Nuclear Science NEA/NSC/DOC(2002)6

VVER-1000 Coolant Transient Benchmark

PHASE 1 (V1000CT-1)
Vol. I: Main Coolant Pump (MCP) switching On – Final Specifications

Boyan Ivanov and Kostadin Ivanov
Nuclear Engineering Program, USA

Pavlin Groudev and Malinka Pavlova
INRNE, Academy of Sciences, Bulgaria

Vasil Hadjiev
Nuclear Power Plant Kozloduy, Bulgaria

US Department of Energy

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), Korea (12th December 1996) and the Slovak Republic (14 December 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of 28 OECD Member countries: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Luxembourg, Mexico, the Netherlands, Norway, Portugal, Republic of Korea, Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The Commission of the European Communities also takes part in the work of the Agency.

The mission of the NEA is:

- to assist its Member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes, as well as
- to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information. The NEA Data Bank provides nuclear data and computer program services for participating countries.

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

FOREWORD

The OECD Nuclear Energy Agency (OECD/NEA) has completed under US NRC sponsorship a PWR Main Steam Line Break (MSLB) Benchmark involving thermal-hydraulic/neutron kinetics codes. Recently, another OECD-NRC coupled code benchmark was initiated for a BWR turbine trip (TT) transient. During the course of defining and co-ordinating the OECD-NRC PWR MSLB and BWR TT benchmarks a systematic approach has been established to validate best-estimate coupled codes. This approach employs a multi-level methodology that not only allows for a consistent and comprehensive validation process but also contributes to determine additional requirements and to prepare a basis for licensing application of the coupled calculations for a specific reactor type, i.e. establishing safety expertise in analysing reactivity transients. Professional communities have been established during the course of these benchmark activities that led to in-depth discussions of the different aspects required for assessing neutron kinetics modelling relative to a given reactor, and finally on how to implement best-estimate methodologies for transient analysis using coupled codes. The above examples demonstrate the benefit of establishing such international coupled standard problems for each type of reactor.

In the framework of the United States Department of Energy (DOE) International Nuclear Safety Program (INSP), a project was started in 2001 with an overall objective to assess computer codes used in the safety analysis of VVER power plants, specifically for their use in analysing reactivity transients in a VVER-1000 reactor. As a result, a coupled benchmark problem based on data from the Bulgarian Kozloduy Nuclear Power Plant (NPP) has been developed for the purpose of assessing neutron kinetics modelling for a VVER-1000 reactor. This problem is being analysed using both point kinetics and three-dimensional kinetics models. Based on the experience accumulated in safety analyses of western-type reactors (see the examples given above for PWR and BWR international standard benchmark problems), it was proposed that Phase 1 of the VVER-1000 benchmark problem be extended to an international standard problem.

During the Starter International VVER-1000 Benchmark Meeting, which took place on 30 May 2002 in Dresden, Germany, this benchmark was proposed and accepted by the participants. It will be labelled as VVER-1000 Coolant Transient Benchmark (V1000CT) and consist of two phases. Phase 1 (V1000CT-1), led by Pennsylvania State University (PSU), is a main coolant pump (MCP) switching on transient when the three other MCPs are in operation. Phase 2 (V1000CT-2), led by the French *Commissariat à l'énergie atomique* (CEA), includes calculation of coolant mixing experiments and a main steam line break (MSLB) analysis. Both PSU and the CEA are working in co-operation with the Bulgarian Institute for Nuclear Research and Nuclear Energy (INRNE). The sponsors of the benchmark are the OECD/NEA, US DOE, CEA and IRSN. The Kozloduy Nuclear Power Plant (KNPP) provides technical support and the Atomic Energy Research (AER) Working Group D participates in the benchmark activities.

This report provides the specifications for the international, coupled VVER-1000 Coolant Transient (V1000CT-1) benchmark problem. The specification report has been prepared jointly by PSU and INRNE in co-operation with leading specialists from KNPP. The work is sponsored by the

US DOE, the OECD/NEA, and the Nuclear Engineering Program at PSU, and is being performed with the assistance of Argonne National Laboratory (ANL).

The reference MCP switching on problem chosen for simulation in a VVER-1000 is an experiment that was conducted by Bulgarian and Russian engineers during the plant-commissioning phase at the KNPP Unit 6 as part of the start-up tests. The test was carried out due to its importance for the safety of the VVER-1000, model 320 reactor at the NPP. This event is characterised by a rapid increase in coolant flow through the core resulting in a coolant temperature decrease, which is spatially dependent. All necessary information to model and analyse the transient with best-estimate system thermal-hydraulic codes using both point kinetics and three-dimensional kinetics models is provided in the report. A KNPP Unit 6 RELAP5 thermal-hydraulic skeleton input deck, as well as the KNPP 6 RELAP5 four-loop model nodalisation diagram are also provided in Appendix A. They represent part of the source information that provides the plant data. They are derived from the baseline VVER-1000 RELAP5 input deck shown in Appendix D, developed and validated by INRNE for KNNP Unit 6. This baseline input deck is considered part of the data specification.

The specification covers the three exercises of Phase 1 and the required output information is specified for each exercise. In addition, a CD-ROM is also being prepared with the transient boundary conditions, decay heat values as a function of time, and cross-section libraries.

In June 2001 the NEA Nuclear Science Committee (NSC) approved and endorsed the coupled Kozloduy benchmark problem to become an international standard problem for validation of the best-estimate safety codes for VVER applications. The collaboration with the AER group addressing VVER coupling benchmarks concerning this benchmark has provided valuable feedback on these specifications. In June 2002 the NSC approved and endorsed the extension of the benchmark to two phases, as described above.

Acknowledgements

This report is dedicated to the students of Penn State University, who form part of the next generation of nuclear engineers.

The authors would like to thank Dr. J. Roglans-Ribas, Dr. T. Taiwo, Dr. P. Pizzica and J. Ahrens from the Argonne National Laboratory (ANL), whose support and encouragement in establishing and carrying out this benchmark are invaluable.

This report is the sum of many efforts, the participants, the funding agencies and their staff – the US Department of Energy and the OECD Nuclear Energy Agency. Special appreciation goes to the report reviewers: N. Todorova from PSU, R. Gencheva from INRNE, P. Demerdjiev from KNPP, J.W. Ahrens from ANL-INSC, J.E. Cahalan from ANL, J.E. Fisher from the Idaho National Engineering and Environmental Laboratory (INEEL), and T.A. Taiwo from ANL. Their comments and suggestions were very valuable and significantly improved the quality of this report.

The authors wish to express their sincere appreciation for the outstanding support offered by the KNPP personnel in providing the plant data and discussing the transient characteristics.

Particularly noteworthy have been the efforts of J. Roglans-Ribas, P. Pizzica, M. Petri and J. Ahrens from ANL. With their help, funding has been secured, enabling this project to proceed. We also thank them for their excellent technical advice and assistance.

The authors would like to thank Dr. János Gadó, Director of the Hungarian Central Research Institute for Physics (KFKI), Prof. J. Aragones from *Universidad Politécnica de Madrid* (UPM), both members of the NEA Nuclear Science Committee and Prof. F. D'Auria of the University of Pisa (UP), member of the NEA Committee on the Safety of Nuclear Installations, whose support and encouragement in establishing and carrying out this benchmark are invaluable.

The authors wish to express their sincere appreciation for the outstanding support offered by Dr. Enrico Sartori, who provided efficient administration, organisation and valuable technical recommendations.

Finally, we are grateful to Hélène Déry for having devoted her competence and skills to the preparation of this report for publication.

TABLE OF CONTENTS

List of tables

List of figures

LIST OF ABBREVIATIONS

ADF	Assembly Discontinuity Factor
ANS	American Nuclear Society
APSR	Axial Power Shaping Rods
BOC	Beginning of Cycle
BWR	Boiling Water Reactor
CA	Control Assembly
DOE	Department of Energy
DTC	Doppler Temperature Coefficient
EFPD	Effective Full Power Days
EFW	Emergency Feed Water
EHTC	Electro Hydraulic Turbine Controller
FA	Fuel Assembly
FWP	Feed Water Pump
HP	Hot Power
HZP	Hot Zero Power
ID	Hot Zero Power
INRNE	Institute for Nuclear Research and Nuclear Energy
INSP	International Nuclear Safety Program
KNPP	Kozloduy Nuclear Power Plant
LOCA	Lost of Coolant Accident
LWR	Light Water Reactor
MCP	Main Coolant Pump
MSH	Main Steam Header
MSLB	Main Steam Line Break
MTC	Moderator Temperature Coefficient
NEA	Nuclear Energy Agency
NFMS	Neutron Flux Monitoring System (in-core reactor control system)
ANS	American Nuclear Society
NP	Normalised Power
NRC	Nuclear Regulatory Commission
OD	Outside Diameter
OECD	Organisation for Economic Co-operation and Development
PRV	Pressuriser Relief Valve
PSU	Pennsylvania State University
PWR	Pressuriser Water Reactor
RC	Reactor Coolant
RCS	Reactor Coolant System
RPLC	Reactor Power Limitation Controller
RPC	Reactor Power Controller
SG	Steam Generator
TG	Turbo Generator
TT	Turbine Trip
UES	Universal Electronic System
WP-1	Warning Protection

Chapter 1

INTRODUCTION

Incorporation of full three-dimensional (3-D) models of the reactor core into system transient codes allows for a "best-estimate" calculation of interactions between the core behaviour and plant dynamics. Recent progress in computer technology has made the development of coupled system thermal-hydraulic (T-H) and neutron kinetics code systems feasible. Considerable efforts have been made in various countries and organisations in this direction. To verify the capability of the coupled codes to analyse complex transients with coupled core-plant interactions and to fully test thermal-hydraulic coupling, appropriate Light Water Reactor (LWR) transient benchmarks need to be developed on a higher "best-estimate" level. The previous sets of transient benchmark problems addressed separately system transients (designed mainly for thermal-hydraulic (T-H) system codes with point kinetics models) and core transients (designed for T-H core boundary conditions models coupled with three-dimensional (3-D) neutron kinetics models). The Nuclear Energy Agency (NEA) of the Organisation for Economic Co-operation and Development (OECD) has recently completed under the US Nuclear Regulatory Commission (NRC) sponsorship a PWR Main Steam Line (MSLB) Benchmark [1] for evaluating coupled T-H system and neutron kinetics codes. A benchmark team from the Pennsylvania State University (PSU) has been responsible for developing the benchmark specification, assisting the participants and co-ordinating the benchmark activities. The benchmark was well accepted by the international community. A similar benchmark for codes used in analysis of a BWR plant transient has been recently defined. The Turbine Trip (TT) transients in a BWR are pressurisation events in which the coupling between core phenomena and system dynamics plays an important role. In addition the available real plant experimental data makes the benchmark problem very valuable. The NEA, OECD and US NRC have approved the BWR TT benchmark for the purpose of validating advanced system best-estimate analysis codes. This specification is a further continuation of the above activities and it defines a coupled code benchmark problem for validation of thermal-hydraulics system codes for application to Soviet-designed VVER-1000 reactors based on actual plant data.

1.1 Background

The United States Department of Energy (US DOE), under the auspices of the INSP, provides assistance to the nuclear industry in Central and Eastern Europe and the countries of the Former Soviet Union to help foster and further develop the safety analysis capabilities at individual nuclear power plants and their technical support organisations, to the extent that it supports safety operation.

Most transients in a VVER reactor can be properly analysed with a system thermal-hydraulics code like RELAP5, with simplified neutron kinetics models (point kinetics). A few specific transients require more advanced, three-dimensional (3-D) modelling for neutron kinetics for a proper description. A coupled thermal-hydraulics/3-D neutron kinetics code would be the right tool for such tasks.

The proposed benchmark problem [2] will be analysed with RELAP5/MOD3.2 [3] and the results will be compared with those obtained with coupled codes with 3-D kinetics such as RELAP5-3D [4] and TRAC-PF1/NEM [5].

The reference problem chosen for simulation is a Main Coolant Pump (MCP) switching on when the other three main coolant pumps are in operation, which is a real transient of an operating VVER-1000 power plant. This event is characterised by rapid increase in the flow through the core resulting in a coolant temperature decrease, which is spatially dependent. This leads to insertion of spatially distributed positive reactivity due to the modelled feedback mechanisms and non-symmetric power distribution. Simulation of the transient requires evaluation of core response from a multi-dimensional perspective (coupled three-dimensional (3-D) neutronics/core thermal-hydraulics) supplemented by a one-dimensional (1-D) simulation of the remainder of the reactor coolant system. The purpose of this benchmark is three-fold:

- To verify the capability of system codes to analyse complex transients with coupled core-plant interactions.
- To fully test the 3-D neutronics/thermal-hydraulic coupling.
- To evaluate discrepancies between predictions of coupled codes in best-estimate transient simulations.

1.2 Definition of three benchmark exercises

In addition to being based on a well-defined problem, with reference design and data from the Kozloduy Nuclear Power Plant Unit 6 (KNPP) [6], the benchmark includes a complete set of input data, and consists of three exercises. These exercises are discussed below.

1.2.1 Exercise 1 – Point kinetics plant simulation

The purpose of this exercise is to test the primary and secondary system model responses. Provided are compatible point kinetics model inputs, which preserve axial and radial power distribution, and scram reactivity obtained using a 3-D code neutronics model and a complete system description.

1.2.2 Exercise 2 – Coupled 3-D neutronics/core T-H response evaluation

The purpose of this exercise is to model the core and the vessel only. Inlet and outlet core transient boundary conditions are provided.

1.2.3 Exercise 3 – Best-estimate coupled code plant transient modeling

This exercise combines elements of the first two exercises in this benchmark and is an analysis of the transient in its entirety.

Chapter 2

CORE AND NEUTRONIC DATA

2.1 General

The reference design for the VVER-1000 is derived from the reactor geometry and operational data of the Kozloduy NPP Unit 6 [6, 9]. The data provided in the following paragraphs, appendices, and in the pertinent tables and figures, completely defines the VVER-1000 benchmark exercise. A KNPP Unit 6 RELAP5 thermal-hydraulic skeleton input deck, as well as the KNPP 6 RELAP5 four-loop model nodalization diagram are given in Appendix A. They represent part of the source information that provides the plant data. They are derived from the baseline VVER-1000 RELAP5 input deck, developed and validated by INRNE for KNNP Unit 6. The baseline VVER-1000 RELAP5 input deck is shown in Appendix D. The Engineering Handbook that supports this baseline deck and nodalization diagram has been already reviewed and approved by DOE [7]. The VVER-1000 MCP Switching on transient scenario, described in Section 5.1, is specified.

2.2 Core geometry and fuel assembly (FA) geometry

The radial geometry of the reactor core is shown in Figure 2.2.1. Radially, the core is divided into hexagonal cells with a pitch 23.6 cm, each corresponding to one fuel assembly (FA), plus a radial reflector (shaded area) of the same size. There are a total of 211 assemblies, 163 FA and 48 reflector assemblies. Axially, the reactor core is divided into 10 layers with a height (starting from the bottom) of 35.5 cm, adding up to a total active core height of 355 cm. Both upper and lower axial reflectors have a thickness of 23.6 cm. The axial nodalisation scheme accounts for material changes in the fuel design and for the exposure and moderator temperature (spectral history) variations. Zero flux boundary conditions are specified on outer reflector surface for both radial and axial reflectors.

The mesh used for the calculation is up to the participant, and should be chosen according to the numerical capabilities of the code. For example axially the reactor core can be also modelled with 20 layers with a height of 17.75 cm. Output should, however, give volume-averaged results on the specified mesh in the format described in Chapter 6.

Fuel assemblies with different ^{235}U enrichments are present in the core. This is the first cycle for NPP Kozloduy Unit 6 and all assemblies are fresh. The radial distributions of the enrichment can be found in Section 2.4; the geometric data for the FA is given in Table 2.2.1.

The available gap width is 0.08 mm (distance between pellet surface and inside clad wall). For the neutronic problem, each of the FAs is considered to be homogeneous.

The radial arrangement of the control assemblies (CA) is shown in Figure 2.2.2. The sixty-one CAs, grouped into ten groups, are full-length control rods except group #5, which consists of part-length control rods. The part-length control rods have neutron absorber only in its lower half and they are used to damp the Xe-oscillations. The full-length control rods contain a strong neutron absorber over a length that spans most of the active core region. In addition to the radial arrangement, the position of control rod insertion in units of cm is given from the bottom of the lower reflector. The total CA length, which coincides with the absorber length, is 371 cm. No tip of control rods is defined. The position of the lower CA absorber edge from the bottom of the lower reflector is 23.6 cm for a completely inserted CA, and 378.6 cm for a completely withdrawn CA. The definition completely withdrawn means withdrawn from the active core, i.e. out of the core.

2.3 Neutron modelling

Two neutron energy groups and six decay groups for delayed neutrons are modelled. The energy release per fission for the two prompt neutron groups is 0.3213×10^{-10} and 0.3206×10^{-10} W-s/fission, and this energy release is considered to be independent of time and space. Table 2.3.1 shows the time constants and fractions of delayed neutrons.

It is recommended that ANS-79 be used as a decay heat standard model. In total 71 decay-heat groups are used: 69 groups are used for the three isotopes ^{235}U, ^{239}Pu and ^{238}U with the decay-heat constants defined in the 1979 ANS standard; plus, the heavy-element decay heat groups for ^{239}U and ^{239}Np are used with constants given in Table 2.3.2. It is recommended that the participants also use the operational history provided in Table 2.3.3. For participants who are not capable of using the ANS-79 decay heat standard, a file of the decay heat evolution throughout the transient for both scenario versions is provided on CD-ROM under the directory **Decay-Heat**. These predictions are obtained using the Pennsylvania State University (PSU) coupled code TRAC-PF1/NEM [5]. The effective decay heat energy fraction of the total thermal power (the relative contribution in the steady state) is equal to 0.07143.

2.4 Two-dimensional assembly types and three-dimensional composition maps

Twenty-nine assembly types are contained within the core geometry. There are 283 unrodded and 110 rodded compositions. The corresponding sets of cross-sections are provided. Each composition is defined by material properties (due to changes in the fuel design) and burn-up. The burn-up dependence is a three-component vector variables: exposure (MWd/kgU), spectral history (T_{mod}) and control rod (CR) history. The definition of assembly types is shown in Table 2.4.1. The radial distribution of these assembly types within the reactor geometry is shown in Figure 2.4.1. The 2-D assembly type map is shown in a one-sixth-core symmetry sector together with the assembly exposure values at the 30.7 EFPD in cycle depletion. The axial locations of compositions for each assembly are shown in Table 2.4.2.

2.5 Cross-section library

A complete set of diffusion coefficients and macroscopic cross-sections for scattering, absorption, and fission as a function of the moderator density and fuel temperature is defined for each composition. The assembly discontinuity factors (ADFs) are taken into consideration implicitly by incorporating them into the cross-sections (i.e. by dividing the cross sections with ADFs for each energy group) in order to minimise the size of the cross-section tables. The group inverse neutron velocities are also provided for each composition. All the data in the cross-section library was obtained using the HELIOS code [19]. Dependence of the cross-sections on the above variables is specified through a two-dimensional table look-up. Each composition is assigned to a cross-section set containing separate tables for the diffusion coefficients and cross-sections, with each point in the table representing a possible core state. The expected range of the transient is covered by the selection of an adequate range for the independent variables shown in Table 2.5.1. A linear interpolation scheme is used to obtain the appropriate total cross-sections from the tabulated ones based on the reactor conditions being modelled. Table 2.5.2 shows the definition of a cross-section table associated with a composition. Table 2.5.3 shows the macroscopic cross-section table structure for one cross-section set. All cross-section sets are assembled into a cross-section library. The cross-sections are provided in separate libraries for rodded **(nemtabr)** (numerical nodes with a CA) and unrodded compositions **(nemtab)**. The format of each library is as follows:

- The first line of data is used to show the number of data points used for the independent thermal-hydraulic (T-H) parameters. These parameters include fuel temperature, moderator density, boron concentration and moderator temperature.

- Each cross-section set is in the order shown in Table 2.5.3. Each table is in the format described in Table 2.5.2. More detailed information on this format is presented in Appendix B. First, the values of the independent thermal-hydraulic parameters (fuel temperature and moderator density) used to specify that particular set of cross-sections are listed, followed by the values of the cross-sections. Finally, the group inverse neutron velocities complete the data for a given cross-section set.

- The dependence on fuel temperature in the reflector cross-section tables is also modelled. This is because the reflector cross-sections are generated by performing lattice physics transport calculations, including the next fuel region. In order to simplify the reflector feedback modelling the following assumptions are made for this benchmark: an average fuel temperature value equal to 600 K is used for the radial reflector cross-section modelling in both the initial steady-state and transient simulations, and the average coolant density for the radial reflector is equal to the inlet coolant density. For the axial reflector regions the following assumptions are made: for the bottom – the fuel temperature is equal to the inlet coolant temperature (per T-H channel or cell) and the coolant density is equal to the inlet coolant density (again per channel); for the top – the fuel temperature is equal to the outlet coolant temperature (per channel) and the coolant density is equal to the outlet coolant density (per channel).

All cross-section data, along with a program for linear interpolation, are supplied on CD-ROM under the directory **XS-Lib** in the format described above.

Table 2.2.1. FA geometry data

Parameter	Value
Pellet diameter, mm	7.56
Central void diameter, mm	1.40
Clad diameter (outside), mm	9.10
Clad wall thickness, mm	0.69
Fuel rod total length, mm	3837
Fuel rod active length (cold state), mm	3530
Fuel rod active length (hot state), mm	3550
Fuel rod pitch, mm	12.75
Fuel rod grid	Triangular
Number of guide tubes	18
Guide tube diameter (outside), mm	12.60
Guide tube diameter (inside), mm	11.00
Number of fuel pins	312
Number of water rods/assembly	1
Water rod diameter (outside), mm	11.20
Water rod diameter (inside), mm	9.60
FA wrench size, mm	234
FA pitch, mm	236

Table 2.3.1. Decay constant and fractions of delayed neutrons

Group	Decay constant (s^{-1})	Relative fraction of delayed neutrons in %
1	0.0125	0.0209
2	0.0305	0.1493
3	0.0111	0.1368
4	0.3050	0.2866
5	1.1300	0.0984
6	3.0000	0.0348

Total fraction of delayed neutrons: 0.7268%.

Table 2.3.2. Heavy-element decay heat constants

Group no. (isotope)	Decay constant (s^{-1})	Available energy from a single atom (MeV)
70 (^{239}U)	4.91×10^{-4}	0.474
71 (^{239}Np)	3.41×10^{-6}	0.419

Table 2.3.3. Operational history

No.	Time, EFPD	Thermal power, MW	No.	Time, EFPD	Thermal power, MW
1	2.00	750	7	12.85	240
2	2.55	840	8	19.90	1 500
3	3.25	90	9	20.47	1 710
4	6.49	1 230	10	25.50	2 160
5	6.94	1 350	11	26.70	1 800
6	12.37	1 470	12	30.30	2 160

Table 2.4.1. Definition of assembly types

Assembly type	Enrichment, w/o	Exposure, MWd/kgU
1	2.0	1.219
2	2.0	1.283
3	2.0	1.311
4	3.0	1.553
5	2.0	1.360
6	2.0	1.409
7	3.3[1]	1.391
8	3.0	1.603
9	2.0	1.271
10	2.0	1.286
11	3.0	1.676
12	3.0	1.578
13	3.3	0.909
14	2.0	1.271
15	2.0	1.213
16	2.0	1.271
17	2.0	1.246
18	3.3	1.065
19	2.0	1.286
20	2.0	1.271
21	3.0	1.489
22	3.3	1.053
23	3.0	1.676
24	2.0	1.246
25	3.3	1.053
26	3.0	1.578
27	3.3	1.065
28	3.3	0.909
29	Radial reflector	

1. Profiled fuel assembly – see Figure 2.4.2.

Table 2.4.2. Composition numbers in axial layers for each assembly type

Bottom

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
1	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281	281
2	1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231	241	251	261	271	282
3	2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192	202	212	222	232	242	252	262	272	282
4	3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193	203	213	223	233	243	253	263	273	282
5	4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194	204	214	224	234	244	254	264	274	282
6	5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195	205	215	225	235	245	255	265	275	282
7	6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196	206	216	226	236	246	256	266	276	282
8	7	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197	207	217	227	237	247	257	267	277	282
9	8	18	28	38	48	58	68	78	88	98	108	118	128	138	148	158	168	178	188	198	208	218	228	238	248	258	268	278	282
10	9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199	209	219	229	239	249	259	269	279	282
11	10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240	250	260	270	280	282
12	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283	283

Top

Table 2.5.1. Range of variables

T Fuel (°K)	Rho M. (kg/m^3)
540.00	786.84
760.00	786.84
855.00	786.84
1 000.00	786.84
1 500.00	786.84
540.00	761.78
760.00	761.78
855.00	761.78
1 000.00	761.78
1 500.00	761.78
540.00	712.50
760.00	712.50
855.00	712.50
1 000.00	712.50
1 500.00	712.50
540.00	661.68
760.00	661.68
855.00	661.68
1 000.00	661.68
1 500.00	661.68

Table 2.5.2. Key to macroscopic cross-section tables

T_{f1}	T_{f2}	T_{f3}	T_{f4}	T_{f5}
ρ_{m1}	ρ_{m2}	ρ_{m3}	ρ_{m4}	Σ_1
Σ_2	…			
	…	Σ_{19}	Σ_{20}	

Where:

– T_f is the Doppler (fuel) temperature (°K)

– ρ_m is the moderator density (kg/m^3)

Macroscopic cross-sections are in units of cm^{-1}

Table 2.5.3. Macroscopic cross-section table's structure

****

NEM – Cross-section table input.

T fuel	Rho mod.	Boron ppm.	T Mod.
5	4	0	0

************* Cross-section set #

#

****

Group no. 1.

************* Diffusion coefficient table.

************* Absorption cross-section table.

************* Fission cross-section table.

************* Nu-fission cross-section table.

************* Scattering from group 1 to 2 cross-section table.

****

Group no. 2.

************* Diffusion coefficient table.

************* Absorption cross-section table.

************* Fission cross-section table.

************* Nu-fission cross-section table.

************* Xenon absorption cross-section table.

****

Inv. neutron velocities.

Figure 2.2.1. Cross-section of the reactor core

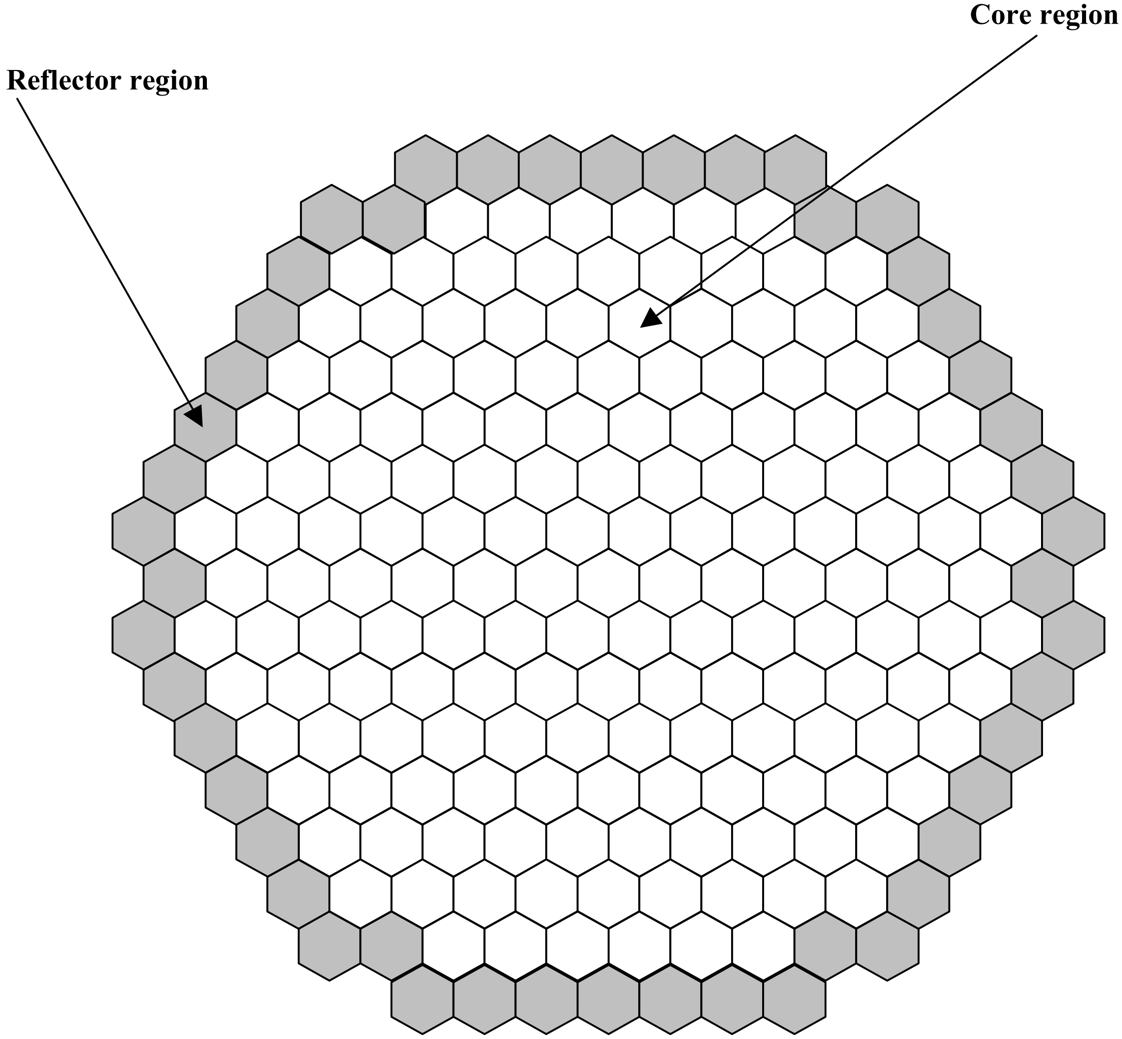
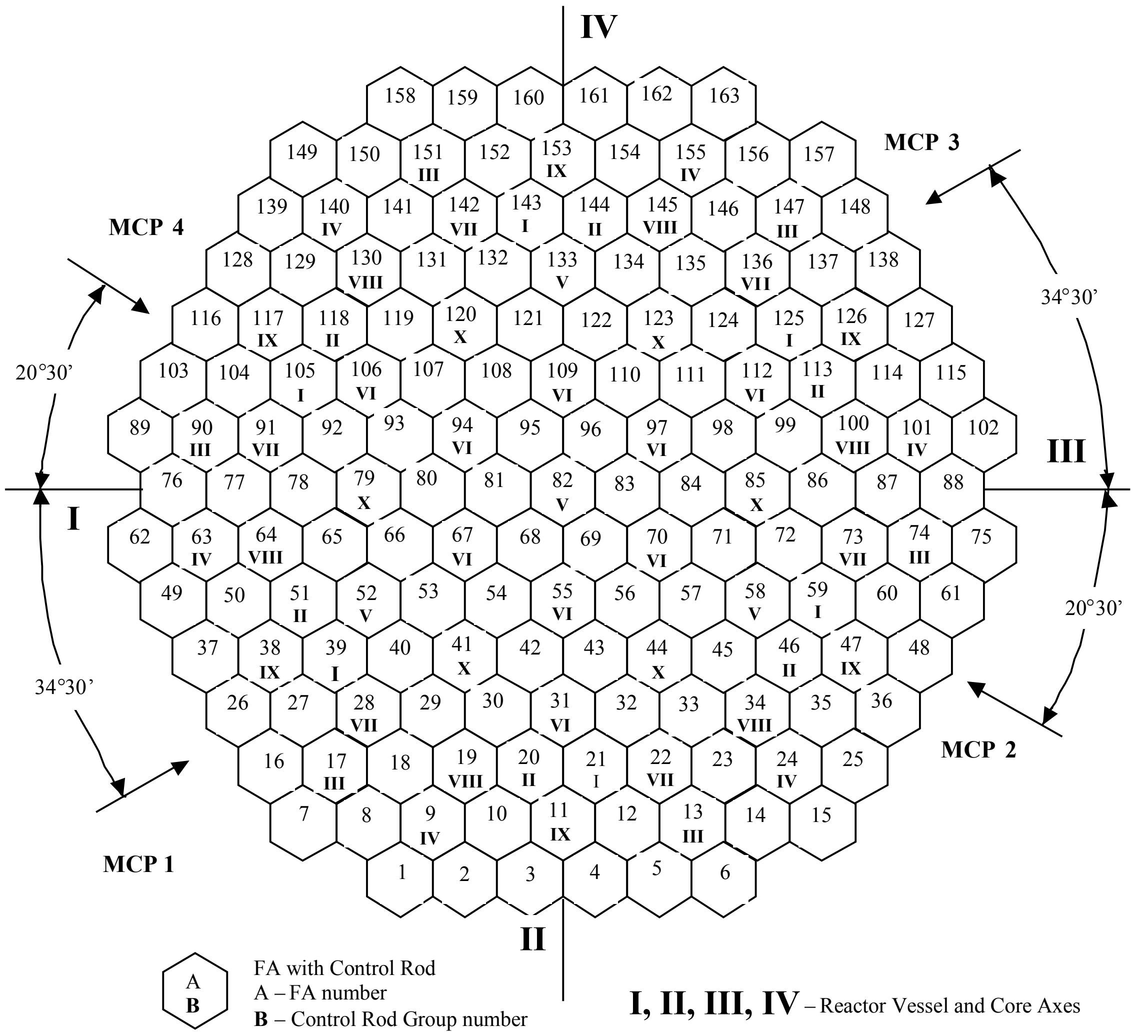


Figure 2.2.2. Arrangement of control rods



Bank	No rods	Purpose
I	6	Safety
II	6	Safety
III	6	Safety
IV	6	Safety
V	4	Parth-lenght
VI	9	Safety
VII	6	Safety
VIII	6	Safety
IX	6	Safety
X	6	Regulating

Figure 2.4.1. Two-dimensional assembly type map

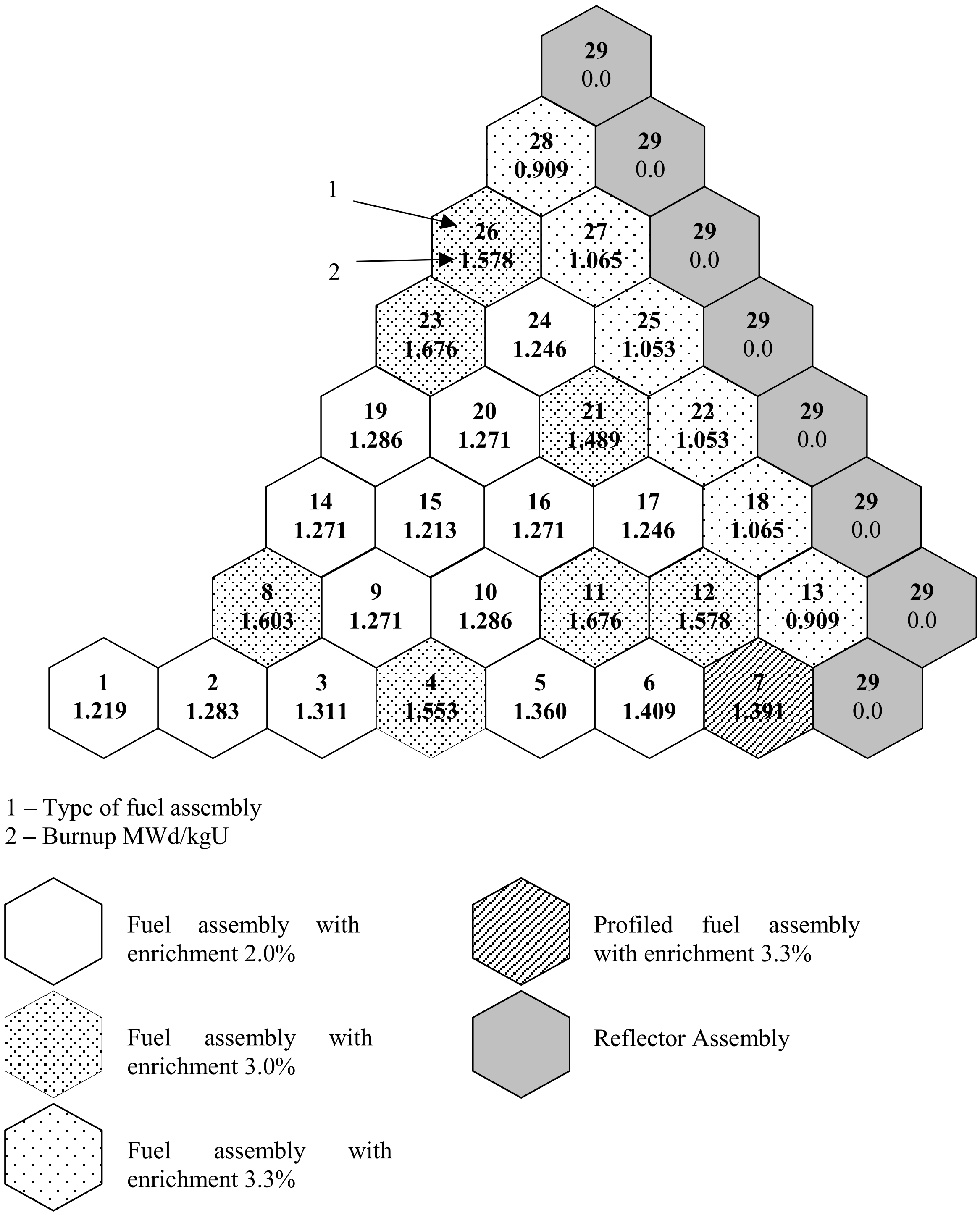
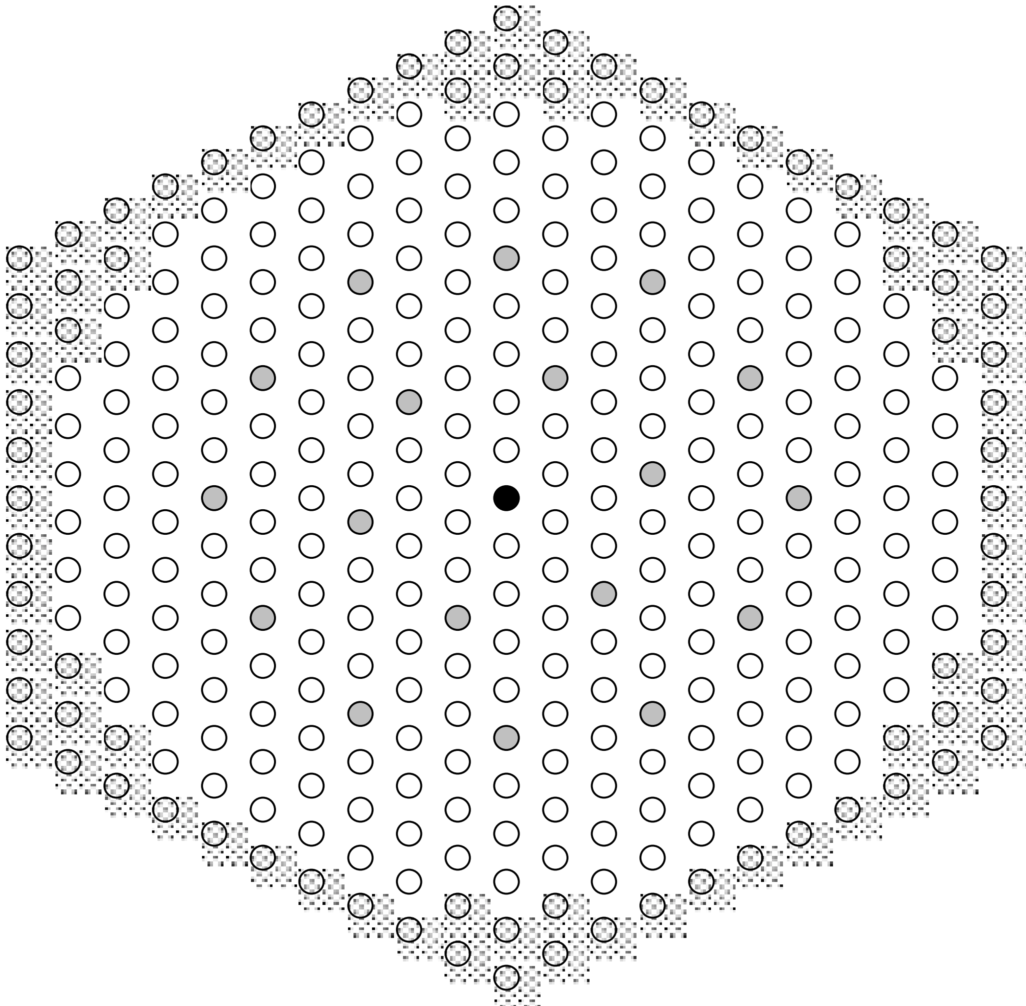


Figure 2.4.2. Profiled fuel assembly



● - water rod

○ - 234 fuel rods with enrichment 3.3 w/o

◉ - control rod guide tube

◌ - 78 fuel rods with enrichment 3.0 w/o

Chapter 3

THERMAL-HYDRAULIC DATA

A KNPP Unit 6 RELAP5 skeleton thermal-hydraulic (T-H) input deck, as well as the KNPP Unit 6 four-loop model nodalisation diagrams [7], are provided in Appendix A. The baseline VVER-1000 RELAP5 input deck is shown in Appendix D.

3.1 Component specifications for the full thermal-hydraulic system model

3.1.1 Reactor vessel

The following tables provide all of the necessary data about the KNPP Unit 6 Reactor Vessel. The KNPP Unit 6 RELAP5 thermal-hydraulic skeleton input deck (given in Appendix A) represents part of the source information that provides the plant data. It is derived from the baseline VVER-1000 RELAP5 input deck, developed and validated by INRNE for KNNP Unit 6. The Engineering Handbook that supports this baseline deck has been already reviewed and approved by DOE [7]. Table 3.1.1.1 contains all of the design data, and Table 3.1.1.2 contains the volume data. The volumes given in tables are the actual physical volumetric data. Figures 3.1.1.3 through 3.1.1.7 provide more specific details about all of the components in the pressure vessel.

The reactor pressure vessel is the pressure boundary of the reactor core and high-pressure coolant. The detailed geometry of the reactor pressure vessel is presented on Figures 3.1.1.1 and 3.1.1.2.

The lower part of the core barrel consists of an elliptical flow distributor plate with perforations passing through the inner vessel. The perforations are circular holes 40 mm in diameter and 1 344 holes are present (Figure 3.1.1.3.). The curvature of the reactor shaft elliptic bottom is greater than the curvature of the reactor vessel elliptic bottom. This configuration allows for a significant amount of flow area to be present even during the most severe loss of coolant accident (LOCA) and high vessel temperatures. Thus, this increase in area was a way to try and guarantee that a significant part of the flow path will be available so that coolant will be able to reach the active section of the core during severe conditions. Once the coolant passes through the perforation of the inner vessel, the flow reaches the lower plenum, which is adjacent to the fuel support columns.

The fuel support columns are also perforated to allow the coolant to enter into the fuel assemblies themselves. The fuel support columns are welded to the inner vessel and welded together at the top such that no flow passes around the fuel support columns. The upper part of support columns has a hexagonal shape with a central circular opening for the bottom of the fuel assemblies. There are 163 fuel support columns since there is a one to one correspondence between the fuel assemblies and the support columns. The fuel support columns have an outside diameter 194 mm with a metal thickness of 12 mm. The perforations in the support column are ellipsoidal slits about 30 mm long (major axe) and 3 mm wide (minor axe). Each column along the height has 12 rows of slits. Every two adjacent rows are shifted in a chess layout. The distance between two adjacent slits in a row is 60 mm, thus every four adjacent slits form a rhomboid 30 mm wide. Primary coolant flows through the slits, upward through the supporting columns and into the fuel assemblies. The perforations act as an orifice to distribute the flow. Another function of the slots is to prevent debris from entering the active fuel region and completely blocking off an assembly. Supporting columns also ensure that an even stress is applied to the elliptic bottom of the inner vessel while providing the support for the fuel.

The core barrel rests on a support ledge recessed in the upper part of the reactor pressure vessel immediately below the level where the upper head is bolted on. Outside of the upper part of the core barrel is the supporting ring. The core barrel is secured in place by the reactor pressure vessel head. The top of the core barrel has an "o" ring around its circumference. When the head is bolted on, the "o" rings are elastically compressed between the head and the supporting ring of the core barrel to ensure a complete seal. The core barrel is shown on Figure 3.1.1.3.

3.1.2 Reactor coolant system

This section provides participants with the data for the reactor coolant system (RCS). Table 3.1.2.1 summarises the basic RCS parameters, such as pressure drop. Table 3.1.2.2 provides the elevations for the primary system components, while Table 3.1.2.3 provides all of the data on the system piping [6]. Tables 3.1.2.4 and 3.1.2.5 contain the flow areas and volume data for the system, respectively. Table 3.1.2.6 gives the pressuriser description, and Tables 3.1.2.7 through 3.1.2.9 list the system flow data, all of the safety valve data and MCP performance data respectively. Figures 3.1.2.1 through 3.1.2.7 provide specific details about the RCS arrangement, the hot and cold leg pipes, the surge line, the pressuriser, and the main coolant pump.

Primary heat transport system transfers the heat produced in the reactor through four parallel loops to horizontal steam generators. The layout and elevations of the primary circuit are presented on Figures 3.1.2.1 through 3.1.2.4.

The hot leg nozzle for each loop of VVER-1000/V320 is located on the reactor pressure vessel directly above the cold leg nozzle for each corresponding primary loop. The distance between the centres of the hot and cold leg is 1 800 mm. The hot leg pipe runs directly to the nearest steam generator header and has only one elbow of 90 degrees. This configuration was selected to provide the shortest path to the steam generator and to reduce the hydraulic losses at the same time.

The Kozloduy VVER-1000 reactor uses standard Russian built main coolant pumps (MCP). There are four units, which are of the type GCN 195M series. MCP is shown on Figure 3.1.2.5. These pumps are run by electrical motors 6kV AC. The GCN-195M pumps are vertical, single stage, and centrifugal. More information about the MCP can be found in Appendix A. The nominal flow of the MCP at 50 Hz is 5.889 m^3/s. For the normal operation of the MCPs the following supporting systems are required:

- Oil lubrication system.
- Intermediate circuit water system.
- Sealing water system.

- Service water system.
- Independent cooling circuit.

In case of loss of service water or intermediate circuit water the operation of MCPs is available up to 3 min. In case of loss of sealing water – up to 2 h. In case of primary saturation or containment overpressure protection signals 15 s after the closure of the isolation valves the MCPs are stopped by self-protection on low oil pressure. The pump coast down time in case of loss of power supply for 1 out of 4 MCP is 55 s, and for 4 out of 4 MCP – 210 s.

The pressuriser is shown on Figures 3.1.2.6 and 3.1.2.7. The interface between the water and the steam in the pressuriser reduces the risk from water hammer and provides a compressible steam (gas) space, which is used to set the absolute pressure of the reactor vessel. The bottom of the volume is connected to one of the hot legs by the surge line while the top of the pressuriser has sprays with piping connected to a cold leg and the make-up system. This configuration for the spray injection inherently allows the high pressure in the cold leg to inject into the pressuriser, but other systems are available to inject water to condense and reduce the steam in the system. The pressuriser has four groups of heaters, which have the following power: group #1 – 360 kW; group #2 – 180 kW; group #3 – 720 kW and group #4 – 1 260 kW.

Coolant inventory in primary side is regulated by Make-up and Let-down systems. The Make-up system delivers coolant to the cold legs of primary loops #1, 2, 3 and 4. The nominal flow rate to the four loops is 8.19 kg/s at a pressuriser water level 8.77 m, the maximum flow rate to the four loops is 22.136 kg/s. The Let-down system is connected to the cold legs of primary loops #2 and 3. The nominal flow rate is 8.19 kg/s at Pressuriser water level 8.77 m, the maximum flow rate is 22.136 kg/s.

3.1.3 Steam generator

This section contains information about the horizontal U-tube natural circulation type steam generator (Figures 3.1.3.1 and 3.1.3.2). Table 3.1.3.1 gives the design data, Table 3.1.3.2 gives nominal characteristics, and Table 3.1.3.3 provides the geometry description.

The main components of the system are:

- Steam generator (SG) vessel.
- Heat transfer tubes and primary coolant heads.
- Seedwater nozzle facility.
- Emergency feedwater nozzle facility.
- A perforated plate.
- Moisture separator.

Tube bundle configuration is provided in Tables 3.1.3.4. and 3.1.3.5.

3.1.3.1. *Feedwater system*

Feedwater flows into the steam generator through a pipe ∅426x24 mm, then through 16 collectors of 80 mm inside diameter which couple to the distribution pipes. Each of these distribution pipes has 38 perforated pipes. Some are at the upper steam tubing elevation while another portion is over the perforated sheet in order to balance the non-uniform steam generation. This is achieved by partial condensation of the voids in high steam areas.

3.2 Definition of the core thermal-hydraulic boundary conditions model

The full KNPP Unit 6 thermal-hydraulic (T-H) model can be converted to a core T-H boundary condition model by defining an inlet condition at the vessel bottom and an outlet condition at the vessel top. The boundary conditions (BC) for this model are provided on the CD-ROM under the directory **3D-BC**. The BC are calculated using the TRAC-PF1/NEM best-estimate core plant system code. Radial distributions are provided for 18 T-H cells (from 1 to 18) as shown in Figure 3.2.1. These 18 T-H cells are coupled to the neutronic core model in the radial plane as shown in Figure 3.2.1. This mapping scheme follows the spatial mesh overlays developed for the KNPP Unit 6 TRAC-PF1/NEM model.

The KNPP Unit 6 TRAC-PF1 model is a 3-D vessel model in cylindrical geometry. A majority of the existing coupled codes model the core thermal-hydraulically using parallel channel models, which leads to difficulties in the interpretation of the mass flow BC generated with TRAC-PF1/NEM. In order to avoid this source of modelling uncertainty, BC have been generated where mass flows are corrected for direct use as input data in the multi-channel core models. A geometrical interpolation method is used to process the TRAC-PF1/NEM BC in order to obtain inlet conditions for each assembly. The detailed mapping scheme (see Figure 3.2.1) shows how the provided 18 BC values are distributed per assembly.

There are several files of data, available on the CD-ROM, which are used for definition of the core T-H boundary condition model (Exercise #2). This data is taken from the best-estimate core plant system code calculations performed with the PSU version of TRAC-PF1/NEM:

A. File TEMP.BC

The transient inlet radial distribution of liquid temperatures from 0 s to 129 s during the transient. The values are extracted from the TRAC vessel axial layer #3 which is mapped to the bottom reflector of the core neutronics model. For each time interval the first number is the time, followed by 18 numbers corresponding to the liquid temperatures (°K) in the 18 azimuthal sectors that make up the core region.

B. File MASS_FLOWS.BC

The same as above for the inlet radial distribution of axial mass flows (kg/s).

C. File Press_Inlet.BC

The same as above for the inlet radial distribution of pressure (Pa).

D. File Press_Outlet.BC

The same as above for the outlet radial distribution of pressure (Pa). The values in the file Press_Outlet.BC are extracted from the TRAC vessel axial layer #14, which is mapped to the top reflector.

The average pressure drop between the third and fourteenth layers (i.e. across the core) at time=0 s is about 0.106 MPa. In the TRAC nodalisation the lower plenum is represented with the first, second and third layers. The upper plenum is represented with the fourteenth and eighteenth layers.

In addition a file, Cold Temp.BC, is provided. The file contains cold leg temperatures for the four loops as a function of time.

3.3 Thermal-physical and heat-transfer specifications

The Doppler temperature, T_f, is found from the fuel temperature at the fuel rod centre $T_{f,c}$ and the fuel rod surface $T_{f,s}$ via the relation:

$$T_f = (1-\alpha)T_{f,c} + \alpha T_{f,s}$$

where α=0.7.

The UO_2 density is 10.6 g/cm^3 (95% of the theoretical density) at a temperature of 293.15°K. The pellet dishing amounts to 1.956%. The cladding material is Zr+1% Nb with a density of 6.55 g/cm^3.

Participants should use Tables 3.3.1 through 3.3.3 for the heat conductivity λ (W/m°K) and specific heat capacity c_p (J/kg°K) of fuel, cladding and gap. The pressure of He in fuel rod gas gap is 2.0±0.25 MPa at the BOL.

In Tables 3.3.4 through 3.3.7 are shown the properties of different steel types.

Expansion effects of fuel and cladding will not be considered in this benchmark.

The heat transfer coefficient between cladding and moderator has to be calculated using code specific correlations.

Table 3.1.1.1. Reactor vessel design data

Item	Data
Average coolant temperature (°K)	576.15
Overall height of reactor vessel (m)	10.897
Total volume of the vessel (m^3)	110
Inlet nozzle ID (mm)	850
Outlet nozzle ID (mm)	850
Coolant operating temperature – inlet (°K)	560.15
Coolant operating temperature – outlet (°K)	592.05
Reactor coolant flow (kg/s)	17 611
Height of active fuel region (mm)	3 550
Outer diameter of reactor pressure vessel D_1(mm)	4 535
Inner diameter of reactor pressure vessel D_2(mm)	4 136
Outer diameter of reactor shaft D_3(mm)	3 620
Height of elliptical bottom, (mm)	967
Wall thickness of elliptical bottom, (mm)	$237^{+0\ -22}$
Wall thickness of cylindrical part, (mm)	192
Inside coating of elliptical bottom, (mm)	$7.0^{+2\ -1}$
Inside coating of cylindrical part, (mm)	7.0
Total height (inside) of vessel and reactor cover, (mm)	12 433
Elevation above inside bottom of reactor vessel, (mm)	
• inlet nozzles axis	6 973
• outlet nozzles axis	8 773
• bottom of heated part of core	1 823

Table 3.1.1.2. Reactor vessel volume data

Description	Value
Lower plenum (m^3)	16.0
Core (m^3)	14.8
Down comer (m^3)	18.0
Upper plenum (m^3)	61.2

Table 3.1.1.3. Description of vessel plates

Item	Data
Lower core support plate	
• thickness, (mm)	100
• elevation from bottom of reactor vessel to top of plate, (mm)	1 633
Upper core support plate	
• elevation from bottom of reactor vessel, (mm)	6 103
• thickness, (mm)	265
Perforation of upper core support plate	
• holes for fuel assemblies top head	163
• holes for coolant	186 x ϕ122 mm
• holes for in-core measurements	72 x ϕ108 mm 12 x ϕ92 mm
Plate at the top of the block of control rod guide tubes (CRGT)	
• elevation from bottom of reactor vessel, (mm)	9 925
• thickness, (mm)	200
Perforation of plate at the top of CRGT	
• holes for control rod guide tubes	61 x ϕ185 mm
• holes for in-core measurements	72 x ϕ115 mm
• holes for coolant	42 x ϕ100 mm 90 x ϕ90 mm
• holes for temperature measurements on the periphery	30 x ϕ22 mm
Plate between cylindrical and elliptical part of upper head	
• elevation from bottom of reactor vessel, (mm)	10 660
• thickness, (mm)	90
• diameter of plate, (mm)	3 240
• OD of annulus, (mm)	3 280
• gap, (mm)	20
Perforation of plate	
• for tubes penetration	61 x ϕ63 mm
• holes for coolant	36 x ϕ200 mm 6 x ϕ145 mm

Table 3.1.1.4. Description of control rod guide tubes above the core

Parameter	Value
Number of tubes	61
Shape	cylindrical
OD, (mm)	180
ID, (mm)	166
Total length between the plates, (mm)	3 557

Table 3.1.1.5. Description of reactor cover

Parameter	Value
Reactor cover heights, (mm)	
• total (incl. wall)	2 062
• upper elliptical part	1 085
• to the end of nozzle for control rods	2 710
Reactor cover inside diameter, (mm)	3 396
Reactor cover outside diameter, (mm)	4 580
Reactor cover inside coating of elliptical part, (mm)	9
Perforation of elliptical head:	
• CRGT nozzles:	61
– nozzles for penetration of temperature measurements	14
– nozzles for penetration of neutron flux measurements	16
– nozzle of air evacuation line	1

Table 3.1.1.6. Description of core barrel

Parameter	Value
Core barrel elliptical bottom	
• elevation from bottom of reactor vessel, (mm)	106
• thickness, (mm)	120
Perforation of core barrel elliptical bottom	
• number of holes	1 344
• diameter of holes, (mm)	40
Perforation of core barrel above the core	
• number of rows	6
• elevation of row # 3 from bottom of reactor vessel, (hot leg axis), (mm)	8 773
• distance between axes of rows, (mm)	250
• number of holes in row 3 (38 for coolant and 2 for hydro accumulators)	38 x ϕ180 mm 2 x ϕ300 mm
• number of holes in other rows	40 x ϕ180 mm

Table 3.1.1.7. Description of basket

Parameter	Value
Total height, (mm)	4 070
OD, (mm)	3 485
Bottom elevation above inside bottom of reactor vessel, (mm)	1 533

Table 3.1.2.1. Reactor coolant system nominal steady-state parameters

Parameter	Value
Total core power output (MWt)	3 000
Reactor inlet pressure drop (MPa)	0.201
Core pressure drop (MPa)	0.142
Block of shielding tubes region pressure drop (MPa)	0.029
Reactor exit pressure drop (MPa)	0.037
Reactor without inlet/outlet nozzles pressure drop (MPa)	0.392

Table 3.1.2.2. Primary system component elevations

Component	Elevation (m)
Reactor outlet piping	∇25.70
Reactor inlet piping	∇23.90
Reactor vessel lower head	∇16.69
Pressuriser lower head	∇22.03

Table 3.1.2.3. Reactor coolant system piping design data

Parameter		Value
Reactor inlet piping	Pipe, ID (mm)	850
	Minimum thickness (mm)	140
	Coolant volume (hot-system total) (m^3)	60.28
Reactor outlet piping	Pipe, ID (mm)	850
	Minimum thickness (mm)	140
	Coolant volume (hot-system total) (m^3)	22.96
Pressuriser surge piping	Pipe size (m)	18
	Pipe ID (m)	0.346
	Pipe OD (m)	0.426
	Coolant volume, hot (m^3)	1.690

Table 3.1.2.4. Flow areas

Component	Location	Flow area (m^2)
Hot leg		0.567
Cold leg		0.567
Steam generator	RC inlet nozzle	0.546
Reactor vessel	RC outlet nozzle	2.268 (4 loops)

Table 3.1.2.5. Reactor coolant system volume data

Description	Value
Pressuriser (at 8.77 m nominal water level)	
Water volume (m^3)	55.00
Steam volume (m^3)	24.00
Cold leg – each (m^3)	15.07
Hot leg – each (m^3)	5.74
Reactor coolant pumps (m^3)	3.00
Surge line (m^3)	1.69

Table 3.1.2.6. Pressuriser description

Description	Value
Nominal pressure (kgf/cm^2)	160
Internal diameter (m)	3
Outer diameter (m)	3.3
Full height (m)	12.7
Heater elevation (m)	0.257
Liquid volume change in case of level deviation of 0.1m (m^3)	0.707
Spray line length (m)	38
Spray line OD (mm)	219
Spray line ID (mm)	181
Pressuriser bottom elevation (m)	22.03
Single relief valve steam flow (kg/s)	50
Constant flow through relief valves (l/hr)	50
Time for open/close the pressurise relief valves (PRV) (s)	1
PRV line ID (mm)	200

Table 3.1.2.7. Reactor coolant system flow data

Description	Value
Total reactor flow (kg/s)	17 611
Average flow path lengths (m)	
Hot leg	10.12
Cold leg	26.60
Steam generator	11.10
Reactor coolant pumps	
Actual pump capacity	
4 pumps in operation (m^3/s/pump)	5.889
3 pumps in operation (m^3/s/pump)	6.764
2 pumps in operation (m^3/s/pump)	7.333
1 pumps in operation (m^3/s/pump)	7.500

Table 3.1.2.8. Safety valve data

Description	Value
Pressuriser safety valves (3 valves)	
Pressure set point (MPa)	17.7
	18.6
	18.6
Capacity (kg/sec) total	50.0

Table 3.1.2.9. Main coolant pump description

Description	Value
Coolant volume, (m^3)	3.0
Nominal flow at 50 Hz, (m^3/s)	5.9
Nominal flow at 49 Hz, (m^3/s)	5.555
Nominal speed of the rotor, (Rad/s)	104.2
Rated torque, (NM)	47 500

Table 3.1.3.1. Steam generator design data

Item	Data per steam generator
Steam conditions at full load, outlet nozzles	
Steam flow (kg/s)	437.0
Steam temperature (°C)	278.5
Steam pressure (MPa)	6.28±0.2
Feedwater temperature (°C)	220±5 (with PVN)
Reactor coolant side	
Operating pressure (MPa)	15.7±0.3
Operating temperature (°K)	
Outlet	559.15±2.0
Inlet	593.15±3.5
Coolant volume – hot (m^3)	20.5 – primary side volume

Table 3.1.3.2. Steam generator nominal characteristics

Description	Value
Pressure drop between steam collector and turbo-generator (Pa)	1×10^5
Pressure drop between SG and steam collector (Pa)	2×10^5
Feedwater temperature with HP pre-heaters on (°K)	493.15±5
Feedwater temperature with HP pre-heaters off (°K)	437.15±4
Thermal power (MW)	750^{+33}
Steam load (MPa)	$437.22^{+2.843}$
Live steam pressure (MPa)	6.28±0.2
Live steam temperature (°K)	551.65
SG primary side pressure drop (MPa)	0.133
SG secondary side pressure drop (MPa)	0.1
Steam quality at steam generator outlet (%)	<0.2
Nominal secondary side level (m)	2.55

Table 3.1.3.3. Steam generator geometry description

Description	Value
Steam lines volume from SG to the steam collector (m^3)	100
Steam lines volume from the steam collector to the turbo-generator (m^3)	62
Upper level of the tubing (m)	2.19
Length of a cylindrical part of the SG (m)	11.34
SG ID (m)	4
SG OD (m)	4.29
Upper level of perforated plate (m)	2.45
Number of primary side heads	2
Volume of one SG head (m^3)	2.4
Total height of a head (m)	4
Primary side volume (m^3)	20.5
Number of heat transfer tubes	11 000
Average length of the tubes (m)	11.1
Heat transfer tube OD (mm)	16
Heat transfer tube ID (mm)	13
Total cross-section area of heat transfer tubes (m^2)	1.46
Total heat transfer area (secondary side) (m^2)	6 115
Relative elevation of FW nozzle (m)	2.72
Equivalent hydraulic diameter (secondary side) (mm)	17.4
Distance between axes of rows (mm)	19
Distance between tubes axes in a row (mm)	23

Table 3.1.3.4. Tube bundle data

No. of row	Tubes of row	Axis height	No. of tubes total	No. of row	Tubes in row	Axis height	No. of tubes total	No. of row	Tubes of row	Axis height	No. of tubes total
1	16	119	16	41	102	879	2 920	81	118	1 639	7 548
2	26	138	42	42	102	898	3 024	82	120	1 658	7 668
3	32	157	74	43	104	917	3 128	83	118	1 677	7 786
4	40	176	114	44	106	936	3 234	84	120	1 696	7 906
5	44	195	158	45	106	955	3 340	85	118	1 715	8 024
6	50	214	208	46	108	974	3 448	86	120	1 734	8 144
7	54	233	262	47	108	993	3 556	87	118	1 753	8 262
8	58	252	320	48	110	1 012	3 666	88	120	1 772	8 382
9	60	271	380	49	110	1 031	3 776	89	118	1 791	8 500
10	60	290	440	50	112	1 050	3 888	90	120	1 810	8 620
11	60	309	500	51	112	1 069	4 000	91	118	1 829	8 738
12	60	328	560	52	114	1 088	4 114	92	120	1 848	8 858
13	60	347	620	53	114	1 107	4 228	93	118	1 867	8 976
14	60	366	680	54	116	1 126	4 344	94	120	1 886	9 096
15	60	385	740	55	116	1 145	4 460	95	118	1 905	9 214
16	60	404	800	56	118	1 164	4 582	96	120	1 924	9 334
17	60	423	860	57	116	1 183	4 794	97	118	1 943	9 452
18	60	442	920	58	118	1 202	4 812	98	120	1 962	9 572
19	60	461	980	59	118	1 221	4 930	99	118	1 981	9 690
20	60	480	1 040	60	120	1 240	5 050	100	120	2 000	9 810
21	60	499	1 100	61	118	1 259	5 168	101	118	2 019	9 928
22	60	518	1 160	62	120	1 278	5 288	102	120	2 038	10 048
23	76	537	1 236	63	118	1 292	5 406	103	118	2 057	10 166
24	84	556	1 320	64	120	1 316	5 526	104	120	2 076	10 286
25	84	575	1 404	65	118	1 335	5 644	105	118	2 095	10 404
26	86	594	1 490	66	120	1 354	5 764	106	120	2 114	10 524
27	86	613	1 576	67	118	1 373	5 882	107	118	2 133	10 642
28	90	632	1 666	68	120	1 392	6 002	108	120	2 152	10 762
29	90	651	1 756	69	118	1 411	6 120	109	118	2 171	10 880
30	92	670	1 848	70	120	1 430	6 240	110	120	2 190	11 000
31	92	689	1 940	71	118	1 449	6 358				
32	94	708	2 034	72	120	1 468	6 478				
33	94	727	2 128	73	118	1 487	6 596				
34	96	746	2 224	74	120	1 506	6 716				
35	96	765	2 320	75	118	1 525	6 834				
36	98	784	2 418	76	120	1 544	6 954				
37	98	803	2 516	77	118	1 563	7 072				
38	100	822	2 616	78	120	1 582	7 192				
39	100	841	2 716	79	118	1 601	7 310				
40	102	860	2 818	80	120	1 620	7 430				

Table 3.1.3.5. SG secondary side data

Elevation, m	HT area, m^2	Sec. vol, m^3
0.0	0.00	0.53
0.2	10.23	2.18
0.4	446.00	5.90
0.6	877.00	10.76
0.8	1 385.00	15.80
1.0	1 673.00	18.50
1.2	2 627.00	28.00
1.4	3 342.50	34.40
1.6	4 057.50	42.00
1.8	4 772.50	47.80
2.0	5 487.50	55.16
2.19	6 115.00	62.80
2.50	6 115.00	77.63
2.60	6 115.00	82.50
3.00	6 115.00	100.50
3.50	6 115.00	119.90
4.00	6 115.00	127.00

Table 3.3.1. Properties of fuel [11, 13, 14, 18]

Parameter	Value						
T, °K	300	500	700	900	1 100	1 300	1 500
λ, W/m°K	8.15	6.7	5.4	4.4	3.75	3.25	2.80
c_p, J/kg°K	270	287	302	310	314	319	320
ρ, kg/m^3	10 400 ÷ 10 800						
c_v, kJ/m^3 °K	2 862.0	3 042.2	3 201.2	3 286	3 328.4	3 381.4	3 392

Parameter	Value						
T, °K	1 700	1 900	2 100	2 300	2 500	2 700	2 900
λ, W/m°K	2.50	2.40	2.42	2.44	2.5	2.65	3.0
c_p, J/kg°K	328	340	364	390	426	470	520
ρ, kg/m^3	10 400 ÷ 10 800						
c_v, kJ/m^3 °K	3 476.8	3 604	3 858.4	4 134	4 515.6	4 982	5 512

Table 3.3.2. Properties of cladding [18]

Parameter	Value								
t, °C	20	100	200	300	400	500	600	700	800
T, °K	293.15	373.15	473.15	573.15	673.15	773.15	873.15	973.15	1 073.15
λ, W/m°K	17.2	18.0	19.3	20.1	20.5	20.9	21.8	22.9	
c_p, J/kg°K		280	301	322	343	368	398	448	420
c_v, kJ/m^3 °K		1 834	1 972	2 109.1	2 246.7	2 410.4	2 606.9	2 934.4	2 751

Parameter	Value						
t, °C	900	1 000	1 100	1 200	1 300	1 400	1 500
T, °K	1 173.15	1 273.15	1 373.15	1 473.15	1 573.15	1 673.15	1 773.15
λ, W/m°K		27.8	29.0	30.1	31.2	32.3	33.4
c_p, J/kg°K	380	290					
c_v, kJ/m^3 °K	2 489	1 899.5					

Table 3.3.3. Properties of fuel rod gap [11, 14, 15]

Parameter	Value						
T, °K	273.15	373.15	473.15	573.15	673.15	873.15	1 073.15
λ, W/(m °K)	0.145	0.181	0.214	0.246	0.279	0.334	0.387
c_p, J/(kg °K)	5 193.0						
ρ, kg/m^3	3.50	2.59	2.04	1.69	1.44	1.11	0.90
$c_{v}*10^{-3}$, J/(m^3 °K)	18.176	13.450	10.594	8.776	7.478	5.764	4.674

Table 3.3.4. Properties of steel 15ХНМФА [18]

Properties	Value			
t, °C	100	200	300	400
T, °K	373	473	573	673
λ	26.4	27.0	29.0	30.0
c_p	495	520	545	575
ρ	7 860 (at 20°C)			
c_v	3 890.7	4 087.2	4 283.7	4 519.5

Table 3.3.5. Properties of steel 08Х18Н10Т [12, 16, 17]

T, °K	λ[W/m°K]	c_p, J/(kg°K)	ρ, kg/m^3	$c_{v}*10^{-3}$, J/(m^3 °K)
293.15	15.07	461	7 900	3 641.9
373.15	16.33	494	7 860	3 882.8
473.15	17.58	515	7 820	4 027.3
573.15	18.84	536	7 780	4 170.1
673.15	21.35	548	7 740	4 241.5

Table 3.3.6. Properties of steel 12X18H10T [12, 13]

T, °K	λ[W/m°K]	c_p, J/(kg°K)	ρ, kg/m^3	$c_{v*}10^{-3}$, J/(m^3 °K)
293.15	15.0	462	7 900	3 649.8
373.15	16.0	496	7 860	3 898.6
473.15	18.0	517	7 820	4 042.9
573.15	19.0	538	7 780	4 185.6
673.15	21.0	550	7 740	4 257.0
773.15	23.0	563	7 690	4 329.5
873.15	25.0	575	7 650	4 398.8

Table 3.3.7. Properties of steel 10ГН2МФА [18]

T, °K	λ[W/m°K]	ρ, kg/m^3	$c_{v*}10^{-3}$, J/(m^3 °K)
293.15	32.70	7 860	3 594.8
373.15	35.16		3 880.0
473.15	38.28		4 236.6
573.15	41.40		4 593.1
623.15	42.96	7 778	4 771.4
673.15	44.52		4 949.7
773.15	47.64		5 306.2
873.15	50.76		5 662.8

Figure 3.1.1.1. Reactor

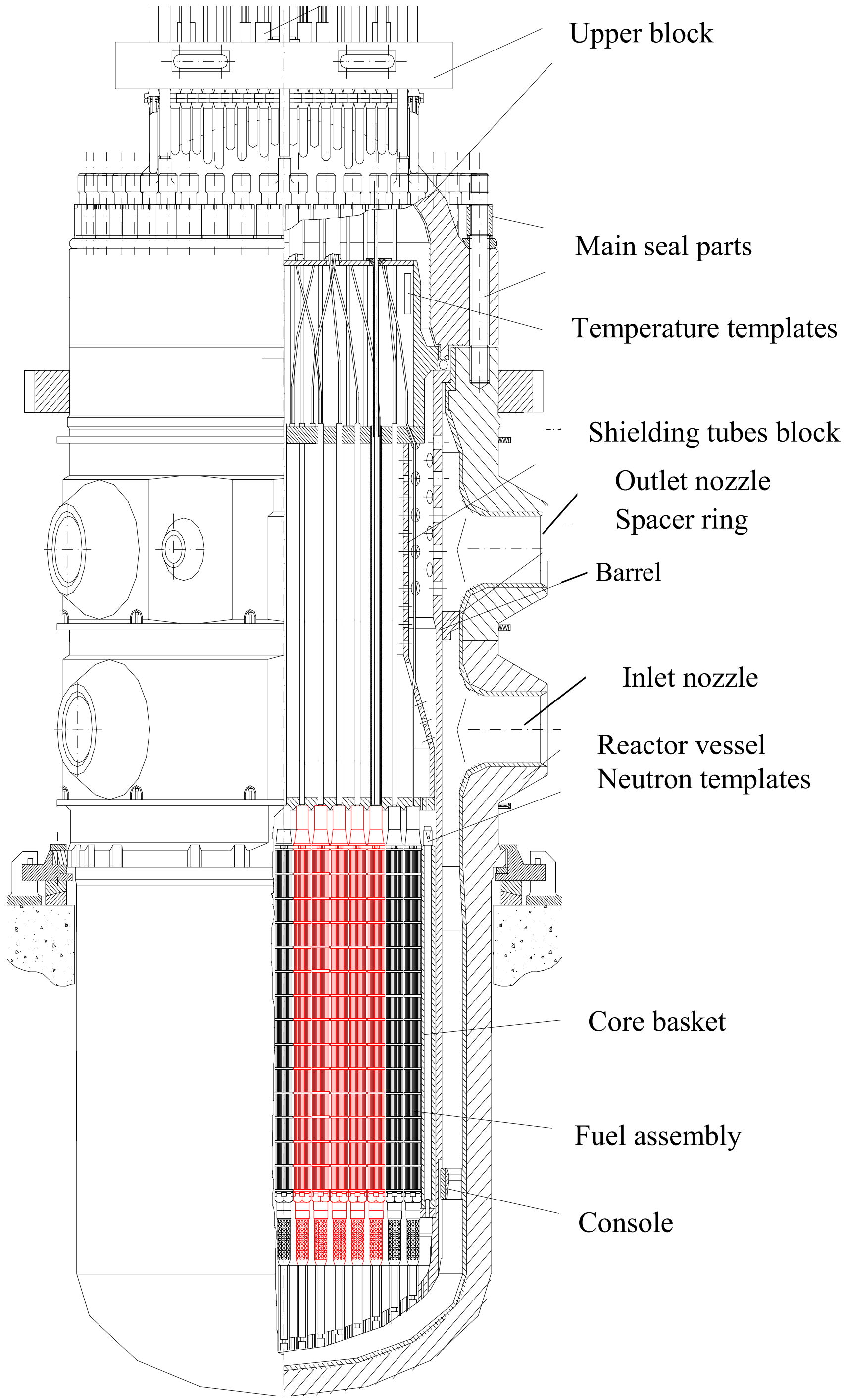
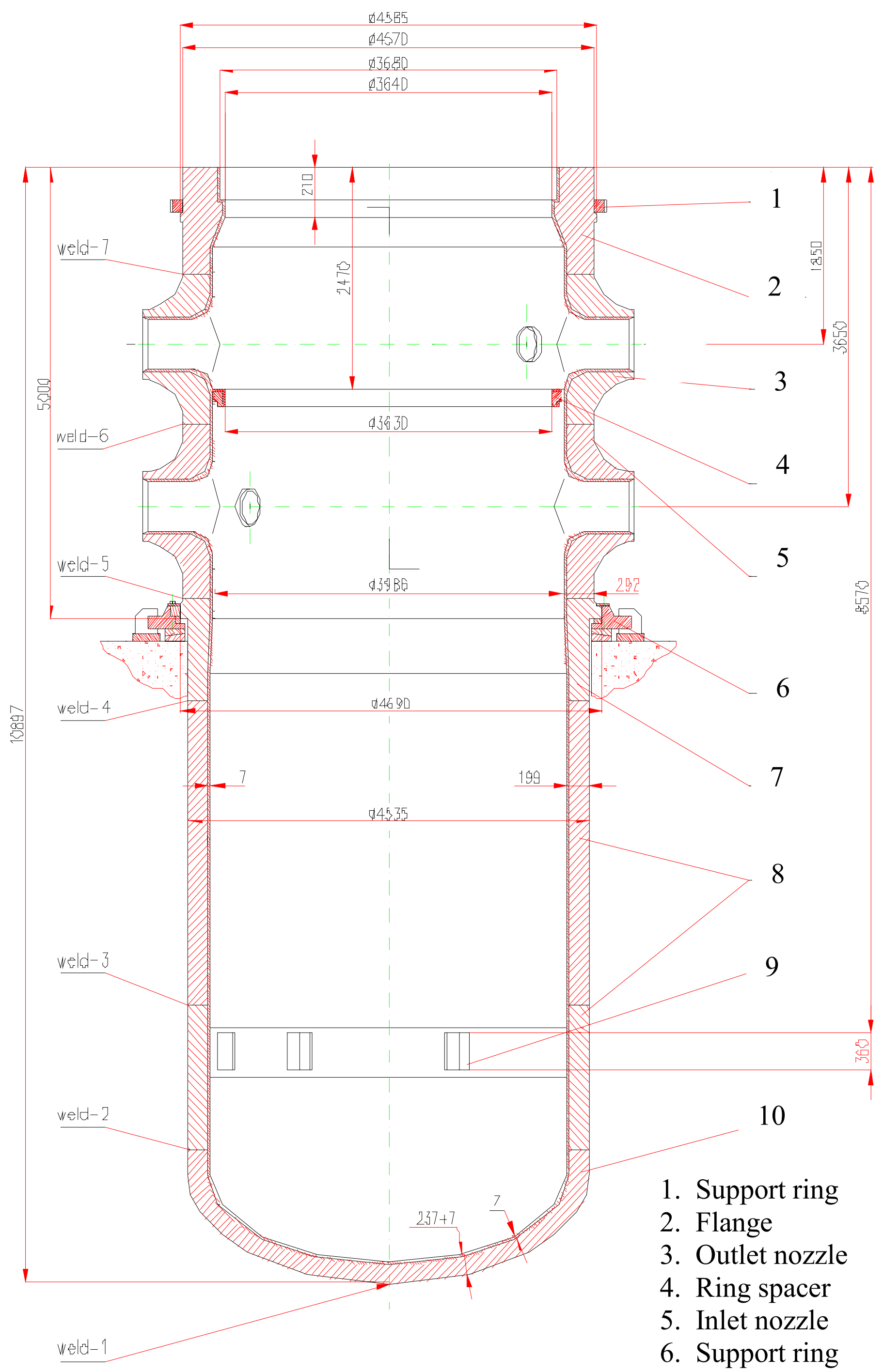


Figure 3.1.1.2. Reactor vessel



1. Support ring
2. Flange
3. Outlet nozzle
4. Ring spacer
5. Inlet nozzle
6. Support ring
7. Support cylinder
8. Cylinders
9. Consoles
10. Bottom plate

Figure 3.1.1.3. Core barrel

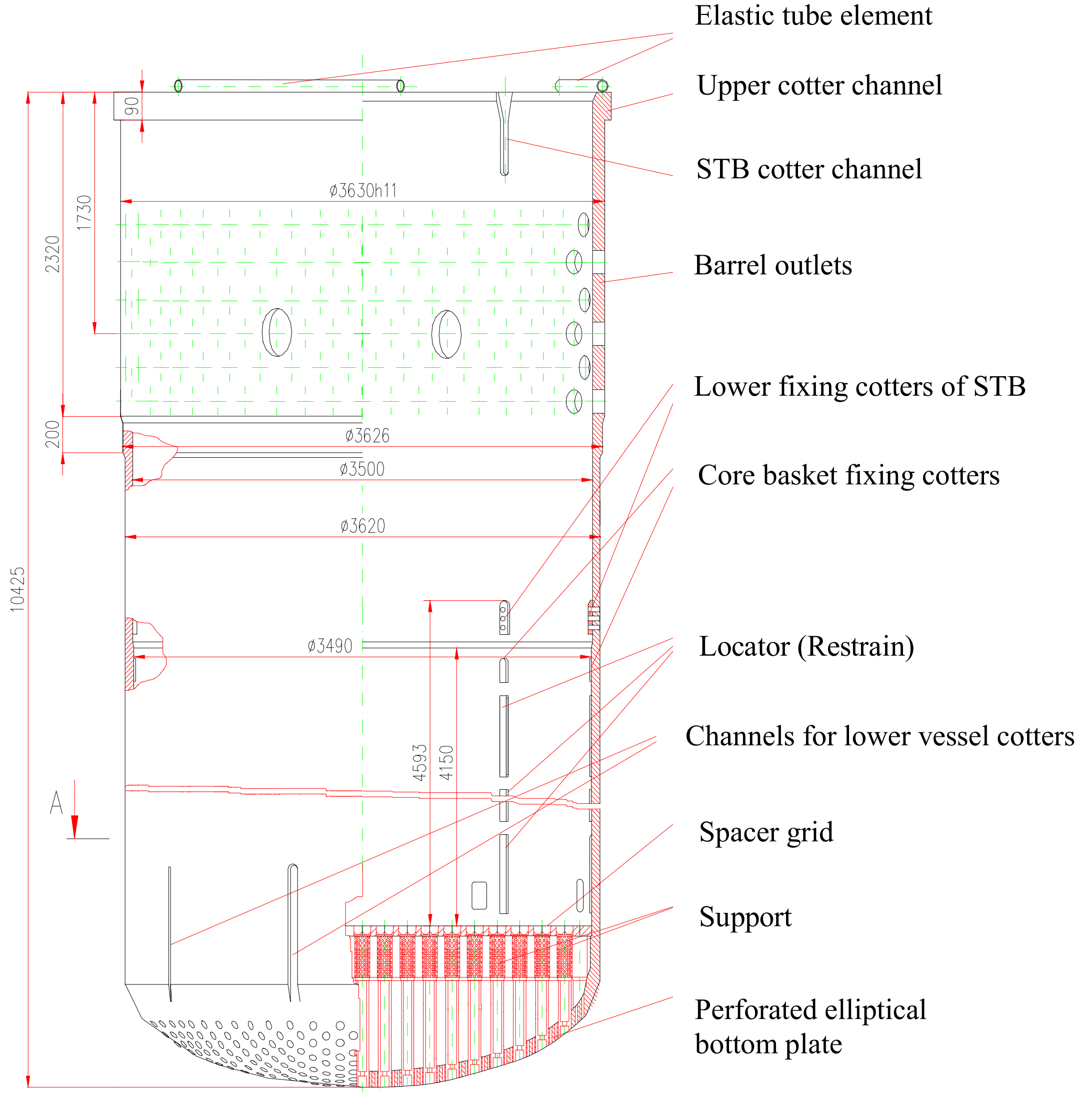
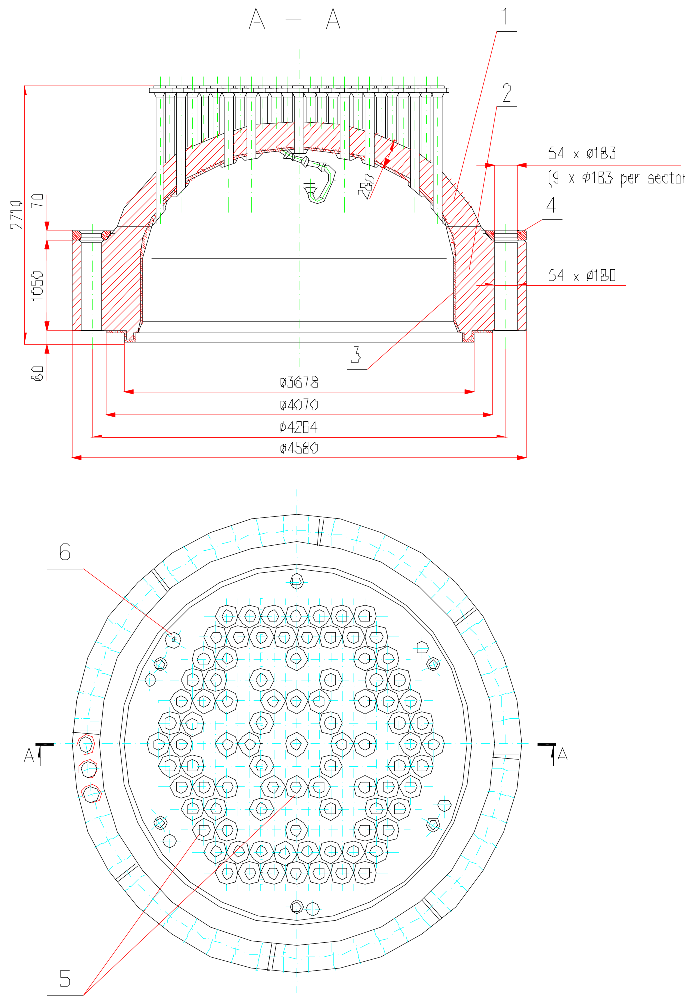
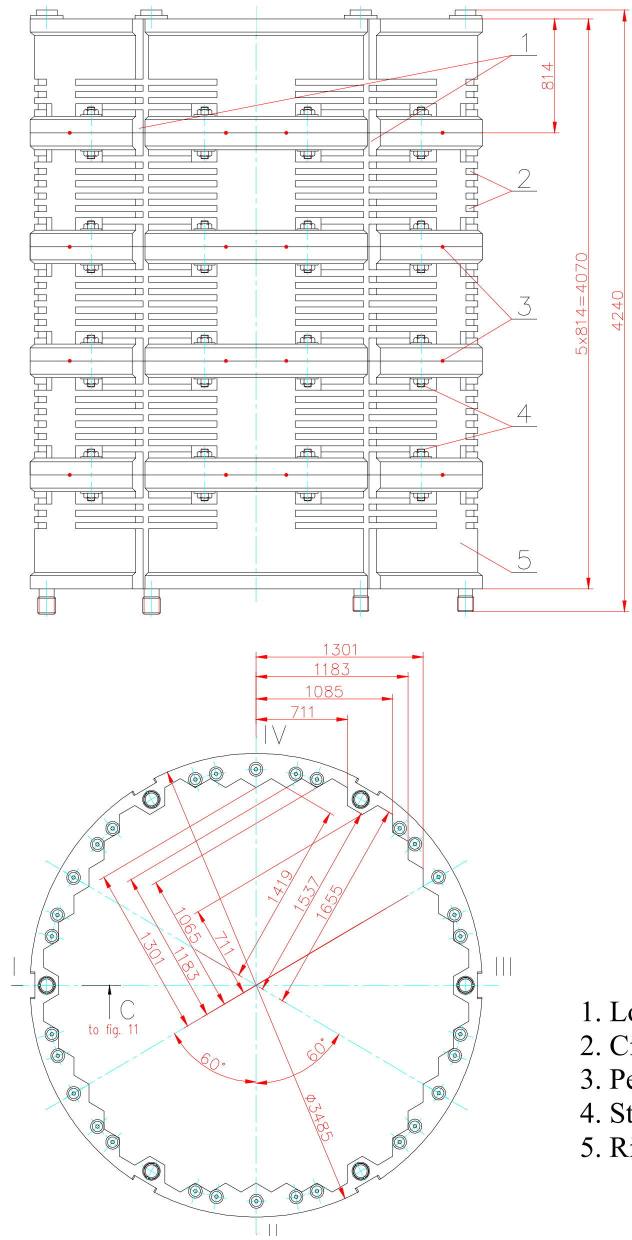


Figure 3.1.1.4. Reactor cover



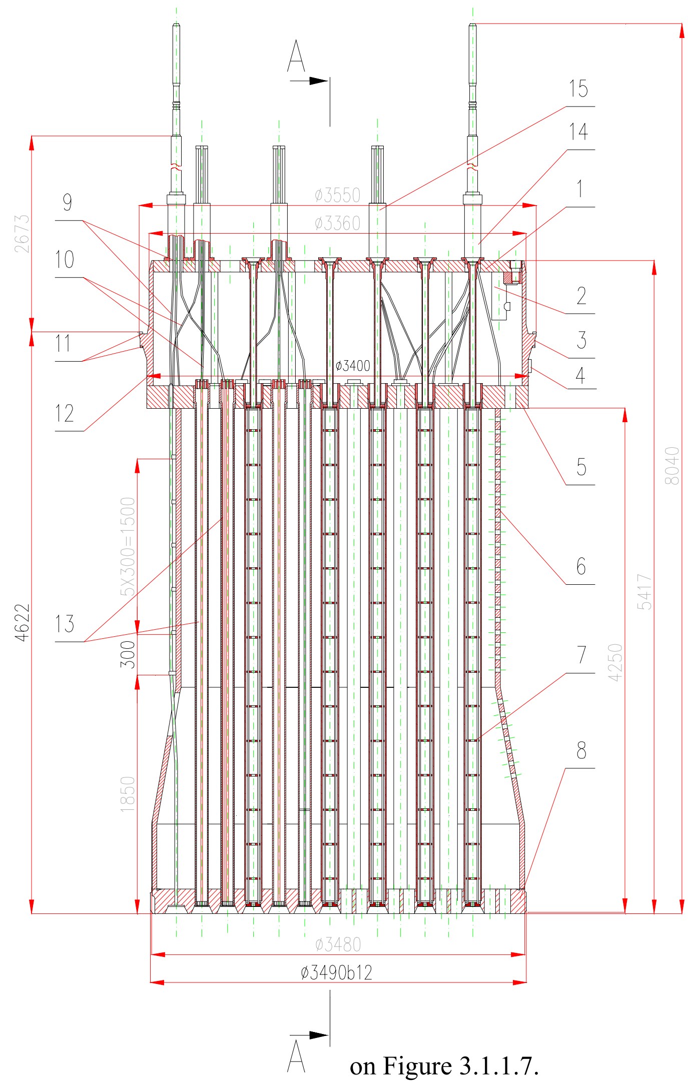
1. Truncated ellipsoid
2. Cover flange
3. Anti-corrosion cladding
4. Circle sector
5. Control rod drive flange (or TC-, or NIS flange)
6. Gaz – removal nozzle flange

Figure 3.1.1.5. Core basket



1. Longitudinal channel
2. Circular channel
3. Peg
4. Stud
5. Ring

Figure 3.1.1.6. Reactor shielding tubes block

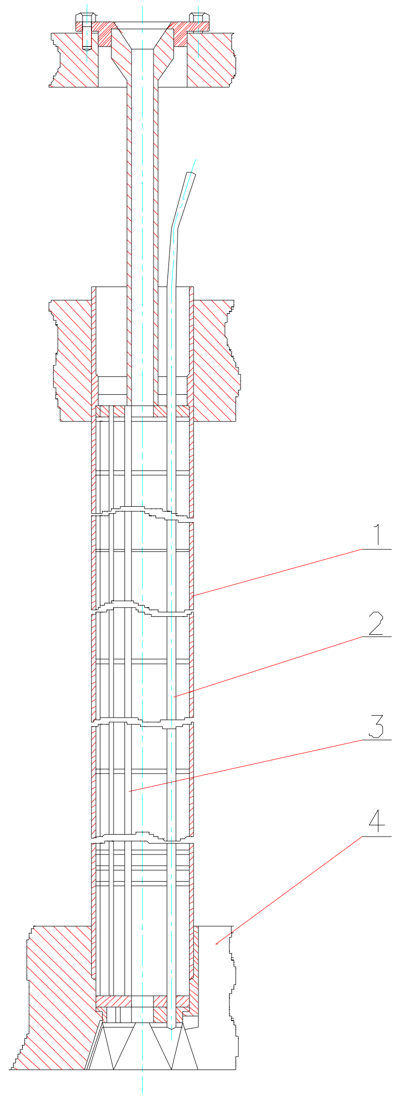


on Figure 3.1.1.7.

1. Upper plate
2. Templates assembly tube
3. Support ring
4. Cotter
5. Middle plate
6. Perforated frame
7. Shielding tube
8. Lower support plate
9. NIS assembly channel
10. Tight frames
11. Plates
12. Upper plate
13. ICIS tubes
14. TC bundle
15. NIS bundle

Figure 3.1.1.7. Shielding tube

A – A from Figure 3.1.1.6.



1. Shielding tube
2. Sealing tube for sensors
3. Metal guide structure
4. Lower support plate

Figure 3.1.1.8. Fuel assembly

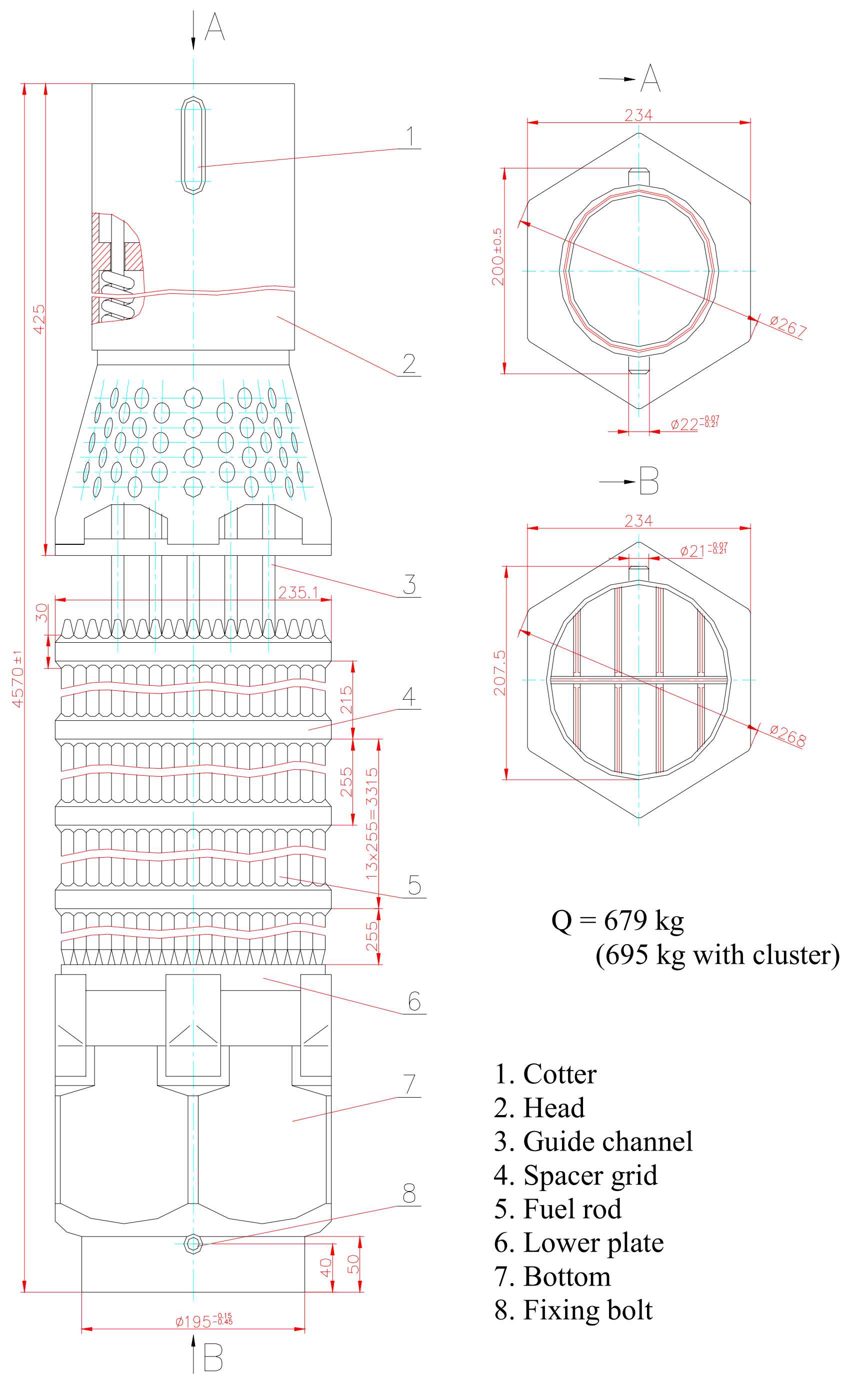
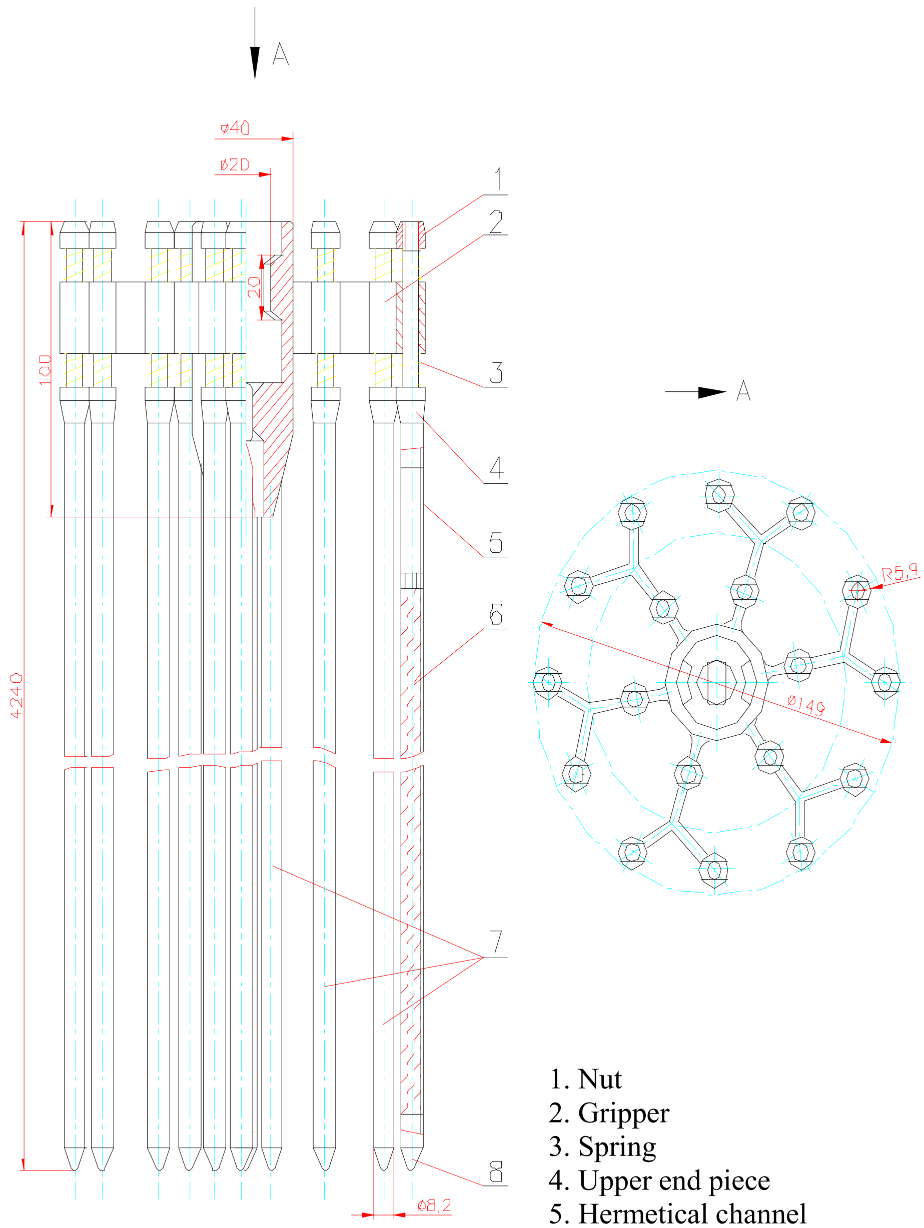


Figure 3.1.1.9. Control rod cluster



1. Nut
2. Gripper
3. Spring
4. Upper end piece
5. Hermetical channel
6. Absorber material
7. 18 absorber rods
8. Lower end piece

Figure 3.1.2.1. Primary circuit loops – layout

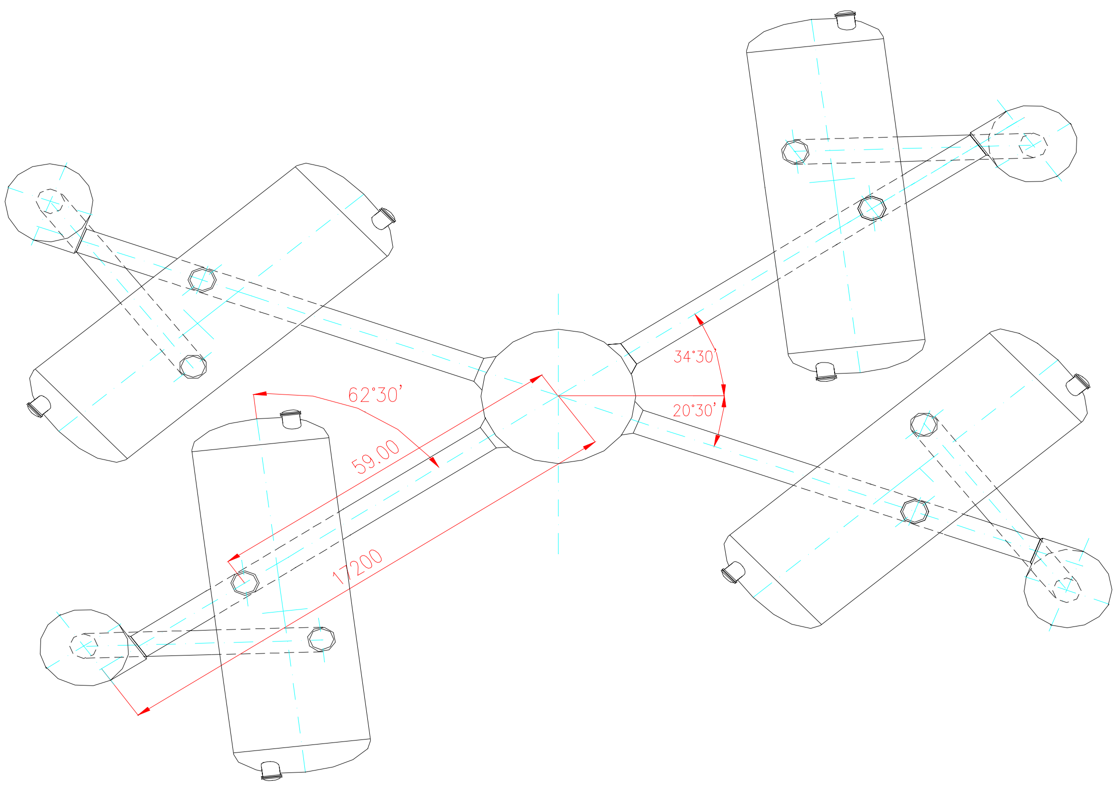
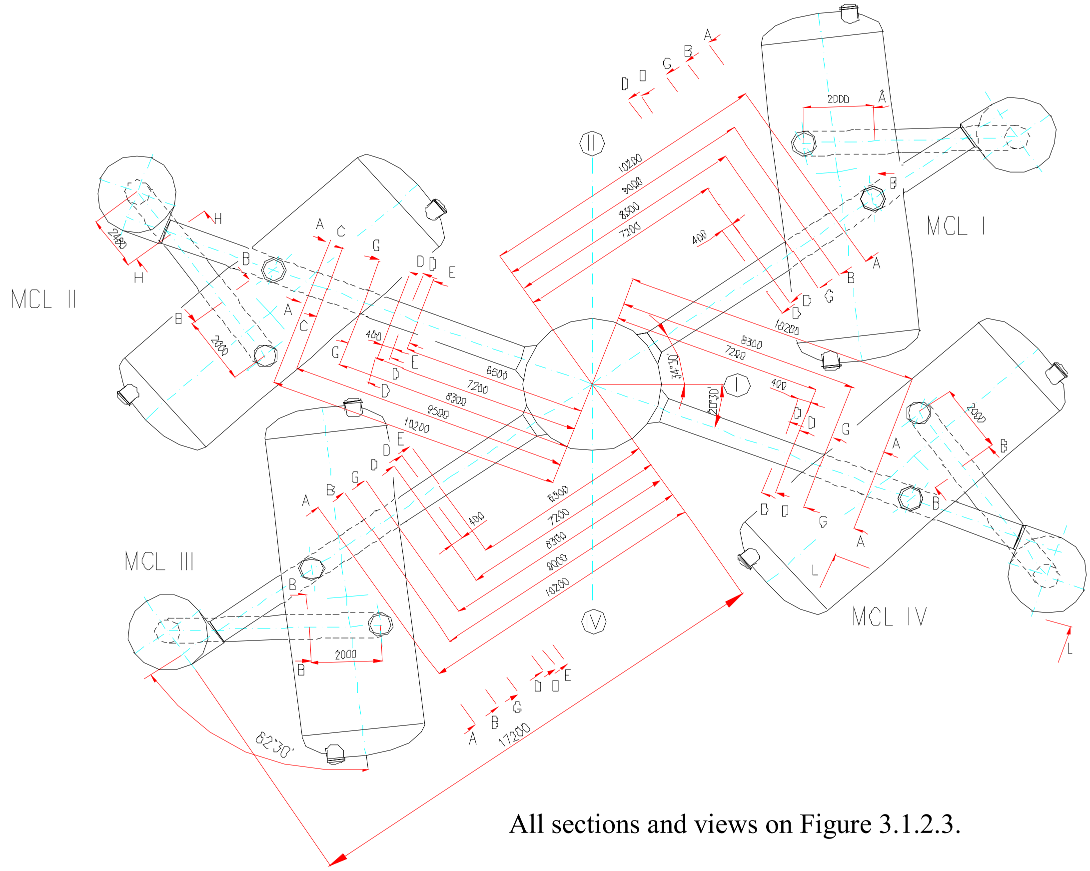


Figure 3.1.2.2. Primary circuit layout 1



All sections and views on Figure 3.1.2.3.

Figure 3.1.2.3. Primary circuit layout 2

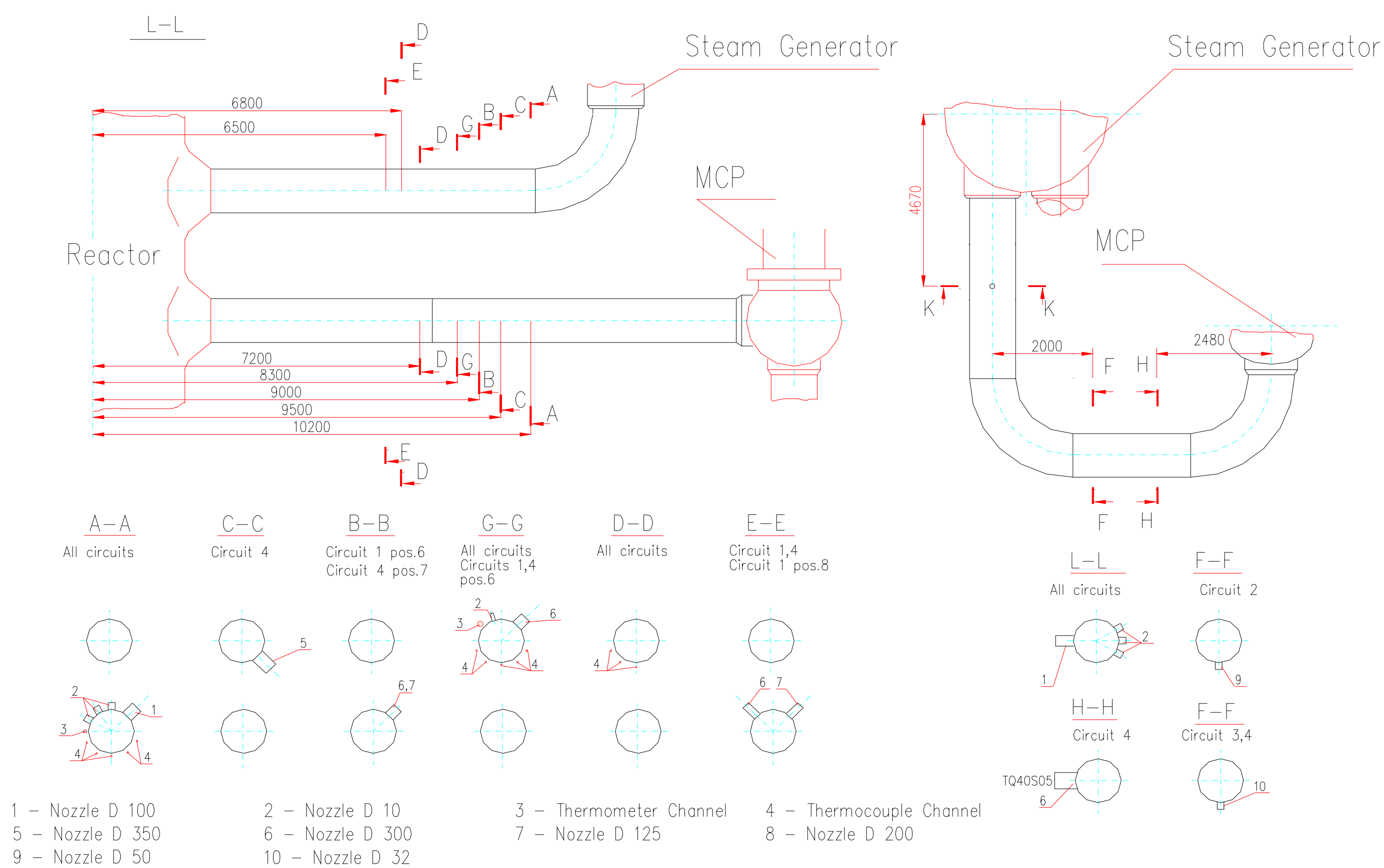
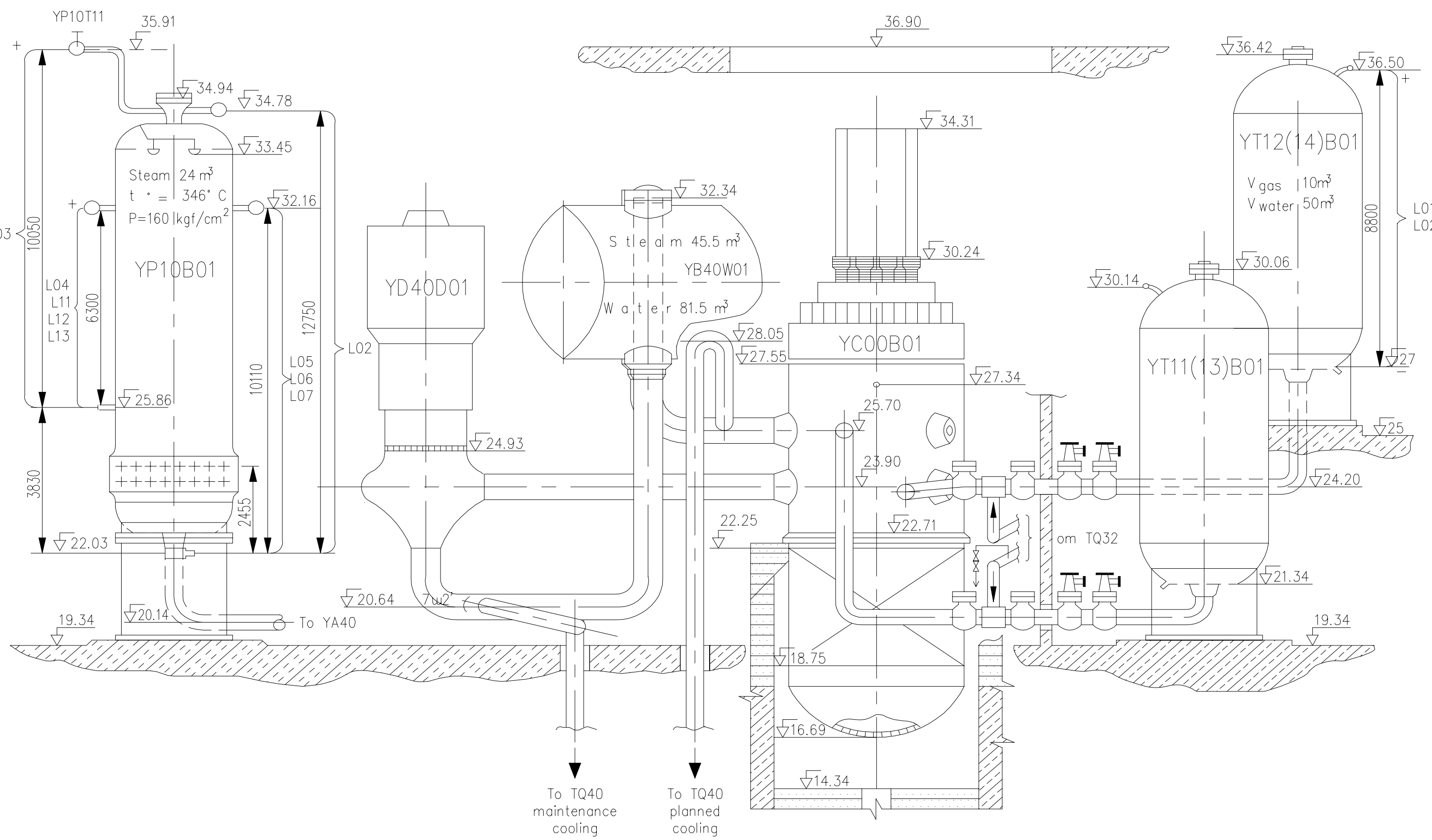
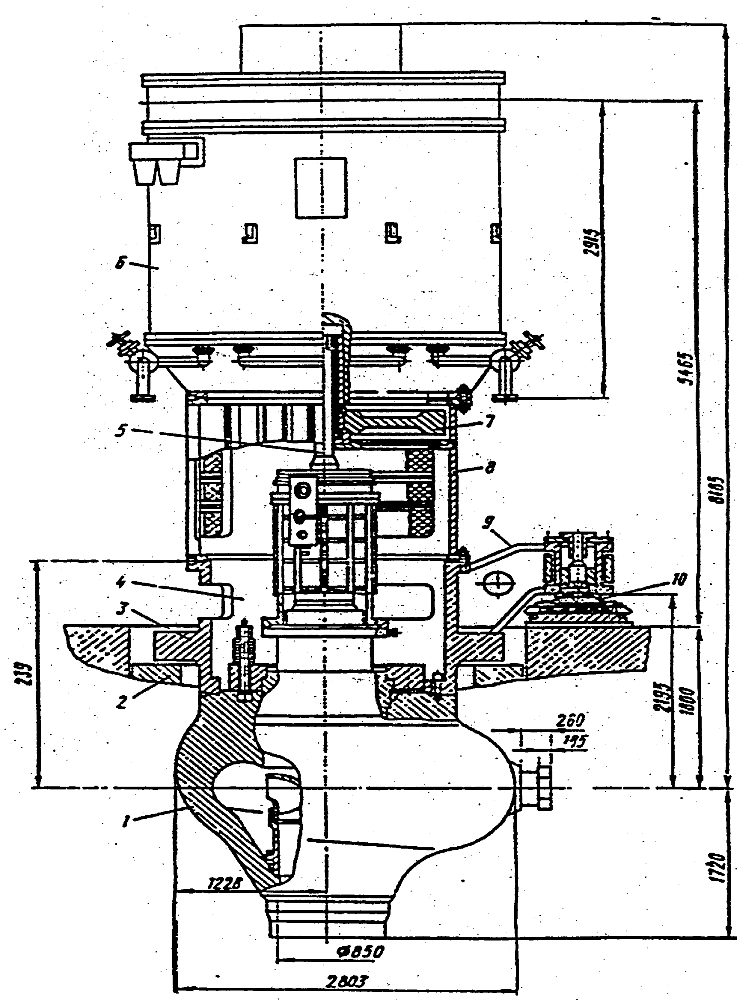


Figure 3.1.2.4. Main equipment layout



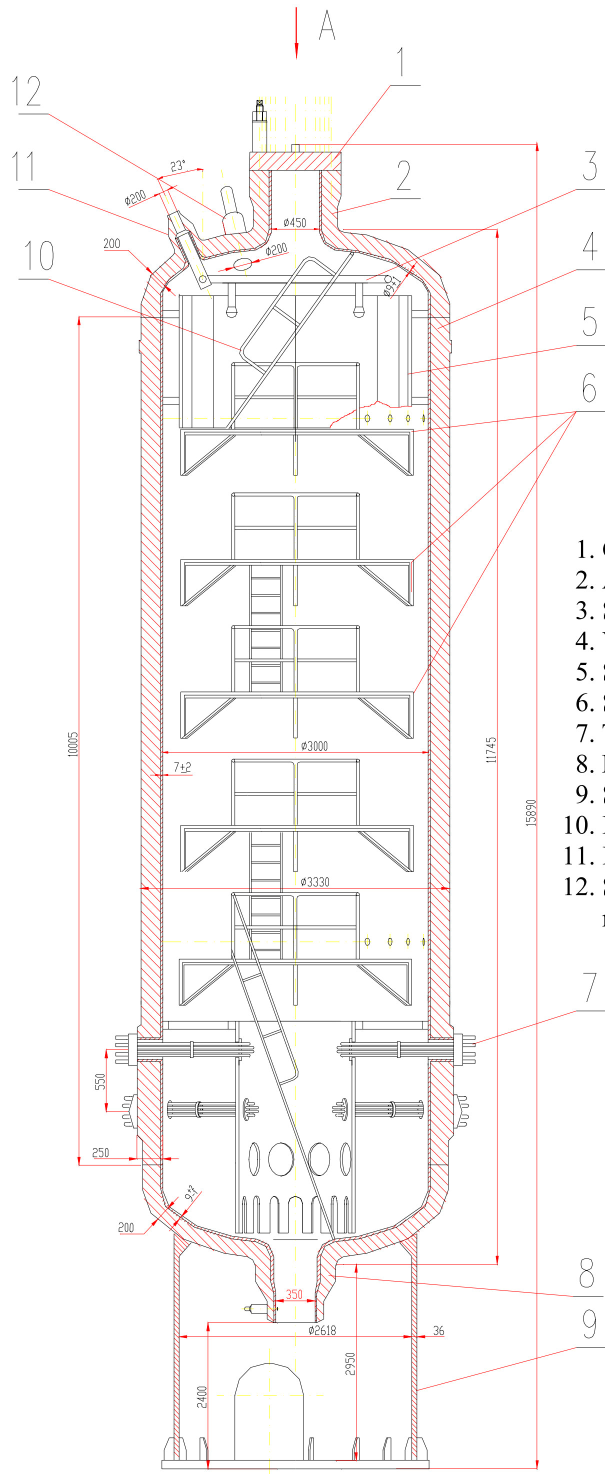
55

Figure 3.1.2.5. Main coolant pump



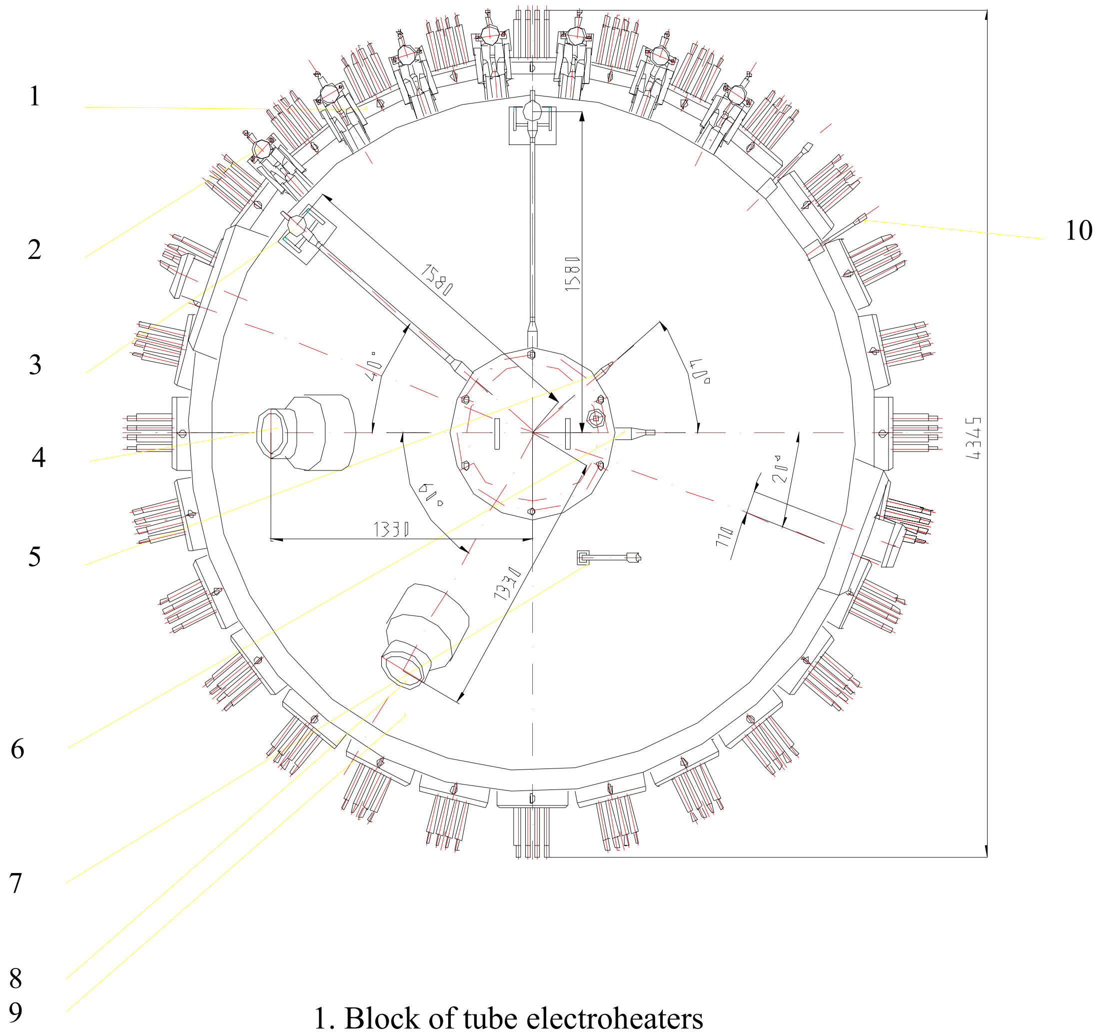
1. Pump body
2. Radiation protection ring
3. Console
4. Lower shroud
5. Torsion shaft
6. Motor
7. Balance wheel
8. Upper shroud
9. Console
10. Moving support

Figure 3.1.2.6. Pressuriser



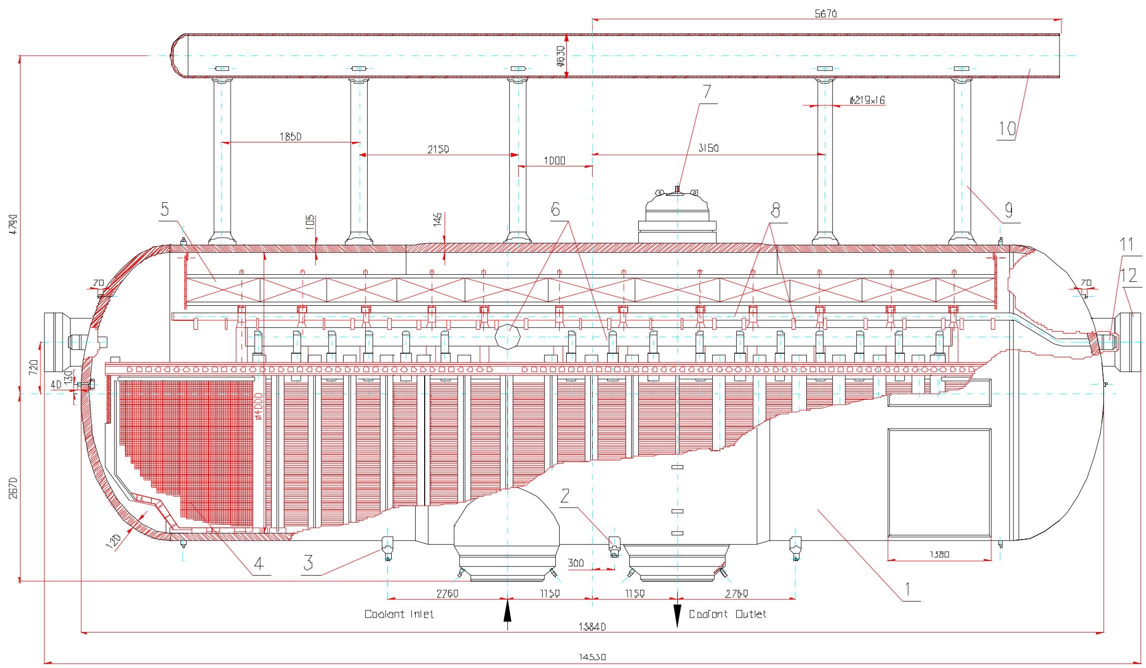
1. Cover
2. Access airlock
3. Spray system
4. Vessel
5. Shield
6. Service sites
7. Tube electroheaters
8. Pipe nozzle to primary circuit
9. Support
10. Ladder
11. Injection inlet
12. Steam outlet to pressuriser relief valve

Figure 3.1.2.7. Pressuriser cross-section



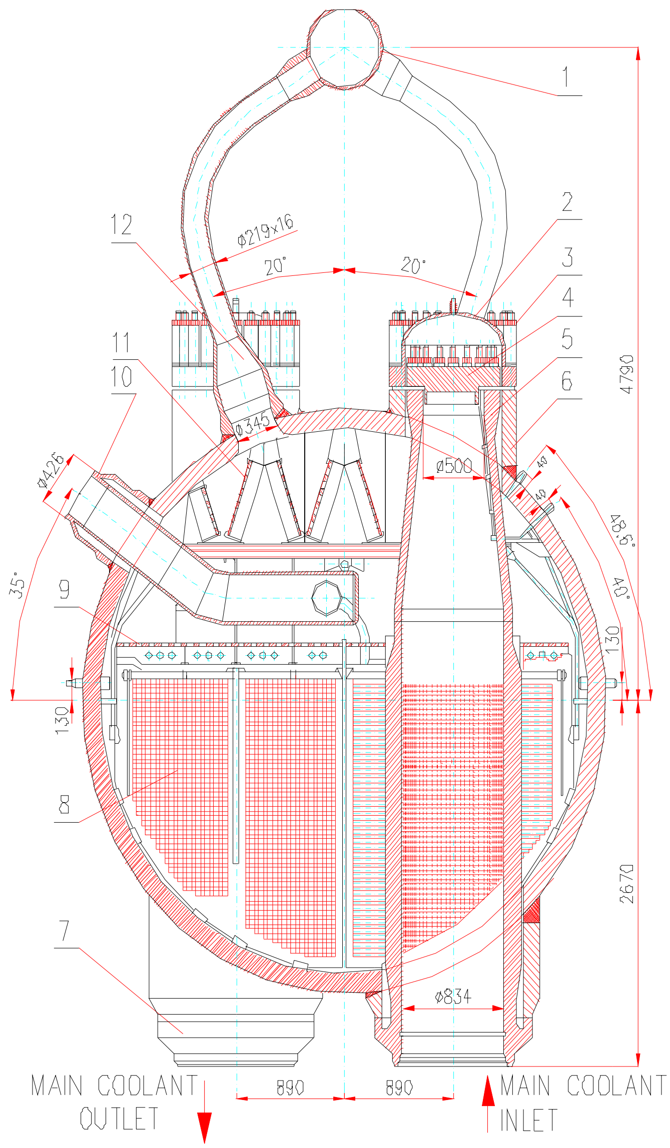
1. Block of tube electroheaters
2. Expansion vessel
3. Expansion vessel
4. Steam outlet to pressuriser relief valve
5. Leakage output nozzle
6. Vent
7. Thermocouple casing
8. Cold coolant inlet
9. Vessel
10. Thermocouple casing

Figure 3.1.3.1. Steam generator



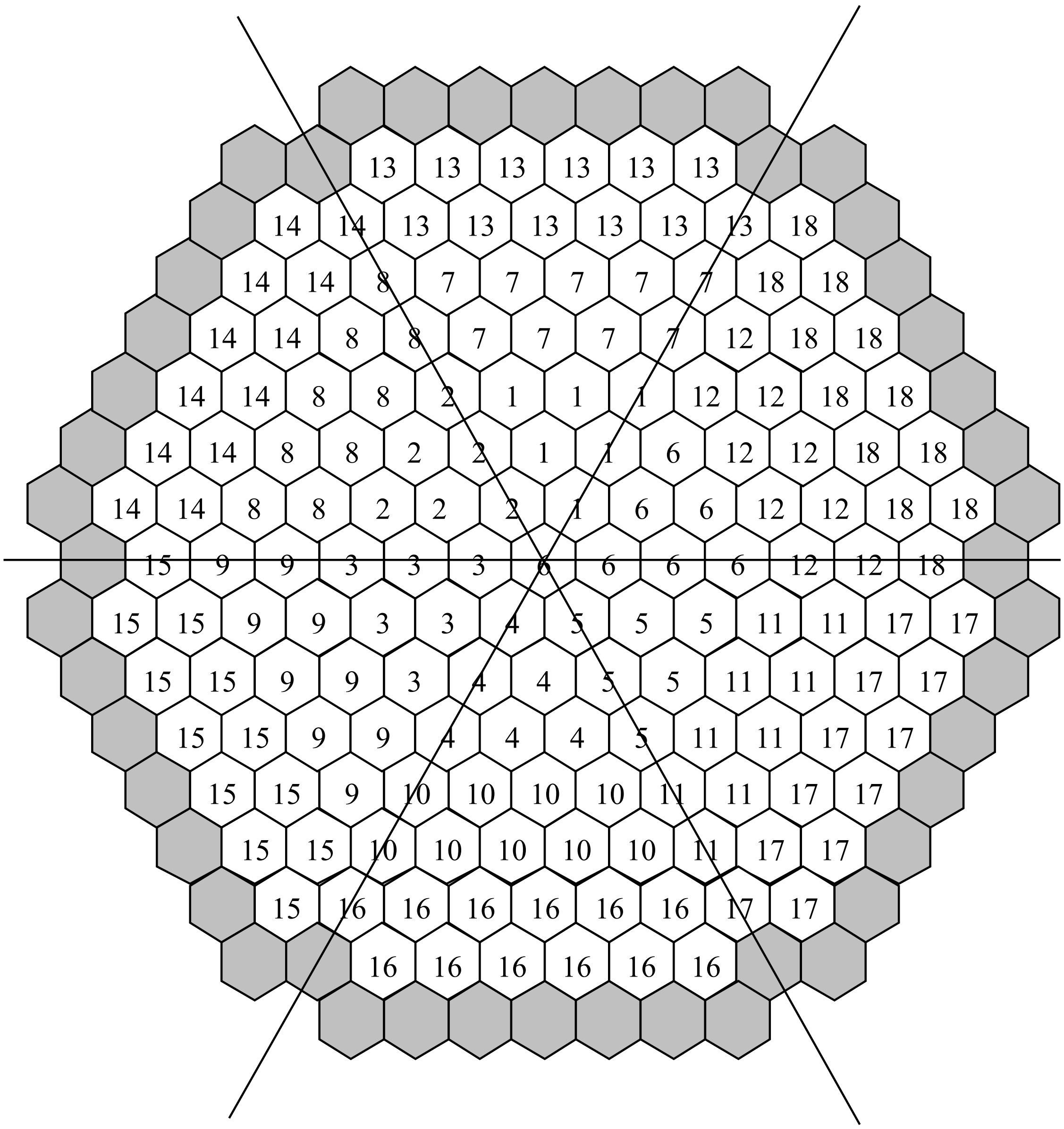
1. Vessel
2. Drainage nozzle
3. Blow down nozzle
4. Heat-exchange tubes
5. Separation units
6. Main feedwater spray unit
7. Gas removal nozzle
8. Emergency feedwater spray unit
9. Steam nozzle
10. Steam header
11. Emergency feedwater nozzle
12. Access airlock

Figure 3.1.3.2. Steam generator cross-section



1. Steam header
2. Secondary circuit (SC) header cover
3. Nuts
4. Primary circuit (PC) header cover
5. SC header
6. PC header
7. MCC nozzles
8. Heat exchange tubes
9. Steam pressure equalization
10. Feedwater nozzle
11. Separation units
12. Steam nozzle

Figure 3.2.1. Transient core boundary conditions mapping scheme for the second exercise



Chapter 4

NEUTRONIC/THERMAL-HYDRAULIC COUPLING

The feedback, or coupling, between neutronics and thermal-hydraulics (T-H) can be characterised by choosing user supplied mapping schemes (spatial mesh overlays) in the radial and axial core planes.

Some of the inlet perturbations (inlet disturbances of both temperature and flow rate) are specified as a fraction of the position across the core inlet. This requires either three-dimensional (3-D) modelling of the vessel or some type of a multi-channel model.

For the purposes of this benchmark (Exercises 2 and 3), it is recommended that an assembly flow area of 256 cm^2 be used in the core T-H multi-channel models.

Chapter 5

VVER-1000 MCP SWITCHING ON PROBLEM

5.1 Description of MCP switching on scenario

During the plant-commissioning phase at the Kozloduy NPP – Unit #6 a number of experiments were performed. One of them is the investigation of the behaviour of the nuclear power reactor parameters in case of switching on one main coolant pump (MCP) when the other three main coolant pumps are in operation [2]. This investigation was performed jointly by the Bulgarian and Russian specialists on the stage when the reactor power was at 75% of the nominal level. The purpose of the experiment was the complete testing of reliability of all power plant equipment, testing the reliability of the main regulators (Power Reactor Controller, Electro-hydraulic Turbine Controller and the regulator of the level in the steam generator) and defining the jump of the neutron reactor power in case of switching on of one main coolant pump.

Before the experiment the reactor power level was reduced from 75% (2250 MW) to approximately 21% by consecutive switching off of MCP#2 and MCP#3. A few hours before the experiment MCP #2 was switched on, and the power was stabilised at 30% following the Technical specification requirements. According to the Technical specification for safety operation of the Units 5 and 6, switching on one main coolant pump in operation is performed when the reactor power is at 30% of the nominal level.

The Reactor Power Controller (RPC) is a part of the Unit Power Control System and operates in co-ordination with the Reactor Power Limitation Controller (RPLC) and the Electro-hydraulic Turbine Controller (EHTC). The controller stabilises the reactor power or makes it to follow the turbine power. The RPC does not set any setpoint specification devices and stores the current values of neutron power or main steam header pressure as a setpoint at the time of switching on. In order to reset a setpoint, switching off and then switching on to the appropriate mode is needed. The controller usually uses the control rod group #10 to operate. In this particular transient the control rod group #10 is not changing its position during the transient.

RPLC is used to constrain the maximum thermal and neutron power to setpoints automatically chosen depending on the operational status of certain plant components such as MCP, Feed Water Pump (FWP), Steam Generator (SG), and Turbo Generator (TG). RPLC inserts the control rod group #10 with normal operation speed of 2 cm/sec. Control signal is the neutron flux, measured by the neutron flux monitoring system (NFMS). This signal is corrected once in every 50 seconds using the thermal power evaluated on the basis of the average temperature rise in the operating loops.

When RPLC is in operation, RPC is automatically disconnected and WP-1 (warning protection) signals are not used.

Depending on the initiating event, the reactor power is lowered to and then kept at specified setpoints by RPLC as follows:

1) 1 out of 4 MCPs trip: to 67% N_n.

2) 2 out of 4 diametrically placed MCPs trip; to 50% N_n.

3) 2 out of 4 (neighbouring) MCPs trip; to 40% N_n.

During the experiment of switching on the MCP #3 the system and equipment of the Unit 6 performed according to design requirements for the corresponding level of the reactor power. Registrations of the parameters when there is a transient event are recorded by the design equipment, which includes the universal electronic system (UES), and NFMS (in-core reactor control system).

The initial power level is about 29.45% of the nominal with control rod group #10 inserted into the core at about 36% of the reactor core height. Control rod group #10 is not changing its position during the transient. Analysis of the initial 3-D relative power distribution showed that this insertion introduced axial neutronics asymmetry in the core. At the beginning of the transient there is also a thermal-hydraulic asymmetry coming from the colder water introduced in ¼ of the core when MCP #3 is switched on. This causes a spatial asymmetry in the reactivity feedback, which has been propagated through the transient and combined with insertion of positive reactivity.

Different code predictions will be compared and evaluated in regard to time and value of a power peak after the switching on MCP #3.

5.2 Initial steady-state conditions

The reactor is at the beginning of cycle (BOC) with average core exposure of 30.7 EFPD and boron concentration 5.95 g/kgH_2O. At the beginning of the experiment there are three pumps in operation – 1st, 2nd and 4th main coolant pumps and the reactor power is at 29.45% of nominal power level according to the equipment that controls neutron flux. MCP #1, #2 and #4 are working under stable conditions and MCP #3 is out of operation. Initial conditions are given in Table 5.2.1. The inlet temperature in the reactor core is about 555.00°K. The temperature differences between the hot and cold legs for the loop with working MCP vary between 8.3-11.5°K while the same temperature difference for the loop #3 with the MCP out of operation is -3.6°K. The total mass flow through the core is about 13 611 kg/s with an average flow of 5 000 kg/s through each of the working loops and negative (reverse) flow of -1 544 kg/s in loop #3. There is a core axial non-symmetry as it can be seen from the value of the axial offset of the core power distribution at the initial state – 28.5%. The Electro-hydraulic Regulative System supports the pressure in the main steam collector when the Turbine Generator works at 164.0±10 MW. All regulators are in automatic regime. Definition of the initial steady state is given in Table 5.2.2. The above described initial conditions of the transient are referred as Hot Power (HP) conditions. Additional Hot Zero Power (HZP) state is defined for initialization of the 3-D core neutronics model for the second exercise. The HZP conditions are defined as follows: the power level is 0.1% of the nominal power; the fuel temperature is 552.15°K and the moderator density is 767.1 kg/m^3.

5.3 Point kinetics model inputs

Point kinetics model inputs, which preserve axial and radial core power distributions obtained with 3-D neutronics model, must be specified in order to make both simulations compatible. The following parameters for the point kinetics model and the 3-D neutronic transient core model should be consistent:

- Control rod group #10 worth.
- Radial power distribution.
- Axial power distribution.
- Moderator temperature coefficient.
- Doppler temperature coefficient.
- Other kinetics parameters.

All other initial and boundary conditions also have to be identical between the two cases. A summary of the point kinetics analysis input values can be found in Table 5.3.1. HP radial and axial relative power distributions (based on 10 equal nodes of 35.5 cm axial height) are shown in Figures 5.3.1 and 5.3.2, respectively.

5.4 Transient calculations

The key assumptions for performing the point and 3-D kinetics MCP transient analyses are summarised in Table 5.4.1.

The transient test scenario is as follows:

1) At reactor power 29.45% N_{nom} MCP#3 is switched on.

2) After switching on of MCP#3 the reactor power gradually increases to 29.8% N_{nom}.

3) Pressuriser water level decreases from 744 cm to 728 cm.

4) Water level in the steam generator #3 decreases by 9 cm.

5) EHTC is supporting the pressure in MSH at level 6.0±0.05 MPa when the TG power is 164.0±10 MW.

6) The flow rate in loop #3 reverses back to normal at the 13th second of the switching on of MCP#3. The timing is consistent with reactivity increase, as observed through the reactor power setpoints.

During the transient as a result of the switching on of MCP #3 there is an increased mass flow through the core. The cooling of the core is improved and re-distributed while the thermal core power level increase slightly (the total power increase during the transient is between 29.45% and 29.8% of nominal level). The non-symmetric cooling of the reactor core results in non-symmetric reactivity feedback and subsequently non-symmetric radial power distribution.

At the end of the transient the temperature difference between hot and cold legs of loops #1, #2, and #4 slightly decreases:

- For loop #1 – from 11.5°K to 8.8°K.
- For loop #2 – from 8.3°K to 8.4°K.
- For loop #4 – from 10.9°K to 8.9°K.
- For loop #3 – from -3.6°K to 8.2°K.

The most noticeable change is in the temperature difference for loop #3. This results in a dynamically changing spatial distribution of reactivity feedback during the transient and subsequently in a dynamically changing spatial power distribution. MCP test plant data is shown in Appendix C.

Since the objective of this benchmark is not to examine pump model of different codes, boundary conditions of MCP #3 rotor speed are provided in Table 5.4.2.

Transient boundary conditions for feedwater flow and secondary side pressure for each stem generator are provided in Tables 5.4.3 and 5.4.4 respectively. Feedwater temperature during the transient is 437.0°K.

The logic of the pressuriser heaters during the transient is given in Table 5.4.5.

The neutronics and thermal-hydraulic information presented in Chapter 3, suffices for performing Exercises 1, 2, and 3. In addition, an extreme version of Exercise 3 is defined as follows.

The control rod of group #10 located in the sector of the core cooled by MCP 3 is ejected after switching on of the MCP 3. The ejection of the rod begins at 13^{th} second of the transient and the velocity of ejection is 17.75 m/sec. The scram is activated upon reaching the high neutron flux setpoint, which is 40% of the nominal value. The scram delay is 0.3 sec. After that all control rod groups except group #5 fall down simultaneously from their initial position. Control rod group #5 does not operate during the scram and fall down with a delay of 4 seconds. The velocity of control rod insertion during the scram is 1.04 m/s. Everything else should remain the same as for Exercise 3.

This extreme scenario will develop very peaked spatial power distribution and nonlinear asymmetric feedback effects. It is designed to test and compare better the predictions of coupled 3-D kinetics/thermal-hydraulic codes.

Table 5.2.1. Initial conditions for KNPP unit 6 at 883.5 MWt

Parameter	Value
Core power, MWt	883.50
Primary side pressure, MPa	15.60
RCS first cold leg temperature, °K	555.55
RCS second cold leg temperature, °K	554.55
RCS third cold leg temperature, °K	554.35
RCS fourth cold leg temperature, °K	555.25
RCS first hot leg temperature, °K	567.05
RCS second hot leg temperature, °K	562.85
RCS third hot leg temperature, °K	550.75
RCS fourth hot leg temperature, °K	566.15
Core flow rate, kg/s	13 611
First loop flow rate, kg/s	5 031
Second loop flow rate, kg/s	5 069
Third loop flow rate, kg/s	-1 544
Fourth loop flow rate, kg/s	5 075
Pressuriser level, m	7.44
Water level in SG1, m	2.30
Water level in SG2, m	2.41
Water level in SG3, m	2.49
Water level in SG4, m	2.43
Secondary side pressure, MPa	5.937

Table 5.2.2. Definition of steady-states

Number	T-H conditions	Control rod positions
0	HZP	Groups 1-3 ARO[1] Group 4 – 57.3% wd (227 cm) Group 5 ARO Groups 6-10 ARI[2]
1	HP	Groups 1-9 ARO Group 10 – 36% wd

1. ARO – all rods out.
2. ARI – all rods inserted.

Table 5.3.1. Summary of point kinetics analysis input values

Parameter	Value
HP MTC, %/°K	-3.1000E-03
HP DTC, %/°K	-1.6610E-03
HP delayed neutron fraction (β_{eff})	0.7268E-02
HP prompt neutron lifetime	0.2670E-04
Control rod group #10 worth, %dk/k	0.91
Ejected rod worth, %dk/k	0.15
Tripped rod worth, %dk/k	7.85
Control rod group #5 worth, %dk/k	0.20

Table 5.4.1. KNPP analysis assumptions

Parameter	Value
Thermal power loop #1, MWt	278
Thermal power loop #2, MWt	231
Thermal power loop #3, MWt	34
Thermal power loop #4, MWt	280

Table 5.4.2. MCP#3 rotor speed boundary conditions

Time, s	MCP#3 Rotor speed, rad/s
0	0
0.5	9.4732
1	19.9464
1.5	31.4196
2	41.8928
4	61.3660
6	73.8392
8	83.3124
10	90.7856
11	94.3567
14	102.3032
15	104.1964
17	104.1964
18-129	104.1964

Table 5.4.3. Feedwater flow boundary conditions

Time, s	SG1 FW flow, kg/s	SG2 FW flow, kg/s	SG3 FW flow, kg/s	SG4 FW flow, kg/s
0	155.624	170.7111	13.61540	155.362
4	155.407	158.3780	14.05300	155.239
8	153.289	141.7140	14.22340	154.096
12	164.448	225.1120	4.27314	160.604
16	167.115	204.9680	14.94800	163.023
20	169.039	178.8350	15.78160	164.004
24	168.173	162.8140	19.67410	163.498
28	164.576	150.4810	26.39720	161.854
32	161.860	139.1290	30.98240	160.053
36	158.205	128.5570	49.25790	157.671
40	154.204	125.5240	71.71070	155.385
44	149.555	124.7210	87.59740	153.143
48	145.487	123.5100	98.76420	149.429
52	142.210	124.3690	106.57600	146.329
56	139.657	125.3380	111.81300	143.729
60	137.894	124.5630	115.07000	141.335
64	136.221	123.8120	117.47900	139.125
68	134.795	124.4220	119.37100	137.255
72	133.601	124.6930	120.83300	135.691
76	132.590	124.7900	121.96300	134.357
80	131.723	125.0700	122.81400	133.197
84	130.954	125.0810	123.43000	132.184
88	130.284	125.0770	123.95300	131.321
92	129.699	125.2440	124.31100	130.572
96	129.212	125.3440	124.66200	129.925
100	128.786	125.4090	124.91800	129.371
104	128.419	125.4830	125.12200	128.898
108	128.102	125.5100	125.26800	128.506
112	127.833	125.6180	125.39700	128.163
116	127.617	125.7100	125.48600	127.868
120	127.420	125.7320	125.58100	127.614
124	127.253	125.7510	125.69900	127.411
128	127.111	125.8410	125.77100	127.236
129	127.087	125.8550	125.77600	127.187

Table 5.4.4. Steam generators pressure boundary conditions

Time, s	SG1 pressure, Pa	SG2 pressure, Pa	SG3 pressure, Pa	SG4 pressure, Pa
0	6.09141e+06	6.09231e+06	6.05465e+06	6.09254e+06
4	6.09005e+06	6.09068e+06	6.04962e+06	6.09124e+06
8	6.09277e+06	6.09410e+06	6.06253e+06	6.09375e+06
12	6.09989e+06	6.09878e+06	6.09698e+06	6.09993e+06
16	6.08386e+06	6.08218e+06	6.08846e+06	6.08383e+06
20	6.06502e+06	6.06322e+06	6.07210e+06	6.06525e+06
24	6.06749e+06	6.06662e+06	6.07461e+06	6.06771e+06
28	6.07324e+06	6.07323e+06	6.08046e+06	6.07365e+06
32	6.07338e+06	6.07426e+06	6.08057e+06	6.07403e+06
36	6.07351e+06	6.07498e+06	6.08052e+06	6.07419e+06
40	6.07401e+06	6.07565e+06	6.08056e+06	6.07466e+06
44	6.07375e+06	6.07530e+06	6.07930e+06	6.07432e+06
48	6.07364e+06	6.07509e+06	6.07802e+06	6.07417e+06
52	6.07388e+06	6.07516e+06	6.07732e+06	6.07440e+06
56	6.07445e+06	6.07555e+06	6.07716e+06	6.07497e+06
60	6.07482e+06	6.07586e+06	6.07703e+06	6.07537e+06
64	6.07492e+06	6.07591e+06	6.07676e+06	6.07550e+06
68	6.07492e+06	6.07582e+06	6.07649e+06	6.07552e+06
72	6.07495e+06	6.07577e+06	6.07632e+06	6.07557e+06
76	6.07503e+06	6.0758e0+06	6.07626e+06	6.07568e+06
80	6.07513e+06	6.07584e+06	6.07623e+06	6.07579e+06
84	6.07521e+06	6.07588e+06	6.07622e+06	6.07588e+06
88	6.07528e+06	6.07591e+06	6.07621e+06	6.07596e+06
92	6.07533e+06	6.07592e+06	6.07620e+06	6.07602e+06
96	6.07537e+06	6.07594e+06	6.07619e+06	6.07607e+06
100	6.07541e+06	6.07595e+06	6.07618e+06	6.07612e+06
104	6.07544e+06	6.07596e+06	6.07618e+06	6.07616e+06
108	6.07547e+06	6.07597e+06	6.07619e+06	6.07620e+06
112	6.07550e+06	6.07598e+06	6.07620e+06	6.07623e+06
116	6.07553e+06	6.07599e+06	6.07620e+06	6.07626e+06
120	6.07555e+06	6.07600e+06	6.07621e+06	6.07629e+06
124	6.07557e+06	6.07601e+06	6.07621e+06	6.07631e+06
128	6.07559e+06	6.07602e+06	6.07622e+06	6.07633e+06
129	6.07559e+06	6.07602e+06	6.07622e+06	6.07633e+06

Table 5.4.5. Pressuriser heaters logic

Heaters group number	Condition	State
1	P<15.60 MPa	On
2	P<15.60 MPa	On
3	P<15.30MPa	On
4	P<15.30 MPa	On
1	P>15.78 MPa	Off
2	P>15.60 MPa	Off
3	P>15.50 MPa	Off
4	P>15.50 MPa	Off

Figure 5.3.1. Initial HP radial power distribution

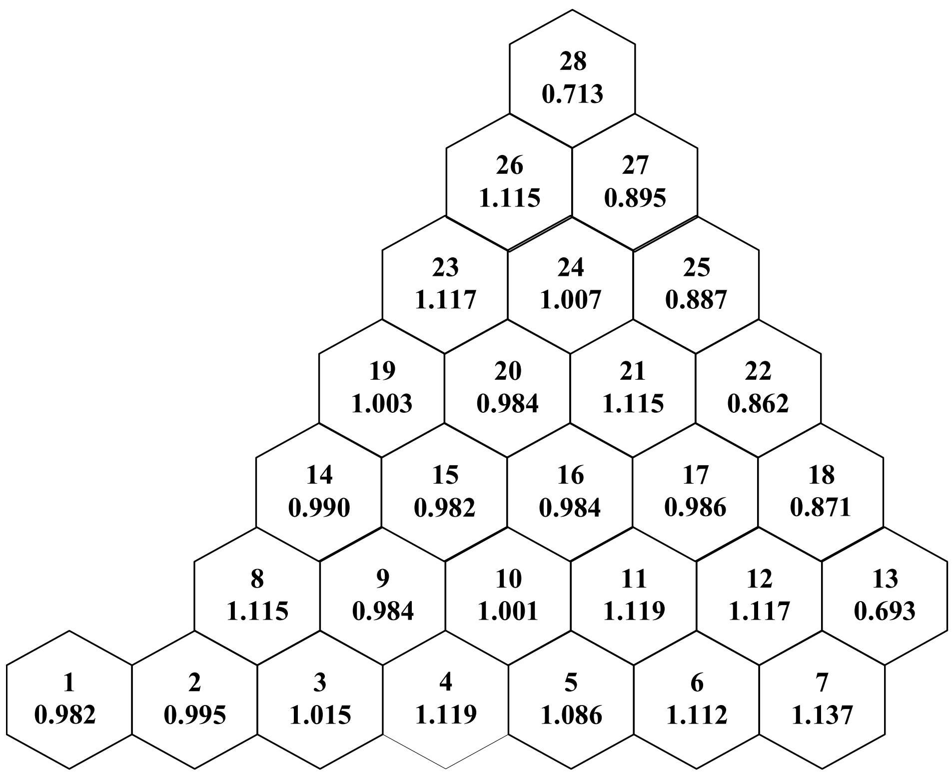


Figure 5.3.2. Initial HP core average axial relative power distribution

Bottom

0.82 0.86 0.89 0.91 0.92 0.93 1.02 1.32 1.21 1.13

Top

Chapter 6

OUTPUT REQUESTED

- The analysis results will be presented in a benchmark analysis report, which will be made available in both hard copy and electronic form.
- Results should be presented on paper ***and*** diskette (format details are given in Section 6.3).
- All data should be in SI units (kg, m, sec.).
- For time histories, data should be at 0.1-second intervals.
- Graphical comparison of calculated results and test data should be performed.

6.1 Initial steady-state results

The parameters given in Table 6.1 will be compared for **Exercise 1**.

The following results will be compared for **Exercise 2**:

- For the initial HZP state (state 1), the following parameters will be compared: K_{eff}; 2-D normalised power (NP) distribution; core averaged axial power distribution; the power peaking factors F_{xy}, F_z and axial offset; scram rod worth (SRW), ejected rod worth (ERW), and control rod group #10 worth (CRW).
- For the initial HP steady-state (state 2), the same information as for the HZP state plus: 2-D maps for inlet coolant temperature, inlet flow rate and outlet coolant temperature, coolant density, mass flow rate and Doppler temperature. The spatial distributions should follow the format of the radial and axial power distributions.

The following results will be compared for the initial HP steady state for **Exercise 3**:

- K_{eff}.
- Radial power distribution – 2-D assembly NP distribution – axially averaged radial power distribution for 163 radial nodes (full core) normalised to core average power (relative radial power distribution).
- Axial power distribution – core average axial shape – radially averaged axial power distribution for 10 axial nodes (each 35.5 cm in length), normalised to core average power (relative axial power distribution).

- Power peaking factors – F_{xy}, F_z, and axial offset.

- Primary system pressure, temperatures and mass flow rates – core inlet and outlet pressure values; core average axial temperature and axial velocity distributions; core inlet radial coolant temperature and flow rate distributions; core outlet radial coolant temperature distributions. The spatial distributions should follow the format of the radial and axial power distributions respectively.

6.2 Transient results

Exercise 1

- Sequence of events.

- Transient core average results (time histories): total core power; fission power; RCS pressure – core average, loop 3 (loop 3 is associated with the start up of MCP #3); core average coolant temperature; hot and cold leg coolant temperatures in all four loops (last cell before/after vessel); coolant heat-up temperature in all four loops; pressuriser water level; SG water levels; secondary side pressure; primary side flow rates; reactivity edits; and core average fuel temperature.

Exercise 2

- Snapshots at time of maximum power after switching on MCP #3, and at 129 seconds – the same data as for the HP steady-state except the total and fission power levels will be compared instead of K_{eff}.

- Time histories (core volume averaged without the reflector region): total power, fission power; coolant density; and Doppler temperature. In addition, the maximum nodal Doppler temperature vs. time will be compared.

Exercise 3

The following results will be compared for both scenarios of Exercise 3 – basic and extreme.

- Sequence of events.

- Transient average results (time histories): RCS pressure – core average, loop 3 (loop 3 is associated with the start up of MCP #3); core average coolant temperature; hot and cold leg coolant temperatures in all four loops (last cell before/after vessel); coolant heat-up temperature in all four loops; pressuriser water level; SG water levels; secondary side pressure; primary side flow rates; and reactivity edits.

- Time histories (core volume averaged without the reflector region): total power; fission power; coolant density; and Doppler temperature. In addition, the maximum nodal Doppler temperature vs. time will be compared.

- Snapshots at time of maximum power after switching on MCP #3 for both basic and extreme scenarios (states 3 and 4), and snapshots at 129 seconds (end of transient) for both scenarios (states 5 and 6) – the same data as for the HP steady-state except the total and fission power levels will be compared instead of K_{eff}.

6.3 Output format

Contents should be typed as close as possible to sample format.

Remarks

- Time histories consist of data pairs (time, value), one per line, starting at 0 seconds, up to 129 seconds. Please provide the units on the first line of each time history.
- A plot of time histories would be appreciated for a first comparison of the transient results.
- The plots of calculated results and test results should be compared on the same graph.
- Radial and axial profiles should be given according to the form shown in Figures 6.3.1 and 6.3.2.
- Please do not use tabs in the data files.
- Start each line in column one and end each line with a carriage return <CR>.

Output sample

A. VVER-1000 Kozloduy NPP BENCHMARK
KNPPB at Hot Full Power
RESULTS FROM CODE "XXXXXXXX"
EXERCISE 1: Point kinetics

B. STEADY STATE RESULTS

B1) K_{eff} = 1.0000

B2) Radial power distribution (full core) – start each line in column one, leave a blank space in between each number, and use a total of six spaces per number):

```
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.99990.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
```

B3) Axial power distribution – place all data starting in column one, leave a blank in between each number, and use a total of six spaces per number:

0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999

B4) Scram rod worth: 1.000% dk/k

- Ejected rod worth: 1.000% dk/k.

- Control rod group #10 worth: 1.000% dk/k.

B5) Calculated steady state conditions compared to those in the test.

Steady state calculation should be compared to the steady state test parameters according to Table 6.1.

Table 6.1. Steady state conditions. Measured plant parameters and uncertainty measurement ranges

Parameter	Test	Accuracy	Result	Deviation, %
Core power, MWt	883.50	±60 MW		
Primary side pressure, MPa	15.6	±0.3 MPa		
RCS first cold leg temperature, °K	555.55	±2.0 K		
RCS second cold leg temperature, °K	554.55	±2.0 K		
RCS third cold leg temperature, °K	554.35	±2.0 K		
RCS fourth cold leg temperature, °K	555.25	±2.0 K		
RCS first hot leg temperature, °K	567.05	±2.0 K		
RCS second hot leg temperature, °K	562.85	±2.0 K		
RCS third hot leg temperature, °K	550.75	±2.0 K		
RCS fourth hot leg temperature, °K	566.15	±2.0 K		
Core flow rate, kg/s	13 611	±800.0 kg/s		
First loop flow rate, kg/s	5 031	±200.0 kg/s		
Second loop flow rate, kg/s	5 069	±200.0 kg/s		
Third loop flow rate, kg/s	-1 544	±200.0 kg/s		
Fourth loop flow rate, kg/s	5 075	±200.0 kg/s		
Pressuriser level, m	7.44	±0.15 m		
Water level in SG1, m	2.30	±0.075 m		
Water level in SG2, m	2.41	±0.075 m		
Water level in SG3, m	2.49	±0.075 m		
Water level in SG4, m	2.43	±0.075 m		
Secondary side pressure, MPa	5.937	±0.2 MPa		
Pressure difference in the reactor		±0.02 MPa		
Pressure difference in MCP		±0.02 MPa		

C. SEQUENCE OF EVENTS

Transient calculation should be compared to the sequence of events given in Table 6.2.

Table 6.2. Sequence of events

Event description	Experiment, s	Calculation, s
MCP #3 switched on	0	
Minimum pressure above the core	12	
MCP #3 pressure drop stabilises	12	
Reactor pressure drop stabilises	16	
Primary side pressure stabilises	≈ 25	
Pressuriser water level stabilises	≈ 60	
Hot leg #3 temperature stabilises	60	
Transient ends	129	

Extreme scenario transient calculations should be compared to the sequence of events given in Table 6.3.

Table 6.3. Sequence of events for extreme scenario of Exercise 3

Event description	Specification, s	Calculation, s
MCP #3 switched on		
Rod of group 10 is ejected		
High neutron flux setpoint reached		
Maximum power after ejection		
Start of scram		
Transient ends		

D. TRANSIENT CORE AVERAGED RESULTS (TIME HISTORIES)

For each of the results in Section D, the first column of numbers should be the time covering a time interval of 0-129 seconds, with data taken every 0.1 second. The second column should include the data at that time, with a space between the first and second columns.

D1) Fission power (W):

0.0000 9.9999E+99
99.999 9.9999E+99

D2) Coolant (liquid) temperature (core average, hot and cold leg) (K):

0.0000 9.9999E+99
99.999 9.9999E+99

D3) Pressure (core average, loop 3, and loops 1,2,4) (Pa):

0.0000 9.9999E+99
99.999 9.9999E+99

D4) Reactivity edits (dk/k):

Total core reactivity and reactivity components (contributions from changes in moderator density, fuel temperature and neutron flux distribution – optional):

0.0000 9.999E+99
99.999 9.999E+99

D8) Core average fuel temperature (K):

0.0000 9.999E+99
99.999 9.999E+99

E. SNAPSHOTS

- At time of maximum power before switching on MCP #3.
- At time of maximum power after switching on MCP #3.
- At time of maximum power after rod ejection.
- At the end of the transient (129 seconds).

E1) Fission power:

9.9999E+99

E2) Radial power distribution (full core) – start each line in column one, leave a blank space in between each number, and use a total of six spaces per number):

```
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.99990.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
0.9999 0.9999 0.9999 0.9999 0.9999 0.9999
```

E3) Axial power distribution – place all data starting in column one, leave a blank in between each number, and use a total of six spaces per number:

0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999 0.9999

Figure 6.3.1. Form for axial power distribution

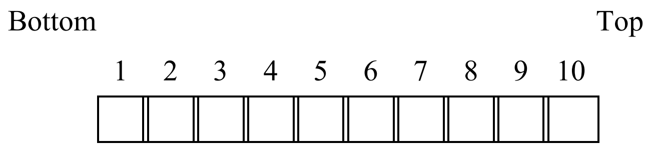
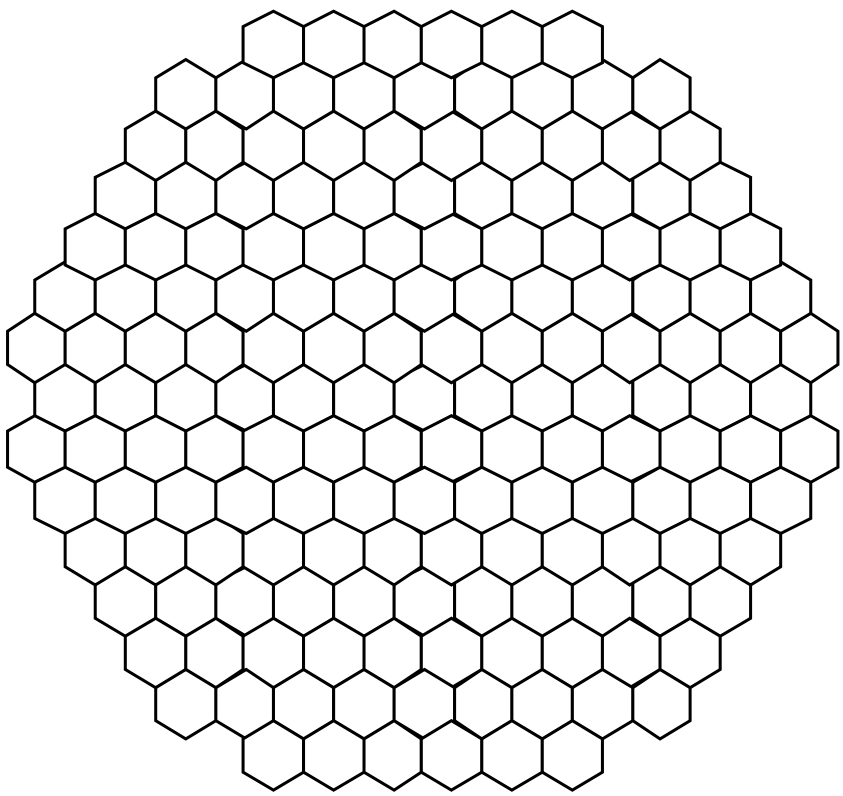


Figure 6.3.2. Form for radial power distribution



REFERENCES

[1] Ivanov, K. *et al*, "PWR MSLB benchmark. Volume 1: Final Specifications", NEA/NSC/DOC (99) 8, April 1999.

[2] Ivanov, K., P. Groudev, R. Gencheva and B. Ivanov, "Letter-report on Kozloduy NPP transient", US DOE, September 2000.

[3] RELAP 5/MOD3.2 Code manual, INEEL.

[4] RELAP-3D Code manual, Volume 1, INEEL.

[5] Ivanov, K., *et al*, "Features and performance of a coupled three dimensional thermal-hydraulics/kinetics code TRAC-PF1/NEM PWR analysis code", *Ann. Nucl. Energy*, **26**, 1407 (1999).

[6] Database for VVER1000, "Safety analysis capability improvement of KNPP (SACI of KNPP) in the field of thermal hydraulic analysis", BOA 278065-A-R4, INRNE-BAS, Sofia.

[7] Engineering handbook, "Safety analysis capability improvement of KNPP (SACI of KNPP) in the field of thermal hydraulic analysis", BOA 278065-A-R4, INRNE-BAS, Sofia.

[8] Model validation for units 5&6, "Safety analysis capability improvement of the Kozloduy NPP in the field of thermal hydraulic analysis", BOA 278065-A-R4.

[9] B0401.04.00.000 VVER assemblies - Catalogue discription for 2 years fuel campaign.

[10] Guideline for performing code validation within the DOE International Nuclear Safety Center (INSC), US/Russian International Nuclear Safety Center, ANL, Chicago and Moscow, September 23, 1997.

[11] Исходные Данные для Кода, "Течь-М-4", УДК 681.3: 621.039.586 8624606.00256-018101. ОКБ "Гидропресс", 1995. (Available only in Russian.)

[12] Марочник Сталей и Сплавов под Редакцей Сорокина В.Г., Москва, Машиностроение, 1989. (Available only in Russian.)

[13] Чиркин В.С. Теплофизические Свойства Материалов Ядреной Энергетики, Москва, Атомиздат, 1968. (Available only in Russian.)

[14] Запорожская АЭС Блок 5, Проект, Техническое Обоснование Безопасности Сооружения и Эксплутации АЭС, Атомэнергопроект, Москва, 1991. (Available only in Russian.)

[15] Справочник по Теплогидравлическим Расчетам (ядреные реакторы, теплоприемнники, парогенераторы), Кириллов П.Л., Юрьев Ю.С., Бобков В.П., Москва, 1984. (Available only in Russian.)

[16] Характеристики Сталей, Сварных Соединений, Сварных и Наплавочных Материалов для Корпуса и Крышки Реактора ВВЭР – 1000. Отчет ВНИИАЭС №85-031 /60200/I Москва, 1982. (Available only in Russian.)

[17] Разработка Алгоритмов и Программ Расчета Деформации и Элементах Оборудования 1–го контура. Отчет ВНИИАЭС УДК 539.4.62Г, Москва, 1987. (Available only in Russian.)

[18] Database for the Kozloduy NSSS for accident analysis of WWER-1000 model 320 nuclear plants, TC/RER/020, Reproduced by the IAEA, Vienna, Austria, 1994.

[19] "HELIOS Methods", StudsvikScandpower, 2000.

Appendix A

RELAP5 NODALISATION SCHEMES AND SKELETON INPUT DECK

Figure A.1. VVER-1000 Unit 6 reactor and pressuriser RELAP5 four loops model

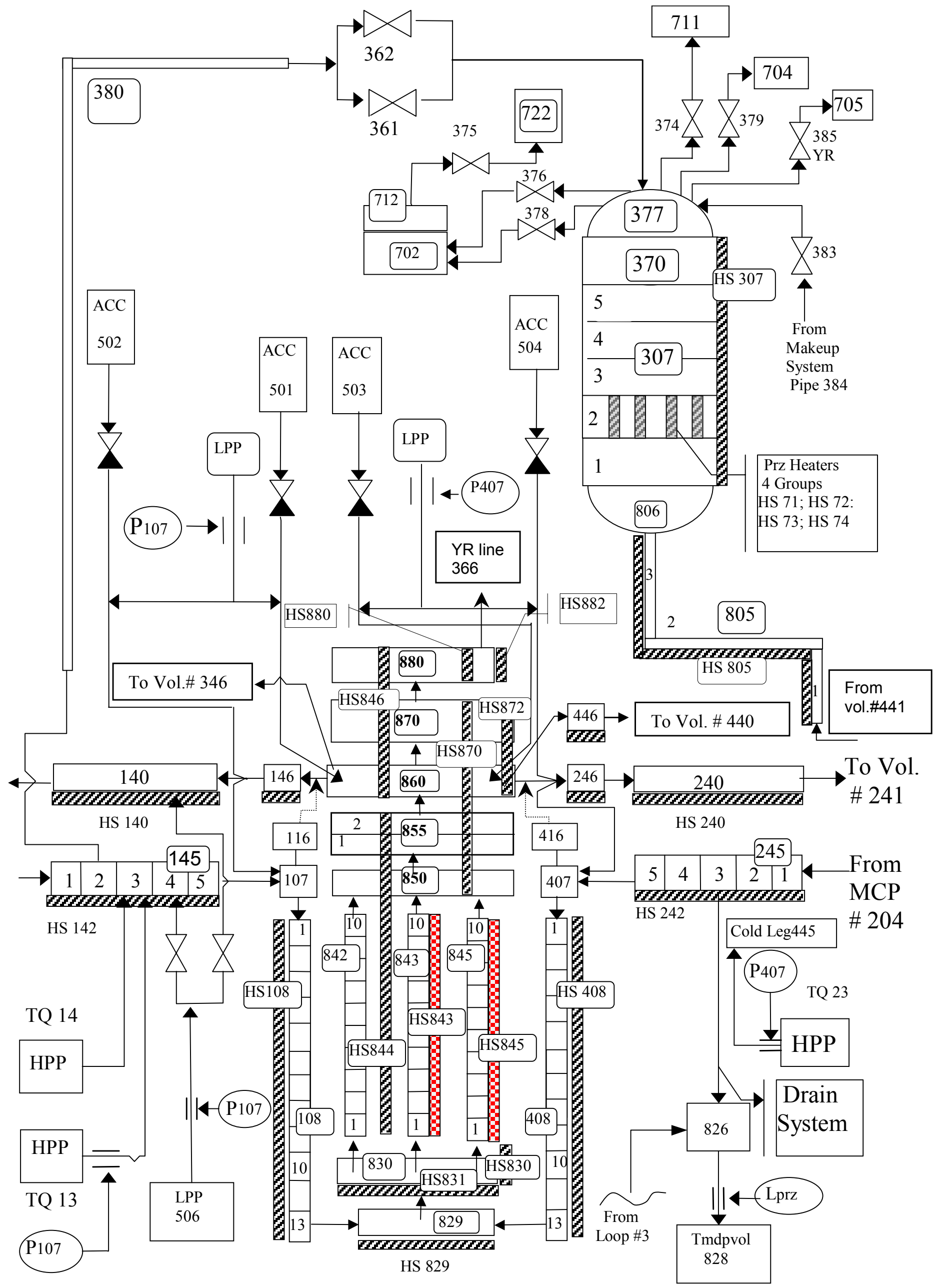
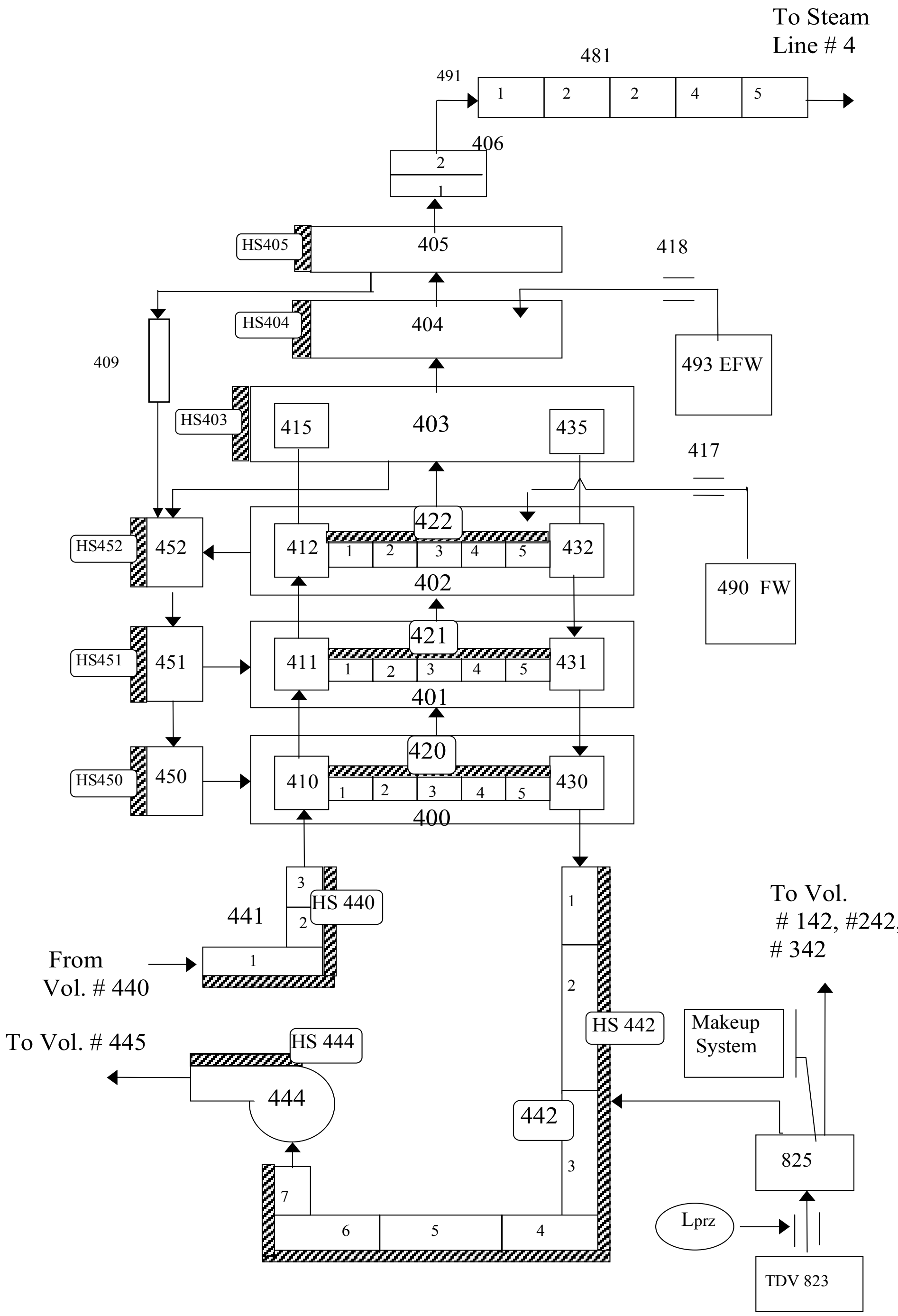


Figure A.2. VVER-1000 Unit 6 steam generator RELAP5 four loops model



SKELETON INPUT DECK

REACTOR

Number of Volume	I.D/O.D. m	Elevation, m -bottom -top	Height, m	Flow area, m^2	Hydraulic diameter, m	Volume, m^3	Note
107	3.62/3.986	23.475 24.325	0.85	0.5466	0.366	0.4646	Upper part of downcommer.
108-01	3.62/3.986	23.03 23.475	0.445	0.5466	0.366	0.2432	Downcomer. Note: 208, 308, 408 are identical.
108-02	3.62/3.986	22.28 23.03	0.75	0.5466	0.366	0.41	
108-03	3.61/4.136	21.8388 22.28	0.44125	0.8	0.526	0.353	
108-04	3.61/4.136	21.39755 21.8388	0.44125	0.8	0.526	0.353	
108-05	3.61/4.136	20.9563 21.39755	0.44125	0.8	0.526	0.353	
108-06	3.61/4.136	20.51505 20.9563 20.0738	0.44125	0.8	0.526	0.353	
108-07	3.61/4.136	20.51505 19.6326 20.0738	0.44125	0.8	0.526	0.353	
108-08	3.61/4.136	19.1913 19.6326	0.44125	0.8	0.526	0.353	
108-09	3.61/4.136	18.7501 19.1913	0.44125	0.8	0.526	0.353	
108-10	3.61/4.136	18.4601 18.7501	0.44125	0.8	0.526	0.353	
108-11	3.61/4.136	17.894 18.4601	0.29	0.8	0.526	0.2328	
108-12	3.61/4.136		0.566	0.8	0.526	0.4528	
108-13	3.61/4.136	16.9301 17.8971	0.967	0.8	0.526	0.7736	Note: 208-13, 308-13, 408-13 are identical.
116	3.63/3.986	24.75 25.7	0.95	0.5324	0.21667	0.5058	Appendix of the downcomer. Note: 216, 316, 416 are identical.
830	3.47	17.894 18.46	0.566	9.4569	3.47	5.3526	Lower plenum- cylindrical part of core basket.
829		16.927 17.894	0.967			3.5757	lower plenum – lower part.
843-01		18.46 18.75	0.29	4.4498		1.2905	Reactor core.
843-02		18.75 19.19125	0.44125	3.8165		1.68404	
843-03 - 843-09			0.44125	3.8165		1.68404	
843-10		22.28 23.03	0.75	7.5192		5.6394	Note: The sub-volumes are with identical geometry.
845-01		18.46 18.75	0.29	0.4181		0.1212491	
845-02		18.75 19.19125	0.44125	0.3586		0.15823	
845-03 - 845-09			0.44125	0.3586		0.15823	Note: The sub-volumes are with identical geometry.
845-10		22.28 23.03	0.75	0.77238		0.57929	
842-01		18.46 18.75	0.29	0.14604		0.04235	Core bypass.
842-02		18.75 19.19125	0.44125	0.1253		0.05529	
842-03 - 842-09			0.44125	0.1253		0.05529	Note: The sub-volumes are with identical geometry.
842-10		22.28 23.03	0.75	0.11883		0.08912	
850		23.03 23.475	0.445	8.2916		3.68976	Mixing volume.
855-01		23.475 24.325	0.85	8.2916		7.04786	Down part of upper volume.
855-02		24.325 25.275	0.95	8.2916		7.87702	
860		25.275 26.125	0.85	11.8180		10.04532	Upper volume.
870		26.125 28.125	2.00	8.66612		17.332242	Upper part of upper volume.
880		28.125 29.36	1.235			8.9	Upper volume below reactor heat.

STEAM GENERATORS

Steam generator primary side

Number of volume	Length/(height), m	Flow area, m^2	Volume, m^3	Note
120	10.95	0.33395	3.658	SG#1 tubes. Note: Volumes 220, 320, 420 for SG #2,#3 and #4 tubes are identical.
121	11.09	0.636317	7.025	SG#1 tubes. Note: Volumes 221, 321, 421 for SG #2, #3 and #4 tubes are identical.
122	11.09	0.4898	5.432	SG#1 tubes. Note: Volumes 222, 322, 422 for SG #2, #3 and #4 tubes are identical.
110	0.8	0.546	0.4368	Hot collector. The Volumes 111, 112 are identical.
141-03	0.67 top elev. 27.91 bottom 27.24	0.546	0.3658	Inlet of SG #1 hot collector.
115	1.875 top elev. 32.185 bottom 30.31	0.386	0.7238	Upper part of SG#1 hot collector .
130	0.8 top elev. 28.71 bottom 27.91	0.546	0.4368	SG #1 cold collector. The Volumes 230, 330 and 430 are identical.
131	0.8 top elev. 29.51 bottom 28.71	0.546	0.4368	SG #1 cold collector. The Volumes 231, 331 and 431 are identical.
132	0.8 top elev. 30.31 bottom 29.51	0.546	0.4368	SG #1 cold collector. The Volumes 232, 332 and 432 are identical.
135	1.875 top elev. 32.185 bottom 30.31	0.386	0.7238	Upper part of SG #1 cold collector The Volumes 235, 335 and 435 are identical.
210	0.8	0.546	0.4368	SG#2 hot collector. The Volumes 211, 212 are identical.
241-03	0.67 top elev. 27.91 bottom 27.24	0.546	0.3658	Inlet of SG#2 hot collector.
215	1.875	0.386	0.7238	SG#2 hot collector.
310	0.8	0.546	0.4368	SG#3 hot collector. The Volumes 311, 312 are identical.
341-03	0.67 top elev. 27.91 bottom 27.24	0.546	0.3658	Inlet of SG#2 hot collector.
315	1.875	0.386	0.7238	SG#3 hot collector.
410	0.8	0.546	0.4368	SG#4 hot collector. Volumes 411, 412 are identical.
441-03	0.67 top elev. 27.91 bottom 27.24	0.546	0.3658	Inlet of SG#4 hot collector.
415	1.875	0.386	0.7238	SG#4 hot collector.

Note: Data for Volumes 110-115 (hot collectors) and Volumes 130-135 (cold collectors) are analogues.
SG#2, 3 and 4 cold and hot collectors are analogues.

Steam generator secondary side – modelled corresponding to the SG – primary side

Number of volume	Height, m	Volume, m^3	Note
100	0.80	11.80	
101	0.80	22.60	
102	0.80	22.05	
103	0.30	14.15	
104	0.80	32.90	
105	0.50	7.10	
150	0.80	4.00	
151	0.80	3.60	
152	0.80	8.80	

Note: The total volume is 127 m^3: Steam generators # 2, 3 and 4 volumes are analogous.

PRIMARY LOOPS

Hot leg

Number of volume	Length, m	Flow area, m^2	Volume, m^3	Elevation (axis elevation), m	Note
146	1.64	0.5675	0.9307	25.70	Outlet of reactor vessel. Volumes 246, 346 and 446 are identical.
140	5.87	0.5675	3.331225	25.70	Volumes 240, 340 and 440 are identical.
141-01 141-02 141-03	1.714 1.54 0.67	0.5675 0.5675 0.546	0.9727 0.87395 0.3658	25.70 25.70 bottom 27.24 top 27.24 bottom 27.91 top	Hot leg of loop#1. Volumes 241-01, 341-01 and 441-01 are identical. Hot leg of loop#1. Volumes 241-02, 341-02 and 441-03 are identical. Inlet of SG#1 hot collector. Volumes 241-03, 341-03 and 441-03 are identical.

Note: Date the volume of hot loops #2, 3 and 4 volumes are analogues.

Cold leg

Number of volume	Height, m	Flow area, m^2	Volume, m^3	Elevation • bottom • top	Note
142-01 142-02 142-03 142-04 142-05 142-06 142-07	0.67 3.34 3.26 1.9467 1.9467 1.9467 3.26	0.546 0.567 0.567 0.567 0.567 0.567 0.567	0.36582 1.89378 1.848 1.103779 1.103779 1.103779 1.84842	27.24 27.91 23.90 27.24 20.64 23.90 20.64 – axis 20.64 – axis 20.64 – axis 23.90 27.91	Volume 142 – Pipe, outlet of cold collector. Volumes 242, 342 and 442 are identical.
145-01 145-02 145-03 145-04 145-05	2.308 2.308 2.308 2.308 2.308	0.5675 0.5675 0.5675 0.5675 0.5675	1.3097 1.3097 1.3097 1.3097 1.3097	23.90 23.90 23.90 23.90 23.90	Volume 145 is a pipe after MCP. Volumes 245, 345 and 445 are identical.

Note: Date the volume of cold loops #2, 3 and 4 volumes are analogues.

MAIN COOLANT PUMP GCN – 195 M

Pump components in the model are volumes 144, 244, 344 and 444.

Input data for pump – component 144, having 1 volume and 2 junctions

Volume no.	Flow area, (m^2)	Flow length, (m)	Volume, (m^3)	Horizontal angle, (deg)	Vertical angle, (deg)	Elevation changes, (m)
144 010 000	0.500000	6.00000	3.00000	0.00000	0.00000	0.00000

Junction no.	Initial liquid flow	Initial vapour flow
144 010 000	4 405.00	4 405.00
144 020 000	4 405.00	4 405.00

Edit of pump index & option indicators

Single phase table set index	0
2 phase head & torque multiplier table index	0
2 phase difference table set index	0
Pump motor torque table index	-1
Time dependent pump speed table index	0
Pump reverse indicator	0

Edit of pump fixed data parameters

Parameter	Value
Rated pump speed	104.199 (rad/sec)
Pump speed ratio (initial/rated)	1.00000
Rated pump flow	5.88889 (m^3/sec)
Rated pump head	82.9000 (m)
Rated pump torque	47500.0 (n-m)
Pump moment of inertia	7600.00 (kg-m^2)
Pump rated density	0.00000 (kg/m^3)
Pump rated motor torque	0.00000 (n-m)
Pump frictional torque coefficient #3	0.00000 (n-m)
Pump frictional torque coefficient #1	400.000 (n-m)
Pump frictional torque coefficient #2	0.00000 (n-m)
Pump frictional torque coefficient #4	0.00000 (n-m)

Pump stop parameter values input

Parameter	Value
Pump stop time	0.00000 (sec)
Pump maximum forward speed	0.00000 (rad/sec)
Pump maximum reverse speed	0.00000 (rad/sec)

Rundown characteristics for 4 pumps at p = 15.4 MPa and T = 300°C are presented below

τ, sec	Q, m^3/h	P, kgf/cm^2	N, Rad/sec
0	20 000	6.5	104.196
0.5	19 450	6.15	103.46
1.0	18 900	5.8	98.44
1.5	18 450	5.5	96.03
2.0	16 000	5.3	93.72
2.5	17 750	5.0	91.42
3.0	17 150	4.8	89.33
3.5	16 750	4.6	87.23
4.0	16 350	4.35	85.14
5.0	15 650	4.0	81.68
7.0	14 400	3.4	74.98

τ, sec	Q, m^3/h	P, kgf/cm^2	N, Rad/sec
10	12 850	2.70	67.02
15	10 900	2.00	56.76
20	9 400	1.45	45.87
25	8 400	1.15	43.77
30	7 500	1.00	39.06
50	5 160	0.45	26.91
90	3 200	0.15	15.71
135	1 820	0.05	9.42
180	1 100	0.02	5.76
210	720	0.01	3.98
232	0	0	0

Homologous curves (see Figure A3 and Figure A4)

The differences shown in tables are for the eight curve types used for determining pump head.

Edit for pump single phase table input

Curve no.	Indep. variable	Depend. variable
For head curve no. 1	0.000000	1.56000
	0.179000	1.47000
	0.304000	1.42000
	0.431000	1.39000
	0.582000	1.35000
	0.860000	1.18000
	0.966000	1.08000
	1.000000	1.00000
For head curve no. 2	0.000000	-1.40000
	0.161000	-1.10000
	0.247000	-0.93000
	0.315000	-0.78000
	0.424000	-0.54000
	0.500000	-0.35000
	0.556000	-0.21000
	0.610000	-8.00000E-02
	0.673000	0.10000
	0.736000	0.26000
	0.815000	0.45000
	0.904000	0.73000
	1.000000	1.00000
For head curve no. 3	-1.000000	4.00000
	-0.823000	2.30000
	-0.770000	2.13000
	-0.720000	2.13000
	-0.571000	2.07000
	-0.450000	1.92000
	-0.120000	1.70000
	0.000000	1.56000
For head curve no. 4	-1.000000	4.00000
	-0.767000	2.94000
	-0.500000	2.50000
	0.000000	1.76000

Curve no.	Indep. variable	Depend. variable
For head curve no. 5	0.000000	0.00000
	7.700000E-02	8.00000E-02
	0.110000	0.11000
	0.150000	0.15000
	0.208000	0.21000
	0.250000	0.25000
	0.286000	0.29000
	0.333000	0.33000
	0.381000	0.38000
	0.730000	0.73000
	0.800000	0.80000
	1.000000	1.00000
For head curve no. 6	0.000000	1.76000
	4.100000E-02	1.70000
	0.211100	1.53000
	0.324000	1.41000
	0.380400	1.34000
	0.473000	1.25000
	0.611000	1.11000
	0.865200	1.01000
	1.000000	1.00000
For head curve no. 7	-1.000000	-2.78000
	-0.913000	-2.54000
	-0.839000	-2.33000
	-0.659000	-1.83000
	-0.570000	-1.58000
	-0.526000	-1.46000
	-0.475000	-1.32000
	-0.410000	-1.14000
	-0.327000	-0.91000
	-0.210000	-0.58000
	-0.119000	-0.33000
	-6.000000E-02	-0.17000
	0.000000	0.00000
For head curve no. 8	-1.000000	-2.78000
	-0.881000	-2.62000
	-0.730000	-2.41000
	-0.453000	-2.03000
	-0.368000	-1.91000
	0.000000	-1.40000

Curve no.	Indep. variable	Depend. variable
For torque curve no. 1	0.000000	0.800000
	8.400000E-02	0.800000
	0.294000	0.820000
	0.406000	0.830000
	0.575000	0.880000
	0.920000	0.980000
	1.000000	1.000000

Curve no.	Indep. variable	Depend. variable
For torque curve no. 2	0.000000	-0.810000
	0.111000	-0.590000
	0.185000	-0.440000
	0.240000	-0.330000
	0.308000	-0.200000
	0.340000	-0.140000
	0.378000	-6.000000E-02
	0.418000	3.000000E-02
	0.483000	0.170000
	0.530000	0.230000
	0.574000	0.300000
	0.633000	0.390000
	0.694000	0.500000
	0.790000	0.630000
	0.970000	0.950000
	1.000000	1.000000
For torque curve no. 3	-1.000000	2.460000
	-0.969000	2.340000
	-0.930000	2.190000
	-0.796000	1.680000
	-0.615000	1.370000
	-0.476000	1.090000
	-0.359000	0.980000
	-0.307000	0.930000
	-8.800000E-02	0.810000
	0.000000	0.800000
For torque curve no. 4	-1.000000	2.460000
	-0.950000	2.400000
	-0.860000	2.280000
	-0.702000	2.120000
	-0.440000	1.860000
	0.000000	1.500000
For torque curve no. 5	0.000000	-1.300000
	9.100000E-02	-1.100000
	0.194000	-0.880000
	0.313000	-0.700000
	0.465000	-0.380000
	0.754000	0.190000
	0.876000	0.430000
	1.000000	0.670000
For torque curve no. 6	0.000000	1.500000
	6.700000E-02	1.450000
	0.113000	1.410000
	0.239000	1.330000
	0.565000	1.060000
	0.681000	0.960000
	0.956000	0.710000
	1.000000	0.670000
For torque curve no. 7	-1.000000	-3.970000
	0.000000	-1.300000

Curve no.	Indep. variable	Depend. variable
For torque curve no. 8	-1.000000	-3.970000
	-0.833000	-3.440000
	-0.600000	-2.700000
	-0.333000	-1.860000
	-0.186000	-1.400000
	-7.500000E-02	-1.050000
	0.000000	-0.810000

Edit for pump head multiplier table input	0.000000	0.000000
	7.000000E-02	0.000000
	8.000000E-02	0.740000
	0.165000	1.000000
	0.900000	1.000000
	1.000000	0.000000
Edit for pump torque multiplier table input	0.000000	0.000000
	1.000000	0.000000

Edit for pump two-phase table set input

Curve no.	Indep. variable	Depend. variable
For head curve no. 1	0.000000	0.000000
	0.100000	0.830000
	0.200000	1.090000
	0.500000	1.020000
	0.700000	1.010000
	0.900000	0.940000
	1.000000	1.000000
For head curve no. 2	0.000000	0.000000
	0.100000	-4.000000E-02
	0.200000	0.000000
	0.300000	0.100000
	0.400000	0.210000
	0.800000	0.670000
	0.900000	0.800000
	1.000000	1.000000
For head curve no. 3	-1.000000	-1.160000
	-0.900000	-1.240000
	-0.800000	-1.770000
	-0.700000	-2.360000
	-0.600000	-2.790000
	-0.500000	-2.910000
	-0.400000	-2.670000
	-0.250000	-1.690000
	-0.100000	-0.500000
	0.000000	0.000000
For head curve no. 4	-1.000000	-1.160000
	-0.900000	-0.780000
	-0.800000	-0.500000
	-0.700000	-0.310000
	-0.600000	-0.170000
	-0.500000	-8.000000E-02

Curve no.	Indep. variable	Depend. variable
For head curve no. 4 (cont'd)	-0.350000	0.000000
	-0.200000	5.000000E-02
	-0.100000	8.000000E-02
	0.000000	0.110000
For head curve no. 5	0.000000	0.000000
	0.200000	-0.340000
	0.400000	-0.650000
	0.600000	-0.950000
	0.800000	-1.190000
	1.000000	-1.470000
For head curve no. 6	0.000000	0.110000
	0.100000	0.130000
	0.250000	0.150000
	0.400000	0.130000
	0.500000	7.000000E-02
	0.600000	-4.000000E-02
	0.700000	-0.230000
	0.800000	-0.510000
	0.900000	-0.910000
	1.000000	-1.470000
For head curve no. 7	-1.000000	0.000000
	0.000000	0.000000
For head curve no. 8	-1.000000	0.000000
	0.000000	0.000000

Curve no.	Indep. variable	Depend. variable
For torque curve no. 1	0.00000	0.00000
	1.00000	0.00000
For torque curve no. 2	0.00000	0.00000
	1.00000	0.00000
For torque curve no. 3	-1.00000	0.00000
	0.00000	0.00000
For torque curve no. 4	-1.00000	0.00000
	0.00000	0.00000
For torque curve no. 5	0.00000	0.00000
	1.00000	0.00000
For torque curve no. 6	0.00000	0.00000
	1.00000	0.00000
For torque curve no. 7	-1.00000	0.00000
	0.00000	0.00000
For torque curve no. 8	-1.00000	0.00000
	0.00000	0.00000

PRESSURISER VESSEL

Number of volume	Height, m	Flow area, m^2	Volume, m^3	Hydraulic diameter, m	Elevation, m • bottom • top	Note
806	0.60	4.7714	2.8628	2.4648	22.03 22.63	Branch. Elliptical bottom of the Prz. Vessel.
307-01 307-02 307 03 307-04 307-05	2.00 2.045 2.045 2.045 1.59	7.0686 2.9757 7.0686 7.0686 7.0686	14.1372 6.0875 14.4553 14.4553 11.2391		22.63 24.63 24.63 26.67 26.67 28.72 28.72 30.76 30.76 32.35	Pipe. The cylindrical part of the vessel. Prz. Heaters.
370	1.825	7.0686	12.9002		32.35 34.175	Branch. The cylindrical part of the vessel.
377	0.60	4.7714		2.4648		Branch. Elliptical head of the vessel.

SURGE LINE & PRESSURISER SPRAY LINE

Number of volume	Length, m	Flow area, m^2	Volume, m^3	Elevation, m • bottom • top	Note
805 805-01 805-02 805-03	18.00 5.56 10.55 1.89	0.094	1.692 0.52264 0.9917 0.17766	 20.14 25.70 20.14 20.14 22.03	Pipe – surge line.
380 380-01 380-02 380-03	38.00 10.00 18.12 9.88	0.02573	0.97774 0.2573 0.466 0.254	 23.90 23.90 23.90 33.78	Pipe – pressuriser spray line.

PRESSURE LOSS COEFICIENTS

All pressure loss coefficients are based on the geometrical data of the corresponding junction. They take into account the flow area change and the change of flow direction.

- $\mathbf{k_f}$ – forward pressure loss coefficient.
- $\mathbf{k_r}$ – reverse pressure loss coefficient.

Reactor pressure loss coefficients

From component no. to component no.	k_f	k_r
From component 147 (247, 347, 447) to component 107 (207, 327, 407)	0.5	0.2
From component 107 to component 207: cross flow junction	0.3	0.2
From component 207 to component 327: cross flow junction	0.3	0.3
From component 327 to component 407: cross flow junction	0.3	0.3
From component 407 to component 107: cross flow junction	0.3	0.3
From component 107 (207, 327, 427) to component 108-01 (208-01, 308-01, 408-01)	0.05	0.02
From component 108-13 (208-13, 308-13, 408-13) to component 829 cross flow junction is applied	1.5	1.8
From component 829 to component 830	1.95	2.2
From component 830 to component 843 (845, 842)	1.2	2.5
From component 843 (845, 842) to component 850	2.0	2.2
From component 850 to component 855	0.8	1.2
From component 860 to component 146 (246, 346, 446) cross flow junction is applied	0.5	0.8
From component 855 to component 860	0.1	0.3
From component 860 to component 870	0.1	0.1
From component 870 to component 880	0.1	0.1
From component 108-01 (up to 108-13) to component 208-01 (up to 208-13): cross flow junction	0.3	0.3
From component 208-01 (up to 208-13) to component 308-01 (up to 308-13): cross flow junction	0.3	0.3
From component 308 (up to 308-13) to component 408 (up to 408-13): cross flow junction	0.3	0.3
From component 108 (up to108-13) to component 408 (up to 408-13): cross flow junction	0.3	0.3

SG #1 primary side pressure loss coefficients

From component no. to component no.	k_f	k_r
From component 110 to 120: abrupt area change option	1.0	1.2
From component 110 to 111	0.0	0.0
From component 141-03 to 110-01	0.3	0.48
From component 111-01 to 112-01	0.0	0.0
From component 111-01 to 121-01	1.0	1.2
From component 112-01 to 115-01	0.0	0.0
From component 131-01 to 130-01	0.0	0.0
From component 120-05 to 130-01	1.0	1.2
From component 130-01 to 142-01	0.3	0.48
From component 132-01 to 131-01	0.0	0.0
From component 121-05 to 131-01	1.0	1.2
From component 135-01 to 132-01	0.0	0.0
From component 122-05 to 132-01	1.0	1.2

Note: Pressure loss coefficients for SG #2, 3 and 4 are identical to SG #11 coefficients.

SG #1 secondary side pressure loss coefficients

From component no. to component no.	k_f	k_r
From component 100-01 to 101-01	0.5	0.5
From component 101-01 to 102-01	0.5	0.5
From component 151-01 to 150-01	0.0	0.0
From component 150-01 to 100-01	3.3	3.3
From component 151-01 to 101-01	1.2	1.2
From component 152-01 to 151-01	0.0	0.0
From component 103-01 to 152-01	0.5	0.5
From component 102-01 to 103-01	1.0	1.2
From component 103-01 to 104-01	0.0	0.0
From component 104-01 to 105-01	5.0	5.5
From component 109-01 to 152-01	0.0	0.0
From component 105-01 to 109-01	0.0	0.0
From component 105-01 to 106-01	3.0	3.5

Note: Pressure loss coefficients for SG #2, 3 and 4 are identical to SG #1 coefficients.

Pressuriser pressure loss coefficients

From component no. to component no.	k_f	k_r
From component #441 (hot leg) to component #805 (surge line): cross flow junction	1.0	1.0
From component #805 to component 806: abrupt area change option, (junction flow area = 0.094)	0.0	0.0
From component #806 to component #307	0.0	0.0

MATERIAL

REACTOR VESSEL

Reactor vessel	Steel 15X2HMΦA
Reactor cover	Steel 15X2HMΦA
Reactor core barrel	08X18H10T
Reactor core barrel elliptical bottom	SS
Reactor core support plate (lower)	08X18H10T
Reactor core support plate (down)	08X18H10T
Plate at the top of the block of control rod guide tubes	SS
Plate between cylindrical and elliptical part of upper head	SS

REAKTOR CORE

Fuel rod pellet	UO_2
Fuel rod cladding	Zr+1%Nb
Gas in gas gap	He
Water rod	Zr+1%Nb
Control rod guide tubes	SS

MAIN CIRCULATION LOOP

Primary loops material	10ΓH2MΦA
Pressuriser vessel	10ΓH2MΦA

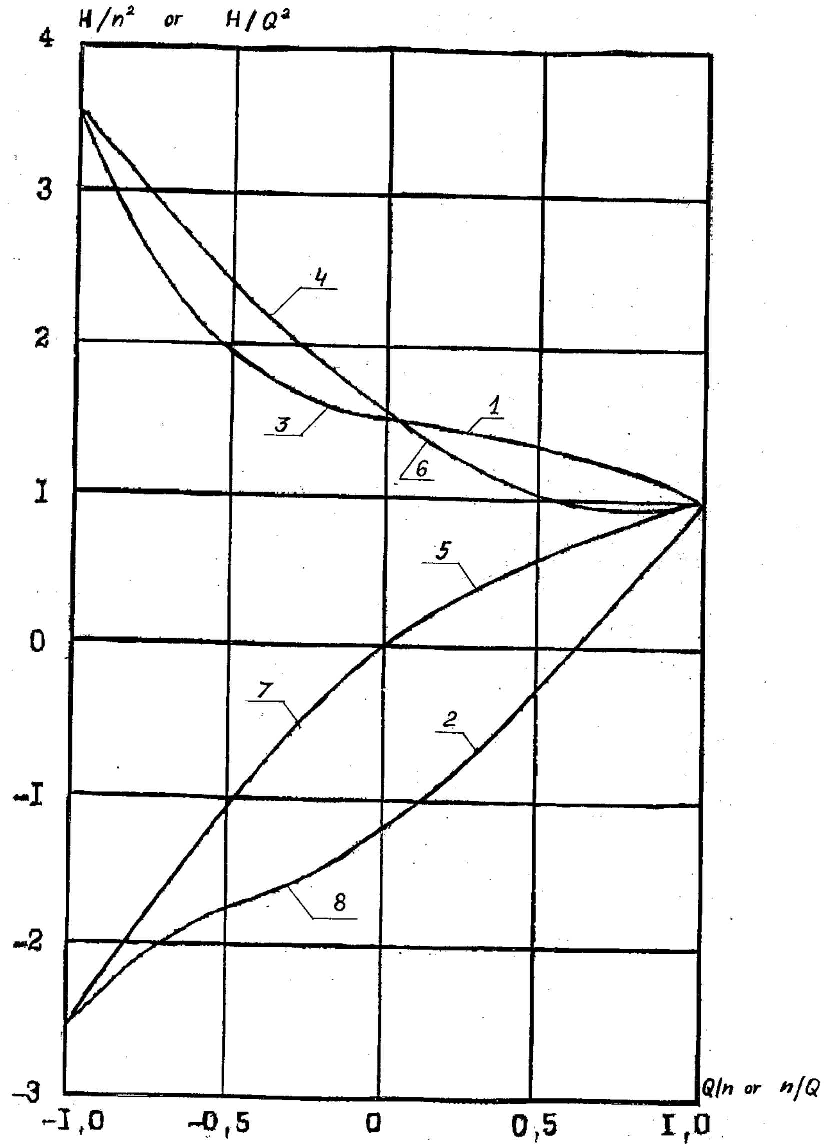
REACTOR COOLANT PUMP

Material of the action wheel	Steel 12X18H10T
Material of the casing	Steel 12X18H10T

STEAM GENERATOR

SG secondary side Vessel	10ΓH2MΦA
SG primary side tubing	08X18H10T

Figure A.3. Four – quadrant MCP head characteristics

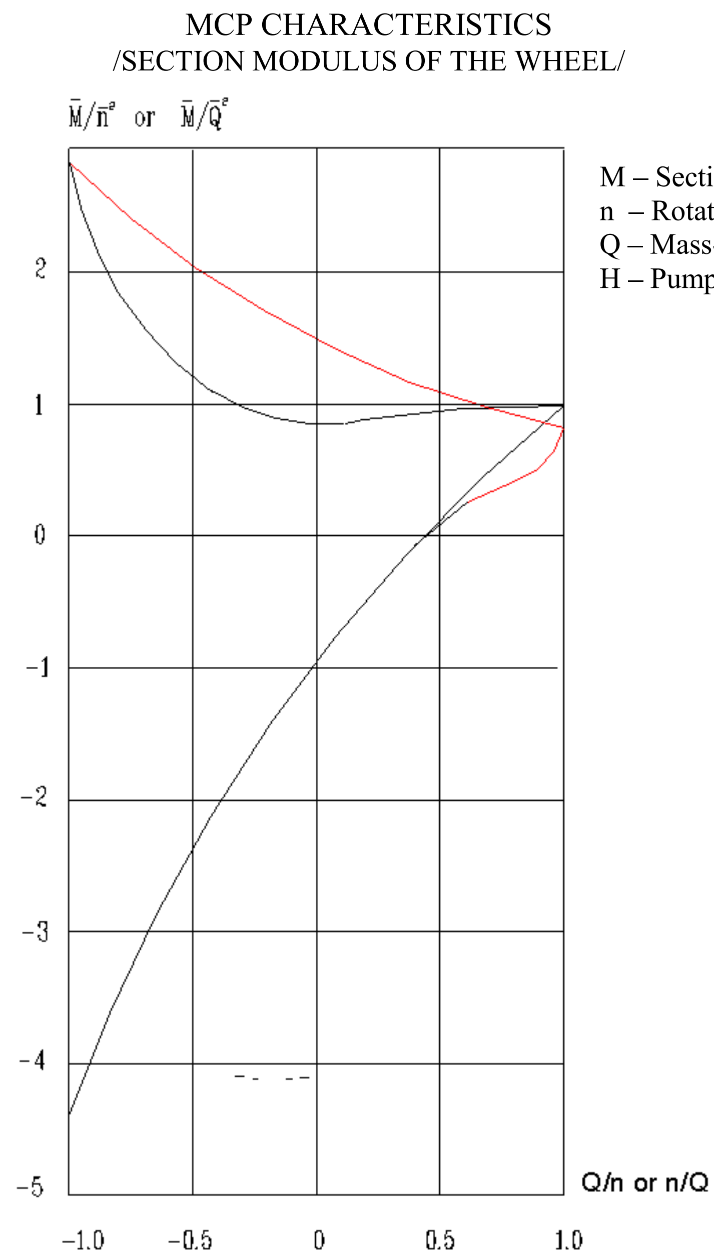


H – Pump head

Q – Mass-flow rate

n – Rotation speed

Figure A.4. Four – quadrant MCP torque characteristics



M – Sectional modulus
n – Rotational speed
Q – Mass-flow rate
H – Pump head

Appendix B

SAMPLE CROSS-SECTION TABLE

```
*  NEM-Cross Section Table Input
*
*    T Fuel        Rho Mod.      Boron ppm.    T Mod.
       5             4             0             0
*
*******           X-Section set #        1
*
*      Group No.  1
*
***************            Diffusion Coefficient Table
*
  .5400000E+03  .7600000E+03  .8550000E+03  .1000000E+04  .1500000E+04
  .7868400E+03  .7617800E+03  .7125000E+03  .6616800E+03  .1508700E+01
  .1514300E+01  .1437800E+01  .1440100E+01  .1441000E+01  .1441500E+01
  .1446600E+01  .1388600E+01  .1390800E+01  .1391700E+01  .1392100E+01
  .1397000E+01  .1387100E+01  .1389300E+01  .1390200E+01  .1390700E+01
  .1395500E+01  .1380300E+01  .1382500E+01  .1383300E+01
*
***************       Total Absorption X-Section Table
*
  .5400000E+03  .7600000E+03  .8550000E+03  .1000000E+04  .1500000E+04
  .7868400E+03  .7617800E+03  .7125000E+03  .6616800E+03  .1079000E-01
  .1103800E-01  .1074100E-01  .1089800E-01  .1095500E-01  .1098300E-01
  .1123800E-01  .1087400E-01  .1103400E-01  .1109300E-01  .1112100E-01
  .1138300E-01  .1087900E-01  .1104000E-01  .1109800E-01  .1112700E-01
  .1138900E-01  .1089800E-01  .1105900E-01  .1111800E-01
*
***************            Fission X-Section Table
*
  .5400000E+03  .7600000E+03  .8550000E+03  .1000000E+04  .1500000E+04
  .7868400E+03  .7617800E+03  .7125000E+03  .6616800E+03  .1965171E-02
  .1948015E-02  .2007931E-02  .2000111E-02  .1996925E-02  .1995221E-02
  .1978074E-02  .2030571E-02  .2022701E-02  .2019584E-02  .2017878E-02
  .2000667E-02  .2031764E-02  .2023930E-02  .2020737E-02  .2019030E-02
  .2001854E-02  .2035185E-02  .2027312E-02  .2024119E-02
*
***************            Nu-Fission X-Section Table
*
  .5400000E+03  .7600000E+03  .8550000E+03  .1000000E+04  .1500000E+04
  .7868400E+03  .7617800E+03  .7125000E+03  .6616800E+03  .5309500E-02
  .5264900E-02  .5418000E-02  .5397900E-02  .5389700E-02  .5385300E-02
  .5340800E-02  .5473200E-02  .5453000E-02  .5444800E-02  .5440400E-02
  .5396000E-02  .5475400E-02  .5455300E-02  .5447100E-02  .5442700E-02
  .5398200E-02  .5483400E-02  .5463200E-02  .5455000E-02
*
***************            Scattering X-Section Table
*
****    From group 1 to 2
  .5400000E+03  .7600000E+03  .8550000E+03  .1000000E+04  .1500000E+04
  .7868400E+03  .7617800E+03  .7125000E+03  .6616800E+03  .1321800E-01
  .1306600E-01  .1510700E-01  .1501300E-01  .1497800E-01  .1496100E-01
  .1480100E-01  .1650500E-01  .1640800E-01  .1637200E-01  .1635400E-01
  .1618700E-01  .1654500E-01  .1644800E-01  .1641200E-01  .1639400E-01
  .1622600E-01  .1674700E-01  .1665000E-01  .1661300E-01
```

```
*
*      Group No.  2
*
***************          Diffusion Coefficient Table
*
  .5400000E+03  .7600000E+03  .8550000E+03  .1000000E+04  .1500000E+04
  .7868400E+03  .7617800E+03  .7125000E+03  .6616800E+03  .4056100E+00
  .4069800E+00  .3693900E+00  .3699500E+00  .3701800E+00  .3703000E+00
  .3715600E+00  .3440200E+00  .3445600E+00  .3447800E+00  .3448900E+00
  .3460800E+00  .3427700E+00  .3433100E+00  .3435300E+00  .3436400E+00
  .3448300E+00  .3390900E+00  .3396200E+00  .3398400E+00
*
***************     Total Absorption X-Section Table
*
  .5400000E+03  .7600000E+03  .8550000E+03  .1000000E+04  .1500000E+04
  .7868400E+03  .7617800E+03  .7125000E+03  .6616800E+03  .9817500E-01
  .9774600E-01  .9955400E-01  .9934400E-01  .9925900E-01  .9921600E-01
  .9876400E-01  .1005400E+00  .1003200E+00  .1002300E+00  .1001800E+00
  .9970400E-01  .1006500E+00  .1004300E+00  .1003400E+00  .1002900E+00
  .9980900E-01  .1008400E+00  .1006100E+00  .1005200E+00
*
***************          Fission X-Section Table
*
  .5400000E+03  .7600000E+03  .8550000E+03  .1000000E+04  .1500000E+04
  .7868400E+03  .7617800E+03  .7125000E+03  .6616800E+03  .5128803E-01
  .5106745E-01  .5171034E-01  .5160071E-01  .5155243E-01  .5153199E-01
  .5130000E-01  .5196260E-01  .5184540E-01  .5179896E-01  .5177478E-01
  .5152942E-01  .5200564E-01  .5188840E-01  .5184004E-01  .5181586E-01
  .5156494E-01  .5206176E-01  .5194078E-01  .5189240E-01
*
***************          Nu-Fission X-Section Table
*
  .5400000E+03  .7600000E+03  .8550000E+03  .1000000E+04  .1500000E+04
  .7868400E+03  .7617800E+03  .7125000E+03  .6616800E+03  .1385700E+00
  .1380200E+00  .1395300E+00  .1392600E+00  .1391400E+00  .1390900E+00
  .1385100E+00  .1400600E+00  .1397700E+00  .1396500E+00  .1395900E+00
  .1389800E+00  .1401500E+00  .1398600E+00  .1397400E+00  .1396800E+00
  .1390500E+00  .1402700E+00  .1399700E+00  .1398500E+00
*
***************          Xe X-Section Table
*
  .5400000E+03  .7600000E+03  .8550000E+03  .1000000E+04  .1500000E+04
  .7868400E+03  .7617800E+03  .7125000E+03  .6616800E+03  .3316200E-02
  .3293900E-02  .3327400E-02  .3317700E-02  .3313600E-02  .3311500E-02
  .3289200E-02  .3335000E-02  .3325100E-02  .3321000E-02  .3318800E-02
  .3296200E-02  .3340400E-02  .3330500E-02  .3326300E-02  .3324200E-02
  .3301400E-02  .3344100E-02  .3334100E-02  .3329900E-02
*
***************          Inv. Neutron Velocities
*
  .5456850E-07  .2491910E-05
*
```

Appendix C

MCP TEST PLANT DATA

Table C.1. Water level in the pressuriser during the transient

Time, s	Level, m	Time, s	Level, m	Time, s	Level, m
0	7.44	44	7.34	88	7.30
4	7.44	48	7.33	92	7.30
8	7.44	52	7.32	96	7.29
12	7.41	56	7.32	100	7.29
16	7.39	60	7.31	104	7.29
20	7.39	64	7.31	108	7.28
24	7.37	68	7.31	112	7.28
28	7.36	72	7.31	116	7.29
32	7.36	76	7.32	120	7.28
36	7.36	80	7.30	124	7.28
40	7.35	84	7.30	128	7.28

Figure C.1. Water level in the pressuriser during the transient

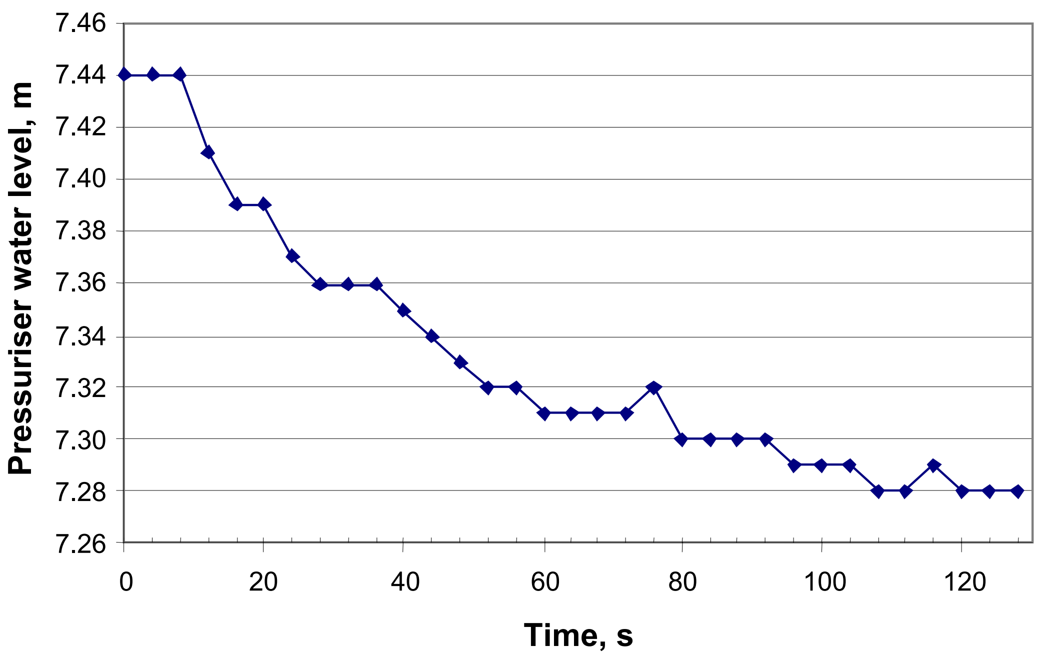


Table C.2. Water level in SG #1 during the transient

Time, s	Level, m	Time, s	Level, m	Time, s	Level, m
0	2.30	44	2.32	88	2.37
4	2.30	48	2.33	92	2.36
8	2.30	52	2.33	96	2.36
12	2.30	56	2.35	100	2.36
16	2.29	60	2.35	104	2.36
20	2.28	64	2.36	108	2.35
24	2.28	68	2.36	112	2.35
28	2.28	72	2.36	116	2.35
32	2.29	76	2.36	120	2.35
36	2.30	80	2.36	124	2.35
40	2.30	84	2.36	128	2.35

Figure C.2. Water level in SG #1 during the transient

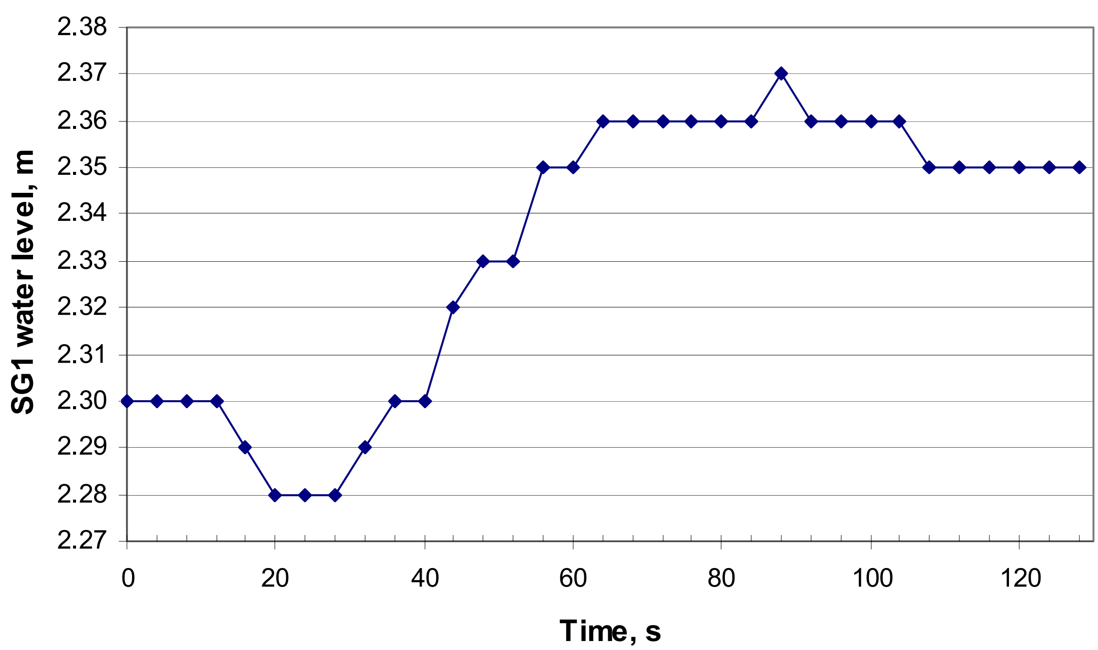


Table C.3. Water level in SG #2 during the transient

Time, s	Level, m	Time, s	Level, m	Time, s	Level, m
0	2.41	44	2.38	88	2.40
4	2.41	48	2.39	92	2.41
8	2.41	52	2.39	96	2.41
12	2.42	56	2.40	100	2.41
16	2.42	60	2.39	104	2.42
20	2.40	64	2.39	108	2.41
24	2.40	68	2.40	112	2.41
28	2.40	72	2.41	116	2.42
32	2.39	76	2.40	120	2.41
36	2.39	80	2.40	124	2.42
40	2.39	84	2.41	128	2.41

Figure C.3. Water level in SG #2 during the transient

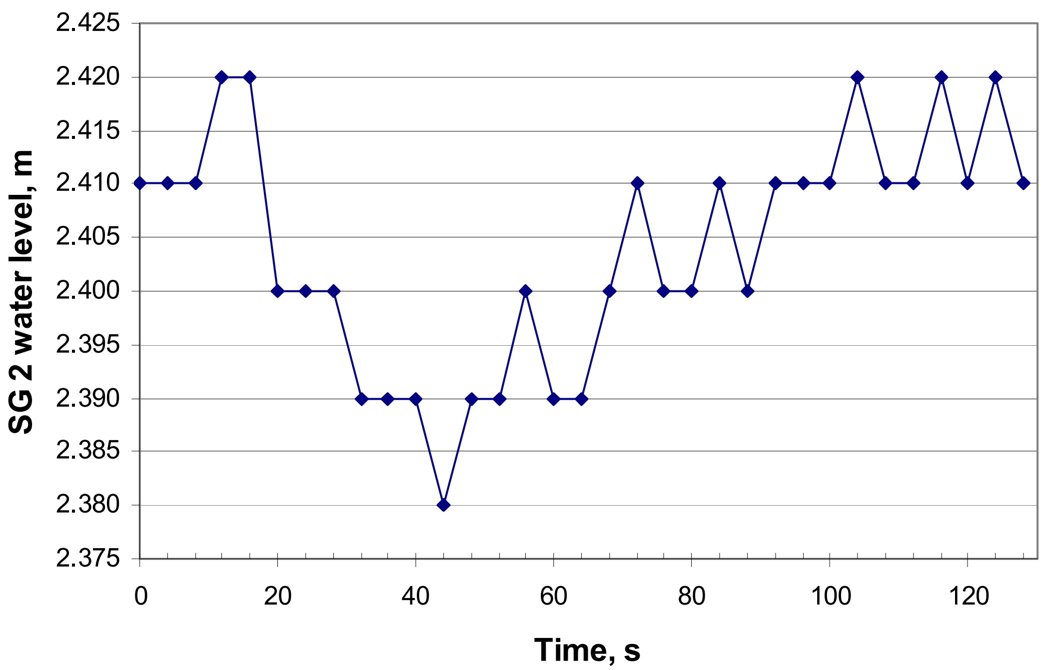


Table C.4. Water level in SG #3 during the transient

Time, s	Level, m	Time, s	Level, m	Time, s	Level, m
0	2.49	44	2.49	88	2.35
4	2.49	48	2.47	92	2.35
8	2.48	52	2.45	96	2.35
12	2.48	56	2.42	100	2.36
16	2.56	60	2.40	104	2.36
20	2.57	64	2.39	108	2.36
24	2.56	68	2.36	112	2.37
28	2.56	72	2.35	116	2.37
32	2.54	76	2.34	120	2.38
36	2.53	80	2.34	124	2.38
40	2.51	84	2.35	128	2.39

Figure C.4. Water level in SG #3 during the transient

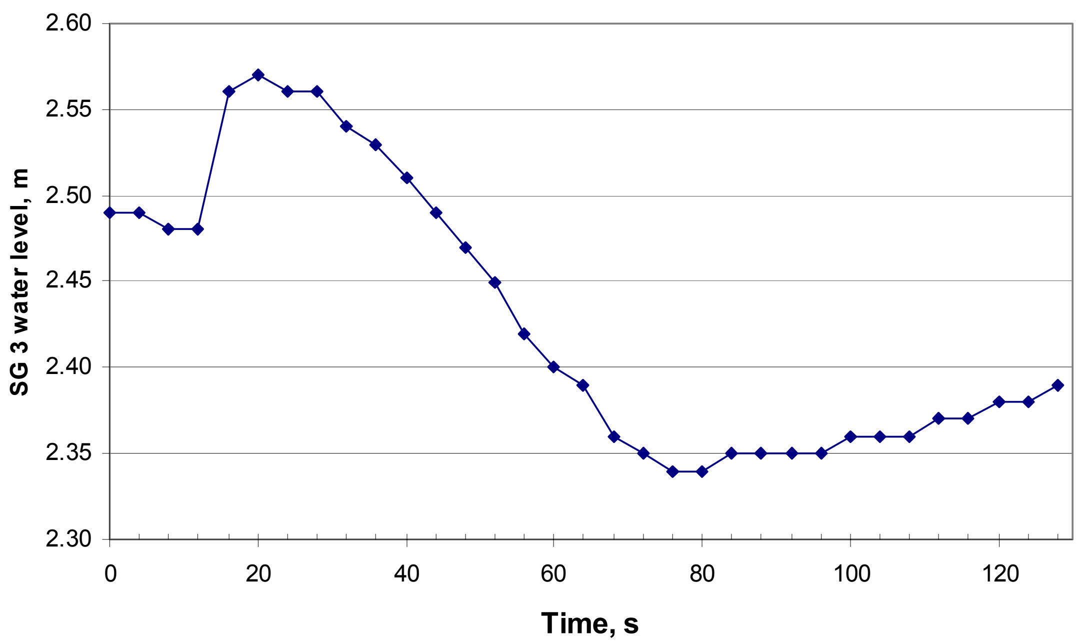


Table C.5. Water level in SG #4 during the transient

Time, s	Level, m	Time, s	Level, m	Time, s	Level, m
0	2.43	44	2.46	88	2.49
4	2.43	48	2.47	92	2.49
8	2.43	52	2.47	96	2.49
12	2.43	56	2.48	100	2.49
16	2.42	60	2.49	104	2.49
20	2.41	64	2.49	108	2.49
24	2.40	68	2.49	112	2.48
28	2.41	72	2.49	116	2.48
32	2.43	76	2.49	120	2.48
36	2.43	80	2.49	124	2.48
40	2.44	84	2.49	128	2.48

Figure C.5. Water level in SG #4 during the transient

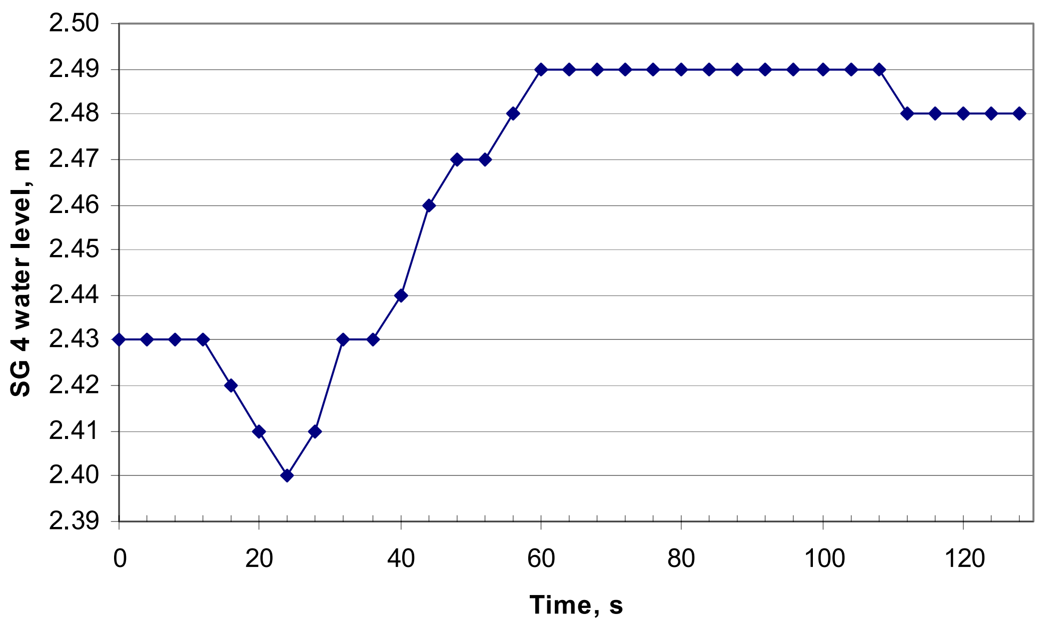


Table C.6. Cold leg #1 coolant temperature during the transient

Time, s	Temperature, K	Time, s	Temperature, K	Time, s	Temperature, K
1	555.55	45	555.15	89	554.65
5	555.65	49	555.05	93	554.65
9	555.65	53	554.75	97	554.55
13	555.65	57	554.85	101	554.65
17	555.55	61	554.85	105	554.65
21	555.55	65	554.65	109	554.55
25	555.25	69	554.65	113	554.25
29	555.25	73	554.65	117	554.25
33	555.05	77	554.55	121	554.25
37	555.15	81	554.65	125	554.45
41	555.05	85	554.75	129	554.75

Figure C.6. Cold leg #1 coolant temperature during the transient

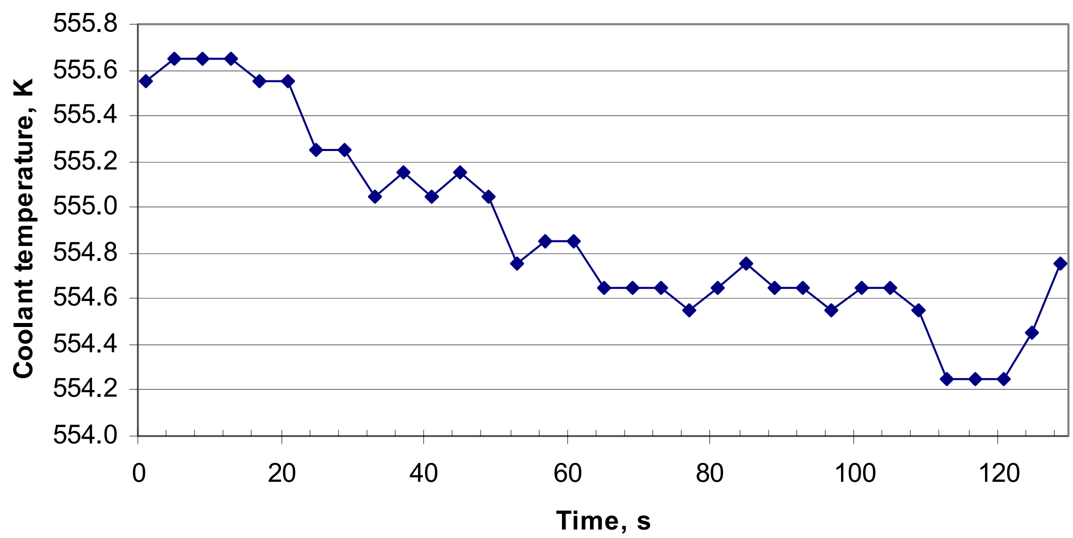


Table C.7. Cold leg #2 coolant temperature during the transient

Time, s	Temperature, K	Time, s	Temperature, K	Time, s	Temperature, K
1	554.55	45	554.65	89	554.35
5	554.45	49	554.75	93	554.35
9	554.35	53	554.45	97	554.35
13	554.65	57	554.65	101	554.45
17	554.75	61	554.45	105	554.35
21	554.75	65	554.55	109	554.25
25	554.65	69	554.65	113	554.35
29	554.65	73	554.45	117	554.15
33	554.75	77	554.35	121	554.25
37	554.65	81	554.55	125	554.45
41	554.75	85	554.45	129	554.25

Figure C.7. Cold leg #2 coolant temperature during the transient

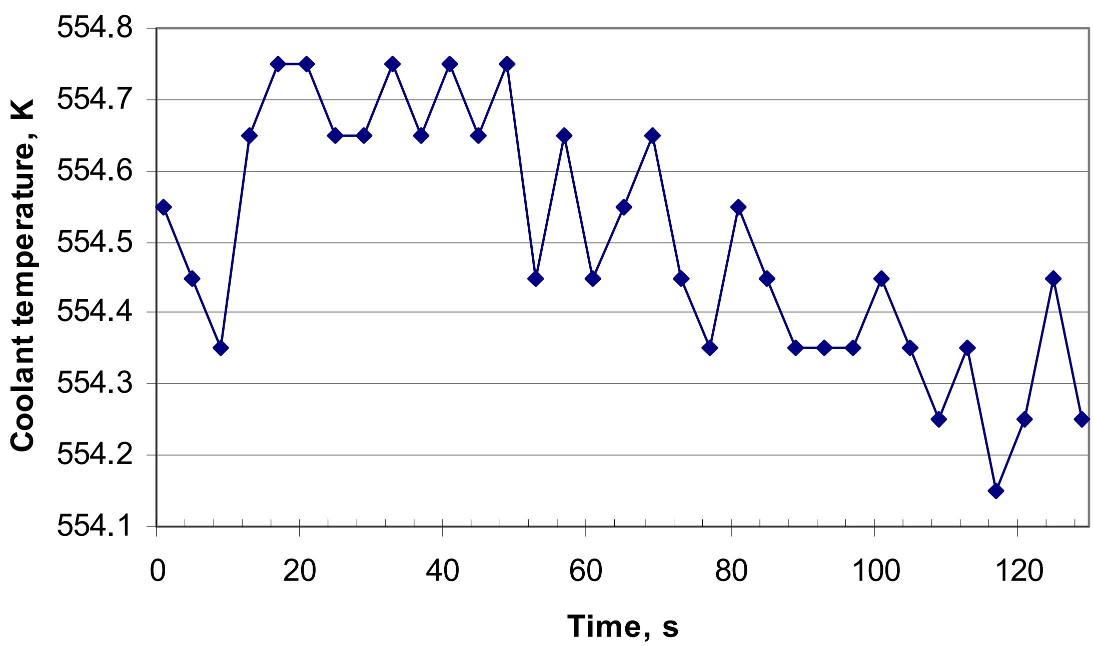


Table C.8. Cold leg #3 coolant temperature during the transient

Time, s	Temperature, K	Time, s	Temperature, K	Time, s	Temperature, K
1	554.35	45	554.55	89	554.85
5	554.25	49	554.65	93	554.85
9	554.35	53	554.55	97	554.65
13	554.35	57	554.75	101	554.55
17	554.05	61	554.85	105	554.55
21	553.75	65	554.75	109	554.65
25	554.05	69	554.75	113	554.55
29	554.15	73	554.75	117	554.75
33	554.35	77	554.65	121	554.45
37	554.55	81	554.65	125	554.45
41	554.75	85	554.65	129	554.45

Figure C.8. Cold leg #3 coolant temperature during the transient

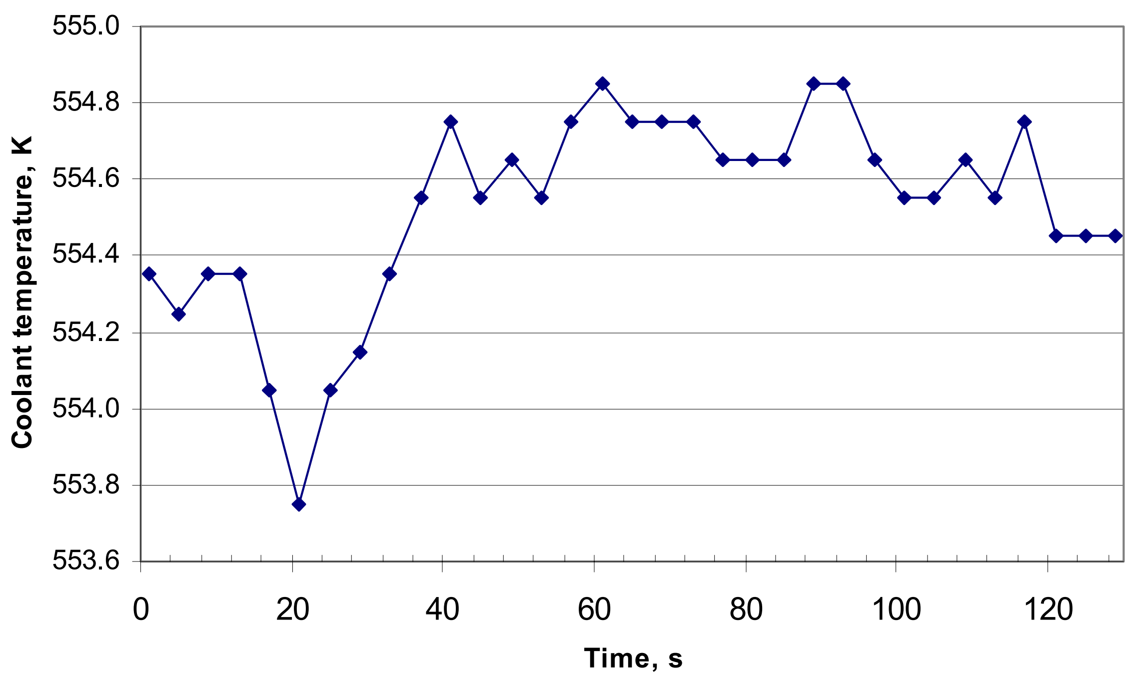


Table C.9. Cold leg #4 coolant temperature during the transient

Time, s	Temperature, K	Time, s	Temperature, K	Time, s	Temperature, K
1	555.25	45	554.65	89	554.35
5	555.25	49	554.75	93	554.35
9	555.25	53	554.55	97	554.45
13	555.25	57	554.55	101	554.25
17	555.25	61	554.45	105	554.15
21	555.15	65	554.65	109	554.25
25	555.15	69	554.55	113	554.35
29	555.05	73	554.55	117	554.25
33	554.95	77	554.45	121	554.45
37	554.95	81	554.45	125	554.55
41	554.65	85	554.65	129	554.25

Figure C.9. Cold leg #4 coolant temperature during the transient

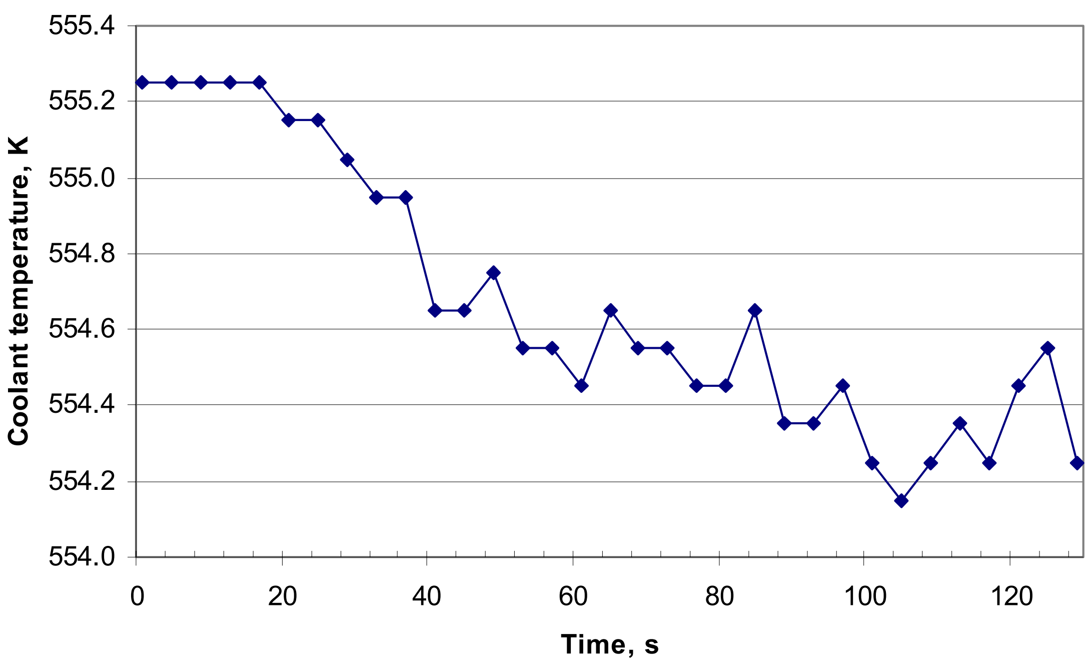


Table C.10. Hot leg #1 coolant temperature during the transient

Time, s	Temperature, K	Time, s	Temperature, K	Time, s	Temperature, K
1	567.05	45	564.45	89	563.65
5	567.05	49	564.35	93	563.65
9	566.95	53	564.15	97	563.55
13	566.85	57	563.75	101	563.65
17	566.35	61	563.85	105	563.65
21	566.15	65	563.85	109	563.65
25	565.85	69	563.75	113	563.65
29	565.15	73	563.65	117	563.65
33	564.75	77	563.75	121	563.65
37	564.85	81	563.65	125	563.65
41	564.55	85	563.65	129	563.55

Figure C.10. Hot leg #1 coolant temperature during the transient

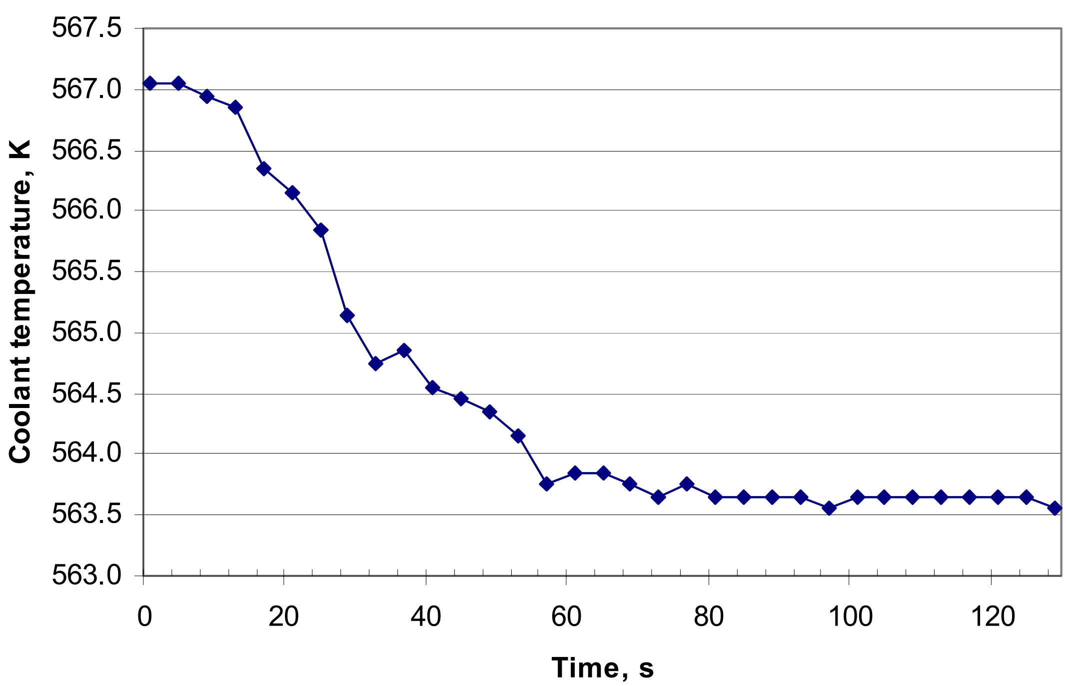


Table C.11. Hot leg #2 coolant temperature during the transient

Time, s	Temperature, K	Time, s	Temperature, K	Time, s	Temperature, K
1	562.85	45	563.05	89	562.75
5	562.65	49	563.05	93	562.65
9	562.85	53	562.75	97	562.65
13	563.15	57	562.65	101	562.65
17	563.45	61	562.65	105	562.45
21	563.55	65	562.55	109	562.45
25	563.45	69	562.65	113	562.65
29	563.45	73	562.65	117	562.45
33	563.35	77	562.65	121	562.55
37	563.05	81	562.65	125	562.65
41	563.05	85	562.75	129	562.65

Figure C.11. Hot leg #2 coolant temperature during the transient

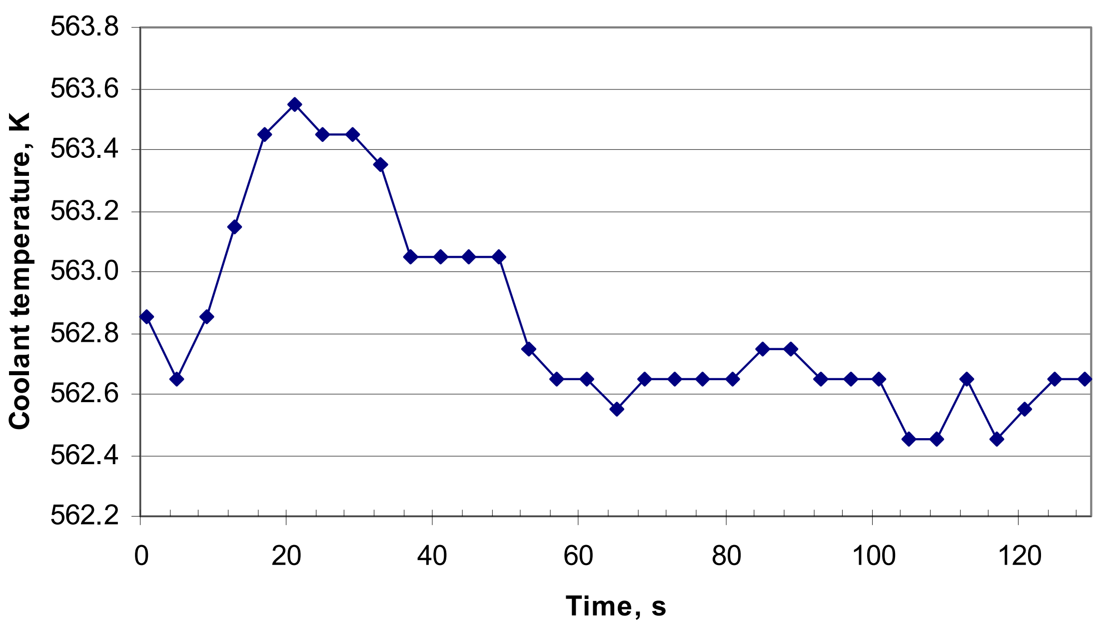


Table C.12. Hot leg #3 coolant temperature during the transient

Time, s	Temperature, K	Time, s	Temperature, K	Time, s	Temperature, K
1	550.75	45	561.45	89	562.65
5	550.75	49	561.85	93	562.35
9	550.95	53	562.05	97	562.55
13	551.95	57	562.35	101	562.55
17	556.55	61	562.35	105	562.65
21	557.25	65	562.45	109	562.35
25	558.05	69	562.55	113	562.45
29	559.75	73	562.55	117	562.75
33	559.95	77	562.65	121	562.65
37	560.65	81	562.45	125	562.45
41	561.45	85	562.65	129	562.65

Figure C.12. Hot leg #3 coolant temperature during the transient

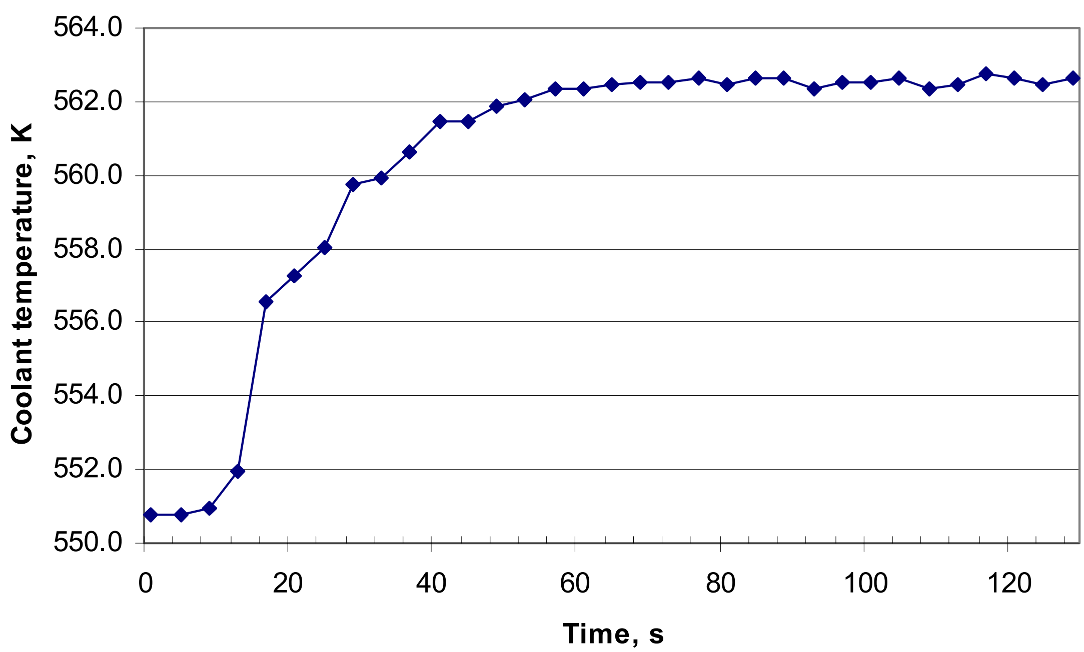


Table C.13. Hot leg #4 coolant temperature during the transient

Time, s	Temperature, K	Time, s	Temperature, K	Time, s	Temperature, K
1	566.15	45	563.15	89	563.15
5	566.15	49	563.15	93	563.15
9	566.15	53	563.15	97	563.15
13	565.15	57	563.15	101	563.15
17	565.15	61	563.15	105	563.15
21	564.15	65	563.15	109	563.15
25	564.15	69	563.15	113	563.15
29	564.15	73	563.15	117	563.15
33	563.15	77	563.15	121	563.15
37	563.15	81	563.15	125	563.15
41	563.15	85	563.15	129	563.15

Figure C.13. Hot leg #4 coolant temperature during the transient

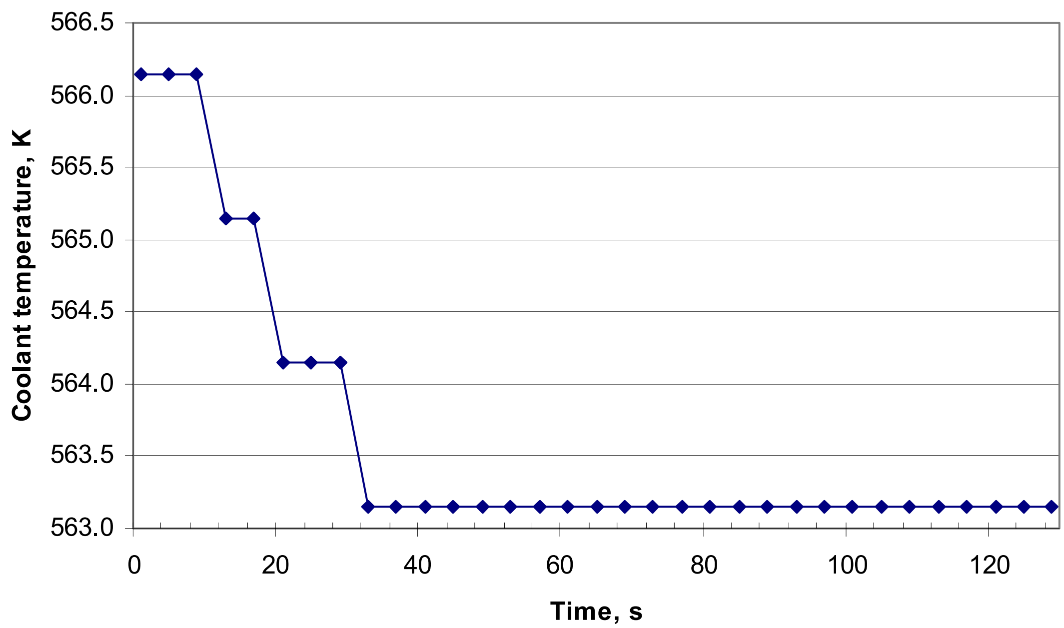


Table C.14. Pressure above the core

Time, s	Pressure, MPa	Time, s	Pressure, MPa	Time, s	Pressure, MPa
0	15.60	44	15.53	88	15.54
4	15.60	48	15.54	92	15.54
8	15.59	52	15.54	96	15.53
12	15.53	56	15.54	100	15.54
16	15.53	60	15.54	104	15.53
20	15.53	64	15.54	108	15.53
24	15.54	68	15.54	112	15.54
28	15.54	72	15.54	116	15.53
32	15.54	76	15.53	120	15.54
36	15.54	80	15.53	124	15.54
40	15.54	84	15.54	128	15.54

Figure C.14. Pressure above the core

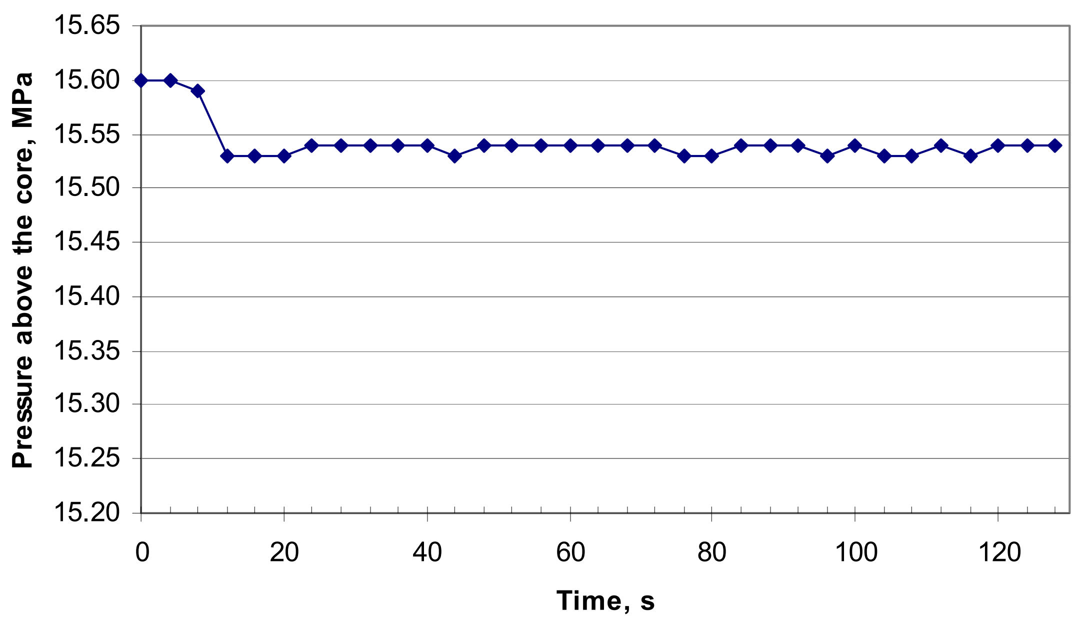


Table C.15. Reactor pressure drop

Time, s	Pressure, MPa	Time, s	Pressure, MPa	Time, s	Pressure, MPa
0	0.225	44	0.400	88	0.399
4	0.235	48	0.399	92	0.399
8	0.313	52	0.397	96	0.400
12	0.380	56	0.402	100	0.400
16	0.397	60	0.401	104	0.398
20	0.397	64	0.399	108	0.398
24	0.400	68	0.400	112	0.399
28	0.398	72	0.397	116	0.398
32	0.399	76	0.399	120	0.400
36	0.397	80	0.398	124	0.400
40	0.399	84	0.396	128	0.399

Figure C.15. Reactor pressure drop

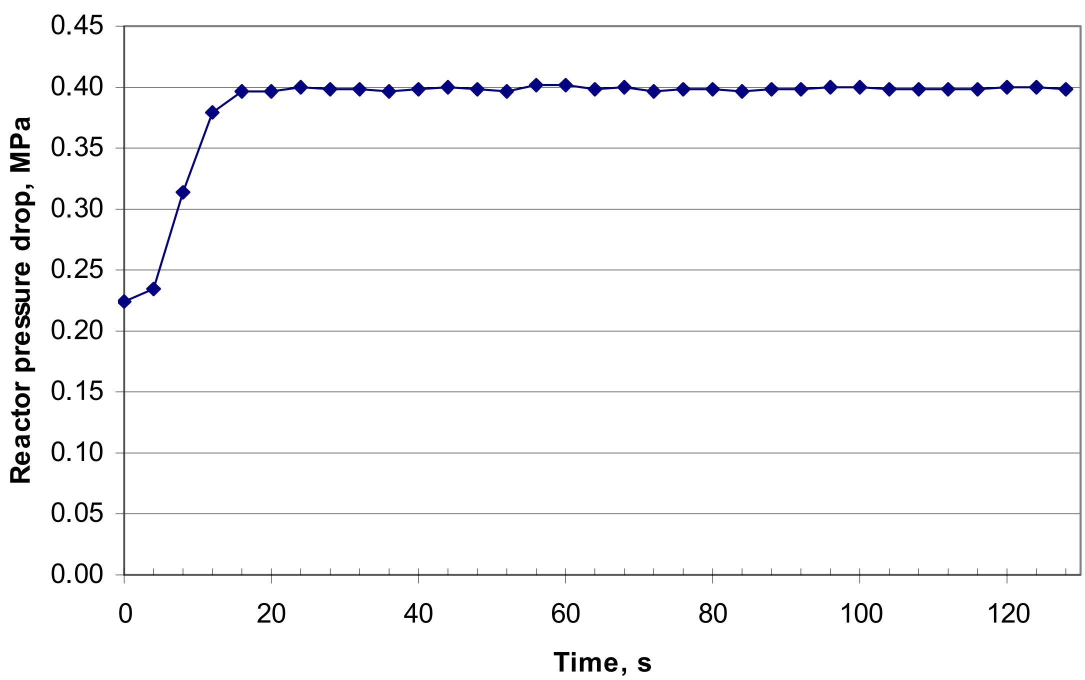


Table C.16. MCP #1 pressure drop

Time, s	Pressure, MPa	Time, s	Pressure, MPa	Time, s	Pressure, MPa
0	0.492	44	0.614	88	0.613
4	0.495	48	0.614	92	0.612
8	0.533	52	0.613	96	0.612
12	0.612	56	0.610	100	0.612
16	0.614	60	0.613	104	0.611
20	0.611	64	0.612	108	0.612
24	0.611	68	0.611	112	0.611
28	0.612	72	0.611	116	0.610
32	0.615	76	0.612	120	0.610
36	0.617	80	0.615	124	0.611
40	0.614	84	0.615	128	0.610

Figure C.16. MCP #1 pressure drop

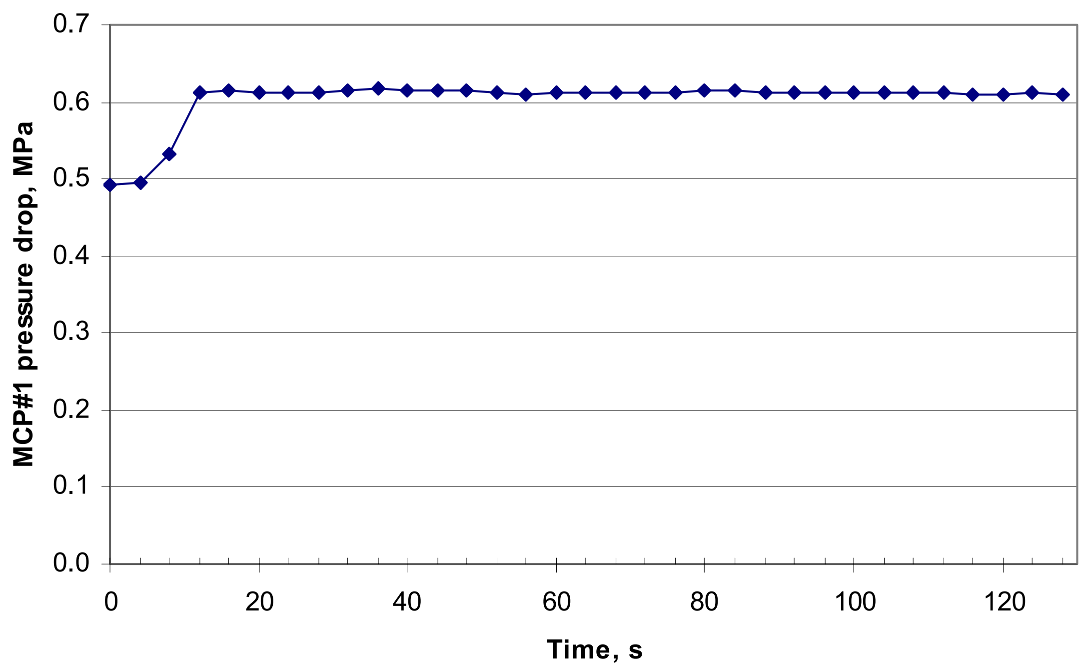


Table C.17. MCP #2 pressure drop

Time, s	Pressure, MPa	Time, s	Pressure, MPa	Time, s	Pressure, MPa
0	0.469	44	0.596	88	0.605
4	0.475	48	0.600	92	0.608
8	0.472	52	0.608	96	0.608
12	0.562	56	0.602	100	0.605
16	0.598	60	0.601	104	0.607
20	0.600	64	0.601	108	0.615
24	0.611	68	0.603	112	0.597
28	0.595	72	0.588	116	0.594
32	0.608	76	0.604	120	0.595
36	0.593	80	0.604	124	0.603
40	0.593	84	0.590	128	0.600

Figure C.17. MCP #2 pressure drop

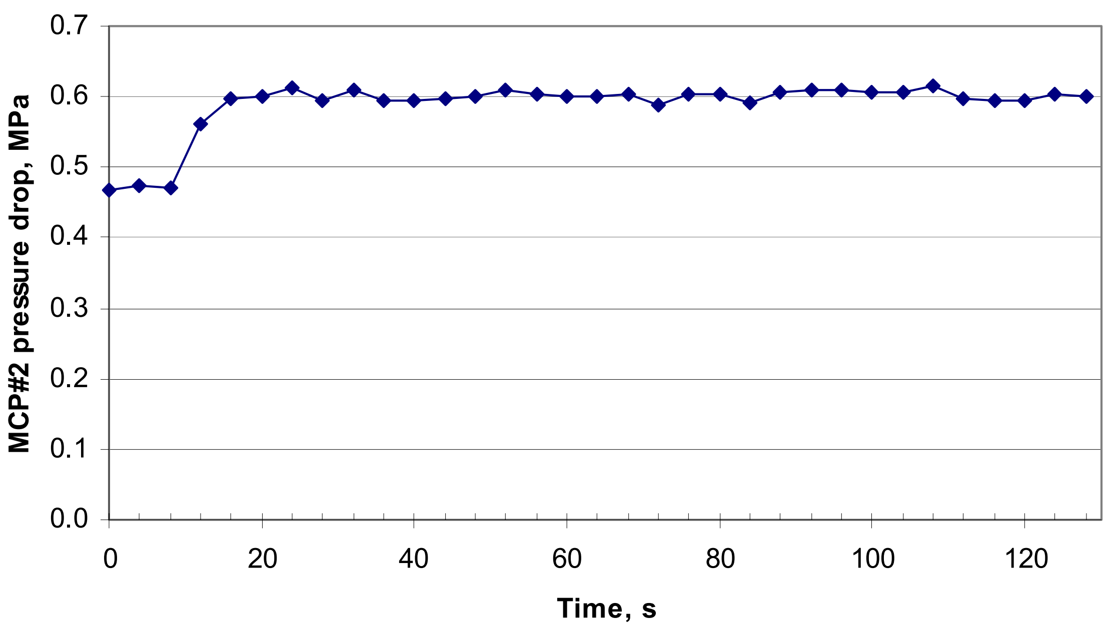


Table C.18. MCP #3 pressure drop

Time, s	Pressure, MPa	Time, s	Pressure, MPa	Time, s	Pressure, MPa
0	0.179	44	0.632	88	0.609
4	0.244	48	0.632	92	0.609
8	0.395	52	0.607	96	0.610
12	0.608	56	0.607	100	0.610
16	0.605	60	0.606	104	0.612
20	0.605	64	0.607	108	0.609
24	0.610	68	0.607	112	0.610
28	0.608	72	0.624	116	0.607
32	0.609	76	0.613	120	0.607
36	0.609	80	0.605	124	0.611
40	0.602	84	0.607	128	0.610

Figure C.18. MCP #3 pressure drop

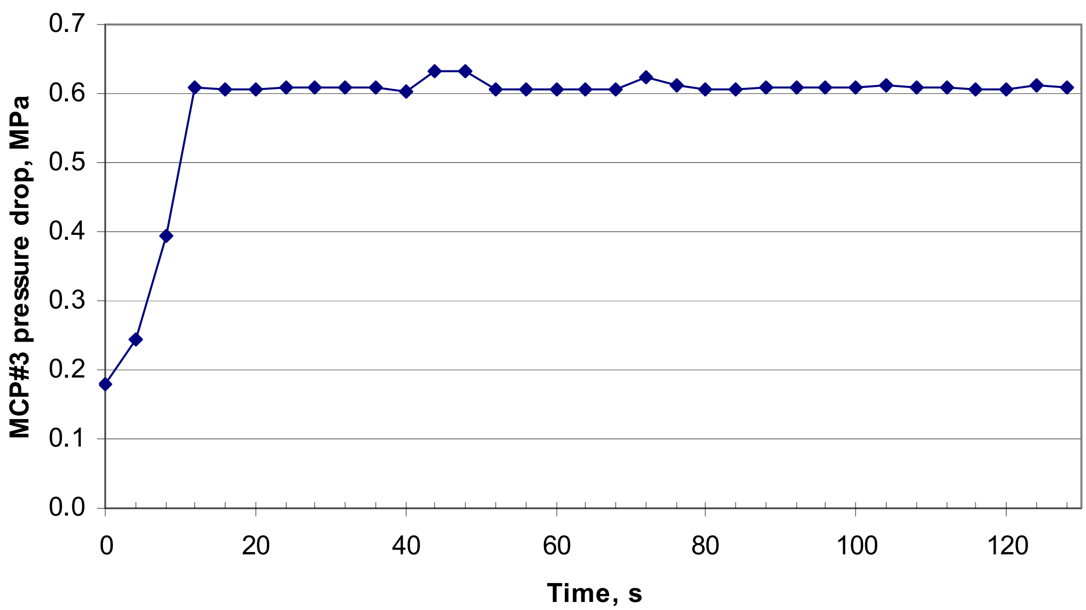
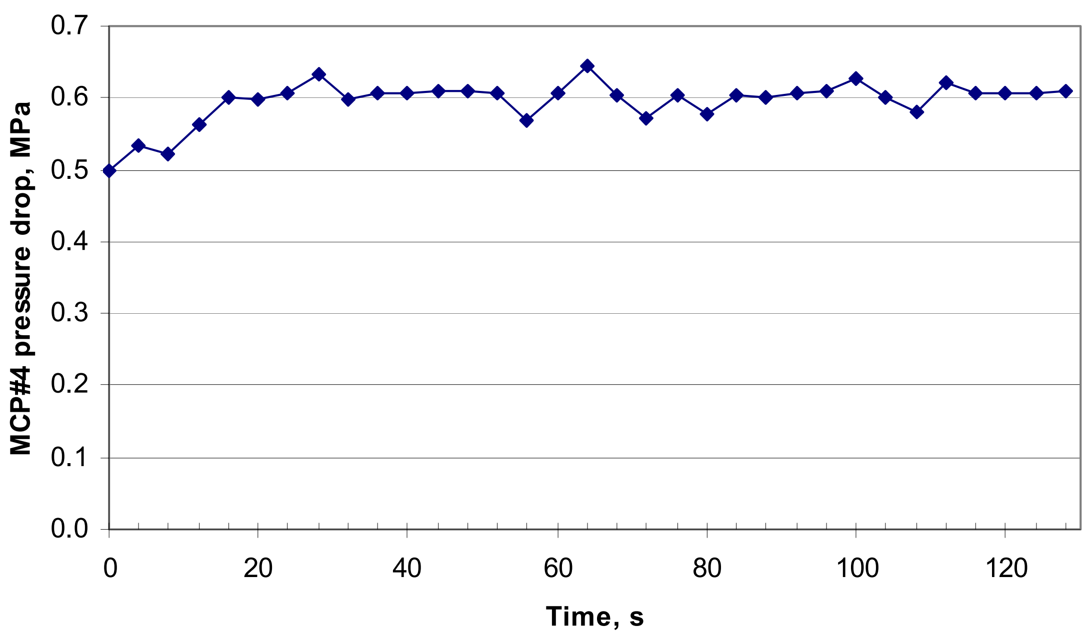


Table C.19. MCP #4 pressure drop

Time, s	Pressure, MPa	Time, s	Pressure, MPa	Time, s	Pressure, MPa
0	0.500	44	0.610	88	0.602
4	0.535	48	0.609	92	0.607
8	0.522	52	0.607	96	0.611
12	0.564	56	0.569	100	0.626
16	0.600	60	0.607	104	0.600
20	0.599	64	0.645	108	0.581
24	0.608	68	0.605	112	0.620
28	0.634	72	0.571	116	0.607
32	0.599	76	0.603	120	0.607
36	0.607	80	0.578	124	0.606
40	0.608	84	0.603	128	0.610

Figure C.19. MCP #4 pressure drop



Appendix D

RELAP5 BASE INPUT

```
*                          2 0 0 1                                       *
*                       relap5/mod3.2                                    *
*                          October                                       *
*                           INRNE                                        *
*             Safety Group Manager Pavlin Groudev                        *
*               VVER - 1000, NPP Kozloduy                                *
*                        100% Power                                      *
*  This problem has four loops for primary side and four loops for      *
*                      secondary side.                                   *
*========================================== ====*
*
=relap5/mod3   vver-1000
*crdno     problem type     option
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
100              new     stdy-st * transnt
101       run
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
**crdno   time1   time2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
105       1.    3.
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
110     nitrogen
115       1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
**crdno end time  min dt   max dt  control  minor ed  major ed  restart
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
201     200.    1.0-9     0.02   003      100   1000   1000
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*202    1000.0   1.0-6     0.01    003     200   100000    100000
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
20800001  dt     0
20800002  dtcrnt 0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*
*           * R E A C T O R   V E S S E L *                  *
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 107  upper part of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1070000       udca  branch
1070001   2         0
1070101   0.5466     0.850    0     0  -90.0    -0.850  4.3-5    0.366   0
1070200   110        16038077.  1248537. 2434747. 0.   .00696915
1071101   145050002  107010003       0         0.5       0.7    0001001
1072101   107010002  108010001       0         0.05      0.05 0001000
1071201   10.50314   10.50314  0. * 4484.91
1072201   10.46208   11.07017  0. * 4475.34
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 207  upper part of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2070000       udca  branch
2070001   2         0
2070101   0.5466    0.850    0     0  -90.0    -0.850  4.3-5    0.366   0
2070200   110       16038077.  1248683. 2434747. 0.   .00696892
2071101   245050002 207010003       0         0.5       0.7    0001001
2072101   207010002 208010001       0         0.05      0.05 0001000
2071201   10.48974   10.48974 0. * 4478.88
2072201   10.46239   11.07047 0. * 4475.17
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 327 upper part of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3270000       udca  branch
3270001   2         0
3270101   0.5466    0.850    0     0  -90.0    -0.850  4.3-5    0.366   0
3270200   110       16038077.  1248658. 2434747. 0.   .00696892
3271101   345050002 327010003       0         0.5       0.7    0001001
3272101   327010002 308010001       0         0.05      0.05 0001000
3271201   10.48975   10.48975 0. * 4478.92
3272201   10.46232   11.0704  0. * 4475.19
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 407 upper part of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4070000       udca  branch
4070001   2         0
4070101   0.5466    0.850    0     0  -90.0    -0.850  4.3-5    0.366   0
4070200   110       16038077.  1248619. 2434747. 0.   .00696891
4071101   445050002 407010003       0         0.5       0.7    0001001
4072101   407010002 408010001       0         0.05      0.05 0001000
4071201   10.4721    10.4721  0. * 4471.48
4072201   10.46222   11.0703  0. * 4475.23
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 108 lower part of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1080000       ldca  annulus
1080001     13
1080101     0.5466                            2
1080102     0.8                               13
```

```
1080301   0.445                1
1080302   0.75                 2
1080303   0.44125              10
1080304   0.29                 11
1080305   0.566                12
1080306   0.967                13
1080601   -90.0                13
1080801   4.0-5   0.366        2
1080802   4.0-5   0.526        13
1080901   0.0   0.0            12
1081601   0.16287              1
1081602   0.2745               2
1081603   0.2321               10
1081604   0.15254              11
1081605   0.29772              12
1081606   0.50864              13
1082301   4.0-5   .366         2
1082302   4.0-5   .526         13
1081001   0                    13
1081101   0001000              12
1081201   110      15998970.  1248541. 2435799. 0. 0. 1
1081202   110      16002588.  1248549. 2435702. 0. 0. 2
1081203   110      16026774.  1248554. 2435051. 0. 0. 3
1081204   110      16029831.  1248558. 2434969. 0. 0. 4
1081205   110      16032887.  1248562. 2434887. 0. 0. 5
1081206   110      16035943.  1248565. 2434805. 0. 0. 6
1081207   110      1.6039+7   1248567. 2434723. 0. 0. 7
1081208   110      16042055.  1248569. 2434641. 0. 0. 8
1081209   110      16045112.  1248571. 2434558. 0. 0. 9
1081210   110      16048168.  1248572. 2434476. 0. 0. 10
1081211   110      16050700.  1248572. 2434408. 0. 0. 11
1081212   110      16056102.  1248573. 2434263. 0. 0. 12
1081213   110      16061401.  1248573. 2434121. 0. 0. 13
1082001   .00696915            1
1082002   .00696915            2
1082003   .00696915            3
1082004   .00696915            4
1082005   .00696915            5
1082006   .00696915            6
1082007   .00696915            7
1082008   .00696915            8
1082009   .00696915            9
1082010   .00696915            10
1082011   .00696915            11
1082012   .00696915            12
1082013   .00696915            13
1081300   0
1081301   10.4626    10.95408    0.     1 * 4475.34
1081302   10.46272   10.99858    0.     2 * 4475.39
1081303   7.43488    7.88111     0.     3 * 4475.4
1081304   7.43489    7.88107     0.     4 * 4475.42
1081305   7.4349     7.88103     0.     5 * 4475.43
1081306   7.4349     7.88099     0.     6 * 4475.44
1081307   7.4349     7.88095     0.     7 * 4475.46
1081308   7.4349     7.8809      0.     8 * 4475.47
1081309   7.4349     7.88085     0.     9 * 4475.48
1081310   7.43489    7.88079     0.     10 * 4475.49
1081311   7.4349     7.88076     0.     11 * 4475.51
1081312   7.4349     7.87932     0.     12 * 4475.54
1081401      0.366     1.0    2.0    1.0     2 * 1520.63
1081402      0.526     1.0    2.0    1.0     12 * 1520.63
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 208 lower part of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2080000     ldca  annulus
2080001     13
2080101   0.5466               2
2080102   0.8                  13
2080301   0.445                1
2080302   0.75                 2
2080303   0.44125              10
2080304   0.29                 11
2080305   0.566                12
2080306   0.967                13
2080601   -90.0                13
2080801   4.0-5  0.366         2
2080802   4.0-5  0.526         13
2080901   0.0    0.0           12
2081601   0.16287              1
2081602   0.2745               2
2081603   0.2321               10
2081604   0.15254              11
2081605   0.29772              12
2081606   0.50864              13
2082301   4.0-5   .366         2
2082302   4.0-5   .526         13
```

```
2081001   0                      13
2081101   0001000                12
2081201   110   15998970.  1248686. 2435799. 0. 0. 1
2081202   110   16002588.  1248694. 2435702. 0. 0. 2
2081203   110   16026774.  1248699. 2435051. 0. 0. 3
2081204   110   16029831.  1248703. 2434969. 0. 0. 4
2081205   110   16032887.  1248707. 2434887. 0. 0. 5
2081206   110   16035943.  1248710. 2434805. 0. 0. 6
2081207   110   1.6039+7   1248712. 2434723. 0. 0. 7
2081208   110   16042055.  1248714. 2434641. 0. 0. 8
2081209   110   16045112.  1248716. 2434558. 0. 0. 9
2081210   110   16048168.  1248716. 2434476. 0. 0. 10
2081211   110   16050700.  1248717. 2434408. 0. 0. 11
2081212   110   16056102.  1248718. 2434263. 0. 0. 12
2081213   110   16061401.  1248718. 2434121. 0. 0. 13
2082001   .00696892                1
2082002   .00696892                2
2082003   .00696892                3
2082004   .00696892                4
2082005   .00696892                5
2082006   .00696892                6
2082007   .00696892                7
2082008   .00696892                8
2082009   .00696892                9
2082010   .00696892                10
2082011   .00696892                11
2082012   .00696892                12
2082013   .00696892                13
2081300   0
2081301   10.46292   10.9544    0.    1 * 4475.17
2081302   10.46285   10.9987    0.    2 * 4475.14
2081303   7.43494    7.88116    0.    3 * 4475.13
2081304   7.43491    7.88108    0.    4 * 4475.125
2081305   7.43488    7.881      0.    5 * 4475.12
2081306   7.43484    7.88092    0.    6 * 4475.11
2081307   7.43481    7.88084    0.    7 * 4475.1
2081308   7.43477    7.88076    0.    8 * 4475.09
2081309   7.43473    7.88067    0.    9 * 4475.08
2081310   7.4347     7.88059    0.    10 * 4475.075
2081311   7.43466    7.8805     0.    11 * 4475.06
2081312   7.43458    7.87898    0.    12 * 4475.04
2081401      0.366   1.0   2.0   1.0    1 * 1520.63
2081402      0.526   1.0   2.0   1.0    12 * 1520.63
```

```
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 308 lower part of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3080000    ldca  annulus
3080001     13
3080101    0.5466               2
3080102    0.8                  13
3080301    0.445                1
3080302    0.75                 2
3080303    0.44125              10
3080304    0.29                 11
3080305    0.566                12
3080306    0.967                13
3080601   -90.0                 13
3080801    4.0-5   0.366        2
3080802    4.0-5   0.526        13
3080901    0.0    0.0           12
3081601    0.16287              1
3081602    0.2745               2
3081603    0.2321               10
3081604    0.15254              11
3081605    0.29772              12
3081606    0.50864              13
3082301    4.0-5   .366         2
3082302    4.0-5   .526         13
3081001    0                    13
3081101   0001000               12
3081201   110   15998970.  1248661. 2435799. 0. 0. 1
3081202   110   16002588.  1248670. 2435702. 0. 0. 2
3081203   110   16026774.  1248674. 2435051. 0. 0. 3
3081204   110   16029831.  1248678. 2434969. 0. 0. 4
3081205   110   16032887.  1248682. 2434887. 0. 0. 5
3081206   110   16035943.  1248685. 2434805. 0. 0. 6
3081207   110   1.6039+7   1248688. 2434723. 0. 0. 7
3081208   110   16042055.  1248690. 2434641. 0. 0. 8
3081209   110   16045112.  1248691. 2434558. 0. 0. 9
3081210   110   16048168.  1248692. 2434476. 0. 0. 10
3081211   110   16050700.  1248692. 2434408. 0. 0. 11
3081212   110   16056102.  1248694. 2434263. 0. 0. 12
3081213   110   16061401.  1248694. 2434121. 0. 0. 13
3082001   .00696892                1
3082002   .00696892                2
3082003   .00696892                3
```

```
3082004    .00696892                              4
3082005    .00696892                              5
3082006    .00696892                              6
3082007    .00696892                              7
3082008    .00696892                              8
3082009    .00696892                              9
3082010    .00696892                              10
3082011    .00696892                              11
3082012    .00696892                              12
3082013    .00696892                              13
3081300     0
3081301    10.46286   10.95433      0.        1 * 4475.19
3081302    10.4628    10.99866      0.        2 * 4475.17
3081303    7.43491    7.88113       0.        3 * 4475.17
3081304    7.43489    7.88106       0.        4 * 4475.16
3081305    7.43486    7.88099       0.        5 * 4475.16
3081306    7.43484    7.88092       0.        6 * 4475.15
3081307    7.43481    7.88084       0.        7 * 4475.15
3081308    7.43478    7.88076       0.        8 * 4475.14
3081309    7.43475    7.88068       0.        9 * 4475.14
3081310    7.43472    7.8806        0.       10 * 4475.134
3081311    7.43468    7.88053       0.       11 * 4475.13
3081312    7.43462    7.87902       0.       12 * 4475.12
3081401       0.366      1.0    2.0    1.0      1 * 1520.63
3081402       0.526      1.0    2.0    1.0     12 * 1520.63
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 408 lower part of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4080000      ldca  annulus
4080001       13
4080101     0.5466                         2
4080102     0.8                           13
4080301     0.445                          1
4080302     0.75                           2
4080303     0.44125                       10
4080304     0.29                          11
4080305     0.566                         12
4080306     0.967                         13
4080601    -90.0                          13
4080801     4.0-5   0.366                  2
4080802     4.0-5   0.526                 13
4080901     0.0     0.0                   12
4081601     0.16287                        1
4081602     0.2745                         2
4081603     0.2321                        10
4081604     0.15254                       11
4081605     0.29772                       12
4081606     0.50864                       13
4082301     4.0-5   .366                   2
4082302     4.0-5   .526                  13
4081001     0                             13
4081101    0001000                        12
4081201    110        15998970.  1248623. 2435799. 0. 0. 1
4081202    110        16002588.  1248631. 2435702. 0. 0. 2
4081203    110        16026774.  1248636. 2435051. 0. 0. 3
4081204    110        16029831.  1248640. 2434969. 0. 0. 4
4081205    110        16032887.  1248643. 2434887. 0. 0. 5
4081206    110        16035943.  1248646. 2434805. 0. 0. 6
4081207    110        1.6039+7   1248649. 2434723. 0. 0. 7
4081208    110        16042055.  1248651. 2434641. 0. 0. 8
4081209    110        16045112.  1248652. 2434558. 0. 0. 9
4081210    110        16048168.  1248653. 2434476. 0. 0. 10
4081211    110        16050700.  1248654. 2434408. 0. 0. 11
4081212    110        16056102.  1248655. 2434263. 0. 0. 12
4081213    110        16061401.  1248655. 2434121. 0. 0. 13
4082001    .00696892                              1
4082002    .00696891                              2
4082003    .00696891                              3
4082004    .00696891                              4
4082005    .00696891                              5
4082006    .00696891                              6
4082007    .00696891                              7
4082008    .00696891                              8
4082009    .00696891                              9
4082010    .00696891                              10
4082011    .00696891                              11
4082012    .00696891                              12
4082013    .00696891                              13
4081300     0
4081301    10.46276   10.95423      0.        1 * 4475.23
4081302    10.46273   10.9986       0.        2 * 4475.23
4081303    7.43487    7.8811        0.        3 * 4475.23
4081304    7.43486    7.88104       0.        4 * 4475.23
4081305    7.43484    7.88097       0.        5 * 4475.23
4081306    7.43483    7.88091       0.        6 * 4475.23
4081307    7.43481    7.88085       0.        7 * 4475.23
```

```
4081308    7.43479    7.88078        0.          8 * 4475.23
4081309    7.43477    7.88071        0.          9 * 4475.23
4081310    7.43474    7.88064        0.         10 * 4475.23
4081311    7.43472    7.88058        0.         11 * 4475.23
4081312    7.43468    7.87909        0.         12 * 4475.24
4081401         0.366       1.0     2.0    1.0        1  * 1520.63
4081402         0.526       1.0     2.0    1.0       12  * 1520.63
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 116 Appendix of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1160000       udca  branch
1160001   1         0
1160101   0.00      0.95000  0.5058  0  90.0  0.95000  4.3-5  0.356   0
1160200   110       16031430.  1255905.  2434926.  0.  .00696864
1161101   116010001 107010001      0           0.        0.  100
1161201   -.01101321  -.01181298   0. * -3.314757
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 216 Appendix of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2160000       udca  branch
2160001   1         0
2160101   0.00      0.95000  0.5058  0  90.0   0.95000 4.3-5  0.356   0
2160200   110       16031430.  1256041. 2434926. 0.  .00696835
2161101   216010001 207010001       0         0.        0.  100
2161201   -.0110136   -.01181342  0. * -3.31465
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 316 Appendix of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3160000       udca  branch
3160001   1         0
3160101   0.00      0.95000  0.5058 0  90.0   0.95000  4.3-5  0.356   0
3160200   110       16031430.  1256019. 2434926. 0.  .00696835
3161101   316010001 327010001       0         0.        0.  100
3161201   -.01101354  -.01181334  0. * -3.31467
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 416 Appendix of downcomer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4160000       udca  branch
4160001   1         0
4160101   0.0       0.95000  0.5058  0  90.0   0.95000  4.3-5  0.356  0
4160200   110       16031430.  1255983. 2434926. 0.  .00696834
4161101   416010001 407010001       0         0.        0.  100
4161201   -.01101343  -.01181322  0. * -3.314695
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 830  lower plenum - mixing cammer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*crdno        name         type
8300000   lplenum   branch
8300001        3       0
8300101  0.0   0.56600 5.352    0.   90.0    0.56600 4.3-5   0.0     0
8300200    110         15967053.   1248658.  2436659.  0.    .00696897
8301101  830010002     843010001        0         3.2      3.25 0011000
8302101  830010002     845010001        0         3.2      3.25 0011000
8303101  830010002     842010001        0         3.2      3.25 0011000
8301201       4.46199     4.97555  0. * 15886.
8302201       3.79407     4.14451  0. * 1488.927
8303201       3.72233     4.02448  0. * 526.01
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 829  lower plenum - elept. botom
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*crdno        name         type
8290000   lplenum   branch
8290001        5       0
8290101  0.0   .96700  3.5757    0.  90.0      .96700 4.3-5    0.0     0
8290200    110        16023877.   1248660.  2435129.  0.   .00696897
8291101  108130004     829010003        0.8       2.5       2.6   0031003
8292101  208130004     829010003        0.8       2.5       2.6   0031003
8293101  308130004     829010003        0.8       2.5       2.6   0031003
8294101  408130004     829010003        0.8       2.5       2.6   0031003
8295101  829010002     830010001        3.2       3.3       3.4   0001000
8291201       7.4345      7.4345  0. * 4475.33
8292201       7.43474     7.43474 0. * 4475.17
8293201       7.4347      7.4347  0. * 4475.2
8294201       7.43464     7.43464 0. * 4475.24
8295201       7.435       8.0732  0. * 17900.93
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*      Reactor Core
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 843  core - average channel
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
8430000   core      pipe
8430001         10
8430101       4.44985                           1
8430102       3.8165                            9
8430103       7.5192                           10
8430301       0.29000                           1
```

```
8430302     0.44125                         9
8430303     0.75000                        10
8430601    90.0                            10
8430801     4.4-5     0.3                   1
8430802     1.50-5    0.00964                  9
8430803     4.4-5     0.3                  10
8430901     0.52      0.52                  9
8431001     100                            10
8431101     0001000                         9
8431201          110        15956308. 1248658.  2436949. 0. 0. 1
8431202          110        15935335.  1265960. 2437516. 0. 0. 2
8431203          110        15915043.  1289233. 2438064. 0. 0. 3
8431204          110        15894540.  1313326. 2438577. 0. 0. 4
8431205          110        15873852.  1337172. 2439059. 0. 0. 5
8431206          110        15852977.  1360240. 2439546. 0. 0. 6
8431207          110        15831914.  1382635. 2440038. 0. 0. 7
8431208          110        15810666.  1401763. 2440535. 0. 0. 8
8431209          110        15789274.  1414688. 2441036. 0. 0. 9
8431210          110        15770194.  1414680. 2441484. 0. 0. 10
8432001    .00696897                        1
8432002    .00696897                        2
8432003    .00696897                        3
8432004    .00696897                        4
8432005    .00696897                        5
8432006    .00696897                        6
8432007    .00696897                        7
8432008    .00696897                        8
8432009    .00696897                        9
8432010    .00696897                       10
8431300     0
8431301        5.71084     5.71084       0.         1 * 15886.
8431302        5.75831     5.75831       0.         2 * 15886.
8431303        5.82564     5.82564       0.         3 * 15886.
8431304        5.89825     5.89825       0.         4 * 15886.
8431305        5.974       5.974         0.         5 * 15886.
8431306        6.05149     6.05149       0.         6 * 15886.
8431307        6.12939     6.12939       0.         7 * 15886.
8431308        6.20076     6.20076       0.         8 * 15886.
8431309        6.5808      6.5808        0.         9 * 15886.
8431401        0.3         1.0     2.0    1.0       1 * 1520.63
8431402        0.0106      1.0     2.0    1.0       8 * 1520.63
8431403        0.3         1.0     2.0    1.0       9 * 1520.63
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
```

```
* Hot channel - 845-14 assemblies  8.589%, 8.3313%
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
8450000   core     pipe
8450001    10
8450101      .4181                          1
8450102      .3586                          9
8450103      .77238                        10
8450301     0.29000                         1
8450302     0.44125                         9
8450303     0.75000                        10
8450601    90.0                            10
8450801     4.4-5    0.3                    1
8450802     1.5-5    0.00964                   9
8450803     4.4-5    0.3                   10
8450901     0.52     0.52                   9
8451001    100                             10
8451101      0001000                        9
8451201          110        15958845. 1248658.  2436881. 0. 0. 1
8451202          110        15937977.  1271654. 2437444. 0. 0. 2
8451203          110        15917685.  1302584. 2437993. 0. 0. 3
8451204          110        15897104.  1334601. 2438517. 0. 0. 4
8451205          110        15876266.  1366281. 2439003. 0. 0. 5
8451206          110        15855159.  1396921. 2439495. 0. 0. 6
8451207          110        15833779.  1426650. 2439995. 0. 0. 7
8451208          110        15812109.  1452042. 2440502. 0. 0. 8
8451209          110        15790226.  1469195. 2441014. 0. 0. 9
8451210          110        15770759.  1469195. 2441470. 0. 0. 10
8452001     .00696897                       1
8452002     .00696897                       2
8452003     .00696897                       3
8452004     .00696897                       4
8452005     .00696897                       5
8452006     .00696897                       6
8452007     .00696897                       7
8452008     .00696897                       8
8452009     .00696897                       9
8452010     .00696897                      10
8451300     0
8451301        5.69651     5.69651       0.         1 * 1488.927
8451302        5.75987     5.75987       0.         2 * 1488.927
8451303        5.85098     5.85098       0.         3 * 1488.927
8451304        5.95042     5.95042       0.         4 * 1488.927
8451305        6.05643     6.05643       0.         5 * 1488.927
```

```
8451306        6.16631    6.16631      0.        6 * 1488.927
8451307        6.28162    6.28162      0.        7 * 1488.927
8451308        6.38641    6.38641      0.        8 * 1488.927
8451309        6.80265    6.80265      0.        9 * 1488.927
8451401        0.3        1.0     2.0    1.0        1 * 1520.63
8451402        0.0106     1.0     2.0    1.0        8 * 1520.63
8451403        0.3        1.0     2.0    1.0        9 * 1520.63
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  842 bypass
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
8420000   core      pipe
8420001     10
8420101      0.14604                         1
8420102       .1253                          9
8420103       .11883                         10
8420301      0.29000                         1
8420302      0.44125                         9
8420303      0.75000                         10
8420601     90.0                             10
8420801      4.4-5    0.3                    1
8420802      1.5-5    0.00964                9
8420803      4.4-5    0.3                    10
8420901      0.52     0.52                   9
8421001      0                               10
8421101     0001000                          9
8421201          110       15959294. 1248658.  2436869. 0. 0. 1
8421202          110       15937893.  1248674. 2437446. 0. 0. 2
8421203          110       15916250.  1248690. 2438031. 0. 0. 3
8421204          110       15894606.  1248706. 2438575. 0. 0. 4
8421205          110       15872962.  1248722. 2439080. 0. 0. 5
8421206          110       15851318.  1248738. 2439585. 0. 0. 6
8421207          110       15829673.  1248754. 2440091. 0. 0. 7
8421208          110       15808027.  1248770. 2440597. 0. 0. 8
8421209          110       15786381.  1248785. 2441104. 0. 0. 9
8421210          110       15767748.  1248785. 2441541. 0. 0. 10
8422001    .00696897                   1
8422002    .00696897                   2
8422003    .00696897                   3
8422004    .00696897                   4
8422005    .00696897                   5
8422006    .00696897                   6
8422007    .00696897                   7
8422008    .00696897                   8
8422009    .00696897                   9
8422010    .00696897                   10
8421300     0
8421301        5.58891     5.91884       0.        1 * 526.01
8421302        5.5891      5.5891        0.        2 * 526.01
8421303        5.58929     5.58929       0.        3 * 526.01
8421304        5.58949     5.58949       0.        4 * 526.01
8421305        5.58968     5.58968       0.        5 * 526.01
8421306        5.58988     5.58988       0.        6 * 526.01
8421307        5.59007     5.59007       0.        7 * 526.01
8421308        5.59026     5.59026       0.        8 * 526.01
8421309        5.88544     6.22669       0.        9 * 526.01
8421401        0.3        1.0     2.0    1.0        1 * 1520.63
8421402        0.009      1.0     2.0    1.0        8 * 1520.63
8421403        0.3        1.0     2.0    1.0        9 * 1520.63
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 850  upper mixing volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
8500000     uplenum branch
8500001       4      0
8500101  0.0   0.44500 3.68976   0   90.0    0.44500  4.2-5  0.0     0
8500200     110        15742177.   1414351.  2442141.  0.   .00696897
*crdno   from          to            area     floss     rloss     flag
8501101  843100002    850010001       3.51217   1.4       1.5 0101000
8502101  850010002    855010001       0.0       1.3       1.4 0001000
8503101  845100002    850010001        .33      1.4       1.5 0101000
8504101  842100002    850010001        .11883   1.4       1.5 0101000
8501201       6.58118         6.58118   0. * 15886.
8502201       2.010203        2.385275  0. * 17900.93
8503201       6.80316         6.80316   0. * 1488.927
8504201       5.88557         6.25179   0. * 526.01
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 855  down part of upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
8550000   core_up   pipe
8550001       2
8550101       8.2916                          2
8550301       0.85000                         1
8550302       0.95000                         2
8550601      90.0                             2
8550801       4.2-5    0.0                    2
8550901       0.4      0.45                   1
8551001       0                               2
```

```
8551101      0001000                              1
8551201           110        15736695.  1414346.  2442270. 0. 0. 1
8551202           110        15730625.  1414340.  2442413. 0. 0. 2
8552001     .00696897                           1
8552002     .00696896                           2
8551300    0
8551301         2.01022     2.385367       0.         1 * 17900.93
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 860  upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
8600000     uplenum branch
8600001        5       0
8600101  0.0   0.85000  10.04532  0   90.0   .85000     4.2-5  0.0     0
8600200     110        15724626.   1414223. 2442554. 0.  .00696896
*crdno   from          to            area     floss     rloss     flag
8601101  860010004     446010001        0.5675   0.10       0.15 0001002
8602101  860010004     146010001        0.5675   0.10       0.15 0001002
8603101  860010004     246010001        0.5675   0.10       0.15 0001002
8604101  860010004     346010001        0.5675   0.10       0.15 0001002
8605101  855020002     860010001        0.       0.25        .35 0001000
8601201        11.478           11.478    0. * 4477.64
8602201        11.4804          11.4804   0. * 4478.57
8603201        11.48118         11.4818   0. * 4478.88
8604201        11.4813          11.4813   0. * 4478.92
8605201         2.181915        2.56975  0. * 17900.94
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 870 upper part of upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
8700000   free-vol  branch
8700001   1         0
8700101   0.0       2.0      17.33224   .0       90.        2.0
8700102   4.0-5     0.0       00
8700200   110       15716146. 1407376.  2442753.  0.       .00695048 *
8701101   860010002 870010001 0.0        0.1      0.1       0001000
8701201   5.01044-5   5.01316-5   0. * .1722118
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 880 upper volume below reactor head
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
8800000   free-vol  branch
8800001   1         0
8800101   0.0       1.235    8.9         .0       90.       1.235
8800102   4.0-5     0.0       00
8800200   110       15705243. 1425958. 2443010.   0.       .00695
```

```
8801101   870010002 880010001 0.0        0.1      0.1       0001000
8801201   4.98199-5    4.98468-5   0. * .1719627
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Connection between down commer and outlet nozles
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
5610000  connec1   mtpljun
5610001  4         0
5610011  116010002  860010001  0.00035  5.      5.          001000
5610012  1.0        1.0        1.0   100000000 000000000    0       4
5611011  12.63057   12.63057     1 * 3.31479
5611021  12.63097   12.63098     2 * 3.31468
5611031  12.6309    12.6309      3 * 3.314696
5611041  12.6308    12.6308      4 * 3.31472
5612011  0.0001     0.0        1.0   1.0      4
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Crossflow connection in down commer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1530000  connec1   mtpljun
1530001  13        0
1530011  108010004  208010003   0.    0.3       0.3          001003
1530012  1.0        1.0        1.0   000010000 000010000    0      13
1531011  .003947944 .003947944  1 * .322594
1531021  .00532104  .00532104   2 * .4347924
1531031  .00417762  .00417762   3 * .467107
1531041  .0041834   .0041834    4 * .467754
1531051  .00418405  .00418405   5 * .467827
1531061  .00418535  .00418535   6 * .467974
1531071  .00418451  .00418451   7 * .4678815
1531081  .00418993  .00418993   8 * .468489
1531091  .004176    .004176     9 * .466932
1531101  .00421914  .00421914   10 * .471758
1531111  .002638923 .002638923  11 * .295069
1531121  .00788192  .00788192   12 * .881315
1531131  2.28188-4  2.28188-4   13 * .1373618
1532011  0.52       0.0        1.0   1.0      13
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Crossflow connection in down commer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1540000  connec1   mtpljun
1540001  13        0
1540011  208010004  308010003   0.    0.3       0.3          001003
1540012  1.0        1.0        1.0   000010000 000010000    0      13
1541011  .00394952  .00394952   1 * .322701
```

```
1541021  .00562994  .00562994   2 * .460003
1541031  .00426467  .00426467   3 * .476808
1541041  .00426479  .00426479   4 * .476821
1541051  .0042648   .0042648    5 * .4768235
1541061  .0042648   .0042648    6 * .476825
1541071  .00426474  .00426474   7 * .476819
1541081  .0042647   .0042647    8 * .476816
1541091  .00426424  .00426424   9 * .476766
1541101  .00426361  .00426361   10 * .476698
1541111  .00276     .00276      11 * .3085857
1541121  .00805219  .00805219   12 * .900292
1541131  1.488061-5 1.488061-5  13 * .00895704
1542011  0.52       0.0         1.0   1.0      13
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Crossflow connection in down commer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1550000  connec1   mtpljun
1550001  13        0
1550011  308010004  408010003   0.    0.3       0.3          001003
1550012  1.0        1.0         1.0   000010000 000010000    0       13
1551011  .00393116  .00393116   1 * .3212044
1551021  .00586485  .00586485   2 * .479202
1551031  .00431444  .00431444   3 * .482378
1551041  .00431133  .00431133   4 * .482031
1551051  .004311    .004311     5 * .481995
1551061  .00431026  .00431026   6 * .481913
1551071  .004310635 .004310635  7 * .481956
1551081  .00430748  .00430748   8 * .481605
1551091  .00431468  .00431468   9 * .482412
1551101  .00428905  .00428905   10 * .479547
1551111  .00282982  .00282982   11 * .3163955
1551121  .00814878  .00814878   12 * .911102
1551131  -1.19309-4 -1.19309-4  13 * -.0718174
1552011  0.52       0.0         1.0   1.0      13
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Crossflow connection in down commer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1560000  connec1   mtpljun
1560001  13        0
1560011  108010003  408010004   0.    0.3       0.3          001003
1560012  1.0        1.0         1.0   000010000 000010000    0       13
1561011  -.00388778 -.00388778  1 * -.317666
1561021  -.00595984 -.00595984  2 * -.486972
1561031  -.00430546 -.00430546  3 * -.4813825
1561041  -.00430294 -.00430294  4 * -.481101
1561051  -.00430269 -.00430269  5 * -.481075
1561061  -.00430209 -.00430209  6 * -.481009
1561071  -.004302404 -.004302404 7 * -.481045
1561081  -.00429983 -.00429983  8 * -.480759
1561091  -.0043057  -.0043057   9 * -.481416
1561101  -.00428441 -.00428441  10 * -.479038
1561111  -.002817344 -.002817344 11 * -.3150066
1561121  -.00813191 -.00813191  12 * -.909233
1561131  1.23975-4  1.23975-4   13 * .074629
1562011  0.52       0.0         1.0   1.0      13
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Crossflow connection
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1570000   junct1    sngljun
1570101   107010004 207010003 0.16      0.3       0.3       0001003
1570110   0.52      0.        1.        1.
1570201   0         .01411397 .01411397 0. * 1.69921
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Crossflow connection
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1580000   junct2    sngljun
1580101   207010004 327010003 0.16      0.3       0.3       0001003
1580110   0.52      0.        1.        1.
1580201   0         .0174236  .0174236 0. * 2.09752
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Crossflow connection
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1590000   junct3    sngljun
1590101   327010004 407010003 0.16      0.3       0.3       0001003
1590110   0.52      0.        1.        1.
1590201   0         .02088496 .02088496 0. * 2.51424
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Crossflow connection
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1600000   junct4    sngljun
1600101   407010004 107010003 0.16      0.3       0.3       0001003
1600110   0.52      0.        1.        1.
1600201   0         -.03780566 -.03780566 0. * -4.5515
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  146
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
```

```
1460000      hlega branch
1460001  1       0
1460101  0.5675   1.64    0     0    0.0     0.0     4.5-5   0.0     0
1460200  110   15656317. 1414221. 2444163. 0.  .00696896
1461101  146010002     140010001        0.5675    0.0       0.0  0001000
1461201   11.48194   11.48194 0. * 4478.57
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  140
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1400000      hlega branch
1400001  1       0
1400101  0.5675   5.87     0     0    0.0     0.0     4.5-5   0.0     0
1400200  110   15654351. 1414175. 2444209. 0.  .0069692
1401101  140010002     141010001        0.5675    0.0       0.0  0001000
1401201   11.48327   11.48327 0. * 4479.2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  141
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1410000    hot-leg  pipe
1410001        3
1410101    0.5675                          2
1410102    0.546                           3
1410301     1.71400                         1
1410302     1.54000                         2
1410303     0.67000                         3
1410601      0.0                           1
1410602     90.0                            2
1410603     90.0                            3
1410801       4.5-5  0.85                    3
1410901        .50    .5                     1
1410902        .0     .0                     2
1411001      0                              3
1411101      0001000                         2
1411201      110       15652181. 1414176. 2444260. 0. 0. 1
1411202      110       1.5637+7  1414177. 2444619. 0. 0. 2
1411203      110       15615815. 1414177. 2445119. 0. 0. 3
1412001      .0069692                            1
1412002      .0069692                            2
1412003      .0069692                            3
1411300      0
1411301    11.48333    11.48333      0.        1 * 4479.2
1411302    11.48368    12.1123       0.        2 * 4479.2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
```

```
*  Cold leg, loop # 1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  142
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1420000     cold-leg      pipe
1420001         7
1420101    0.546                           1
1420102    0.5675                           7
1420301     0.67000                         1
1420302     3.34000                         2
1420303     3.26000                         3
1420304     1.94670                         4
1420305     1.94670                         5
1420306     1.94670                         6
1420307     3.26000                         7
1420601     -90.0                          1
1420602     -90.0                          3
1420603     0.0                            6
1420604     90.0                           7
1420801     4.5-5    0.85                    7
1420901       0.0    0.0                   2
1420902       0.5    0.5                   3
1420903       0.0    0.0                   5
1420904       0.5    0.5                   6
1421001      0                            7
1421101      0001000                        6
1421201      110       15444803. 1248350. 2449182. 0. 0. 1
1421202      110       15456869. 1248219. 2448894. 0. 0. 2
1421203      110       15456869. 1248219. 2448894. 0. 0. 3
1421204      110       15456869. 1248219. 2448894. 0. 0. 4
1421205      110       15461203. 1248224. 2448791. 0. 0. 5
1421206      110       15461203. 1248224. 2448791. 0. 0. 6
1421207      110       15430132. 1248225. 2449532. 0. 0. 7
1422001      .00696919                           1
1422002      .00696916                           2
1422003      .00696916                           3
1422004      .00696916                           7
1421300      0
1421301    10.49648    11.11749      0.        1 * 4479.2
1421302    10.51012    11.13133      0.        3 * 4485.365
1421303    10.51009    10.51009      0.        6 * 4485.365
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  145
```

```
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1450000      clega pipe
1450001        5
1450101   0.5675                          5
1450301     2.3080                        5
1450601     0.0                         5
1450801      4.5-5  0.85                  5
1450901       .05   .05                 1
1450902       .05   .05                 2
1450903       .05   .05                 3
1450904       .05    .05                4
1451001     0                           5
1451101     0001000                      4
1451201     110       16030824. 1248669.  2434942. 0. 0. 1
1451202     110       16027641. 1248670.  2435028. 0. 0. 2
1451203     110       16024433. 1248672.  2435114. 0. 0. 3
1451204     110       16021225. 1248673.  2435200. 0. 0. 4
1451205     110       16018017. 1248675.  2435287. 0. 0. 5
1452001    .00696893                      1
1452002    .00696893                      2
1452003    .00696893                      3
1452004    .00696893                      4
1452005    .00696892                      5
1451300     0
1451301    10.48955   10.48955     0.        1 * 4478.88
1451302    10.4896    10.4896      0.        2 * 4478.88
1451303    10.48965   10.48965     0.        3 * 4478.88
1451304     10.4897    10.4897     0.        4 * 4478.88
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Hot leg, loop #2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  246
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2460000      hlega branch
2460001  1       0
2460101  0.5675   1.64    0     0    0.0     0.0     4.5-5   0.0     0
2460200  110   15656308. 1414221. 2444163. 0.  .00696896
2461101  246010002     240010001       0.5675    0.0       0.0  0001000
2461201   11.48273   11.48273 0. * 4478.88
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  240
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2400000      hlega branch
2400001  1       0
2400101  0.5675   5.87     0     0    0.0     0.0     4.5-5   0.0     0
2400200  110   15654343. 1414226. 2444209. 0.  .00696896
2401101  240010002     241010001       0.5675    0.0       0.0  0001000
2401201   11.48281   11.48281 0. * 4478.88
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*   241
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2410000    hot-leg  pipe
2410001       3
2410101    0.5675                         2
2410102    0.546                        3
2410301     1.71400                       1
2410302     1.54000                       2
2410303     0.67000                       3
2410601     0.0                         1
2410602     90.0                        2
2410603     90.0                        3
2410801      4.5-5  0.85                  3
2410901       .50    .5                 1
2410902       .0     .0                 2
2411001     0                          3
2411101     0001000                      2
2411201     110       15652181. 1414176. 2444260. 0. 0. 1
2411202     110       1.5637+7  1414177. 2444619. 0. 0. 2
2411203     110       15615815. 1414177. 2445119. 0. 0. 3
2412001     .0069692                          1
2412002     .0069692                          2
2412003     .0069692                          3
2411300     0
2411301    11.48333    11.48333     0.       1 * 4479.2
2411302    11.48368    12.1123      0.       2 * 4479.2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Cold leg, loop # 2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  242
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2420000     cold-leg      pipe
2420001        7
2420101    0.546                        1
2420102    0.5675                         7
2420301     0.67000                       1
2420302     3.34000                       2
```

```
2420303     3.26000                           3
2420304     1.94670                           4
2420305     1.94670                           5
2420306     1.94670                           6
2420307     3.26000                           7
2420601     -90.0                           1
2420602     -90.0                           3
2420603     0.0                            6
2420604     90.0                            7
2420801     4.5-5    0.85                      7
2420901       0.0    0.0                    2
2420902       0.5    0.5                    3
2420903       0.0    0.0                    5
2420904       0.5    0.5                    6
2421001      0                              7
2421101      0001000                          6
2421201      110        15444803. 1248350. 2449182. 0. 0. 1
2421202      110        15456869. 1248219. 2448894. 0. 0. 2
2421203      110        15456869. 1248219. 2448894. 0. 0. 3
2421204      110        15456869. 1248219. 2448894. 0. 0. 4
2421205      110        15461203. 1248224. 2448791. 0. 0. 5
2421206      110        15461203. 1248224. 2448791. 0. 0. 6
2421207      110        15430132. 1248225. 2449532. 0. 0. 7
2422001      .00696919                               1
2422002      .00696916                               2
2422003      .00696916                               3
2422004      .00696916                               7
2421300      0
2421301    10.49648     11.11749      0.         1 * 4479.2
2421302    10.51012     11.13133      0.         3 * 4485.365
2421303    10.51009     10.51009      0.         6 * 4485.365
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  245
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2450000       clega pipe
2450001          5
2450101    0.5675                            5
2450301      2.3080                          5
2450601      0.0                           5
2450801       4.5-5  0.85                     5
2450901        .05   .05                    1
2450902        .05   .05                    2
2450903        .05   .05                    3
2450904        .05     .05                       4
2451001      0                              5
2451101      0001000                          4
2451201      110        16030824. 1248669.  2434942. 0. 0. 1
2451202      110        16027641. 1248670.  2435028. 0. 0. 2
2451203      110        16024433. 1248672.  2435114. 0. 0. 3
2451204      110        16021225. 1248673.  2435200. 0. 0. 4
2451205      110        16018017. 1248675.  2435287. 0. 0. 5
2452001     .00696893                        1
2452002     .00696893                        2
2452003     .00696893                        3
2452004     .00696893                        4
2452005     .00696892                        5
2451300      0
2451301     10.48955   10.48955      0.          1 * 4478.88
2451302     10.4896    10.4896       0.          2 * 4478.88
2451303     10.48965   10.48965      0.          3 * 4478.88
2451304      10.4897    10.4897      0.          4 * 4478.88
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Hot leg, loop # 3
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  346
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3460000       hlega branch
3460001  1       0
3460101  0.5675   1.64    0     0    0.0     0.0     4.5-5   0.0     0
3460200  110   15656307. 1414221. 2444163. 0.  .00696896
3461101  346010002     340010001        0.5675    0.0       0.0  0001000
3461201   11.48284   11.48284 0. * 4478.92
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  340
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3400000       hlega branch
3400001  1       0
3400101  0.5675   5.87      0     0    0.0     0.0     4.5-5   0.0     0
3400200  110   15654342. 1414226. 2444209. 0.  .00696896
3401101  340010002     341010001        0.5675    0.0       0.0  0001000
3401201   11.48292   11.48292 0. * 4478.924
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  341
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3410000    hot-leg  pipe
3410001        3
```

```
3410101    0.5675                            2
3410102    0.546                             3
3410301     1.71400                          1
3410302     1.54000                          2
3410303     0.67000                          3
3410601      0.0                             1
3410602     90.0                             2
3410603     90.0                             3
3410801       4.5-5  0.85                    3
3410901        .50    .5                     1
3410902        .0     .0                     2
3411001      0                               3
3411101      0001000                         2
3411201      110       15652181. 1414176. 2444260. 0. 0. 1
3411202      110       1.5637+7  1414177. 2444619. 0. 0. 2
3411203      110       15615815. 1414177. 2445119. 0. 0. 3
3412001      .0069692                        1
3412002      .0069692                        2
3412003      .0069692                        3
3411300      0
3411301    11.48333    11.48333      0.        1 * 4479.2
3411302    11.48368    12.1123       0.        2 * 4479.2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Cold leg, loop # 3
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  342
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3420000     cold-leg      pipe
3420001          7
3420101    0.546                             1
3420102    0.5675                            7
3420301     0.67000                          1
3420302     3.34000                          2
3420303     3.26000                          3
3420304     1.94670                          4
3420305     1.94670                          5
3420306     1.94670                          6
3420307     3.26000                          7
3420601     -90.0                            1
3420602     -90.0                            3
3420603     0.0                              6
3420604     90.0                             7
3420801     4.5-5    0.85                    7
3420901       0.0    0.0                     2
3420902       0.5    0.5                     3
3420903       0.0    0.0                     5
3420904       0.5    0.5                     6
3421001      0                               7
3421101      0001000                         6
3421201      110       15444803. 1248350. 2449182. 0. 0. 1
3421202      110       15456869. 1248219. 2448894. 0. 0. 2
3421203      110       15456869. 1248219. 2448894. 0. 0. 3
3421204      110       15456869. 1248219. 2448894. 0. 0. 4
3421205      110       15461203. 1248224. 2448791. 0. 0. 5
3421206      110       15461203. 1248224. 2448791. 0. 0. 6
3421207      110       15430132. 1248225. 2449532. 0. 0. 7
3422001      .00696919                       1
3422002      .00696916                       2
3422003      .00696916                       3
3422004      .00696916                       7
3421300      0
3421301    10.49648    11.11749      0.        1 * 4479.2
3421302    10.51012    11.13133      0.        3 * 4485.365
3421303    10.51009    10.51009      0.        6 * 4485.365
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  345
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3450000      clega pipe
3450001         5
3450101    0.5675                            5
3450301      2.3080                          5
3450601      0.0                             5
3450801       4.5-5  0.85                    5
3450901        .05   .05                     4
3451001      0                               5
3451101      0001000                         4
3451201      110       16030824. 1248651.  2434942. 0. 0. 1
3451202      110       16027640. 1248653.  2435028. 0. 0. 2
3451203      110       16024433. 1248654.  2435114. 0. 0. 3
3451204      110       16021225. 1248655.  2435200. 0. 0. 4
3451205      110       16018017. 1248657.  2435287. 0. 0. 5
3452001     .00696893                        1
3452002     .00696893                        2
3452003     .00696893                        3
3452004     .00696893                        4
3452005     .00696892                        5
```

```
3451300      0
3451301     10.48956   10.48956      0.          1 * 4478.92
3451302     10.4896    10.4896       0.          2 * 4478.92
3451303     10.48966   10.48966      0.          3 * 4478.92
3451304     10.4897    10.4897       0.          4 * 4478.92
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Hot leg, loop # 4
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  446
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4460000       hlega branch
4460001  1        0
4460101  0.5675   1.64    0     0    0.0     0.0     4.5-5   0.0     0
4460200  110   15656346. 1414221. 2444162. 0.  .00696896
4461101  446010002     440010001        0.5675    0.0       0.0  0001000
4461201   11.47955   11.47955 0. * 4477.64
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  440
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4400000       hlega branch
4400001  1        0
4400101  0.5675   5.87      0     0    0.0     0.0     4.5-5   0.0     0
4400200  110   15654873. 1414224. 2444197. 0.  .00696896
4401101  440010002     441010001        0.5675    0.0       0.0  0001000
4401201   11.4796    11.4796  0. * 4477.64
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  441
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4410000    hot-leg  pipe
4410001         3
4410101    0.5675                            2
4410102    0.546                            3
4410301     1.71400                          1
4410302     1.54000                          2
4410303     0.67000                          3
4410601      0.0                           1
4410602     90.0                            2
4410603     90.0                            3
4410801       4.5-5  0.85                    3
4410901        .50    .5                    1
4410902        .0     .0                   2
4411001      0                            3
4411101      0001000                         2
4411201      110        15652181. 1414176. 2444260. 0. 0. 1
4411202      110        1.5637+7  1414177. 2444619. 0. 0. 2
4411203      110        15615815. 1414177. 2445119. 0. 0. 3
4412001      .0069692                              1
4412002      .0069692                              2
4412003      .0069692                              3
4411300     0
4411301    11.48333    11.48333      0.        1 * 4479.2
4411302    11.48368    12.1123       0.        2 * 4479.2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Cold leg, loop # 4
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  442
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4420000     cold-leg      pipe
4420001          7
4420101    0.546                            1
4420102    0.5675                            7
4420301     0.67000                          1
4420302     3.34000                          2
4420303     3.26000                          3
4420304     1.94670                          4
4420305     1.94670                          5
4420306     1.94670                          6
4420307     3.26000                          7
4420601     -90.0                           1
4420602     -90.0                           3
4420603     0.0                            6
4420604     90.0                            7
4420801     4.5-5    0.85                    7
4420901       0.0    0.0                    2
4420902       0.5    0.5                    3
4420903       0.0    0.0                    5
4420904       0.5    0.5                    6
4421001      0                            7
4421101      0001000                         6
4421201      110        15444803. 1248350. 2449182. 0. 0. 1
4421202      110        15456869. 1248219. 2448894. 0. 0. 2
4421203      110        15456869. 1248219. 2448894. 0. 0. 3
4421204      110        15456869. 1248219. 2448894. 0. 0. 4
4421205      110        15461203. 1248224. 2448791. 0. 0. 5
4421206      110        15461203. 1248224. 2448791. 0. 0. 6
4421207      110        15430132. 1248225. 2449532. 0. 0. 7
```

```
4422001    .00696919                    1
4422002    .00696916                    2
4422003    .00696916                    3
4422004    .00696916                    7
4421300    0
4421301   10.49648   11.11749    0.      1 * 4479.2
4421302   10.51012   11.13133    0.      3 * 4485.365
4421303   10.51009   10.51009    0.      6 * 4485.365
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  445
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4450000    clega pipe
4450001      5
4450101   0.5675                  5
4450301    2.3080                 5
4450601    0.0                  5
4450801     4.5-5  0.85             5
4450901      .05   .05             4
4451001    0                  5
4451101    0001000                4
4451201    110      16030720. 1248605.  2434945. 0. 0. 1
4451202    110      16027535. 1248607.  2435031. 0. 0. 2
4451203    110      16024326. 1248608.  2435117. 0. 0. 3
4451204    110      16021281. 1248610.  2435199. 0. 0. 4
4451205    110      16018084. 1248611.  2435285. 0. 0. 5
4452001    .00696892                1
4452002    .00696892                2
4452003    .00696892                3
4452004    .00696892                4
4452005    .00696892                5
4451300    0
4451301    10.4913    10.4913     0.      1 * 4479.765
4451302    10.49135   10.49135    0.      2 * 4479.765
4451303    10.472     10.472     0.      3 * 4471.48
4451304    10.47205   10.47205    0.      4 * 4471.48
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*        * S T E A M  G E N E R A T O R  *
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Steam generator primery side
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Steam generator # 1 tubes
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 120
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1200000   sg-pr    pipe
1200001   5
1200101   0.33395    5
1200301   0.0      5
1200401   0.7316    5
1200501   0.0      5
1200601   0.0      5
1200701   0.0      5
1200801   1.2-5     0.013     5
1200901   0.1      0.1      4
1201001   00       5
1201101   00000     4
1201201   110      15566458. 1358977.  2446288.  0.      0.      1
1201202   110      15542915. 1318275.  2446847.  0.      0.      2
1201203   110      15519838. 1288249.  2447395.  0.      0.      3
1201204   110      15497079. 1266129.  2447936.  0.      0.      4
1201205   110      15474547. 1249743.  2448473.  0.      0.      5
1202001   .0069692                          1
1202002   .0069692                          2
1202003   .0069692                          3
1202004   .0069692                          4
1202005   .0069692                          5
1201300   0
1201301   4.35669   4.35669   0.      1 * 1023.127
1201302   4.26048   4.26048   0.      2 * 1023.127
1201303   4.195135  4.195135  0.      3 * 1023.127
1201304   4.14921   4.14921   0.      4 * 1023.127
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  121
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1210000   sg-pr    pipe
1210001   5
1210101   0.636317    5
1210301   0.0      5
1210401   1.405     5
1210501   0.0      5
1210601   0.0      5
1210701   0.0      5
1210801   1.2-5     0.013     5
1210901   0.1      0.1      4
1211001   00       5
1211101   00000     4
```

```
1211201   110       15582790. 1357108.  2445901.  0.        0.        1
1211202   110       15561149. 1315423.  2446414.  0.        0.        2
1211203   110       15539937. 1284977.  2446917.  0.        0.        3
1211204   110       15519020. 1262752.  2447414.  0.        0.        4
1211205   110       15498303. 1246451.  2447907.  0.        0.        5
1212001   .0069692                                1
1212002   .0069692                                2
1212003   .0069692                                3
1212004   .0069692                                4
1212005   .00696919                               5
1211300   0
1211301   4.17252   4.17252   0.        1 * 1892.416
1211302   4.07848   4.07848   0.        2 * 1892.416
1211303   4.01523   4.01523   0.        3 * 1892.416
1211304   3.97139   3.97139   0.        4 * 1892.416
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  122
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1220000   sg-pr     pipe
1220001   5
1220101   0.4898    5
1220301   0.0       5
1220401   1.0864    5
1220501   0.0       5
1220601   0.0       5
1220701   0.0       5
1220801   1.2-5     0.013     5
1220901   0.1       0.1       4
1221001   00        5
1221101   00000     4
1221201   110       15594028. 1359528.  2445635.  0.        0.        1
1221202   110       15569127. 1318963.  2446225.  0.        0.        2
1221203   110       15544718. 1288825.  2446804.  0.        0.        3
1221204   110       15520649. 1266452.  2447375.  0.        0.        4
1221205   110       15496822. 1249734.  2447942.  0.        0.        5
1222001   .0069692                                1
1222002   .0069692                                2
1222003   .0069692                                3
1222004   .0069692                                4
1222005   .00696919                               5
1221300   0
1221301   4.482995  4.482995  0.        1 * 1563.658
1221302   4.38428   4.38428   0.        2 * 1563.658
1221303   4.31677   4.31677   0.        3 * 1563.66
1221304   4.268944  4.268944  0.        4 * 1563.66
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Steam generator # 2 tubes
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  220
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2200000   sg-pr     pipe
2200001   5
2200101   0.33395   5
2200301   0.0       5
2200401   0.7316    5
2200501   0.0       5
2200601   0.0       5
2200701   0.0       5
2200801   1.2-5     0.013     5
2200901   0.1       0.1       4
2201001   00        5
2201101   00000     4
2201201   110       15566465. 1359014.  2446288.  0.        0.        1
2201202   110       15542925. 1318301.  2446846.  0.        0.        2
2201203   110       15519851. 1288268.  2447394.  0.        0.        3
2201204   110       15497096. 1266143.  2447936.  0.        0.        4
2201205   110       15474567. 1249754.  2448472.  0.        0.        5
2202001   .00696895                               1
2202002   .00696895                               2
2202003   .00696895                               3
2202004   .00696894                               4
2202005   .00696894                               5
2201300   0
2201301   4.35645   4.35645   0.        1 * 1023.05
2201302   4.26022   4.26022   0.        2 * 1023.05
2201303   4.19486   4.19486   0.        3 * 1023.05
2201304   4.14893   4.14893   0.        4 * 1023.05
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  221
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2210000   sg-pr     pipe
2210001   5
2210101   0.636317  5
2210301   0.0       5
2210401   1.405     5
2210501   0.0       5
```

```
2210601   0.0       5
2210701   0.0       5
2210801   1.2-5     0.013     5
2210901   0.1       0.1       4
2211001   00        5
2211101   00000     4
2211201   110       15582793. 1357144.  2445901.  0.        0.        1
2211202   110       15561156. 1315449.  2446414.  0.        0.        2
2211203   110       15539947. 1284996.  2446917.  0.        0.        3
2211204   110       15519033. 1262766.  2447414.  0.        0.        4
2211205   110       15498320. 1246461.  2447906.  0.        0.        5
2212001   .00696895                               1
2212002   .00696895                               2
2212003   .00696895                               3
2212004   .00696894                               4
2212005   .00696894                               5
2211300   0
2211301   4.1723    4.1723    0.        1 * 1892.28
2211302   4.07824   4.07824   0.        2 * 1892.28
2211303   4.014985  4.014985  0.        3 * 1892.28
2211304   3.97113   3.97113   0.        4 * 1892.28
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  222
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2220000   sg-pr     pipe
2220001   5
2220101   0.4898    5
2220301   0.0       5
2220401   1.0864    5
2220501   0.0       5
2220601   0.0       5
2220701   0.0       5
2220801   1.2-5     0.013     5
2220901   0.1       0.1       4
2221001   00        5
2221101   00000     4
2221201   110       15594038. 1359564.  2445635.  0.        0.        1
2221202   110       15569138. 1318989.  2446225.  0.        0.        2
2221203   110       15544730. 1288844.  2446804.  0.        0.        3
2221204   110       15520663. 1266467.  2447375.  0.        0.        4
2221205   110       15496838. 1249745.  2447942.  0.        0.        5
2222001   .00696895                               1
2222002   .00696895                               2
2222003   .00696895                               3
2222004   .00696894                               4
2222005   .00696894                               5
2221300   0
2221301   4.48278   4.48278   0.        1 * 1563.552
2221302   4.38404   4.38404   0.        2 * 1563.552
2221303   4.31652   4.31652   0.        3 * 1563.55
2221304   4.26868   4.26868   0.        4 * 1563.55
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Steam generator # 3 tubes
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  320
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3200000   sg-pr     pipe
3200001   5
3200101   0.33395   5
3200301   0.0       5
3200401   0.7316    5
3200501   0.0       5
3200601   0.0       5
3200701   0.0       5
3200801   1.2-5     0.013     5
3200901   0.1       0.1       4
3201001   00        5
3201101   00000     4
3201201   110       15566464. 1359007.  2446288.  0.        0.        1
3201202   110       15542923. 1318290.  2446846.  0.        0.        2
3201203   110       15519849. 1288254.  2447394.  0.        0.        3
3201204   110       15497093. 1266127.  2447936.  0.        0.        4
3201205   110       15474564. 1249736.  2448472.  0.        0.        5
3202001   .00696895                               1
3202002   .00696895                               2
3202003   .00696895                               3
3202004   .00696895                               4
3202005   .00696894                               5
3201300   0
3201301   4.35648   4.35648   0.        1 * 1023.06
3201302   4.26023   4.26023   0.        2 * 1023.06
3201303   4.19487   4.19487   0.        3 * 1023.06
3201304   4.14893   4.14893   0.        4 * 1023.06

*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  321
```

```
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3210000   sg-pr     pipe
3210001   5
3210101   0.636317    5
3210301   0.0       5
3210401   1.405    5
3210501   0.0       5
3210601   0.0       5
3210701   0.0       5
3210801   1.2-5     0.013     5
3210901   0.1       0.1       4
3211001   00        5
3211101   00000     4
3211201   110       15582793. 1357138.  2445901.  0.        0.        1
3211202   110       15561155. 1315438.  2446414.  0.        0.        2
3211203   110       15539945. 1284982.  2446917.  0.        0.        3
3211204   110       15519030. 1262750.  2447414.  0.        0.        4
3211205   110       15498317. 1246443.  2447907.  0.        0.        5
3212001   .00696895                                         1
3212002   .00696895                                         2
3212003   .00696895                                         3
3212004   .00696894                                         4
3212005   .00696894                                         5
3211300   0
3211301   4.17233   4.17233   0.        1 * 1892.3
3211302   4.07826   4.07826   0.        2 * 1892.3
3211303   4.014995  4.014995  0.        3 * 1892.3
3211304   3.97114   3.97114   0.        4 * 1892.3
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  322
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3220000   sg-pr     pipe
3220001   5
3220101   0.4898    5
3220301   0.0       5
3220401   1.0864    5
3220501   0.0       5
3220601   0.0       5
3220701   0.0       5
3220801   1.2-5     0.013     5
3220901   0.1       0.1       4
3221001   00        5
3221101   00000     4
```

```
3221201   110       15594030. 1359559.  2445635.  0.        0.        1
3221202   110       15569132. 1318979.  2446225.  0.        0.        2
3221203   110       15544726. 1288831.  2446804.  0.        0.        3
3221204   110       15520659. 1266451.  2447375.  0.        0.        4
3221205   110       15496834. 1249728.  2447942.  0.        0.        5
3222001   .00696895                                         1
3222002   .00696895                                         2
3222003   .00696895                                         3
3222004   .00696894                                         4
3222005   .00696894                                         5
3221300   0
3221301   4.482805  4.482805  0.        1 * 1563.565
3221302   4.38406   4.38406   0.        2 * 1563.565
3221303   4.31653   4.31653   0.        3 * 1563.565
3221304   4.26869   4.26869   0.        4 * 1563.566
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Steam generator # 4 tubes
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  420
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4200000   sg-pr     pipe
4200001   5
4200101   0.33395    5
4200301   0.0       5
4200401   0.7316    5
4200501   0.0       5
4200601   0.0       5
4200701   0.0       5
4200801   1.2-5     0.013     5
4200901   0.1       0.1       4
4201001   00        5
4201101   00000     4
4201201   110       15566540. 1359004.  2446286.  0.        0.        1
4201202   110       15543014. 1318286.  2446844.  0.        0.        2
4201203   110       15519952. 1288251.  2447392.  0.        0.        3
4201204   110       15497210. 1266126.  2447933.  0.        0.        4
4201205   110       15474693. 1249737.  2448469.  0.        0.        5
4202001   .00696895                                         1
4202002   .00696895                                         2
4202003   .00696895                                         3
4202004   .00696895                                         4
4202005   .00696894                                         5
4201300   0
```

```
4201301   4.3552    4.3552    0.       1 * 1022.762
4201302   4.25898   4.25898   0.       2 * 1022.762
4201303   4.193645  4.193645  0.       3 * 1022.762
4201304   4.147726  4.147726  0.       4 * 1022.762
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  421
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4210000   sg-pr     pipe
4210001   5
4210101   0.636317    5
4210301   0.0       5
4210401   1.405     5
4210501   0.0       5
4210601   0.0       5
4210701   0.0       5
4210801   1.2-5     0.013     5
4210901   0.1       0.1       4
4211001   00        5
4211101   00000     4
4211201   110       15582857. 1357134.  2445899.  0.        0.        1
4211202   110       15561231. 1315433.  2446412.  0.        0.        2
4211203   110       15540033. 1284978.  2446915.  0.        0.        3
4211204   110       15519131. 1262749.  2447412.  0.        0.        4
4211205   110       15498429. 1246444.  2447904.  0.        0.        5
4212001   .00696895                                1
4212002   .00696895                                2
4212003   .00696895                                3
4212004   .00696894                                4
4212005   .00696894                                5
4211300   0
4211301   4.17111   4.17111   0.       1 * 1891.753
4211302   4.07707   4.07707   0.       2 * 1891.752
4211303   4.01383   4.01383   0.       3 * 1891.752
4211304   3.96999   3.96999   0.       4 * 1891.75
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  422
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4220000   sg-pr     pipe
4220001   5
4220101   0.4898    5
4220301   0.0       5
4220401   1.0864    5
4220501   0.0       5
4220601   0.0       5
4220701   0.0       5
4220801   1.2-5     0.013     5
4220901   0.1       0.1       4
4221001   00        5
4221101   00000     4
4221201   110       15594085. 1359555.  2445634.  0.        0.        1
4221202   110       15569201. 1318974.  2446223.  0.        0.        2
4221203   110       15544808. 1288827.  2446802.  0.        0.        3
4221204   110       15520755. 1266449.  2447373.  0.        0.        4
4221205   110       15496944. 1249728.  2447939.  0.        0.        5
4222001   .00696895                                1
4222002   .00696895                                2
4222003   .00696895                                3
4222004   .00696894                                4
4222005   .00696894                                5
4221300   0
4221301   4.4815    4.4815    0.       1 * 1563.114
4221302   4.38278   4.38278   0.       2 * 1563.115
4221303   4.31528   4.31528   0.       3 * 1563.115
4221304   4.26745   4.26745   0.       4 * 1563.115
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*     steam generator#1 hot collector
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1100000   tube-con  branch
1100001   3         0
1100101   0.546     0.80      0.0       0.0       90.0      0.80
1100102   4.5-5     0.834     00
1100200   110       15593675. 1414177. 2445643. 0.   .0069692
1101101   110010000 111000000 0.0       0.0       0.0       00000
1101201   9.21031   9.76748   0. * 3456.074
1102101   110010004 120000000 0.0       0.7       0.7       00100
1102201   4.50173   4.50173   0. * 1023.127
1103101   141010000 110000000 0.0       0.1       0.1       0001000
1103201   11.93638  12.5752   0. * 4479.2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1110000   tube-con  branch
1110001   2         0
1110101   0.546     0.80      0.0       0.0       90.0      0.80
1110102   4.5-5     0.834     00
1110200   110       15610201. 1414178. 2445252. 0.   .0069692
1111101   111010000 112000000 0.0       0.0       0.0       00000
1111201   4.166955  4.53132   0. * 1563.657
```

```
1112101   111010004 121000000 0.0       0.7      0.7      00100
1112201   5.256     5.256     0. * 1892.417
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1120000   tube-con  branch
1120001   2         0
1120101   0.546     0.80      0.0       0.0      90.0     0.80
1120102   4.5-5     0.834     00
1120200   110       15621690. 1414178. 2444981. 0.   .0069692
1121101   112010000 115000000 0.0       0.0      0.0      00000
1121201   1.271435-6  1.271452-6  0. * 1.99736-4
1122101   112010004 122000000 0.0       0.7      0.7      00100
1122201   4.63079   4.63079   0. * 1563.657
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*   steam generator collector upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1150000   sg-col-u  branch
1150001   0         0
1150101   0.0       1.875     0.7238     0.0      90.      1.875
1150102   4.5-5     0.0       00
1150200   110       15617370. 1429161. 2445083. 0.   .00695001
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1300000   tube-con  branch
1300001   3         0
1300101   0.546     0.80      0.0       0.0      -90.0    -0.80
1300102   4.5-5     0.834     00
1300200   110       15460278. 1248349. 2448813. 0.   .00696919
1301101   131010000 130000000 0.546     0.0      0.0      01000
1301201   8.41585   8.9648    0. * 3456.074
1302101   120010000 130010003 0.0       0.7      0.7      01100
1302201   4.11692   4.11692   0. * 1023.127
1303101   130010000 142000000 0.546     0.1      0.1      0001000
1303201   10.90958  11.53988  0. * 4479.2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1310000   tube-con  branch
1310001   2         0
1310101   0.546     0.80      0.0       0.0      -90.0    -0.80
1310102   4.5-5     0.834     00
1310200   110       15476449. 1247936. 2448427. 0.   .00696919
1311101   132010000 131000000 0.0       0.0      0.0      01000
1311201   3.81085   4.17003   0. * 1563.66
1312101   121010000 131010003 0.0       0.7      0.7      01100
1312201   4.79925   4.79925   0. * 1892.416
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1320000   tube-con  branch
1320001   2         0
1320101   0.546     0.80      0.0       0.0      -90.0    -0.80
1320102   4.5-5     0.834     00
1320200   110       15479379. 1249734. 2448357. 0.   .00696919
1321101   135010000 132000000 0.0       0.0      0.0      00000
1321201   6.20814-8   6.20812-8   0. * 1.066377-5
1322101   122010000 132010003 0.0       0.7      0.7      01100
1322201   4.23505   4.23505   0. * 1563.66
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  steam generator cold collector upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1350000   sg-col-u  branch
1350001   0         0
1350101   0.0       1.875     0.7238     0.0      -90.     -1.875
1350102   4.5-5     0.0       00
1350200   110       15470023. 1262863. 2448580. 0.  .00695
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2100000   tube-con  branch
2100001   3         0
2100101   0.546     0.80      0.0       0.0      90.0     0.80
2100102   4.5-5     0.834     00
2100200   110       15593677. 1414227. 2445643. 0.   .00696895
2101101   210010000 211000000 0.0       0.0      0.0      00000
2101201   9.20996   9.7671    0. * 3455.834
2102101   210010004 220000000 0.0       0.7      0.7      00100
2102201   4.50153   4.50153   0. * 1023.05
2103101   241010000 210000000 0.0       0.1      0.1      0001000
2103201   11.93591  12.5747   0. * 4478.884
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2110000   tube-con  branch
2110001   2         0
2110101   0.546     0.80      0.0       0.0      90.0     0.80
2110102   4.5-5     0.834     00
2110200   110       15610201. 1414228. 2445252. 0.   .00696896
2111101   211010000 212000000 0.0       0.0      0.0      00000
2111201   4.16681   4.53117   0. * 1563.553
2112101   211010004 221000000 0.0       0.7      0.7      00100
2112201   5.25579   5.25579   0. * 1892.28
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2120000   tube-con  branch
2120001   2         0
2120101   0.546     0.80      0.0       0.0      90.0     0.80
```

```
2120102   4.5-5     0.834     00
2120200   110       15621699. 1414229. 2444980. 0.   .00696895
2121101   212010000 215000000 0.0        0.0      0.0       00000
2121201   -1.266622-6 -1.26664-6  0. * -1.971185-4
2122101   212010004 222000000 0.0        0.7      0.7       00100
2122201   4.63062   4.63062   0. * 1563.553
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*   steam generator collector upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2150000   sg-col-u  branch
2150001   0         0
2150101   0.0       1.875      0.7238       0.0       90.       1.875
2150102   4.5-5     0.0       00
2150200   110       15617367. 1429161. 2445083. 0.   .00695001
*151101   212010000 215000000 0.0        0.0      0.0       00000
*151201   0.0       0.0       0.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* steam generator cold leg tube connection volumes
*---- ---1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2300000   tube-con  branch
2300001   3         0
2300101   0.546     0.80      0.0       0.0       -90.0     -0.80
2300102   4.5-5     0.834     00
2300200   110       15460300. 1248359. 2448812. 0.   .00696894
2301101   231010000 230000000 0.546     0.0       0.0       01000
2301201   8.4153    8.96423   0. * 3455.83
2302101   220010000 230010003 0.0       0.7       0.7       01100
2302201   4.11663   4.11663   0. * 1023.05
2303101   230010000 242000000 0.546     0.1       0.1       0001000
2303201   10.90886  11.53913  0. * 4478.88
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2310000   tube-con  branch
2310001   2         0
2310101   0.546     0.80      0.0       0.0       -90.0     -0.80
2310102   4.5-5     0.834     00
2310200   110       15476469. 1247946. 2448427. 0.   .00696894
2311101   232010000 231000000 0.0       0.0       0.0       01000
2311201   3.81061   4.16977   0. * 1563.55
2312101   221010000 231010003 0.0       0.7       0.7       01100
2312201   4.79893   4.79893   0. * 1892.28
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2320000   tube-con  branch
2320001   2         0
2320101   0.546     0.80      0.0       0.0       -90.0     -0.80
2320102   4.5-5     0.834     00
2320200   110       15479397. 1249745. 2448357. 0.   .00696894
2321101   235010000 232000000 0.0       0.0       0.0       00000
2321201   -6.18287-8  -6.18289-8  0. * -1.055394-5
2322101   222010000 232010003 0.0       0.7       0.7       01100
2322201   4.23478   4.23478   0. * 1563.55
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  steam generator collector upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2350000   sg-col-u  branch
2350001   0         0
2350101   0.0       1.875     0.7238       0.0       -90.      -1.875
2350102   4.5-5     0.0       00
2350200   110       15470038. 1262863. 2448580. 0.  .00695
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3100000   tube-con  branch
3100001   3         0
3100101   0.546     0.80      0.0       0.0       90.0      0.80
3100102   4.5-5     0.834     00
3100200   110       15593678. 1414227. 2445643. 0.   .00696895
3101101   310010000 311000000 0.0       0.0       0.0       00000
3101201   9.21004   9.7672    0. * 3455.864
3102101   310010004 320000000 0.0       0.7       0.7       00100
3102201   4.50157   4.50157   0. * 1023.06
3103101   341010000 310000000 0.0       0.1       0.1       0001000
3103201   11.93602  12.57482  0. * 4478.92
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3110000   tube-con  branch
3110001   2         0
3110101   0.546     0.80      0.0       0.0       90.0      0.80
3110102   4.5-5     0.834     00
3110200   110       15610202. 1414228. 2445252. 0.   .00696896
3111101   311010000 312000000 0.0       0.0       0.0       00000
3111201   4.16684   4.5312    0. * 1563.564
3112101   311010004 321000000 0.0       0.7       0.7       00100
3112201   5.25584   5.25584   0. * 1892.3
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3120000   tube-con  branch
3120001   2         0
3120101   0.546     0.80      0.0       0.0       90.0      0.80
3120102   4.5-5     0.834     00
3120200   110       15621690. 1414229. 2444981. 0.   .00696895
```

```
3121101   312010000 315000000 0.0        0.0      0.0       00000
3121201   1.267122-6  1.26714-6   0. * 1.99052-4
3122101   312010004 322000000 0.0        0.7      0.7       00100
3122201   4.63066   4.63066   0. * 1563.564
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*   steam generator collector upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3150000   sg-col-u  branch
3150001   0        0
3150101   0.0       1.875      0.7238       0.0       90.       1.875
3150102   4.5-5     0.0       00
3150200   110       15617369. 1429161. 2445083. 0.   .00695001
*151101   312010000 315000000 0.0        0.0      0.0       00000
*151201   0.0       0.0       0.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* steam generator cold leg tube connection volumes
*---- ---1----  ----2--- - ----3---- ----4---- ----5---- ----6---- ----7
3300000   tube-con  branch
3300001   3        0
3300101   0.546     0.80      0.0       0.0       -90.0     -0.80
3300102   4.5-5     0.834     00
3300200   110       15460297. 1248342. 2448812. 0.   .00696894
3301101   331010000 330000000 0.546     0.0       0.0       01000
3301201   8.4153    8.96424   0. * 3455.864
3302101   320010000 330010003 0.0       0.7       0.7       01100
3302201   4.11663   4.11663   0. * 1023.06
3303101   330010000 342000000 0.546     0.1       0.1     0001000
3303201   10.90887  11.53914  0. * 4478.92
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3310000   tube-con  branch
3310001   2        0
3310101   0.546     0.80      0.0       0.0       -90.0     -0.80
3310102   4.5-5     0.834     00
3310200   110       15476465. 1247929. 2448427. 0.   .00696894
3311101   332010000 331000000 0.0       0.0       0.0       01000
3311201   3.81061   4.16978   0. * 1563.566
3312101   321010000 331010003 0.0       0.7       0.7       01100
3312201   4.79893   4.79893   0. * 1892.3
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3320000   tube-con  branch
3320001   2        0
3320101   0.546     0.80      0.0       0.0       -90.0     -0.80
3320102   4.5-5     0.834     00
3320200   110       15479394. 1249727. 2448357. 0.   .00696894
3321101   335010000 332000000 0.0       0.0       0.0       00000
3321201   6.19053-8   6.19051-8   0. * 1.063356-5
3322101   322010000 332010003 0.0       0.7       0.7       01100
3322201   4.23478   4.23478   0. * 1563.566
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  steam generator collector upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3350000   sg-col-u  branch
3350001   0        0
3350101   0.0       1.875      0.7238       0.0       -90.      -1.875
3350102   4.5-5     0.0       00
3350200   110       15470038. 1262863. 2448580. 0.  .00695
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  steam generator, tube connection volumes
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4100000   tube-con  branch
4100001   3        0
4100101   0.546     0.80      0.0       0.0       90.0      0.80
4100102   4.5-5     0.834     00
4100200   110       15593739. 1414227. 2445642. 0.   .00696896
4101101   410010000 411000000 0.0       0.0       0.0       00000
4101201   9.20738   9.76444   0. * 3454.866
4102101   410010004 420000000 0.0       0.7       0.7       00100
4102201   4.500265  4.500265  0. * 1022.763
4103101   441010000 410000000 0.0       0.1       0.1     0001000
4103201   11.93257  12.57127  0. * 4477.63
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4110000   tube-con  branch
4110001   2        0
4110101   0.546     0.80      0.0       0.0       90.0      0.80
4110102   4.5-5     0.834     00
4110200   110       15610251. 1414228. 2445251. 0.   .00696896
4111101   411010000 412000000 0.0       0.0       0.0       00000
4111201   4.165635  4.52994   0. * 1563.113
4112101   411010004 421000000 0.0       0.7       0.7       00100
4112201   5.25432   5.25432   0. * 1891.753
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4120000   tube-con  branch
4120001   2        0
4120101   0.546     0.80      0.0       0.0       90.0      0.80
4120102   4.5-5     0.834     00
4120200   110       15621729. 1414229. 2444980. 0.   .00696895
```

```
4121101   412010000 415000000 0.0       0.0     0.0      00000
4121201   1.264666-6  1.264683-6  0. * 1.986663-4
4122101   412010004 422000000 0.0       0.7     0.7      00100
4122201   4.62932   4.62932   0. * 1563.114
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*   steam generator collector upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4150000   sg-col-u  branch
4150001   0        0
4150101   0.0       1.875      0.7238      0.0      90.      1.875
4150102   4.5-5     0.0      00
4150200   110       15617405. 1429160. 2445082. 0.   .00695001
*151101   412010000 415000000 0.0       0.0     0.0      00000
*151201   0.0       0.0       0.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* steam generator primary side
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* steam generator cold leg tube connection volumes
*---- --R-1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4300000   tube-con  branch
4300001   3        0
4300101   0.546     0.80     0.0       0.0      -90.0    -0.80
4300102   4.5-5     0.834    00
4300200   110       15460434. 1248343. 2448809. 0.   .00696894
4301101   431010000 430000000 0.546    0.0      0.0      01000
4301201   8.41288   8.96173   0. * 3454.87
4302101   420010000 430010003 0.0      0.7      0.7      01100
4302201   4.11544   4.11544   0. * 1022.762
4303101   430010000 442000000 0.546    0.1      0.1      0001000
4303201   10.90572  11.5359   0. * 4477.63
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4310000   tube-con  branch
4310001   2        0
4310101   0.546     0.80     0.0       0.0      -90.0    -0.80
4310102   4.5-5     0.834    00
4310200   110       15476590. 1247930. 2448424. 0.   .00696894
4311101   432010000 431000000 0.0      0.0      0.0      01000
4311201   3.80951   4.16862   0. * 1563.115
4312101   421010000 431010003 0.0      0.7      0.7      01100
4312201   4.79755   4.79755   0. * 1891.75
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4320000   tube-con  branch
4320001   2        0
4320101   0.546     0.80     0.0       0.0      -90.0    -0.80
4320102   4.5-5     0.834    00
4320200   110       15479513. 1249728. 2448354. 0.   .00696894
4321101   435010000 432000000 0.0      0.0      0.0      00000
4321201   6.2012-8    6.20119-8   0. * 1.06519-5
4322101   422010000 432010003 0.0      0.7      0.7      01100
4322201   4.23356   4.23356   0. * 1563.115
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  steam generator collector upper volume
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4350000   sg-col-u  branch
4350001   0        0
4350101   0.0       1.875      0.7238      0.0      -90.     -1.875
4350102   4.5-5     0.0      00
4350200   110       15470157. 1262863. 2448577. 0.  .00695
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*   heat structures steam generator tubing
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
11200000  5        5        2        1        0.0065
11200100  0        1
11200101  4        0.008
11200201  4        4
11200301  0.0      4
11200400  0
11200401  565.00   5
11200501  120010000 10000    1        1        5511.    5
11200601  100010000 0        134      1        5511.    5
11200701  0        0.0      0.0      0.0      5
11200801  0.    10.     10.0    0.0     0.     0.   0.   1.   5
11200901  0.    10.0    10.0    0.0     0.0    0.   0.   1.   5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
11210000  5        5        2        1        0.0065
11210100  0        1
11210101  4        0.008
11210201  4        4
11210301  0.0      4
11210400  0
11210401  565.00   5
11210501  121010000 10000    1        1        10634.   5
11210601  101010000 0        134      1        10634.   5
11210701  0        0.0      0.0      0.0      5
11210801  0.     10.0    10.0    0.0    0.     0.    0.   1.   5
11210901  0.     10.0    10.0    0.0    0.0    0.    0.   1.   5
```

```
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
11220000  5        5        2        1        0.0065
11220100  0        1
11220101  4        0.008
11220201  4        4
11220301  0.0      4
11220400  0
11220401  565.00   5
11220501  122010000 10000    1        1        8187.    5
11220601  102010000 0        134      1        8187.    5
11220701  0        0.0      0.0      0.0      5
11220801  0.   10.0   10.0   0.0   0.   0.   0.   1.   5
11220901  0.   10.0   10.0   0.0   0.   0.   0.   1.   5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*   Heat structure steam generator vessel, upper part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
11050000  1        3        2        1        2.0
11050100  0        1
11050101  2        2.125
11050201  6        2
11050301  0.0      2
11050400  0
11050401  551.9    3
11050501  105010000 0        1        1        3.45     1
11050601  0        0        0        1        3.45     1
11050701  0        0.0      0.0      0.00     1
11050801  3.   10.0   10.0   0.00   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
11040000  1        3        2        1        2.0
11040100  0        1
11040101  2        2.125
11040201  6        2
11040301  0.0      2
11040400  0
11040401  551.9    3
11040501  104010000 0        1        1        2.33     1
11040601  0        0        0        1        2.33     1
11040701  0        0.0      0.0      0.00     1
11040801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
11030000  1        3        2        1        2.0
11030100  0        1
11030101  2        2.125
11030201  6        2
11030301  0.0      2
11030400  0
11030401  551.9    3
11030501  103010000 0        1        1        0.73     1
11030601  0        0        0        1        0.73     1
11030701  0        0.0      0.0      0.00     1
11030801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
11520000  1        3        2        1        2.0
11520100  0        1
11520101  2        2.125
11520201  6        2
11520301  0.0      2
11520400  0
11520401  551.9    3
11520501  152010000 0        1        1        2.00     1
11520601  0        0        0        1        2.00     1
11520701  0        0.0      0.0      0.0      1
11520801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
11510000  1        3        2        1        2.0
11510100  0        1
11510101  2        2.125
11510201  6        2
11510301  0.0      2
11510400  0
11510401  551.9    3
11510501  151010000 0        1        1        2.07     1
11510601  0        0        0        1        2.07     1
11510701  0        0.0      0.0      0.0      1
11510801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
11500000  1        3        2        1        2.0
11500100  0        1
11500101  2        2.125
11500201  6        2
11500301  0.0      2
11500400  0
11500401  551.9    3
11500501  150010000 0        1        1        4.43     1
11500601  0        0        0        1        4.43     1
11500701  0        0.0      0.0      0.0      1
```

```
11500801  3.     10.0     10.0     0.0     0.     0.     0.    1.     1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
12200000  5         5         2         1         0.0065
12200100  0         1
12200101  4         0.008
12200201  4         4
12200301  0.0       4
12200400  0
12200401  565.00    5
12200501  220010000 10000     1         1         5511.     5
12200601  200010000 0         134       1         5511.     5
12200701  0         0.0       0.0       0.0       5
12200801  0.    10.     10.0     0.0     0.     0.   0.   1.   5
12200901  0.    10.0    10.0     0.0     0.0    0.   0.   1.   5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
12210000  5         5         2         1         0.0065
12210100  0         1
12210101  4         0.008
12210201  4         4
12210301  0.0       4
12210400  0
12210401  565.00    5
12210501  221010000 10000     1         1         10634.    5
12210601  201010000 0         134       1         10634.    5
12210701  0         0.0       0.0       0.0       5
12210801  0.     10.0    10.0    0.0    0.     0.    0.   1.   5
12210901  0.     10.0    10.0    0.0    0.0    0.    0.   1.   5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
12220000  5         5         2         1         0.0065
12220100  0         1
12220101  4         0.008
12220201  4         4
12220301  0.0       4
12220400  0
12220401  565.00    5
12220501  222010000 10000     1         1         8187.     5
12220601  202010000 0         134       1         8187.     5
12220701  0         0.0       0.0       0.0       5
12220801  0.    10.0    10.0     0.0    0.   0.   0.     1.    5
12220901  0.    10.0    10.0     0.0    0.   0.   0.     1.    5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Heat structure steam generator vessel, upper part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
```

```
12050000  1         3         2         1         2.0
12050100  0         1
12050101  2         2.125
12050201  6         2
12050301  0.0       2
12050400  0
12050401  551.9     3
12050501  205010000 0         1         1         3.45      1
12050601  0         0         0         1         3.45      1
12050701  0         0.0       0.0       0.00      1
12050801  3.    10.0    10.0    0.00  0.    0.   0.    1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
12040000  1         3         2         1         2.0
12040100  0         1
12040101  2         2.125
12040201  6         2
12040301  0.0       2
12040400  0
12040401  551.9     3
12040501  204010000 0         1         1         2.33      1
12040601  0         0         0         1         2.33      1
12040701  0         0.0       0.0       0.00      1
12040801  3.   10.0     10.0     0.0    0.    0.    0.    1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
12030000  1         3         2         1         2.0
12030100  0         1
12030101  2         2.125
12030201  6         2
12030301  0.0       2
12030400  0
12030401  551.9     3
12030501  203010000 0         1         1         0.73      1
12030601  0         0         0         1         0.73      1
12030701  0         0.0       0.0       0.00      1
12030801  3.   10.0     10.0     0.0    0.    0.    0.    1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
12520000  1         3         2         1         2.0
12520100  0         1
12520101  2         2.125
12520201  6         2
12520301  0.0       2
12520400  0
12520401  551.9     3
```

```
12520501  252010000 0    1    1    2.00   1
12520601  0    0    0    1    2.00   1
12520701  0    0.0   0.0   0.0   1
12520801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Heat structure steam generator vessel, lower part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
12510000  1    3    2    1    2.0
12510100  0    1
12510101  2    2.125
12510201  6    2
12510301  0.0   2
12510400  0
12510401  551.9   3
12510501  251010000 0    1    1    2.07   1
12510601  0    0    0    1    2.07   1
12510701  0    0.0   0.0   0.0   1
12510801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
12500000  1    3    2    1    2.0
12500100  0    1
12500101  2    2.125
12500201  6    2
12500301  0.0   2
12500400  0
12500401  551.9   3
12500501  250010000 0    1    1    4.43   1
12500601  0    0    0    1    4.43   1
12500701  0    0.0   0.0   0.0   1
12500801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
13200000  5    5    2    1    0.0065
13200100  0    1
13200101  4    0.008
13200201  4    4
13200301  0.0   4
13200400  0
13200401  565.00   5
13200501  320010000 10000   1    1    5511.   5
13200601  300010000 0    134   1    5511.   5
13200701  0    0.0   0.0   0.0   5
13200801  0.   10.   10.0   0.0   0.   0.   0.   1.   5
13200901  0.   10.0   10.0   0.0   0.0   0.   0.   1.   5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
13210000  5    5    2    1    0.0065
13210100  0    1
13210101  4    0.008
13210201  4    4
13210301  0.0   4
13210400  0
13210401  565.00   5
13210501  321010000 10000   1    1    10634.   5
13210601  301010000 0    134   1    10634.   5
13210701  0    0.0   0.0   0.0   5
13210801  0.   10.0   10.0   0.0   0.   0.   0.   1.   5
13210901  0.   10.0   10.0   0.0   0.0   0.   0.   1.   5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
13220000  5    5    2    1    0.0065
13220100  0    1
13220101  4    0.008
13220201  4    4
13220301  0.0   4
13220400  0
13220401  565.00   5
13220501  322010000 10000   1    1    8187.   5
13220601  302010000 0    134   1    8187.   5
13220701  0    0.0   0.0   0.0   5
13220801  0.   10.0   10.0   0.0   0.   0.   0.   1.   5
13220901  0.   10.0   10.0   0.0   0.   0.   0.   1.   5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  Heat structure  steam generator vessel, upper part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
13050000  1    3    2    1    2.0
13050100  0    1
13050101  2    2.125
13050201  6    2
13050301  0.0   2
13050400  0
13050401  551.9   3
13050501  305010000 0    1    1    3.45   1
13050601  0    0    0    1    3.45   1
13050701  0    0.0   0.0   0.00   1
13050801  3.   10.0   10.0   0.00   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
13040000  1    3    2    1    2.0
13040100  0    1
```

```
13040101  2        2.125
13040201  6        2
13040301  0.0      2
13040400  0
13040401  551.9    3
13040501  304010000 0      1      1      2.33    1
13040601  0        0       0      1      2.33    1
13040701  0        0.0     0.0    0.00   1
13040801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
13030000  1        3       2      1      2.0
13030100  0        1
13030101  2        2.125
13030201  6        2
13030301  0.0      2
13030400  0
13030401  551.9    3
13030501  303010000 0      1      1      0.73    1
13030601  0        0       0      1      0.73    1
13030701  0        0.0     0.0    0.00   1
13030801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
13520000  1        3       2      1      2.0
13520100  0        1
13520101  2        2.125
13520201  6        2
13520301  0.0      2
13520400  0
13520401  551.9    3
13520501  352010000 0      1      1      2.00    1
13520601  0        0       0      1      2.00    1
13520701  0        0.0     0.0    0.0    1
13520801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*   Heat structure  steam generator vessel, lower part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
13510000  1        3       2      1      2.0
13510100  0        1
13510101  2        2.125
13510201  6        2
13510301  0.0      2
13510400  0
13510401  551.9    3
13510501  351010000 0      1      1      2.07    1
13510601  0        0       0      1      2.07    1
13510701  0        0.0     0.0    0.0    1
13510801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
13500000  1        3       2      1      2.0
13500100  0        1
13500101  2        2.125
13500201  6        2
13500301  0.0      2
13500400  0
13500401  551.9    3
13500501  350010000 0      1      1      4.43    1
13500601  0        0       0      1      4.43    1
13500701  0        0.0     0.0    0.0    1
13500801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*    heat structures steam generator tubing
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
14200000  5        5       2      1      0.0065
14200100  0        1
14200101  4        0.008
14200201  4        4
14200301  0.0      4
14200400  0
14200401  565.00   5
14200501  420010000 10000   1     1      5511.   5
14200601  400010000 0      134    1      5511.   5
14200701  0        0.0     0.0    0.0    5
14200801  0.   10.   10.0   0.0   0.   0.   0.   1.   5
14200901  0.   10.0   10.0   0.0   0.0   0.   0.   1.   5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
14210000  5        5       2      1      0.0065
14210100  0        1
14210101  4        0.008
14210201  4        4
14210301  0.0      4
14210400  0
14210401  565.00   5
14210501  421010000 10000   1     1      10634.   5
14210601  401010000 0      134    1      10634.   5
14210701  0        0.0     0.0    0.0    5
14210801  0.   10.0   10.0   0.0   0.   0.   0.   1.   5
```

```
14210901  0.     10.0    10.0    0.0    0.0    0.    0.   1.   5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
14220000  5         5         2         1         0.0065
14220100  0         1
14220101  4         0.008
14220201  4         4
14220301  0.0       4
14220400  0
14220401  565.00    5
14220501  422010000 10000     1         1         8187.     5
14220601  402010000 0         134       1         8187.     5
14220701  0         0.0       0.0       0.0       5
14220801  0.    10.0    10.0     0.0    0.   0.   0.    1.    5
14220901  0.    10.0    10.0     0.0    0.   0.   0.    1.    5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  steam generator vessel, upper part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
14050000  1         3         2         1         2.0
14050100  0         1
14050101  2         2.125
14050201  6         2
14050301  0.0       2
14050400  0
14050401  551.9     3
14050501  405010000 0         1         1         3.45      1
14050601  0         0         0         1         3.45      1
14050701  0         0.0       0.0       0.00      1
14050801  3.    10.0    10.0     0.00   0.    0.   0.    1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
14040000  1         3         2         1         2.0
14040100  0         1
14040101  2         2.125
14040201  6         2
14040301  0.0       2
14040400  0
14040401  551.9     3
14040501  404010000 0         1         1         2.33      1
14040601  0         0         0         1         2.33      1
14040701  0         0.0       0.0       0.00      1
14040801  3.   10.0     10.0     0.0    0.    0.    0.    1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
14030000  1         3         2         1         2.0
14030100  0         1
```

```
14030101  2         2.125
14030201  6         2
14030301  0.0       2
14030400  0
14030401  551.9     3
14030501  403010000 0         1         1         0.73      1
14030601  0         0         0         1         0.73      1
14030701  0         0.0       0.0       0.00      1
14030801  3.   10.0     10.0     0.0   0.    0.    0.    1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
14520000  1         3         2         1         2.0
14520100  0         1
14520101  2         2.125
14520201  6         2
14520301  0.0       2
14520400  0
14520401  551.9     3
14520501  452010000 0         1         1         2.00      1
14520601  0         0         0         1         2.00      1
14520701  0         0.0       0.0       0.0       1
14520801  3.    10.0    10.0     0.0   0.    0.    0.    1.     1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  steam generator vessel, lower part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
14510000  1         3         2         1         2.0
14510100  0         1
14510101  2         2.125
14510201  6         2
14510301  0.0       2
14510400  0
14510401  551.9     3
14510501  451010000 0         1         1         2.07      1
14510601  0         0         0         1         2.07      1
14510701  0         0.0       0.0       0.0       1
14510801  3.     10.0     10.0     0.0     0.    0.    0.    1.    1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
14500000  1         3         2         1         2.0
14500100  0         1
14500101  2         2.125
14500201  6         2
14500301  0.0       2
14500400  0
14500401  551.9     3
```

```
14500501  450010000 0    1    1    4.43   1
14500601  0    0    0    1    4.43   1
14500701  0    0.0    0.0    0.0    1
14500801  3.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Heat structures of down part of reactor vessel
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  108
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
11080000  15    3    2    1    2.07
11080100  0    1
11080101  2    2.27
11080201  5    2
11080301  0.0    2
11080400  0
11080401  560.    3
11080501  116010000 0    1    1    0.2375   1
11080502  107010000 0    1    1    0.2125   2
11080503  108010000 0    1    1    0.11125   3
11080504  108020000 0    1    1    0.1875   4
11080505  108030000 10000   1    1    0.110313 12
11080506  108110000 0    1    1    0.0725   13
11080507  108120000 0    1    1    0.1415   14
11080508  108130000 0    1    1    0.24175  15
11080601  0    0    0    1    0.2375   1
11080602  0    0    0    1    0.2125   2
11080603  0    0    0    1    0.11125   3
11080604  0    0    0    1    0.1875   4
11080605  0    0    0    1    0.110313 12
11080606  0    0    0    1    0.0725   13
11080607  0    0    0    1    0.1415   14
11080608  0    0    0    1    0.24175  15
11080701  0    0.0    0.0    0.0    15
11080801  0.   10.0   10.0   0.0   0.   0.   0.   1.   15
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 208
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
12080000  15    3    2    1    2.07
12080100  0    1
12080101  2    2.27
12080201  5    2
12080301  0.0    2
12080400  0
12080401  560.    3
12080501  216010000 0    1    1    0.2375   1
12080502  207010000 0    1    1    0.2125   2
12080503  208010000 0    1    1    0.11125   3
12080504  208020000 0    1    1    0.1875   4
12080505  208030000 10000   1    1    0.110313 12
12080506  208110000 0    1    1    0.0725   13
12080507  208120000 0    1    1    0.1415   14
12080508  208130000 0    1    1    0.24175  15
12080601  0    0    0    1    0.2375   1
12080602  0    0    0    1    0.2125   2
12080603  0    0    0    1    0.11125   3
12080604  0    0    0    1    0.1875   4
12080605  0    0    0    1    0.110313 12
12080606  0    0    0    1    0.0725   13
12080607  0    0    0    1    0.1415   14
12080608  0    0    0    1    0.24175  15
12080701  0    0.0    0.0    0.0    15
12080801  0.   10.0   10.0   0.0   0.   0.   0.   1.   15
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  308
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
13080000  15    3    2    1    2.07
13080100  0    1
13080101  2    2.27
13080201  5    2
13080301  0.0    2
13080400  0
13080401  560.    3
13080501  316010000 0    1    1    0.2375   1
13080502  327010000 0    1    1    0.2125   2
13080503  308010000 0    1    1    0.11125   3
13080504  308020000 0    1    1    0.1875   4
13080505  308030000 10000   1    1    0.110313 12
13080506  308110000 0    1    1    0.0725   13
13080507  308120000 0    1    1    0.1415   14
13080508  308130000 0    1    1    0.24175  15
13080601  0    0    0    1    0.2375   1
13080602  0    0    0    1    0.2125   2
13080603  0    0    0    1    0.11125   3
13080604  0    0    0    1    0.1875   4
13080605  0    0    0    1    0.110313 12
13080606  0    0    0    1    0.0725   13
```

```
13080607  0         0         0         1         0.1415   14
13080608  0         0         0         1         0.24175  15
13080701  0         0.0       0.0       0.0       15
13080801  0.     10.0      10.0      0.0     0.     0.     0.    1.    15
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  408
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
14080000  15        3         2         1         2.07
14080100  0         1
14080101  2         2.27
14080201  5         2
14080301  0.0       2
14080400  0
14080401  560.      3
14080501  416010000 0         1         1         0.2375    1
14080502  407010000 0         1         1         0.2125    2
14080503  408010000 0         1         1         0.11125   3
14080504  408020000 0         1         1         0.1875    4
14080505  408030000 10000     1         1         0.110313 12
14080506  408110000 0         1         1         0.0725   13
14080507  408120000 0         1         1         0.1415   14
14080508  408130000 0         1         1         0.24175  15
14080601  0         0         0         1         0.2375    1
14080602  0         0         0         1         0.2125    2
14080603  0         0         0         1         0.11125   3
14080604  0         0         0         1         0.1875    4
14080605  0         0         0         1         0.110313 12
14080606  0         0         0         1         0.0725   13
14080607  0         0         0         1         0.1415   14
14080608  0         0         0         1         0.24175  15
14080701  0         0.0       0.0       0.0       15
14080801  0.     10.0      10.0      0.0     0.     0.     0.    1.    15
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  830
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18300000  1         3         2         1         0.09
18300100  0         1
18300101  2         0.097
18300201  4         2
18300301  0.0       2
18300400  0
18300401  562.48    3
18300501  830010000 0         1         1         207.      1
18300601  830010000 0         1         1         207.      1
18300701  0         0.0       0.0       0.0       1
18300801  0.     10.0      10.0      0.0     0.     0.     0.    1.    1
18300901  0.     10.0      10.0      0.0     0.     0.     0.    1.    1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 870
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18700000  5         3         2         1         0.09
18700100  0         1
18700101  2         0.097
18700201  4         2
18700301  0.0       2
18700400  0
18700401  592.      3
18700501  850010000 0         1         1         27.145    1
18700502  855010000 0         1         1         51.85     2
18700503  855020000 0         1         1         57.95     3
18700504  860010000 0         1         1         51.85     4
18700505  870010000 0         1         1         122.      5
18700601  850010000 0         1         1         27.145    1
18700602  855010000 0         1         1         51.85     2
18700603  855020000 0         1         1         57.95     3
18700604  860010000 0         1         1         51.85     4
18700605  870010000 0         1         1         122.      5
18700701  0         0.0       0.0       0.0       5
18700801  0.     10.0      10.0      0.0     0.     0.     0.    1.    5
18700901  0.     10.0      10.0      0.0     0.     0.     0.    1.    5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 872
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18720000  1         3         2         1         2.07
18720100  0         1
18720101  2         2.270
18720201  5         2
18720301  0.0       2
18720400  0
18720401  592.      3
18720501  870010000 0         1         1         2.00      1
18720601  0         0         0         1         2.00      1
18720701  0         0.0       0.0       0.0       1
18720801  0.     10.0      10.0      0.0     0.     0.     0.    1.    1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 880
```

```
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18800000  1    3    2    1    0.09
18800100  0    1
18800101  2    0.097
18800201  4    2
18800301  0.0    2
18800400  0
18800401  592.48   3
18800501  880010000 0    1    1    130.    1
18800601  880010000 0    1    1    130.    1
18800701  0    0.0    0.0    0.0    1
18800801  0.   10.0   10.0   0.0   0.   0.   0.   1.   1
18800901  0.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 831
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18310000  1    3    1    1    0.0
18310100  0    1
18310101  2    0.06
18310201  4    2
18310301  0.0    2
18310400  0
18310401  562.48   3
18310501  830010000 0    1    1    10.2    1
18310601  829010000 0    1    1    10.2    1
18310701  0    0.0    0.0    0.0    1
18310801  0.   10.0   10.0   0.0   0.   0.   0.   1.   1
18310901  0.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 882
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18820000  1    3    2    1    2.07
18820100  0    1
18820101  2    2.270
18820201  5    2
18820301  0.0    2
18820400  0
18820401  592.    3
18820501  880010000 0    1    1    1.235    1
18820601  0    0    0    1    1.235    1
18820701  0    0.0    0.0    0.0    1
18820801  0.   10.0   10.0   0.0   0.   0.   0.   1.   1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
```

```
*---- ----Core barrel - Reactor vessel internals - Lower part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 844
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18441000  14    3    2    1    1.745
18441100  0    1
18441101  2    1.805
18441201  5    2
18441301  0.0    2
18441400  0
18441401  570.    3
18441501  830010000 0    1    1    0.1415    1
18441502  843010000 0    1    1    0.0725    2
18441503  843020000 10000    1    1    0.1103    10
18441504  843100000 0    1    1    0.1875    11
18441505  850010000 0    1    1    0.11125   12
18441506  855010000 0    1    1    0.2125    13
18441507  855020000 0    1    1    0.2375    14
18441601  108120000 0    1    1    0.1415    1
18441602  108110000 0    1    1    0.0725    2
18441603  108100000 0    1    1    0.1103    3
18441604  108090000 0    1    1    0.1103    4
18441605  108080000 0    1    1    0.1103    5
18441606  108070000 0    1    1    0.1103    6
18441607  108060000 0    1    1    0.1103    7
18441608  108050000 0    1    1    0.1103    8
18441609  108040000 0    1    1    0.1103    9
18441610  108030000 0    1    1    0.1103    10
18441611  108020000 0    1    1    0.1875    11
18441612  108010000 0    1    1    0.11125   12
18441613  107010000 0    1    1    0.2125    13
18441614  116010000 0    1    1    0.2375    14
18441701  0    0.0    0.0    0.0    14
18441801  0.   10.0   10.0   0.0   0.   0.   0.   1.   14
18441901  0.   10.0   10.0   0.0   0.   0.   0.   1.   14
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*---- -Core barrel - Reactor vessel internals - Lower part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18442000  14    3    2    1    1.745
18442100  0    1
18442101  2    1.805
18442201  5    2
18442301  0.0    2
```

```
18442400  0
18442401  570.      3
18442501  830010000 0       1       1       0.1415    1
18442502  843010000 0       1       1       0.0725    2
18442503  843020000 10000     1       1       0.1103   10
18442504  843100000 0       1       1       0.1875   11
18442505  850010000 0       1       1       0.11125  12
18442506  855010000 0       1       1       0.2125   13
18442507  855020000 0       1       1       0.2375   14
18442601  208120000 0       1       1       0.1415    1
18442602  208110000 0       1       1       0.0725    2
18442603  208100000 0       1       1       0.1103    3
18442604  208090000 0       1       1       0.1103    4
18442605  208080000 0       1       1       0.1103    5
18442606  208070000 0       1       1       0.1103    6
18442607  208060000 0       1       1       0.1103    7
18442608  208050000 0       1       1       0.1103    8
18442609  208040000 0       1       1       0.1103    9
18442610  208030000 0       1       1       0.1103   10
18442611  208020000 0       1       1       0.1875   11
18442612  208010000 0       1       1       0.11125  12
18442613  207010000 0       1       1       0.2125   13
18442614  216010000 0       1       1       0.2375   14
18442701  0       0.0      0.0      0.0      14
18442801  0.    10.0    10.0    0.0    0.    0.    0.   1.   14
18442901  0.    10.0    10.0    0.0    0.    0.    0.   1.   14
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*---- ----Core barrel - Reactor vessel internals - Lower part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18443000  14      3       2       1       1.745
18443100  0       1
18443101  2       1.805
18443201  5       2
18443301  0.0      2
18443400  0
18443401  570.      3
18443501  830010000 0       1       1       0.1415    1
18443502  843010000 0       1       1       0.0725    2
18443503  843020000 10000     1       1       0.1103   10
18443504  843100000 0       1       1       0.1875   11
18443505  850010000 0       1       1       0.11125  12
18443506  855010000 0       1       1       0.2125   13
18443507  855020000 0       1       1       0.2375   14
18443601  308120000 0       1       1       0.1415    1
18443602  308110000 0       1       1       0.0725    2
18443603  308100000 0       1       1       0.1103    3
18443604  308090000 0       1       1       0.1103    4
18443605  308080000 0       1       1       0.1103    5
18443606  308070000 0       1       1       0.1103    6
18443607  308060000 0       1       1       0.1103    7
18443608  308050000 0       1       1       0.1103    8
18443609  308040000 0       1       1       0.1103    9
18443610  308030000 0       1       1       0.1103   10
18443611  308020000 0       1       1       0.1875   11
18443612  308010000 0       1       1       0.11125  12
18443613  307010000 0       1       1       0.2125   13
18443614  316010000 0       1       1       0.2375   14
18443701  0       0.0      0.0      0.0      14
18443801  0.    10.0    10.0    0.0    0.    0.    0.   1.   14
18443901  0.    10.0    10.0    0.0    0.    0.    0.   1.   14
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*---- ----Core barrel - Reactor vessel internals - Lower part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18444000  14      3       2       1       1.745
18444100  0       1
18444101  2       1.805
18444201  5       2
18444301  0.0      2
18444400  0
18444401  570.      3
18444501  830010000 0       1       1       0.1415    1
18444502  843010000 0       1       1       0.0725    2
18444503  843020000 10000     1       1       0.1103   10
18444504  843100000 0       1       1       0.1875   11
18444505  850010000 0       1       1       0.11125  12
18444506  855010000 0       1       1       0.2125   13
18444507  855020000 0       1       1       0.2375   14
18444601  408120000 0       1       1       0.1415    1
18444602  408110000 0       1       1       0.0725    2
18444603  408100000 0       1       1       0.1103    3
18444604  408090000 0       1       1       0.1103    4
18444605  408080000 0       1       1       0.1103    5
18444606  408070000 0       1       1       0.1103    6
18444607  408060000 0       1       1       0.1103    7
18444608  408050000 0       1       1       0.1103    8
18444609  408040000 0       1       1       0.1103    9
```

```
18444610  408030000 0    1    1    0.1103   10
18444611  408020000 0    1    1    0.1875   11
18444612  408010000 0    1    1    0.11125  12
18444613  407010000 0    1    1    0.2125   13
18444614  416010000 0    1    1    0.2375   14
18444701  0    0.0    0.0    0.0    14
18444801  0.   10.0   10.0   0.0   0.   0.   0.   1.   14
18444901  0.   10.0   10.0   0.0   0.   0.   0.   1.   14
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*---- Core barrel - Reactor vessel internals - Upper part
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
18461000  3    3    2    1    1.745
18461100  0    1
18461101  2    1.805
18461201  5    2
18461301  0.0    2
18461400  0
18461401  590.    3
18461501  860010000 0    1    1    0.850    1
18461502  870010000 0    1    1    2.00     2
18461503  880010000 0    1    1    1.235    3
18461601  860010000 0    1    1    0.850    1
18461602  870010000 0    1    1    2.00     2
18461603  880010000 0    1    1    1.235    3
18461701  0    0.0    0.0    0.0    3
18461801  0.   10.0   10.0   0.0   0.   0.   0.   1.   3
18461901  0.   10.0   10.0   0.0   0.   0.   0.   1.   3
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* Surge Line 805
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
8050000   surgelin  pipe
8050001     3
8050101   0.094        3
8050301    5.56000     1
8050302    10.5500     2
8050303    1.89000     3
8050601    -90.        1
8050602    0.0         2
8050603    90.0        3
8050701    -5.13500    1
8050702    0.00000     2
8050703    1.89000     3
8050801      2.5-5  0.346    3
8050901      .50   .50     2
8051001    0      3
8051101    0001000     2
8051201    110    15672361. 1461525. 2443784. 0. 0. 1
8051202    110    15689145. 1503750. 2443389. 0. 0. 2
8051203    110    15683264. 1529307. 2443527. 0. 0. 3
8052001    .00695037     1
8052002    .00695002     2
8052003    .00694977     3
8051300    0
8051301    1.91311-4   1.91311-4   0.    1 * .0119874
8051302    1.945838-4  1.945838-4  0.    2 * .0118324
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*      * P R E S S U R I Z E R *
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*    806  lower pressurizer
8060000    lprzer    branch
8060001  2     0
8060101  0.0   .40000  1.43252  0  90.   .40000  0.  0.094  0
8060200  110   15676167.   1556932. 2443695. 0.   .00694989
8061101  806010000  307000000  0  0  0  100
8062101  805030002  806010001  0.094  0.5  0.5  000100
8061201  5.12072-6   5.12101-6   0. * .01138047
8062201  1.952666-4  1.953755-4  0. * .0116469
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
* 307 pressurizer
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3070000    przer    pipe
3070001      5
3070101    7.0686     1
3070102    6.1610     4
3070103    7.0686     5
3070301    2.17720    1
3070302    2.04593    4
3070303    1.59000    5
3070601    90.0       5
3070801      0    0    5
3071001    0     5
3071101    0001000    4
3071201    110    15668438.  1576622. 2443877. 0. 0.    1
3071202    110    15655981.  1608179. 2444171.  0.    0. 2
3071203    110    15644103.  1609957. 2444451.  0.    0. 3
3071204    110    15632228.  1608646. 2444731.  0.    0. 4
```

```
3071205    110        15625361.  1609066. 2447336. .967415 0.  5
3072001    .00694926                                   1
3072002    .0069501                                    2
3072003    .00695028                                   3
3072004    .00694697                                   4
3072005    .00695726                                   5
3071300     0
3071301       -1.248884-6 -1.2489-6   0.       1 * -.00455965
3071302       -1.151385-6 -1.1514-6   0.       2 * -.00419584
3071303       -1.120418-6 -1.120432-6 0.       3 * -.00408814
3071304       -3.50111-5  .405436   0.         4 * -.004160755
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3700000     hprzer      branch
3700001  1          0
3700101  0.0    1.44500   6.06   0      90.    1.44500   0.     0.    0
3700200  100    15623718.    1609403. 2455042. 1.
3701101  307010000  370000000  0  0  0  100
3701201  -2.15328     -1.992973-6 0. * -8.46447-4
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3770000     hprzer      branch
3770001  1          0
3770101  0.0    1.00000   3.80   0      90.    1.00000   0.     0.    0
3770200  100    15622503.    1609358. 2453594. 1.
3771101  370010000  377000000  0  0  0  100
3771201  -8.45896-7  -8.45874-7  0. * -3.26377-4
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*        pressurizer spray system pipe
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3800000    prz-spr  pipe
3800001       3
3800101    0.02573                          3
3800301     10.0                          1
3800302     18.12001                        2
3800303     9.87999                         3
3800601      0.0                         1
3800602      0.0                         2
3800603      90.                         3
3800801       4.5-5  0.09                   3
3800901        .20    .20                  2
3801001      0                          3
3801101      0                          2
3801201      110        16025531. 1258493.  2435085. 0. 0. 1
3801202      110        16025531. 1255145.  2435085. 0. 0. 2
3801203      110        15989160. 1253152.  2436064. 0. 0. 3
3802001      .00695                              1
3802002      .00695                              2
3802003      .00695                              3
3801300      0
3801301     -6.96173-11 -6.96173-11  0.        1 * -1.343616-9
3801302     -4.31736-11 -3.094704-11 0.        2 * -8.34-10
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*          * M A I N  C O O L A N T  P U M P *
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  MCP # 1
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  144
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1440000      rcpa        pump
*crdno     area   length volume h-ang   v-ang   delz   ctl
1440101     .5       0.      3.     0    0.0     0.0     0
*crdno     from          area     floss     rloss     flag
1440108    142070002       0.         .1        .1      0001000
*crdno     to            area     floss     rloss     flag
1440109    145010001       0.         .1        .1      0001000
*1040110    0.8            0.        1.       1.    *      0
*1040111    0.8            0.        1.       1.    *      0
*crdno     ctl    pressure     temp
1440200      110     15668743. 1248890. 2443870. 0.   .00695058
*crdno     ctl     flowf    flowg    velj
1440201     1  4405.  4405. 0.  * 0   12.09146  12.75088   0. * 4551.31
1440202     1  4405.  4405. 0.  * 0   12.08868  12.08868   0. * 4551.3
*crdno     id    2faz   2fazd   tork   pvel   ptrip   rvrs
1440301      0     0        0   -1       0   432      0
*crdno     rpvel  initv   rflo   rhead   rtork   momi   rdens
1440302    104.1986 1.   5.88889 82.90   47500.  7600.    0.0
*crdno     rmotk   tf2       tf0       tf1      tf3
1440303    0.       0.0      400.0       0.0       0.
1440310    0.0      0.0  0.0
1446100    499
1446101      -1.   104.1964
1446102     0.     104.1964
1446103    0.5      103.46
1446104    1.      98.44
1446105    1.5      96.03
1446106    2.      93.72
1446107    2.5      91.42
```

```
1446108    3.0      89.33
1446109    3.5      87.23
1446110    4.0      85.14
1446111    5.0      81.68
1446112    7.0      74.98
1446113    10.      67.02
1446114    15.0     56.76
1446115    20.0     45.87
1446116    25.0     43.77
1446117    30.0     39.06
1446118    50.0     26.91
1446119    90.0     15.71
1446120    135.0    9.42
1446121    180.0    5.76
1446122    210.     3.98
1446123    232.     0.
1446124    10000.   0.
1446125    10.+6    0.
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*-         Single phase head  curve
1441100     1     1
*          indep  dependent
1441101     0.0   1.56   0.179  1.47   0.304  1.42
1441102     0.431  1.39   0.582  1.35   0.86   1.18
1441103     0.966  1.08   1.0    1.0
1441200     1     2
1441201     0.0   -1.4   0.161  -1.1   0.247  -0.93
1441202     0.315  -.78   0.424  -.54   0.5    -.35
1441203     0.556  -.21   0.61   -.08   0.673  0.1
1441204     0.736  0.26   0.815  0.45   0.904  0.73
1441205     1.0   1.00
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1441300     1     3
1441301     -1.0   4.00   -.823  2.3    -.770  2.13
1441302     -.720  2.13   -.5710 2.07   -.4500 1.92
1441303     -.12   1.70   0.0    1.56
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1441400     1     4
1441401     -1.0   4.00   -.767  2.94   -.5000 2.5
1441402     0.0   1.76
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1441500     1     5
1441501     0.0    0.0    0.077  0.08   0.110  0.11
```

```
1441502     0.15   0.15   0.208  0.21   0.25   0.25
1441503     0.286  0.29   0.333  0.330  0.381  0.38
1441504     0.73   0.73   0.80   0.8    1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1441600     1     6
1441601     0.0   1.76   0.041  1.70   0.2111 1.53
1441602     0.324  1.41   0.3804 1.34   0.473  1.25
1441603     0.611  1.11   0.8652 1.01   1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1441700     1     7
1441701     -1.0   -2.78  -.913  -2.54  -.839  -2.33
1441702     -.659  -1.830 -.570  -1.58  -.5260 -1.46
1441703     -.475  -1.32  -.410  -1.14  -.327  -0.91
1441704     -.210  -.58   -.119  -.33   -.0600 -.17
1441705     0.0    0.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1441800     1     8
1441801     -1.0  -2.78  -.881  -2.62  -.730  -2.41
1441802     -.453  -2.03  -.368  -1.91  0.0    -1.4
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*          Single phase torque curve
1441900     2     1
1441901     0.0    0.8    0.084  0.80   0.294  0.82
1441902     0.406  0.83   0.575  0.880  0.920  0.98
1441903     1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1442000     2     2
1442002     0.0    -.81   0.111  -.590  0.185  -.440
1442003     0.240  -.33   0.308  -.20   0.340  -.140
1442004     0.378  -.06   0.418  0.03   0.483  0.17
1442005     0.530  0.230  0.574  0.30   0.633  0.39
1442006     0.694  0.500  0.790  0.63   0.97   0.95
1442007     1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1442100     2     3
1442101     -1.0   2.46   -.969  2.340  -.930  2.19
1442102     -.796  1.68   -.615  1.37   -.476  1.09
1442103     -.359  0.98   -.307  0.930  -.088  0.81
1442104     0.0    0.8
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1442200     2     4
1442201     -1.0   2.460  -.950  2.40   -.86   2.280
1442202     -.702  2.120  -.440  1.86   0.0    1.5
```

```
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1442300      2      5
1442301     0.0    -1.3   0.091  -1.10  0.194  -.880
1442302     0.313  -.70   0.4650 -.38   0.754  0.190
1442303     0.876  0.43   1.0    0.67
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1442400      2      6
1442401     0.0    1.5    0.067  1.45   0.113  1.410
1442402     0.239  1.33   0.565  1.06   0.681  0.96
1442403     0.956  0.710  1.0    0.670
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1442500      2      7
1442501     -1.0   -3.97  0.0    -1.3
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1442600      2      8
1442601     -1.0   -3.97  -.833  -3.440 -.60   -2.7
1442602     -.333  -1.860 -.186  -1.4   -.075  -1.05
1442603     0.0    -.810
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1443000     0      0.0    0.0     0.07  0.0     0.08    0.74
1443001            0.165  1.0     0.9   1.0     1.0     0.0
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1443100     0      0.0    0.0     1.00  0.0
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1444100  1  1      0.0    0.0     0.10  0.83    0.20    1.09
1444101            0.5    1.02    0.7   1.01    0.90    0.94
1444102            1.00   1.00
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1444200  1  2      0.0    0.0     0.10 -0.04    0.20    0.00
1444201            0.3    0.10    0.4   0.21    0.80    0.67
1444202            0.90   0.80    1.00  1.00
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1444300  1  3     -1.00  -1.16   -0.90 -1.24   -0.80   -1.77
1444301           -0.70  -2.36   -0.60 -2.79   -0.50   -2.91
1444302           -0.40  -2.67   -0.25 -1.69   -0.10   -0.50
1444303            0.00   0.00
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1444400  1  4     -1.00  -1.16   -0.90 -0.78   -0.80   -0.50
1444401           -0.70  -0.31   -0.60 -0.17   -0.50   -0.08
1444402           -0.35   0.00   -0.20  0.05   -0.10    0.08
1444403            0.00   0.11
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1444500  1  5      0.00   0.00    0.20 -0.34    0.40   -0.65
```

```
1444501            0.60  -0.95    0.80 -1.19    1.00   -1.47
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1444600  1  6      0.00   0.11    0.10  0.13    0.25    0.15
1444601            0.40   0.13    0.50  0.07    0.60   -0.04
1444602            0.70  -0.23    0.80 -0.51    0.90   -0.91
1444603            1.00  -1.47
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1444700  1  7     -1.00   0.00    0.00  0.00
*4--- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1444800  1  8     -1.00   0.00    0.00  0.00
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
1444900  2  1      0.00   0.00    1.00  0.00
1445000  2  2      0.00   0.00    1.00  0.00
1445100  2  3     -1.00   0.00    0.00  0.00
1445200  2  4     -1.00   0.00    0.00  0.00
1445300  2  5      0.00   0.00    1.00  0.00
1445400  2  6      0.00   0.00    1.00  0.00
1445500  2  7     -1.00   0.00    0.00  0.00
1445600  2  8     -1.00   0.00    0.00  0.00
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  MCP # 2
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  244
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2440000      rcpa        pump
*crdno     area   length volume h-ang   v-ang   delz   ctl
2440101    .5      0.      3.     0    0.0     0.0     0
*crdno     from          area     floss     rloss     flag
2440108    242070002       0.        .1        .1      0001000
*crdno     to            area     floss     rloss     flag
2440109    245010001       0.        .1        .1      0001000
*1040110    0.8            0.        1.        1.    *       0
*1040111    0.8            0.        1.        1.    *       0
*crdno     ctl    pressure     temp
2440200      110      15669981. 1249018. 2443840. 0.   .00695058
*crdno     ctl     flowf    flowg    velj
2440201      1 4405. 4405. 0. *  0  12.09146  12.7508    0. * 4544.935
2440202      1 4405. 4405. 0. *  0  12.08868  12.08868   0. * 4544.93
*crdno      id    2faz   2fazd   tork   pvel   ptrip   rvrs
2440301      0     144       144  -1      0   432      0
*crdno     rpvel  initv   rflo   rhead   rtork   momi   rdens
2440302    104.1986 1.    5.88889 82.90   47500.  7600.    0.0
*crdno     rmotk   tf2       tf0       tf1      tf3
```

```
2440303    0.         0.0       400.0        0.0        0.
2440310    0.0        0.0  0.0
2446100    499
2446101       -1.   104.1964
2446102     0.      104.1964
2446103    0.5       103.46
2446104    1.        98.44
2446105    1.5       96.03
2446106    2.        93.72
2446107    2.5       91.42
2446108    3.0       89.33
2446109    3.5       87.23
2446110    4.0       85.14
2446111    5.0       81.68
2446112    7.0       74.98
2446113    10.       67.02
2446114    15.0      56.76
2446115    20.0      45.87
2446116    25.0      43.77
2446117    30.0      39.06
2446118    50.0      26.91
2446119    90.0      15.71
2446120    135.0     9.42
2446121    180.0     5.76
2446122    210.      3.98
2446123    232.      0.
2446124    10000.    0.
2446125    10.+6     0.
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*-          Single phase head  curve
2441100      1      1
*           indep  dependent
2441101     0.0    1.56   0.179  1.47   0.304  1.42
2441102     0.431  1.39   0.582  1.35   0.86   1.18
2441103     0.966  1.08   1.0    1.0
2441200      1      2
2441201     0.0    -1.4   0.161  -1.1   0.247  -0.93
2441202     0.315  -.78   0.424  -.54   0.5    -.35
2441203     0.556  -.21   0.61   -.08   0.673  0.1
2441204     0.736  0.26   0.815  0.45   0.904  0.73
2441205     1.0    1.00
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2441300      1      3
2441301     -1.0   4.00   -.823  2.3    -.770  2.13
2441302     -.720  2.13   -.5710 2.07   -.4500 1.92
2441303     -.12   1.70   0.0    1.56
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2441400      1      4
2441401     -1.0   4.00   -.767  2.94   -.5000 2.5
2441402      0.0   1.76
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2441500      1      5
2441501     0.0    0.0    0.077  0.08   0.110  0.11
2441502     0.15   0.15   0.208  0.21   0.25   0.25
2441503     0.286  0.29   0.333  0.330  0.381  0.38
2441504     0.73   0.73   0.80   0.8    1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2441600      1      6
2441601      0.0   1.76   0.041  1.70   0.2111 1.53
2441602     0.324  1.41   0.3804 1.34   0.473  1.25
2441603     0.611  1.11   0.8652 1.01   1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2441700      1      7
2441701     -1.0   -2.78  -.913  -2.54  -.839  -2.33
2441702     -.659  -1.830 -.570  -1.58  -.5260 -1.46
2441703     -.475  -1.32  -.410  -1.14  -.327  -0.91
2441704     -.210  -.58   -.119  -.33   -.0600 -.17
2441705     0.0    0.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2441800      1      8
2441801      -1.0  -2.78  -.881  -2.62  -.730  -2.41
2441802     -.453  -2.03  -.368  -1.91  0.0    -1.4
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*4          Single phase torque curve
2441900      2      1
2441901     0.0    0.8    0.084  0.80   0.294  0.82
2441902     0.406  0.83   0.575  0.880  0.920  0.98
2441903     1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2442000      2      2
2442002     0.0    -.81   0.111  -.590  0.185  -.440
2442003     0.240  -.33   0.308  -.20   0.340  -.140
2442004     0.378  -.06   0.418  0.03   0.483  0.17
2442005     0.530  0.230  0.574  0.30   0.633  0.39
2442006     0.694  0.500  0.790  0.63   0.97   0.95
2442007     1.0    1.0
```

```
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2442100     2     3
2442101     -1.0   2.46   -.969  2.340  -.930  2.19
2442102     -.796  1.68   -.615  1.37   -.476  1.09
2442103     -.359  0.98   -.307  0.930  -.088  0.81
2442104     0.0    0.8
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2442200     2     4
2442201     -1.0   2.460  -.950  2.40   -.86   2.280
2442202     -.702  2.120  -.440  1.86   0.0    1.5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2442300     2     5
2442301     0.0    -1.3   0.091  -1.10  0.194  -.880
2442302     0.313  -.70   0.4650 -.38   0.754  0.190
2442303     0.876  0.43   1.0    0.67
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2442400     2     6
2442401     0.0    1.5    0.067  1.45   0.113  1.410
2442402     0.239  1.33   0.565  1.06   0.681  0.96
2442403     0.956  0.710  1.0    0.670
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2442500     2     7
2442501     -1.0   -3.97  0.0    -1.3
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
2442600     2     8
2442601     -1.0   -3.97  -.833  -3.440 -.60   -2.7
2442602     -.333  -1.860 -.186  -1.4   -.075  -1.05
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  MCP # 3
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  344
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3440000     rcpa      pump
*crdno    area   length volume h-ang   v-ang   delz   ctl
3440101    .5      0.      3.     0    0.0      0.0     0
*crdno    from         area     floss     rloss     flag
3440108    342070002       0.        .1        .1      0001000
*crdno    to           area     floss     rloss     flag
3440109    345010001       0.        .1        .1      0001000
*1040110    0.8            0.        1.        1.    *       0
*1040111    0.8            0.        1.        1.    *       0
*crdno    ctl    pressure    temp
3440200     110     15669981. 1249018. 2443840. 0.   .00695058
*crdno    ctl     flowf    flowg    velj
3440201     1 4405. 4405. 0. *  0  12.09146  12.7508    0. * 4544.935
3440202     1 4405. 4405. 0. *  0  12.08868  12.08868   0. * 4544.93
*crdno     id    2faz   2fazd   tork   pvel   ptrip   rvrs
3440301      0     144       144  -1       0   432      0
*crdno    rpvel  initv   rflo   rhead   rtork   momi   rdens
3440302    104.1986 1.   5.88889 82.90   47500.  7600.    0.0
*crdno    rmotk   tf2      tf0       tf1     tf3
3440303    0.       0.0      400.0      0.0      0.
3440310    0.0      0.0  0.0
3446100    499
3446101      -1.   104.1964
3446102    0.     104.1964
3446103    0.5     103.46
3446104    1.      98.44
3446105    1.5     96.03
3446106    2.      93.72
3446107    2.5     91.42
3446108    3.0     89.33
3446109    3.5     87.23
3446110    4.0     85.14
3446111    5.0     81.68
3446112    7.0     74.98
3446113    10.     67.02
3446114    15.0    56.76
3446115    20.0    45.87
3446116    25.0    43.77
3446117    30.0    39.06
3446118    50.0    26.91
3446119    90.0    15.71
3446120    135.0   9.42
3446121    180.0   5.76
3446122    210.    3.98
3446123    232.    0.
3446124    10000.  0.
3446125    10.+6   0.
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*-        Single phase head  curve
3441100     1     1
*         indep  dependent
3441101     0.0    1.56   0.179  1.47   0.304  1.42
3441102     0.431  1.39   0.582  1.35   0.86   1.18
3441103     0.966  1.08   1.0    1.0
```

```
3441200     1     2
3441201     0.0    -1.4   0.161  -1.1   0.247  -0.93
3441202     0.315  -.78   0.424  -.54   0.5    -.35
3441203     0.556  -.21   0.61   -.08   0.673  0.1
3441204     0.736  0.26   0.815  0.45   0.904  0.73
3441205     1.0    1.00
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3441300     1     3
3441301     -1.0   4.00   -.823  2.3    -.770  2.13
3441302     -.720  2.13   -.5710 2.07   -.4500 1.92
3441303     -.12   1.70   0.0    1.56
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3441400     1     4
3441401     -1.0   4.00   -.767  2.94   -.5000 2.5
3441402     0.0    1.76
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3441500     1     5
3441501     0.0    0.0    0.077  0.08   0.110  0.11
3441502     0.15   0.15   0.208  0.21   0.25   0.25
3441503     0.286  0.29   0.333  0.330  0.381  0.38
3441504     0.73   0.73   0.80   0.8    1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3441600     1     6
3441601     0.0    1.76   0.041  1.70   0.2111 1.53
3441602     0.324  1.41   0.3804 1.34   0.473  1.25
3441603     0.611  1.11   0.8652 1.01   1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3441700     1     7
3441701     -1.0   -2.78  -.913  -2.54  -.839  -2.33
3441702     -.659  -1.830 -.570  -1.58  -.5260 -1.46
3441703     -.475  -1.32  -.410  -1.14  -.327  -0.91
3441704     -.210  -.58   -.119  -.33   -.0600 -.17
3441705     0.0    0.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3441800     1     8
3441801     -1.0   -2.78  -.881  -2.62  -.730  -2.41
3441802     -.453  -2.03  -.368  -1.91  0.0    -1.4
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*          Single phase torque curve
3441900     2     1
3441901     0.0    0.8    0.084  0.80   0.294  0.82
3441902     0.406  0.83   0.575  0.880  0.920  0.98
3441903     1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3442000     2     2
3442002     0.0    -.81   0.111  -.590  0.185  -.440
3442003     0.240  -.33   0.308  -.20   0.340  -.140
3442004     0.378  -.06   0.418  0.03   0.483  0.17
3442005     0.530  0.230  0.574  0.30   0.633  0.39
3442006     0.694  0.500  0.790  0.63   0.97   0.95
3442007     1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3442100     2     3
3442101     -1.0   2.46   -.969  2.340  -.930  2.19
3442102     -.796  1.68   -.615  1.37   -.476  1.09
3442103     -.359  0.98   -.307  0.930  -.088  0.81
3442104     0.0    0.8
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3442200     2     4
3442201     -1.0   2.460  -.950  2.40   -.86   2.280
3442202     -.702  2.120  -.440  1.86   0.0    1.5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3442300     2     5
3442301     0.0    -1.3   0.091  -1.10  0.194  -.880
3442302     0.313  -.70   0.4650 -.38   0.754  0.190
3442303     0.876  0.43   1.0    0.67
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3442400     2     6
3442401     0.0    1.5    0.067  1.45   0.113  1.410
3442402     0.239  1.33   0.565  1.06   0.681  0.96
3442403     0.956  0.710  1.0    0.670
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3442500     2     7
3442501     -1.0   -3.97  0.0    -1.3
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
3442600     2     8
3442601     -1.0   -3.97  -.833  -3.440 -.60   -2.7
3442602     -.333  -1.860 -.186  -1.4   -.075  -1.05
3442603     0.0    -.810
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  MCP # 4
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*  444
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4440000       rcpa        pump
*crdno     area   length volume h-ang   v-ang   delz   ctl
```

```
4440101   .5      0.      3.     0    0.0     0.0     0
*crdno    from         area     floss    rloss     flag
4440108   442070002       0.        .1       .1      0001000
*crdno    to          area     floss    rloss     flag
4440109   445010001       0.        .1       .1      0001000
*1040110   0.8            0.        1.       1.    *      0
*1040111   0.8            0.        1.       1.    *      0
*crdno    ctl   pressure    temp
4440200     110     15669979. 1248960. 2443840. 0.   .00695058
*crdno    ctl    flowf    flowg    velj
4440201     1 4405. 4405. 0. *  0  12.0934   12.75281   0. * 4545.79
4440202     1 4405. 4405. 0. *  0  12.09063  12.09063   0. * 4545.79
*crdno     id    2faz   2fazd   tork   pvel   ptrip   rvrs
4440301      0     144       144  -1      0    432      0
*crdno    rpvel  initv   rflo   rhead   rtork   momi   rdens
4440302   104.1986 1.   5.88889 82.90   47500.  7600.    0.0
*crdno    rmotk   tf2       tf0       tf1     tf3
4440303   0.       0.0      400.0       0.0       0.
4440310   0.0      0.0  0.0
4446100   499
4446101      -1.   104.1964
4446102     0.     104.1964
4446103   0.5      103.46
4446104   1.       98.44
4446105   1.5      96.03
4446106   2.       93.72
4446107   2.5      91.42
4446108   3.0      89.33
4446109   3.5      87.23
4446110   4.0      85.14
4446111   5.0      81.68
4446112   7.0      74.98
4446113   10.      67.02
4446114   15.0     56.76
4446115   20.0     45.87
4446116   25.0     43.77
4446117   30.0     39.06
4446118   50.0     26.91
4446119   90.0     15.71
4446120   135.0    9.42
4446121   180.0    5.76
4446122   210.     3.98
4446123   232.     0.
4446124   10000.   0.
4446125   10.+6    0.
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*-        Single phase head  curve
4441100     1     1
*         indep  dependent
4441101     0.0    1.56   0.179  1.47   0.304  1.42
4441102     0.431  1.39   0.582  1.35   0.86   1.18
4441103     0.966  1.08   1.0    1.0
4441200     1     2
4441201     0.0    -1.4   0.161  -1.1   0.247  -0.93
4441202     0.315  -.78   0.424  -.54   0.5    -.35
4441203     0.556  -.21   0.61   -.08   0.673  0.1
4441204     0.736  0.26   0.815  0.45   0.904  0.73
4441205     1.0    1.00
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4441300     1     3
4441301     -1.0   4.00   -.823  2.3    -.770  2.13
4441302     -.720  2.13   -.5710 2.07   -.4500 1.92
4441303     -.12   1.70   0.0    1.56
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4441400     1     4
4441401     -1.0   4.00   -.767  2.94   -.5000 2.5
4441402      0.0   1.76
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4441500     1     5
4441501     0.0    0.0    0.077  0.08   0.110  0.11
4441502     0.15   0.15   0.208  0.21   0.25   0.25
4441503     0.286  0.29   0.333  0.330  0.381  0.38
4441504     0.73   0.73   0.80   0.8    1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4441600     1     6
4441601      0.0   1.76   0.041  1.70   0.2111 1.53
4441602     0.324  1.41   0.3804 1.34   0.473  1.25
4441603     0.611  1.11   0.8652 1.01   1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4441700     1     7
4441701     -1.0   -2.78  -.913  -2.54  -.839  -2.33
4441702     -.659  -1.830 -.570  -1.58  -.5260 -1.46
4441703     -.475  -1.32  -.410  -1.14  -.327  -0.91
4441704     -.210  -.58   -.119  -.33   -.0600 -.17
4441705     0.0    0.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
```

```
4441800     1     8
4441801     -1.0  -2.78  -.881  -2.62  -.730  -2.41
4441802     -.453  -2.03  -.368  -1.91  0.0    -1.4
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
*         Single phase torque curve
4441900     2     1
4441901     0.0    0.8    0.084  0.80   0.294  0.82
4441902     0.406  0.83   0.575  0.880  0.920  0.98
4441903     1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4442000     2     2
4442002     0.0    -.81   0.111  -.590  0.185  -.440
4442003     0.240  -.33   0.308  -.20   0.340  -.140
4442004     0.378  -.06   0.418  0.03   0.483  0.17
4442005     0.530  0.230  0.574  0.30   0.633  0.39
4442006     0.694  0.500  0.790  0.63   0.97   0.95
4442007     1.0    1.0
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4442100     2     3
4442101     -1.0   2.46   -.969  2.340  -.930  2.19
4442102     -.796  1.68   -.615  1.37   -.476  1.09
4442103     -.359  0.98   -.307  0.930  -.088  0.81
4442104     0.0    0.8
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4442200     2     4
4442201     -1.0   2.460  -.950  2.40   -.86   2.280
4442202     -.702  2.120  -.440  1.86   0.0    1.5
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4442300     2     5
4442301     0.0    -1.3   0.091  -1.10  0.194  -.880
4442302     0.313  -.70   0.4650 -.38   0.754  0.190
4442303     0.876  0.43   1.0    0.67
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4442400     2     6
4442401     0.0    1.5    0.067  1.45   0.113  1.410
4442402     0.239  1.33   0.565  1.06   0.681  0.96
4442403     0.956  0.710  1.0    0.670
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4442500     2     7
4442501     -1.0   -3.97  0.0    -1.3
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7
4442600     2     8
4442601     -1.0   -3.97  -.833  -3.440 -.60   -2.7
4442602     -.333  -1.860 -.186  -1.4   -.075  -1.05
4442603     0.0    -.810
*---- ----1---- ----2---- ----3---- ----4---- ----5---- ----6---- ----7

.  * end of input *
```

ALSO AVAILABLE

NEA Publications of General Interest

2001 Annual Report (2002) *Free: paper or Web.*

NEA News
ISSN 1605-9581 Yearly subscription: € 40 US$ 45 GBP 26 ¥ 4 800

Nuclear Science

Physics of Plutonium Recycling (2002)
Volume VI – Multiple Pu Recycling in Advanced PWRs
ISBN 92-64-1995768 Price: € 45 US$ 45 GBP 28 ¥ 5 250

Advanced Reactors with Innovative Fuels (2002)
ISBN 92-64-19847-4 Price: € 130 US$ 113 GBP 79 ¥ 15 000

Basic Studies in the Field of High-temperature Engineering(2002)
ISBN 92-64-19796-6 Price: € 75 US$ 66 GBP 46 ¥ 8 600

Fission Gas Behaviour in Water Reactor Fuels (2002)
ISBN 92-64-19715-X Price: € 120 US$ 107 GBP 74 ¥ 12 100

Shielding Aspects of Accelerators, Targets and Irradiation Facilities – SATIF 5 (2001)
ISBN 92-64-18691-3 Price: € 84 US$ 75 GBP 52 ¥ 8 450

Nuclear Production of Hydrogen (2001)
ISBN 92-64-18696-4 Price: € 55 US$ 49 GBP 34 ¥ 5 550

Utilisation and Reliability of High Power Proton Accelerators (2001)
(ISBN 92-64-18749-9 Price: € 130 US$ 116 GBP 80 ¥ 13 100

Pyrochemical Separations (2001)
ISBN 92-64-18443-0 Price: € 77 US$ 66 GBP 46 ¥ 7 230

Evaluation of Speciation Technology (2001)
ISBN 92-64-18667-0 Price: € 80 US$ 70 GBP 49 ¥ 7 600

Comparison Calculations for an Accelerator-driven Minor Actinide Burner (2002)
ISBN 92-64-18478-3 *Free: paper or web.*

Speciation, Techniques and Facilities for Radioactive Materials at Synchrotron Light Sources (2002)
Workshop Proceedings, Grenoble, France, 10-12 September 2000
ISBN 92-64-18485-5 *Free: paper or web.*

Forsmark 1 & 2 Boiling Water Reactor Stability Benchmark (2001)
ISBN 92-64-18669-4 *Free: paper or web.*

Pressurised Water Reactor Main Steam Line Break (MSLB) Benchmark (Volume III) (2002)
ISBN 92-64-18495-3 *Free: paper or web.*

Order form on reverse side.

ORDER FORM

OECD Nuclear Energy Agency, 12 boulevard des Iles, F-92130 Issy-les-Moulineaux, France
Tel. 33 (0)1 45 24 10 15, Fax 33 (0)1 45 24 11 10, E-mail: neapub@nea.fr, Internet: www.nea.fr

Qty	Title	ISBN	Price	Amount
			Total*	

* Prices include postage fees.

❑ Payment enclosed (cheque payable to OECD Publications).

Charge my credit card ❑ VISA ❑ Mastercard ❑ American Express

Card No.	Expiration date	Signature
Name		
Address	Country	
Telephone	Fax	
E-mail		

OECD PUBLICATIONS, 2 rue André-Pascal, 75775 PARIS CEDEX 16
Printed in France.