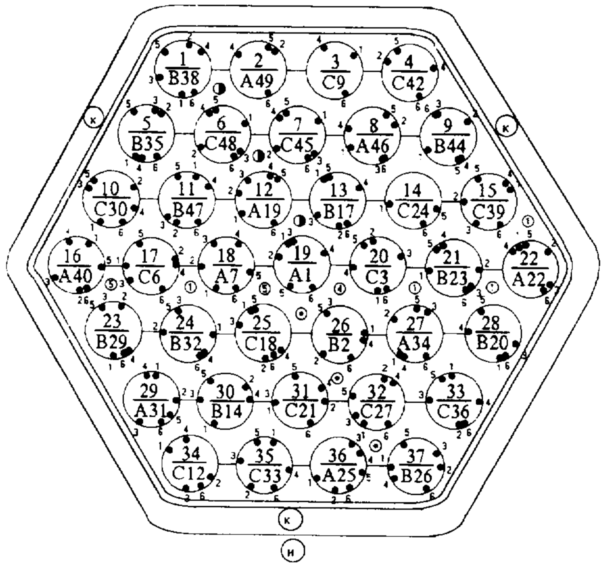
o - fluid thermocouples;

•- a distance from the bottom of the heated zone*(rough values);

232 - a distance from the bottom of the heated zone to the bottom of a grid spacer (measured before the tests).

* - the correct values specified in Table A-2.

a)



b)

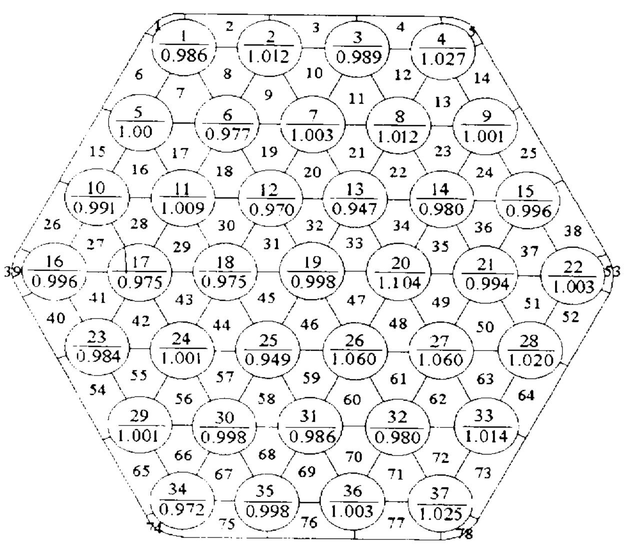


Fig 6A. Transducer arrangement (a) and the power profile map (b) across the test section KB-37.1 (top view)

- rod number,
- type and identification of a rod;

- rod number,
- relative power;

- hydraulic cell number;
- wall thermocouple, thermocouple number in the rod;
- fluid thermocouple, number of thermocouples in a cell along the height;
- grid thermocouple;
- vessel and insulation thermocouples;
- conductive probe.

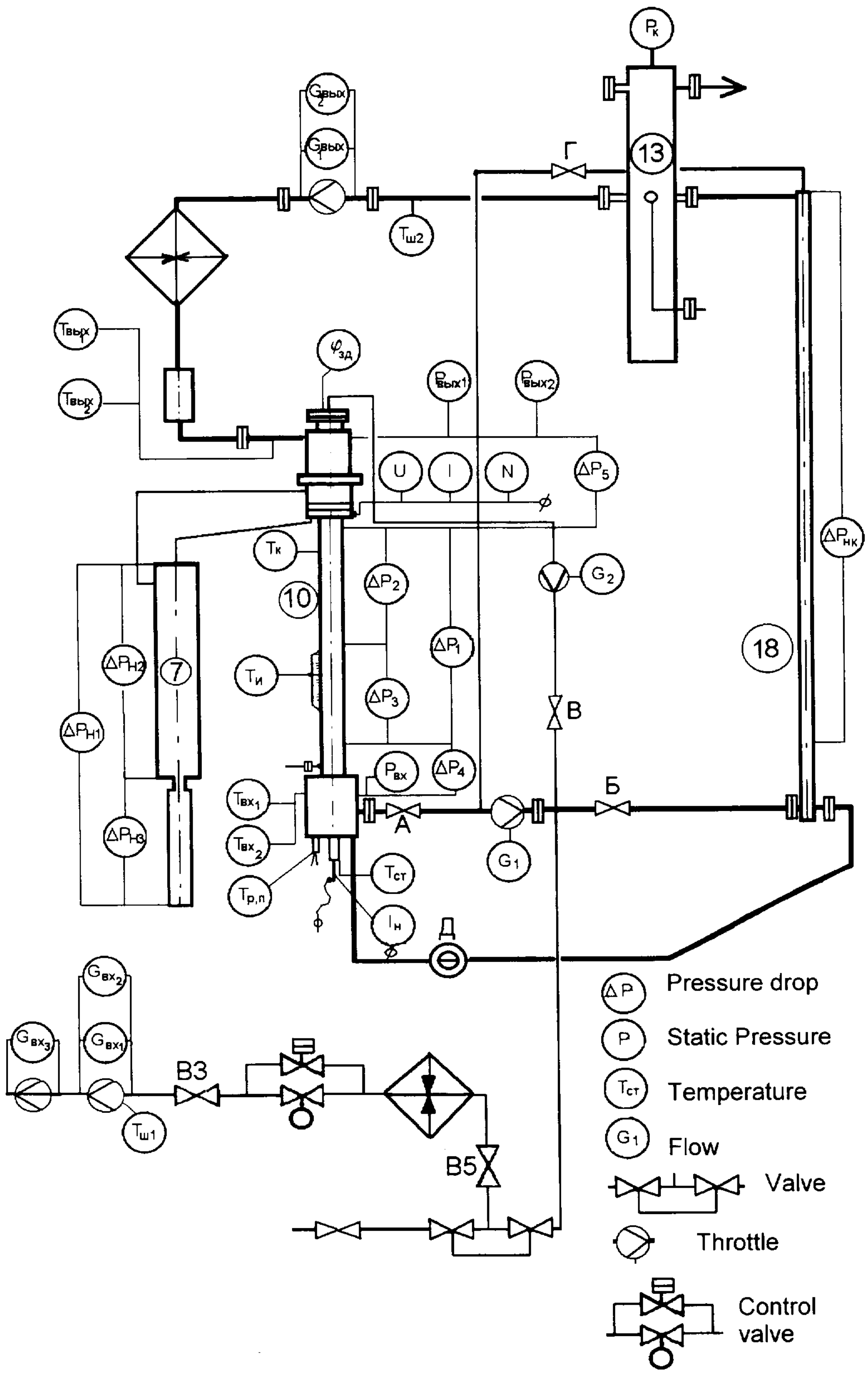


Fig. 7A. Instrumentation for the test section KB-37.1

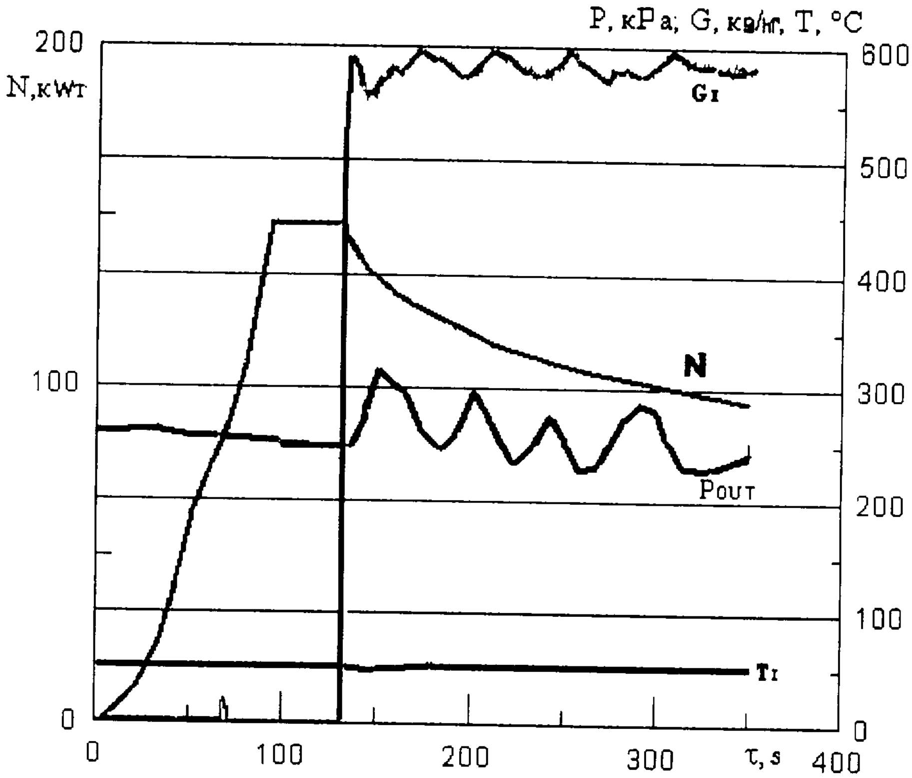


Fig 8A. Main parameters behavior during the experiment

Table A-1 Bundle KB 37.1. Imitator test results

Rod	Number of Tc	Inactive Tc	Identification	d^{max}	$\bar{d}$	$R_{passp.}$	$R_{meas.}$	Kz_i	K_{Ni}	$K_{ZH}=K_Z*K_N$	
1	6		**B-38**	9.16	9.12	0.569	0.567	1.592	0.986	1.57	0.98
16	6		**A-40**	9.12	9.11	0.566	0.561	1.589	0.996	1.58	0.99
34	5	5	**C-12**	9.13	9.12	0.575	0.575	1.620	0.972	1.57	0.98
2	4	1,3	**A-49**	9.13	9.11	0.552	0.552	1.570	1.012	1.59	0.99
5	6		**B-35**	9.14	9.11	0.560	0.559	1.572	1.000	1.57	0.98
10	6		**C-30**	9.25	9.23	0.564	0.564	1.660	0.991	1.64	1.03
23	6		**B-29**	9.15	9.14	0.569	0.568	1.676	0.984	1.65	1.03
29	6		**A-31**	9.16	9.14	0.562	0.558	1.684	1.001	1.69	1.05
35	6		**C-33**	9.16	9.14	0.563	0.560	1.593	0.998	1.59	0.99
6	6		**C-48**	9.11	9.10	0.575	0.572	1.585	0.977	1.55	0.97
17	6		**C-6**	9.19	9.19	0.580	0.573	1.521	0.975	1.48	0.93
30	5	6	**B-14**	9.16	9.12	0.561	0.560	1.597	0.998	1.59	1.00
7	6		**C-45**	9.13	9.12	0.562	0.557	1.596	1.003	1.60	1.00
11	6		**B-47**	9.14	9.12	0.558	0.554	1.569	1.009	1.58	0.99
24	6		**B-32**	9.18	9.16	0.569	0.558	1.689	1.001	1.69	1.06
12	6		**A-19**	9.14	9.13	0.575	0.576	1.522	0.970	1.48	0.92
18	6		**A-7**	9.15	9.13	0.573	0.573	1.655	0.975	1.61	1.01
25	6		**C-18**	9.14	9.13	0.598	0.589	1.578	0.949	1.50	0.94
19	6		**A-1**	9.13	9.12	0.560	0.560	1.571	0.998	1.57	0.98
26	6		**B- 2**	9.15	9.14	0573.	0.527	1.565	1.060	1.66	1.04

20	6		**C-3**	9.14	9.13	0.512	0.506	1.582	1.104	1.75	1.09
13	6		**B-17**	9.15	9.12	0.592	0.590	1.586	0.947	1.50	0.94
31	6		**C-21**	9.17	9.14	0.574	0.567	1.509	0.986	1.49	0.93
27	6		**A-34**	9.15	9.14	0.534	0.527	1.573	1.060	1.67	1.04
14	3	2,3,4	**C-24**	9.20	9.18	0.574	0.570	1.667	0.980	1.63	1.02
32	6		**C-27**	9.17	9.17	0.569	0.570	1.645	0.980	1.61	1.01
21	6		**B-23**	9.18	9.17	0.566	0.562	1.530	0.994	1.52	0.95
8	6		**A-46**	9.14	9.12	0.558	0.552	1.584	1.012	1.60	1.00
36	6		**A-25**	9.33	9.19	0.562	0.557	1.662	1.003	1.67	1.04
33	6		**C-36**	9.15	9.14	0.555	0.551	1.690	1.014	1.71	1.07
28	5	2	**B-20**	9.12	9.17	0.551	0.548	1.665	1.020	1.70	1.06
15	6		**C-39**	9.12	9.11	0.568	0.561	1.599	0.996	1.59	1.00
9	4	3,4	**B-44**	9.20	9.17	0.562	0.558	1.584	1.001	1.59	0.99
3	3	2,3,5	**C-9**	9.13	9.12	0.568	0.565	1.614	0.989	1.60	1.00
37	6		**B-26**	9.14	9.13	0.549	0.545	1.501	1.025	1.54	0.96
22	6		**A-22**	9.15	9.12	0.557	0.55	1.638	1.003	1.64	1.03
4	4	1,3	**C-42**	9.17	9.15	0.549	0.544	1.594	1.027	1.64	1.02
Average values					**9.14**		**0.559**	**1.601**		**1.60**	

Table A-2 Thermocouple arrangement in Bundle KB-37/1

Rod Type	Rod	Thermocouple											
		1		2		3		4		5		6	
		l,mm	φ°	l,mm	φ°	l,mm	φ°	l,mm	φ°	l,mm	φ°	l,mm	φ°
A-1	19	57	186	513	225	1110	184	-----		2704	300	3505	0
A-7	18	180	298	-----		1194	182	2226	120	2725	46	-----	
A-19	12	197	267	688	222	1215	196	2207	128	2727	108	3486	0
A-22	22	117	240	690	103	1215	20	2212	200	2734	164	3501	0
A-25	36	193	280	704	330	1233	120	2226	90	2741	70	3500	0
A-31	29	188	140	694	65	1217	290	2207	160	2725	25	3483	0
A-34	27	184	290	698	200	1222	115	2203	306	2722	142	3477	0
A-40	16	150	110	659	350	1187	273	2195	164	2721	70	3490	0
A-46	8	154	260	666	90	1190	356	2184	220	2706	108	3468	0
A-49	2	-----		682	110	-----		2192	208	2710	120	3467	0

Rod Type	Rod	Thermocouple											
		1		2		3		4		5		6	
		l,mm	φ°	l,mm	φ°	l,mm	φ°	l,mm	φ°	l,mm	φ°	l,mm	φ°
B-2	26	942	68	945	230	2063	194	2067	48	3362	197	3365	0
B-14	30	774	296	775	102	2048	242	2048	68	3313	195	-----	
B-17	13	773	184	773	342	1998	268	1997	103	3306	170	3306	0
B-20	28	793	350	------		2026	40	2027	230	3349	183	3348	0
B-23	21	779	247	779	62	2013	15	2014	197	3334	179	3333	0
B-26	37	820	252	819	60	2022	86	2023	275	3323	188	3325	0
B-29	23	779	338	780	140	2012	185	2010	10	3326	188	3326	0
B-32	24	792	62	790	238	2021	178	2022	8	3341	180	3341	0
B-35	5	-----		764	125	1993	138	1991	325	3317	183	3316	0
B-38	1	756	334	757	138	2010	286	2010	100	3326	195	3325	0
B-44	9	756	290	756	95	-----		1965	6	3306	0	-----	
B-47	11	741	125	741	304	2024	276	2024	98	3335	175	3335	0

Rod Type	Rod	Thermocouple											
		1		2		3		4		5		6	
		l,mm	φ°	l,mm	φ°	l,mm	φ°	l,mm	φ°	l,mm	φ°	l,mm	φ°
C-3	20	1435	330	1437	150	2001	80	2000	250	2748	186	2746	0
C-6	17	1513	250	1514	78	2023	270	2023	70	2736	180	2737	0
C-9	3	1487	85	-----		1990	335	1987	170	-----		2692	0
C-12	34	1517	210	1518	22	2027	330	2026	165	----		2729	0
C-18	25	1414	184	1414	338	1971	218	1971	32	2731	178	2730	0
C-21	31	1488	245	1491	64	2000	248	2001	80	2718	162	2718	0
C-24	14	1232	248	-----		-----		-----		2461	50	2461	-10
C-27	32	1505	298	1505	132	2014	280	2015	113	2733	220	2732	0
C-30	10	1527	290	1524	95	2039	214	2038	46	2759	200	2760	0
C-33	35	1495	130	1493	307	2012	224	2012	46	2736	168	2736	0
C-36	33	1511	160	1510	348	-----		2018	55	2737	175	2739	0
C-39	15	1488	82	1487	254	2004	285	2003	115	2729	170	2730	0
C-42	4	-----		1517	232	2020	235	2022	75	2737	185	-----	
C-45	7	1476	105	1476	275	1987	20	1987	205	2715	176	2715	0
C-48	6	1487	85	1484	270	2004	12	2003	190	2728	170	2727	0

Таблица А-3. Bundle 37.1. Axial power profile

N	Rod	Type	Zone Number														
			1			2			3			4			5		
			L	∅	Kz	L	∅	Kz	L	∅	Kz	L	∅	Kz	L	∅	Kz
1	19	**A-1**	695	3.85	0.657	525	3.23	0.934	1056	2.49	1.571	524	3.3	0.894	730	3.95	0.624
2	18	**A-7**	785	3.9	0.576	501	3.00	0.973	1011	2.30	1.655	496	3.00	0.973	740	3.85	0.591
3	12	**A-19**	774	3.58	0.642	494	3.05	1.022	997	2.50	1.522	494	3.05	1.022	776	3.80	0.659
4	22	**A-22**	768	3.80	0.626	492	3.10	0.941	1005	2.35	1.638	508	3.10	0.941	757	3.85	0.61
5	36	**A-25**	768	3.80	0.609	494	3.00	0.977	1003	2.30	1.662	507	3.10	0.915	759	3.85	0.593
6	29	**A-31**	751	3.80	0.617	501	3.20	0.87	1013	2.30	1.684	503	3.10	0.927	762	3.85	0.601
7	27	**A-34**	835	3.75	0.671	487	3.05	1.015	952	2.45	1.573	487	3.10	0.982	777	3.80	0.654
8	16	**A-40**	747	3.75	0.635	495	3.00	0.992	1023	2.37	1.589	505	3.10	0.929	760	3.80	0.618
9	8	**A-46**	757	3.75	0.633	485	3.00	0.989	1023	2.37	1.584	504	3.05	0.956	761	3.80	0.616
10	2	**A-49**	769	3.75	0.643	493	3.00	1.005	1003	2.40	1.570	500	3.05	0.972	765	3.80	0.626
11	26	**B-2**	770	3.8	0.667	499	3.2	0.940	1043	2.48	1.565	516	3.3	0.884	702	3.84	0.653
12	30	**B-14**	763	3.75	0.638	494	3.00	0.997	1008	2.37	1.597	498	3.10	0.933	767	3.80	0.621
13	13	**B-17**	765	3.85	0.616	499	3.00	1.015	1019	2.40	1.586	501	3.10	0.95	745	3.85	0.616
14	28	**B-20**	786	3.85	0.620	484	3.20	0.898	995	2.35	1.665	502	3.15	0.927	764	3.80	0.637
15	21	**B-23**	747	3.85	0.645	498	3.10	0.995	1020	2.50	1.530	501	3.10	0.995	764	3.85	0.645
16	37	**B-26**	802	3.90	0.642	475	3.10	1.016	998	2.55	1.501	482	3.05	1.049	783	3.80	0.676
17	23	**B-29**	741	3.90	0.583	498	3.15	0.893	1026	2.30	1.676	510	3.10	0.923	756	3.80	0.614
18	24	**B-32**	760	3.85	0.603	485	3.20	0.873	1020	2.30	1.689	501	3.10	0.93	765	3.85	0.603
19	5	**B-35**	736	3.75	0.644	503	3.05	0.974	1026	2.40	1.572	507	3.10	0.942	758	3.80	0.627
20	1	**B-38**	733	3.75	0.625	495	3.05	0.945	1037	2.35	1.592	504	3.05	0.945	761	3.75	0.625
21	9	**B-44**	732	3.75	0.633	501	3.00	0.989	1032	2.37	1.584	504	3.10	0.926	760	3.80	0.616
22	11	**B-47**	759	3.70	0.660	493	3.05	0.971	1013	2.40	1.569	498	3.10	0.940	767	3.75	0.643
23	20	**C-3**	765	3.9	0.676	520	3.35	0.917	1037	2.55	1.582	538	3.45	0.864	670	4	0.643
24	17	**C-6**	749	3.90	0.625	495	3.10	0.989	1022	2.50	1.521	510	3.05	1.022	754	3.80	0.658
25	3	**C-9**	770	3.82	0.611	495	3.05	0.958	1000	2.35	1.614	510	3.00	0.99	755	3.80	0.617
26	34	**C-12**	757	3.7	0.626	499	2.95	0.985	1009	2.3	1.620	500	3.00	0.952	765	3.8	0.593
27	25	**C-18**	692	3.70	0.61	517	2.90	0.992	1056	2.30	1.578	536	3.00	0.927	730	3.75	0.593
28	31	**C-21**	762	3.80	0.653	495	3.10	0.982	1008	2.50	1.509	503	3.00	1.048	762	3.80	0.653
29	14	**C-24**	750	3.80	0.611	514	3.10	0.918	1001	2.30	1.667	515	3.10	0.918	748	3.80	0.611
30	32	**C-27**	754	3.8	0.618	499	3.1	0.929	1011	2.33	1.645	497	3.1	0.927	762	3.8	0.618
31	10	**C-30**	754	3.80	0.608	503	3.10	0.914	1010	2.30	1.660	497	3.05	0.944	766	3.80	0.608
32	35	**C-33**	738	3.80	0.609	500	3.00	0.978	1027	2.35	1.593	502	3.00	0.978	763	3.80	0.609
33	33	**C-36**	745	3.9	0.588	495	3.2	0.873	1025	2.3	1.69	504	3.1	0.93	761	3.85	0.603
34	15	**C-39**	758	3.75	0.639	486	3.05	0.996	1021	2.37	1.599	502	3.10	0.935	763	3.80	0.622
35	4	**C-42**	775	3.80	0.636	480	3.05	0.987	1010	2.40	1.594	505	3.10	0.956	762	3.85	0.620
36	6	**C-48**	748	3.75	0.623	500	3.0	0.973	1017	2.35	1.585	508	3.0	0.973	756	3.75	0.623
37	7	**C-45**	747	3.75	0.638	495	3.05	0.964	1023	2.37	1.596	508	3.10	0.933	758	3.80	0.621

Appendix B. INPUT DECK FOR BASE CASE

```
 = Reflooding for 37 rod assembly
 * Q=48 KWT
0000100 new transnt
0000105 1.   2.
*
0000201  0.5  1.0e-08  0.001    0003  500  500  10000
0000202  50.0  1.0e-08  0.20    0003  50  5000  1000
0000203 130.0  1.0e-09  0.005    0003  200  5000  1000
0000204 200.0  1.0e-09  0.005    0003  2000 5000  1000
0000205 270.0  1.0e-09  0.005    0003  2000 5000  1000
0000206 280.0  1.0e-09  0.002    0003  2000 5000  1000
0000207 400.0  1.0e-08  0.005    0003  2000 5000  1000
*
20800001  cputime 0
20800002  dt     0
*
0000401  time  0  ge  null  0  0.0 1
0000402  time  0  ge  null  0  130.0 1
*
***********************************************************
*                                          *
*              volume data cards                  *
*                                          *
***********************************************************
*
*
* water tank
*
0020000  "tank"  tmdpvol
0020101  1.0     1.0  0.0  0.0  90.0  1.  0.  0. 10
0020200  103
0020200  103
0020201   0.00 2.46000e5  324.15     *
*
* junction no. 4  (lower plenum to core)
*===========
*   V inlet =4.91 sm/c,G= 580 kg/h =0.16 kg/s
0010000  "jun 1"  tmdpjun
0010101  002000000 006000000  0.0113
0010200  1   402
0010201  0.0   0.0        0.0  0.0
0010203 1000.0  0.16        0.0  0.0 *
*=======================
*
*crdno  name   type
0060000    in  branch
*
*crdno jun.no ctrlw
0060001  1     1
*
*crdno area length volume h.ang v.ang elev rgh  dhyd tlpvbfe
0060101 0.0113  0.185 0.0   0.0   90.  0.185 4.0-5  0.0  0010000
```

```
*
*crdno ebt pressure quale
0060200 002   2.460e5   0.0
*
*crdno  from      to        area       floss  rloss   efvcahs
*  Area for  37 rod
0061101 006010000 004000000 0.003328    0.0   0.0   0001100
*
*
*crdno  flowf   flowg  in.vel
0061201 0.0     0.0    0.0
*----------------------

* core *
0040000   "core" pipe
0040001   15
*        vol area
0040101  0.003328     1
0040102  0.003328     2
0040103  0.003328     3
0040104  0.003328     4
0040105  0.003328     5
0040106  0.003328     6
0040107  0.003328     7
0040108  0.003328     8
0040109  0.003328     9
0040110  0.003328     10
0040111  0.003328     11
0040112  0.003328     12
0040113  0.003328     13
0040114  0.003328     14
0040115  0.003328     15
* junctions areas
0040201    0.0027187 1    *
0040202    0.0027187 2    *
0040203    0.0027187 3    *
0040204    0.0027187 4    *
0040205    0.0027187 5    *
0040206    0.0027187 6    *
0040207    0.0027187 7    *
0040208    0.0027187 8    *
0040209    0.0027187 9    *
0040210    0.0027187 10    *
0040211    0.0027187 11    *
0040212    0.0027187 12    *
0040213    0.0027187 13    *
0040214    0.0027187 14    *
*
*
*  L total =3.53m  =====
0040301   0.255     1   *
0040302   0.255     2   *
0040303   0.255     3   *
0040304   0.25      4   *
0040305   0.25      5   *
0040306   0.25      6   *
0040307   0.25      7   *
0040308   0.25      8   *
0040309   0.25      9   *
0040310   0.25      10   *
```

```
0040311  0.25     11   *
0040312  0.255    12   *
0040313  0.255    13   *
0040314  0.255    14   *
0040315  0.237    15   *
*
0040601  90.0     15
*
0040801  0.0      9.07e-3  15
0040901  0.1      0.1      14
*       pvbfe
0041001  01100    15
*       fvcahs
0041101  001000   14
*
*
0041201  102      2.46000e5   1.0  0.0   0.0 0 1
0041202  102      2.46000e5   1.0  0.0   0.0 0 2
0041203  102      2.46000e5   1.0  0.0   0.0 0 3
0041204  102      2.46000e5   1.0  0.0   0.0 0 4
0041205  102      2.46000e5   1.0  0.0   0.0 0 5
0041206  102      2.46000e5   1.0  0.0   0.0 0 6
0041207  102      2.46000e5   1.0  0.0   0.0 0 7
0041208  102      2.46000e5   1.0  0.0   0.0 0 8
0041209  102      2.46000e5   1.0  0.0   0.0 0 9
0041210  102      2.46000e5   1.0  0.0   0.0 0 10
0041211  102      2.46000e5   1.0  0.0   0.0 0 11
0041212  102      2.46000e5   1.0  0.0   0.0 0 12
0041213  102      2.46000e5   1.0  0.0   0.0 0 13
0041214  102      2.46000e5   1.0  0.0   0.0 0 14
0041215  102      2.46000e5   1.0  0.0   0.0 0 15
*
0041300  0
0041301  0.0   0.0 0.0    14
*
*
**+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
*
** upper plenum
*

*crdno  name  type
2040000  out  branch
*
*crdno jun.no ctrlw
2040001  1    1
*
*crdno area    length volume h.ang v.ang elev rgh  dhyd   tlpvbfe
2040101 2438.0e-6 0.1    0.0     0.0   90.  0.1   0.0  0.0  0010000
*     section D-D/37
*2040101  65.89e-6 0.225  0.0     0.0   90.  0.225 0.0  0.0  0010000
*
*crdno ebt pressure tempf
2040200 002  2.46000e5 1.0
*
*crdno  from      to       area floss rloss      efvcahs
2041101  004010000  204000000  2826.0e-6  0.1   0.1   0101000
*
*crdno  flowf   flowg  in.vel
2041201  0.0     0.0   0.0
```

```
*
*----------------------
**+++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
*
** upper plenum
*

*crdno  name   type
2060000   in  branch
*
*crdno jun.no ctrlw
2060001  2     1
*
*crdno area length volume h.ang v.ang elev rgh dhyd    tlpvbfe
2060101 0.0   0.460  30.0e-3   0.0   90.  0.460  0.0  0.0  0010000
*              Total volume/37
*2060101 0.0   0.460  0.8108e-3  0.0   90.  0.460 0.0  0.0  0010000
*
*crdno ebt pressure tempf
2060200 002 2.46000e5  1.0
*  109 holes D=5.3mm + 12 holes D=3.5 mm
*    =2403.5 mm2+ 115.4mm2 =  2519mm2,

2061101  204010000  206000000  2519.00e-6  0.1   0.1    0100000
* Outlet pipe D=60 mm, A= 2826mm2
2062101  206010000  010000000  2826.0e-6  0.1   0.1    0100000
*
*crdno  flowf   flowg  in.vel
2061201  0.0      0.0   0.0
2062201  0.0      0.0   0.0
*----------------------
*
0100000 "u p" tmdpvol
0100101  1.0e6  1.  0.  0.  90.  1.  0.  0.  10
*
0100200   102
0100201   0.0  2.46000e5   1.0
**================================================
*
*********************************************************
*                                     *
*          heat slab structure                  *
*                                     *
*********************************************************
*
*
*
*
*crdno   no.h.s  no.m.p  geo  s.s.flg  left   reffl  bvi no.ax.p
10016000    15     6      2  1       0.   402   1  8
*
10016100    0          1
*
*crdno    intvl    rt.cor     intvl    rt.cor
*                       ????
10016101    1     1.25e-3   1  3.85e-3    1   3.95e-3   2   4.55e-3
*
*crdno    comp  intvl  comp  intvl
*      NIHROM       MGO          INCONEL
*10011201   2      2      3    4       4    5
```

```
*        mgo      nihrom       mgo        s-steel
10016201   3   1      2  2       3   3       4   5
*
*
10016301   0.0       1
10016302   1.0       2
10016303   0.0       5
*
10016400   -1
*
10016401  373.00    373.00    373.00    373.00    373.00    373.00
10016402  373.00    373.00    373.00    373.00    373.00    373.00
10016403  373.00    373.00    373.00    373.00    373.00    373.00
10016404  373.00    373.00    373.00    373.00    373.00    373.00
10016405  373.00    373.00    373.00    373.00    373.00    373.00
10016406  373.00    373.00    373.00    373.00    373.00    373.00
10016407  373.00    373.00    373.00    373.00    373.00    373.00
10016408  373.00    373.00    373.00    373.00    373.00    373.00
10016409  373.00    373.00    373.00    373.00    373.00    373.00
10016410  373.00    373.00    373.00    373.00    373.00    373.00
10016411  373.00    373.00    373.00    373.00    373.00    373.00
10016412  373.00    373.00    373.00    373.00    373.00    373.00
10016413  373.00    373.00    373.00    373.00    373.00    373.00
10016414  373.00    373.00    373.00    373.00    373.00    373.00
10016415  373.00    373.00    373.00    373.00    373.00    373.00
*
10016501   0   0      0   1 9.435     1
10016502   0   0      0   1 9.435     02
10016503   0   0      0   1 9.435     03
10016504   0   0      0   1 9.25      04
10016505   0   0      0   1 9.25      05
10016506   0   0      0   1 9.25      06
10016507   0   0      0   1 9.25      07
10016508   0   0      0   1 9.25      08
10016509   0   0      0   1 9.25      09
10016510   0   0      0   1 9.25      10
10016511   0   0      0   1 9.25      11
10016512   0   0      0   1 9.25      12
10016513   0   0      0   1 9.435     13
10016514   0   0      0   1 9.435     14
10016515   0   0      0   1 9.435     15
*
10016601   004010000   0     1   1    9.287    1
10016602   004020000   0     1   1    9.287    2
10016603   004030000   0     1   1    9.287    3
10016604   004040000   0     1   1    9.2685   4
10016605   004050000   0     1   1    9.2685   5
10016606   004060000   0     1   1    9.361    6
10016607   004070000   0     1   1    9.361    07
10016608   004080000   0     1   1    9.361    08
10016609   004090000   0     1   1    9.361    09
10016610   004100000   0     1   1    9.3684   10
10016611   004110000   0     1   1    9.3684   11
10016612   004120000   0     1   1    9.3277   12
10016613   004130000   0     1   1    9.3277   13
10016614   004140000   0     1   1    9.3277   14
10016615   004150000   0     1   1    8.769    15
*
10016701  10002    0.044      0   0    1
10016702  10004    0.044      0   0    2
```

```
10016703 10006  0.044     0  0  3
10016704 10008  0.0744    0  0  4
10016705 10010  0.0744    0  0  5
10016706 10012  0.11467   0  0  6
10016707 10014  0.11467   0  0  7
10016708 10016  0.11467   0  0  8
10016709 10018  0.11467   0  0  9
10016710 10020  0.07388   0  0  10
10016711 10022  0.07388   0  0  11
10016712 10024  0.0442    0  0  12
10016713 10026  0.0442    0  0  13
10016714 10028  0.0442    0  0  14
10016715 10030  0.00      0  0  15
*
10016901  12.53e-3  20.  20.  0  0  0  0  1.0   15
*
*==============================================
*
*
*
* shroud
*crdno  no.h.s no.m.p geo s.s.flg left  reffl bvi no.ax.p
10121000  15   6    2  1    45.0-3 *  402  0  8
*
10121100  0      1
*
*crdno   intvl   rt.cor
10121102  3      68.3e-3
*
*
*crdno   comp  intvl  comp  intvl
*      Ssteel
10121201  11    2
10121202  12    5    * isolator
*
*
10121301  0.0    2
10121302  0.0    5
*
10121400  -1
*
10121401 373.00   373.00   373.00  373.00  373.00   373.00
10121402 373.00   373.00   373.00  373.00  373.00   373.00
10121403 373.00   373.00   373.00  373.00  373.00   373.00
10121404 373.00   373.00   373.00  373.00  373.00   373.00
10121405 373.00   373.00   373.00  373.00  373.00   373.00
10121406 373.00   373.00   373.00  373.00  373.00   373.00
10121407 373.00   373.00   373.00  373.00  373.00   373.00
10121408 373.00   373.00   373.00  373.00  373.00   373.00
10121409 373.00   373.00   373.00  373.00  373.00   373.00
10121410 373.00   373.00   373.00  373.00  373.00   373.00
10121411 373.00   373.00   373.00  373.00  373.00   373.00
10121412 373.00   373.00   373.00  373.00  373.00   373.00
10121413 373.00   373.00   373.00  373.00  373.00   373.00
10121414 373.00   373.00   373.00  373.00  373.00   373.00
10121415 373.00   373.00   373.00  373.00  373.00   373.00
*
10121501  004010000  0   1  1   0.251  1
10121502  004020000  0   1  1   0.251  2
10121503  004030000  0   1  1   0.251  3
```

```
10121504   004040000   0       1  1    0.2505  4
10121505   004050000   0       1  1    0.2505  5
10121506   004060000   0       1  1    0.253   6
10121507   004070000   0       1  1    0.253   7
10121508   004080000   0       1  1    0.253   8
10121509   004090000   0       1  1    0.253   9
10121510   004100000   0       1  1    0.2532 10
10121511   004110000   0       1  1    0.2532 11
10121512   004120000   0       1  1    0.2521 12
10121513   004130000   0       1  1    0.2521 13
10121514   004140000   0       1  1    0.2521 14
10121515   004150000   0       1  1    0.237  15
*

10121601   -700   0   3701   1   0.251       1
10121602   -700   0   3701   1   0.251       2
10121603   -700   0   3701   1   0.251       3
10121604   -700   0   3701   1   0.2505      4
10121605   -700   0   3701   1   0.2505      5
10121606   -700   0   3701   1   0.253       6
10121607   -700   0   3701   1   0.253       7
10121608   -700   0   3701   1   0.253       8
10121609   -700   0   3701   1   0.253       9
10121610   -700   0   3701   1   0.2532      10
10121611   -700   0   3701   1   0.2532      11
10121612   -700   0   3701   1   0.2521      12
10121613   -700   0   3701   1   0.2521      13
10121614   -700   0   3701   1   0.2521      14
10121615   -700   0   3701   1   0.237       15
*

*
10121701   100  0.0    0  0   1
10121702   100  0.0    0  0   2
10121703   100  0.0    0  0   3
10121704   100  0.0    0  0   4
10121705   100  0.0    0  0   5
10121706   100  0.0    0  0   6
10121707   100  0.0    0  0   7
10121708   100  0.0    0  0   8
10121709   100  0.0    0  0   9
10121710   100  0.0    0  0   10
10121711   100  0.0    0  0   11
10121712   100  0.0    0  0   12
10121713   100  0.0    0  0   13
10121714   100  0.0    0  0   14
10121715   100  0.0    0  0   15
*

10121801   3.4e-3   20.   20.   0  0  0  0   1.0    15
10121901   3.4e-3   20.   20.   0  0  0  0   1.0    15


*
*    109 holes
* upper plate
*crdno  no.h.s  no.m.p  geo  s.s.flg  left  reffl  bvi  no.ax.p
10122000   1    3     2  1      2.65-3  *   402   0  8
*
```

```
10122100   0        1
*
*crdno    intvl   rt.cor
10122101   2        5.29e-3 *    var11  * to obtain need mass of metal
*10122101   2        3.65e-3 *    var10
*
*
*crdno    comp   intvl   comp   intvl
*        Ssteel
10122201   11      2
*
*
10122301   0.0      2
*
10122400   -1
*
10122401  373.00    373.00    373.00
*
10122501   204010000   0     1   1   10.9    1   * 0.1*109
*
10122601   0   0      0   1    10.9    1
*
10122701    0  0.0    0   0   1
*
10122801   3.4e-3   20.   20.   0   0   0   0   1.0     1
10122901   3.4e-3   20.   20.   0   0   0   0   1.0     1
*
*


***************************************************
*    heat structure thermal property data          *
***************************************************
*
20100200  tbl/fctn   1      1    * nihrom
20100300  tbl/fctn   1      1    * MG-O
20100400  tbl/fctn   1      1    * Steel
20101200  tbl/fctn   1      1    * Isolator
*
*
*     thermal conductivity tables
*
*--------1--------1--------1--------1--------1--------1--------1
*  ISOLATOR
*--------1--------1--------1--------1--------1--------1--------1
20101201  293.0     0.05
20101202  2700.0    0.05
*--------1--------1--------1--------1--------1--------1--------1
*  ISOLATOR
*--------1--------1--------1--------1--------1--------1--------1
20101251  300.     1.428e5
20101252  2700.    5.50e6
*--------1--------1--------1--------1--------1--------1--------1

*--------1--------1--------1--------1--------1--------1--------1
*  NICHROME 5  THERMAL CONDUCTIVITY (W/M-K) (004) [HEATERS]
*--------1--------1--------1--------1--------1--------1--------1
```

```
20100201  293.0   12.5
20100202  373.0   13.8
20100203  473.0   15.6
20100204  573.0   17.2
20100205  673.0   19.0
20100206  873.0   22.6
20100212  2700.0  25.0
*--------|--------|--------|--------|--------|--------|--------|
*  NICHROME 5  HEAT CAPACITY (J/M3-K)
*--------|--------|--------|--------|--------|--------|--------|
20100251  300.    3.66e6
20100252  400.    3.96e6
20100253  500.    4.16e6
20100254  600.    4.34e6
20100255  700.    4.46e6
20100256  800.    4.68e6
20100257  900.    4.83e6
20100258  1000.   5.04e6
20100259  1100.   5.18e6
20100260  1200.   5.30e6
20100261  1700.   5.50e6
20100262  2700.   5.50e6
*--------|--------|--------|--------|--------|--------|--------|
*--------|--------|--------|--------|--------|--------|--------|
*  MAGN.OXIDE THERMAL CONDUCTIVITY (W/M-K) (005) [INSULATOR]
*--------|--------|--------|--------|--------|--------|--------|
20100301  293.0   1.7
20100302  473.0   2.75
20100303  573.0   2.6
20100304  673.0   2.5
20100305  873.0   2.52
20100306  1073.0  2.90
20100307  1173.0  3.20
20100308  2573.0  3.2
*--------|--------|--------|--------|--------|--------|--------|
*  MAGN. OXIDE HEAT CAPACITY (J/M3-K)
*--------|--------|--------|--------|--------|--------|--------|
20100351  293.    2.87e6
20100352  373.    3.04e6
20100353  473.    3.15e6
20100354  573.    3.20e6
20100355  673.    3.24e6
20100356  773.    3.29e6
20100357  873.    3.34e6
20100358  973.    3.44e6
20100359  1073.   3.53e6
20100360  1173.   3.63e6
20100361  1573.   3.63e6
20100362  2573.   3.63e6
*--------|--------|--------|--------|--------|--------|--------|
*======================================================================
*- - - - - - S-steel- - - - - - - - - - - - - - - - - - - - - - - - -
*                thermal conductiviti (w/m*k) (004)
20100401   323.0    14.9
20100402   373.0    15.6
20100403   473.0    17.2
20100404   673.0    20.4
20100405   873.0    23.7
20100406   1073.0    27.4
20100407   1273.0    31.0
```

```
20100408   1573.0     31.0
20100409   2573.0     31.0
*-------------------------------------
*                        heat capacity (j / m**3 * k) (004)
20100451    323.0     3.763e6
20100452    373.0     3.855e6
20100453    473.0     4.029e6
20100454    673.0     4.264e6
20100455    873.0     4.680e6
20100456   1073.0     4.985e6
20100457   1273.0     5.340e6
20100458   1573.0     5.340e6
20100459   2573.0     5.340e6
*---------------------------------------------------------------------------
*  s-steel
*-------------------------------------------------------
20101100 tbl/fctn,  1,  1
*----- thermal conductivity table
20101101 2.731500e+02 1.298051e+01
20101102 1.199817e+03 2.510604e+01
*----- volumetric heat capacity table
20101151 2.850000e+02 3.453703e+06, 3.350000e+02 3.769201e+06
20101152 3.664833e+02 3.830413e+06, 4.220389e+02 3.964814e+06
20101153 4.775944e+02 4.099214e+06, 5.331500e+02 4.233615e+06
20101154 5.887056e+02 4.334415e+06, 6.442611e+02 4.435081e+06
20101155 6.998167e+02 4.502416e+06, 8.109278e+02 4.636816e+06
20101156 1.366483e+03 5.376019e+06

*
********************************
*      power table    100     *
********************************
*
20210000 power 0 1.0 1.0e3   * Total power
20210001 0.0 0.00      *     0.
20210002 1.0  0.13     *
20210004 3.0  0.38     *
20210005 4.0  0.55     *
20210006 5.0  0.79     *
20210007 7.0  1.27     *
20210008 8.0  1.59     *
20210009 9.0  1.95     *
20210010 11.0 2.77     *
20210011 13.0 3.81     *
20210012 14.0 4.37     *
20210013 16.0 5.63     *
20210014 21.0 9.68     *
20210015 22.0 10.66    *
20210016 24.0 12.76    *
20210017 25.0 13.85    *
20210018 26.0 15.05    *
20210019 27.0 16.27    *
20210020 29.0 19.03    *
20210021 30.0 20.25    *
20210022 31.0 21.65    *
20210023 32.0 23.2     *
20210024 34.0 26.64    *
20210025 35.0 27.99    *
20210026 37.0 31.59     *
20210027 38.0 33.44     *
```

```
20210028 41.0  39.44     *
20210029 42.0  41.87     *
20210030 45.0  48.38     *
20210031 54.0  66.83     *
20210032 60.0  75.21     *
20210033 66.0  84.00     *
20210034 67.0  85.38     *
20210035 69.0  88.50     *
20210036 71.0  91.85     *
20210037 72.0  93.55     *
20210038 74.0  97.08     *
20210039 75.0  98.99     *
20210040 77.0  102.99    *
20210041 82.0  114.31    *
20210042 83.0  116.92    *
20210043 84.0  119.56    *
20210044 88.0  131.4     *
20210045 89.0  134.58    *
20210046 90.0  137.22    *
20210047 94.0  148.15    *
20210048 95.0  148.16    *
20210049 98.0  148.08    *
20210050 99.0  148.07    *
20210051 100.0 147.9     *
20210052 101.0 148.      *
20210053 102.0 147.8     *
20210054 124.0 147.85    *
20210055 125.0 147.64    *
20210056 126.0 147.80    *
20210057 129.0 147.91    *
20210058 130.0 147.72    *
20210059 131.0 146.48    *
20210060 132.0 143.31    *
20210061 133.0 141.95    *
20210062 134.0 141.37    *
20210063 135.0 140.56    *
20210064 142.0 135.15    *
20210065 143.0 134.60    *
20210066 144.0 133.56    *
20210067 145.0 133.74    *
20210068 150.0 130.56    *
20210069 151.0 130.68    *
20210070 157.0 127.97    *
20210071 170.0 122.89    *
20210072 180.0 119.68    *
20210073 251.0 105.9     *
20210074 270.0 103.61    *
20210075 290.0 101.32    *
20210076 320.0 98.01     *
20210077 340.0 96.68     *
20210078 350.0 95.72     *
*
*         CONTROL VARIABLES
20507100   lev4   sum   1.0   0.0   0
20507101   0.0    0.243   voidf   004010000
20507102          0.255   voidf   004020000
20507103          0.278   voidf   004030000
20507104          0.232   voidf   004040000
20507105          0.268   voidf   004050000
20507106          0.254   voidf   004060000
```

```
20507107        0.255   voidf   004070000
20507108        0.255   voidf   004080000
20507109        0.248   voidf   004090000
20507110        0.322   voidf   004100000
20507111        0.182   voidf   004110000
20507112        0.272   voidf   004120000
20507113        0.255   voidf   004130000
20507114        0.231   voidf   004140000
20507115        0.237   voidf   004150000
*
*
20507200  flf1  mult  2438.0e-6     0.0  0
20507201  rhofj    204010000
20507202  velfj    204010000
20507203  voidfj    204010000
*
20507300  flfi  mult 3328.0e-6    0.0  0
20507301  rhofj    006010000
20507302  velfj    006010000
20507303  voidfj    006010000
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*
20507400  flg   mult 2438.0e-6    0.0  0
20507401  rhogj    204010000
20507402  velgj    204010000
20507403  voidgj    204010000
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*
20507500  dp1 sum  1.0e-3   0.0   0
20507501  0.0    1.       p    004010000
20507502       -1.0       p    004150000
*
20507600  dp2 sum  1.0e-3   0.0   0
20507601  0.0    1.       p    004080000
20507602       -1.0       p     04150000
*
*
*
20507700  dp3 sum  1.0e-3   0.0   0
20507701  0.0    1.       p    004010000
20507702       -1.0       p    004080000
*
*
20507800  dp4 sum  1.0e-3   0.0   0
20507801  0.0    1.       p    006010000
20507802       -1.0       p    004010000
*
20507900  dp5 sum  1.0e-3   0.0   0
20507901  0.0    1.       p    204010000
20507902       -1.0       p    206010000
*
20508000  inflow  integral  1.0   0.0   0
20508001  cntrlvar   73
*
20508100  oflowf integral  1.0   0.0   0
20508101  cntrlvar   72
*
20508200  oflowg  integral  1.0   0.0   0
20508201  cntrlvar   74
*
```

```
*        Core heat
*-------------------------------------------------------------------------*
*crd no      name    type   scale     init     flag
20508300   h_core     sum     1.0      0.0        1
*crd no     a0       a1      var       code
20508301    0.0    1.0      q       004010000
20508302           1.0      q      004020000
20508303           1.0      q      004030000
20508304           1.0      q      004040000
20508305           1.0      q      004050000
20508306           1.0      q      004060000
20508307           1.0      q      004070000
20508308           1.0      q      004080000
20508309           1.0      q      004090000
20508310           1.0      q      004100000
20508311           1.0      q      004110000
20508312           1.0      q      004120000
20508313           1.0      q      004130000
20508314           1.0      q      004140000
20508315           1.0      q      004150000
*-------------------------------------------------------------------------*
*
*        Core heat calculated from cntrlvar
*-------------------------------------------------------------------------*
*crd no      name    type   scale     init     flag
20508400   h_core     sum     1.0      0.0        1
*crd no     a0       a1      var       code
20508401    0.0   0.04433   cntrlvar 2
20508402         0.04433   cntrlvar 4
20508403         0.04433   cntrlvar 6
20508404         0.1065    cntrlvar 8
20508405         0.1065    cntrlvar 10
20508406         0.07975   cntrlvar 12
20508407         0.07975   cntrlvar 14
20508408         0.07975   cntrlvar 16
20508409         0.07975   cntrlvar 18
20508410         0.103     cntrlvar 20
20508411         0.103     cntrlvar 22
20508412         0.043     cntrlvar 24
20508413         0.043     cntrlvar 26
20508414         0.043     cntrlvar 28
*-------------------------------------------------------------------------*
*
20505700    mass4 sum   2438.0e-6   0.0   1   0
20505701     0.0  0.251       rho      004010000
20505702          0.251       rho      004020000
20505703          0.251       rho      004030000
20505704          0.2505      rho      004040000
20505705          0.2505      rho      004050000
20505706          0.253       rho      004060000
20505707          0.253       rho      004070000
20505708          0.253       rho      004080000
20505709          0.253       rho      004090000
20505710          0.2532      rho      004100000
20505711          0.2532      rho      004110000
20505712          0.2521      rho      004120000
20505713          0.2521      rho      004130000
20505714          0.2521      rho      004140000
20505715          0.237       rho      004150000
*=====================================================================
```

```
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*-------------------------------------------------
20500100    heat1   function   1.0   1.0   1
*
*           cccg0nn    no table
20500101    htvat  0016001       036
*
*------------------
20500200    heat2   mult   1.0 1.0       1
*
*                  no table
20500201     cntrlvar 1      cntrlvar 41
*
*-------------------------
20500300    heat1   function   1.0   1.0   1
*
*           cccg0nn    no table
20500301    htvat  0016002       036
*
*------------------
20500400    heat2   mult   1.0 1.0    1
*
*                  no table
20500401     cntrlvar  003    cntrlvar 41
*                                  *
*-------------------------------------------------
*-------------------------
20500500    heat1   function   1.0   1.0   1
*
*           cccg0nn    no table
20500501    htvat  0016003       036
*
*------------------
20500600    heat2   mult   1.0 1.0    1
*
*                  no table
20500601     cntrlvar  005    cntrlvar 41
*                                  *
*-------------------------------------------------
*-------------------------
20500700    heat1   function   1.0   1.0   1
*
*           cccg0nn    no table
20500701    htvat  0016004       036
*
*------------------
20500800    heat2   mult   1.0 1.0    1
*
*                  no table
20500801     cntrlvar  007    cntrlvar 41
*                                  *
*-------------------------------------------------
*-------------------------
20500900    heat1   function   1.0   1.0   1
*
*           cccg0nn    no table
20500901    htvat  0016005       036
*
*------------------
20501000    heat2   mult   1.0 1.0    1
```

```
*
*                  no table
20501001    cntrlvar  009    cntrlvar 41
*                            *
*--------------------------------------------------
*--------------------------
20501100    heat1   function   1.0   1.0   1
*
*           cccg0nn     no table
20501101    htvat  0016006       036
*
*------------------
20501200    heat2   mult   1.0 1.0     1
*
*                  no table
20501201    cntrlvar  011    cntrlvar 41
*                            *
*--------------------------------------------------
*--------------------------
20501300    heat1   function   1.0   1.0   1
*
*           cccg0nn     no table
20501301    htvat  0016007       036
*
*------------------
20501400    heat2   mult   1.0 1.0     1
*
*                  no table
20501401    cntrlvar  013    cntrlvar 41
*                            *
*--------------------------------------------------
*--------------------------
20501500    heat1   function   1.0   1.0   1
*
*           cccg0nn     no table
20501501    htvat  0016008       036
*
*------------------
20501600    heat2   mult   1.0 1.0     1
*
*                  no table
20501601    cntrlvar  015    cntrlvar 41
*                            *
*--------------------------------------------------
*--------------------------
20501700    heat1   function   1.0   1.0   1
*
*           cccg0nn     no table
20501701    htvat  0016009       036
*
*------------------
20501800    heat2   mult   1.0 1.0     1
*
*                  no table
20501801    cntrlvar  017    cntrlvar 41
*                            *
*--------------------------------------------------
*--------------------------
20501900    heat1   function   1.0   1.0   1
*
```

```
*           cccg0nn   no table
20501901    htvat  0016010      036
*
*------------------
20502000    heat2   mult   1.0 1.0    1
*
*                  no table
20502001     cntrlvar  019    cntrlvar 41
*                           *
*-------------------------------------------------
*------------------------------------------------
20502100    heat1   function   1.0   1.0   1
*
*           cccg0nn   no table
20502101    htvat  0016011      036
*
*------------------
20502200    heat2   mult   1.0 1.0    1
*
*                  no table
20502201     cntrlvar 21      cntrlvar 41
*
*--------------------------
20502300    heat1   function   1.0   1.0   1
*
*           cccg0nn   no table
20502301    htvat  0016012      036
*
*------------------
20502400    heat2   mult   1.0 1.0    1
*
*                  no table
20502401     cntrlvar  023    cntrlvar 41
*                           *
*-------------------------------------------------
*-------------------------
20502500    heat1   function   1.0   1.0   1
*
*           cccg0nn   no table
20502501    htvat  0016013      036
*
*------------------
20502600    heat2   mult   1.0 1.0    1
*
*                  no table
20502601     cntrlvar  025    cntrlvar 41
*                           *
*-------------------------------------------------
*-------------------------
20502700    heat1   function   1.0   1.0   1
*
*           cccg0nn   no table
20502701    htvat  0016014      036
*
*------------------
20502800    heat2   mult   1.0 1.0    1
*
*                  no table
20502801     cntrlvar  027    cntrlvar 41
*                           *
```

```
*---------------------------------------------------
*--------------------------
20502900    heat1   function  1.0   1.0   1
*
*              cccg0nn    no table
20502901    htvat  0016015       036
*
*------------------
20503000    heat2   mult   1.0 1.0     1
*
*                     no table
20503001     cntrlvar  029    cntrlvar 41
*                                  *
*---------------------------------------------------
*------------------
20504100    heat   function   1.0  1297.3    1
*                      scale  ini value  flag
20504100    heat   function   1.0     3.902e3     1 * Qmax/Kz*l=1.77/1.601*3.53
*
*                     no table
20504101     time  00          100
*
*--------------------------
*                                  *
20203600    reac-t
*
20203601     293.0      1.0
20203602     373.0      1.0088
20203603     473.0      1.0177
20203604     573.0      1.0177
20203605     673.0      1.035
20203606     773.0      1.035
20203607     873.0      1.035
20203608     973.0      1.027
20203609    1073.0      1.0177
20203610    1273.0      1.0177
20203611    1473.0      1.035
*
*------------------
20504200    heat   function   1.0  6.739e2  1
20504200    heat   function   1.0  3.902e3  1
*
*                     no table
20504201     time   0          100
*
*--------------------------
20504300    R      function 0.1407   0.1407   1
20504301    time  0      36
*
*--------------------------
*--------------------------
20504400    R2     mult     1.0     0.00648  1
20504401           cntrlvar 43  cntrlvar 43
*
*--------------------------
20504500    heatt  function  1.0   1297.3     1
20504501     time   0      100
*
*--------------------------
*
```

```
20530100  T1  sum  1.0     0.0   0
20530101  0.0    1.       httemp     001600106
20530102      -1.0       cntrlvar 233
*
*
20530200  T2  sum  1.0     0.0   0
20530201  0.0    1.       httemp     001600206
20530202      -1.0       cntrlvar 233
*
*
20530300  T3  sum  1.0     0.0   0
20530301  0.0    1.       httemp     001600306
20530302      -1.0       cntrlvar 233
*
*
20530400  T4  sum  1.0     0.0   0
20530401  0.0    1.       httemp     001600406
20530402      -1.0       cntrlvar 233
*
*
20530500  T5  sum  1.0     0.0   0
20530501  0.0    1.       httemp     001600506
20530502      -1.0       cntrlvar 233
*
*
20530600  T6  sum  1.0     0.0   0
20530601  0.0    1.       httemp     001600606
20530602      -1.0       cntrlvar 233
*
*
20530700  T7  sum  1.0     0.0   0
20530701  0.0    1.       httemp     001600706
20530702      -1.0       cntrlvar 233
*
*
20530800  T8  sum  1.0     0.0   0
20530801  0.0    1.       httemp     001600806
20530802      -1.0       cntrlvar 233
*
*
20530900  T9  sum  1.0     0.0   0
20530901  0.0    1.       httemp     001600906
20530902      -1.0       cntrlvar 233
*
*
20531000  T10 sum  1.0     0.0   0
20531001  0.0    1.       httemp     001601006
20531002      -1.0       cntrlvar 233
*
*
20531100  T11 sum  1.0     0.0   0
20531101  0.0    1.       httemp     001601106
20531102      -1.0       cntrlvar 233
*
*
20531200  T12 sum  1.0     0.0   0
20531201  0.0    1.       httemp     001601206
20531202      -1.0       cntrlvar 233
*
*
```

```
20531300  T13 sum  1.0     0.0  0
20531301  0.0   1.       httemp    001601306
20531302     -1.0       cntrlvar 233
*
*
20531400  T14 sum  1.0     0.0  0
20531401  0.0   1.       httemp    001601406
20531402     -1.0       cntrlvar 233
*
*
20531500  T15 sum  1.0     0.0  0
20531501  0.0   1.       httemp    001601506
20531502     -1.0       cntrlvar 233
*
******************* Vessel wall***********
20520100  TK1  sum  1.0     0.0  0
20520101  0.0   1.       httemp    012100402 * zone 1
20520102     -1.0       cntrlvar 233
*
*
20520200  TK2  sum  1.0     0.0  0
20520201  0.0   1.       httemp    012100402 *zone 1
20520202     -1.0       cntrlvar 233
*
*
20520300  TK3  sum  1.0     0.0  0
20520301  0.0   1.       httemp    012100402 * zone 1
20520302     -1.0       cntrlvar 233
*
*
20520400  TK4  sum  1.0     0.0  0
20520401  0.0   1.       httemp    012100902  * zone 2
20520402     -1.0       cntrlvar 233
*
*
20520500  TK5  sum  1.0     0.0  0
20520501  0.0   1.       httemp    012100902 * zone 2
20520502     -1.0       cntrlvar 233
*
*
20520600  TK6  sum  1.0     0.0  0
20520601  0.0   1.       httemp    012100902 *zone 2
20520602     -1.0       cntrlvar 233
*
*
20520700  TK7  sum  1.0     0.0  0
20520701  0.0   1.       httemp    012101102 * zone 3
20520702     -1.0       cntrlvar 233
*
*
20520800  TK8  sum  1.0     0.0  0
20520801  0.0   1.       httemp    012101102  * zone 3
20520802     -1.0       cntrlvar 233
*
*
20520900  TK9  sum  1.0     0.0  0
20520901  0.0   1.       httemp    012101102 * zone 3
20520902     -1.0       cntrlvar 233
*
*
```

```
20521000  TK10 sum  1.0    0.0  0
20521001  0.0   1.      httemp    012101402 *zone 4
20521002     -1.0     cntrlvar 233
*
*
20521100  TK11 sum  1.0    0.0  0
20521101  0.0   1.      httemp    012101402 * zone 4
20521102     -1.0     cntrlvar 233
*
*
20521200  TK12 sum  1.0    0.0  0
20521201  0.0   1.      httemp    012101402  * zone 4
20521202     -1.0     cntrlvar 233
*
*--------------------------------------------------
*            Isolation
20521300  Tiz1 sum  1.0    0.0  0
20521301  0.0   1.      httemp    012100406
20521302     -1.0     cntrlvar 233
*
20521400  Tiz2 sum  1.0    0.0  0
20521401  0.0   1.      httemp    012100906
20521402     -1.0     cntrlvar 233
*
20521500  Tiz3 sum  1.0    0.0  0
20521501  0.0   1.      httemp    012101106
20521502     -1.0     cntrlvar 233
*
20521600  Tiz4 sum  1.0    0.0  0
20521601  0.0   1.      httemp    012101506
20521602     -1.0     cntrlvar 233
*
*
*
20522000  Tin sum  1.0    0.0  0
20522001  0.0   1.      tempf     006010000
20522002     -1.0     cntrlvar 233
*
*
20522100  Tout sum  1.0    0.0  0
20522101  0.0   1.      tempg     206010000
20522102     -1.0     cntrlvar 233
*

*
20522200  Gin  sum  133200.   0.0  0   * *37
20522201  0.0   1.     mflowj     006010000
*
*
20522300  G_gout  sum  133200.   0.0  0
20522301  0.0   1.       cntrlvar 74
*
*
20522400  POWER   sum  0.037    0.0  0       ** 37 rod,KWT
20522401  0.0   1.       cntrlvar 41
*

*
20522500  PIN   sum   1.0e-3   0.0  0
20522501  0.0   1.       p    006010000
```

```
*
*
20522600  Pout  sum  1.0e-3   0.0  0
20522601  0.0   1.       p     206010000
*
*
20522700  mmmm  sum  1.0      0.0  0
20522701  0.0   1.      mflowj  006010000
*
*
20522800  Tg1 sum  1.0    0.0  0    *H=762
20522801  0.0   1.      tempg     004040000
20522802     -1.0      cntrlvar 233
*
*
20522900  Tg2 sum  1.0    0.0  0     * H=1527
20522901  0.0   1.      tempg     004070000
20522902     -1.0      cntrlvar 233
*
*
20523000  Tg3 sum  1.0    0.0  0      *H= 2037
20523001  0.0   1.      tempg     004090000
20523002     -1.0      cntrlvar 233
*
*
20523100  Tg4 sum  1.0    0.0  0      *H= 2802
20523101  0.0   1.      tempg     004120000
20523102     -1.0      cntrlvar 233
*
*
20523200  Tg5 sum  1.0    0.0  0      *H= 3567
20523201  0.0   1.      tempg     004150000
20523202     -1.0      cntrlvar 233
*
*
*          temperature in containment
20270000      temp
*
20270001        0.0   310.0
20270002      1.0e6   310.0
*--------------------------------------------------------------------------------
20270100       htc-t  0   1.0  1.0
20270101       -1.0    300.0
20270102    10000.0    300.0

*crdno   name   c.c.typ   s.fac  in.v. in.flag
20523300  T_CEL  function  1.0     1.0  0
*
*crdno    var   code  table
20523301  time   0     584
*
*                                *
20258400    reac-t
*
20258401       0.0     273.0

. end of problem
```

NRC FORM 335
(2-89)
NRCM 1102,
3201, 3202

U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

(See instructions on the reverse)

1. REPORT NUMBER
(Assigned by NRC, Add Vol., Supp., Rev., and Addendum Numbers, if any.)

NUREG/IA-0207

2. TITLE AND SUBTITLE

RELAP5/MOD3.2.2 GAMMA ASSESSMENT FOR DOWN TO TOP REFLOODING PROCESS AT VVER LIKE 37-ROD BUNDLE

3. DATE REPORT PUBLISHED

MONTH	YEAR
July	2002

4. FIN OR GRANT NUMBER

5. AUTHOR(S)

A.S. Devkin

6. TYPE OF REPORT

technical

7. PERIOD COVERED *(Inclusive Dates)*

8. PERFORMING ORGANIZATION - NAME AND ADDRESS *(If NRC, provide Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address; if contractor, provide name and mailing address.)*

Nuclear Safety Institute
Russian Research Center
"Kurchatov Institute"
123182, Moscow ,Russia

9. SPONSORING ORGANIZATION - NAME AND ADDRESS *(If NRC, type "Same as above"; if contractor, provide NRC Division, Office or Region, U.S. Nuclear Regulatory Commission, and mailing address.)*

Division of System Analysis and Regulatory Effectiveness
Office of Nuclear Regulatory Research
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

10. SUPPLEMENTARY NOTES

This is a Russian CAMP in-kind contribution

11. ABSTRACT *(200 words or less)*

The assessment of RELAP5/MOD3.2.2 Gamma for down to top reflooding at VVER like 37-rod bundle is presented. The experiment have been performed at IPPE test facility at the following parameter s: upper plenum pressure- 0,246 MPa, cooling water temperature- 51N, water velocity- 4.91 sm/s, average linear heat flux density at maximal heat p roduction zone before water supply-1,77 kWt/m. RELAP5/MOD3.2.2Gamma assessment showed that code gives satisfactory results for all parameters behavior. The main discrepancies were get for cladding temperature b ehavior at level H-2.7m, where the calculated cladding temperatures exceed experimental data approximately on 75 K . Computed quenching time for this level are much higher experimental ones. For other levels accordance between experime ntal and RELAP data is rather good.

12. KEY WORDS/DESCRIPTORS *(List words or phrases that will assist researchers in locating the report.)*

reflood, RELAP5, VVER

13. AVAILABILITY STATEMENT

unlimited

14. SECURITY CLASSIFICATION

(This Page)
unclassified

(This Report)
unclassified

15. NUMBER OF PAGES

16. PRICE

Printed on recycled paper

Federal Recycling Program

RELAP5/MOD3.2.2 GAMMA ASSESSMENT FOR DOWN TO TOP REFLOODING PROCESS AT VVER LIKE 37-ROD BUNDLE

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, DC 20555-0001

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