IAEA-TECDOC-815

In-core fuel management code package validation for PWRs

INTERNATIONAL ATOMIC ENERGY AGENCY

The IAEA does not normally maintain stocks of reports in this series. However, microfiche copies of these reports can be obtained from

INIS Clearinghouse
International Atomic Energy Agency
Wagramerstrasse 5
P.O. Box 100
A-1400 Vienna, Austria

Orders should be accompanied by prepayment of Austrian Schillings 100,— in the form of a cheque or in the form of IAEA microfiche service coupons which may be ordered separately from the INIS Clearinghouse.

The originating Section of this publication in the IAEA was:

Nuclear Power Technology Development Section
International Atomic Energy Agency
Wagramerstrasse 5
P.O. Box 100
A-1400 Vienna, Austria

IN-CORE FUEL MANAGEMENT CODE
PACKAGE VALIDATION FOR PWRs
IAEA, VIENNA, 1995
IAEA-TECDOC-815
ISSN 1011-4289

Printed by the IAEA in Austria
August 1995

FOREWORD

In the framework of its reactor physics activities conducted within its nuclear power programme, the IAEA has long provided its Member States with a forum for the exchange of technical information on in-core fuel management.

This has mainly been achieved through the organization of specialists and technical committee meetings and the publication of technical documents. In 1988, the IAEA initiated a number of co-ordinated research programmes (CRPs) on selected reactor core physics aspects of water cooled reactors. The CRP on In-core Fuel Management Code Package Validation for LWRs was set up to obtain well defined cases for the verification of code packages for PWRs, BWRs and WWERs, with the participation of 16 contract/agreement holders and observers. The outline of the CRP was established at a consultancy held at the Jozef Stephan Institute in Ljubljana, Slovenia, from 24 to 28 May 1988. However, because of the significant differences in core layout and core management of these reactor types, the CRP was performed in three separate parts.

The IAEA would like to express its thanks to all those who took part in the programme and contributed to this report, particularly the Almaraz Nuclear Power Plant, Spain, for providing measured data for cycles 1 and 2 (Unit II). Special thanks go to S.H. Levine for his guidance and final editing of the report, to C. Ahnert for assisting in receiving permission to publish the operating data, and to D. Pevec for compiling all the data and text into a consistent report.

PLEASE BE AWARE THAT
ALL OF THE MISSING PAGES IN THIS DOCUMENT
WERE ORIGINALLY BLANK

EDITORIAL NOTE

CONTENTS

1. INTRODUCTION

As a result of many years of research and development activities, co-ordinated and supported by the IAEA, complete in-core fuel management packages for three types of reactors, namely PWRs, BWRs and PHWRs, became available from the NEA Data Bank [1]. For some reactor types, these programme packages are available with three levels of sophistication: level I is useful as a first introduction to in-core fuel management for nuclear engineers; level II is useful for survey-type calculations, scoping and sensitivity analyses, at low computer cost, but having the degree of accuracy which is not sufficient for licensing the reload; level III includes codes sufficiently accurate to provide the data needed for actual reactor design, licensing, and operation.

The next goal of the IAEA supported research and development activities in this field was to develop test cases appropriate to check the fuel management computer code packages and their procedures for both levels II and III [2],[3]. A new co-ordinated research project was started in 1988 in order to validate and, if necessary, to improve the previously developed and proposed code packages. The data needed in calculations had to be supplied from the reactor and fuel manufacturers and utilities for each of the reactor type considered.

For the PWR reactor, the benchmark parameters have been prepared and they consist of the core description and the fuel assembly data for cycles 1 and 2 of the NPP Almaraz[4]. In order to compare the results obtained by different participants to verify their computer code packages, and also to provide the reference solutions for certain in-core fuel management problems, the participants have been provided with a specific format for submitting the results of the lattice analysis. For the same reason a standardized format was specified for giving a brief description of the codes and methods used in the benchmark calculations[5].

For the benchmark specifications a set of realistic reactor data has been defined that provide the information needed to develop the input data for running in-core fuel management codes. Secondly, the results of measurements and/or data have been provided to verify and compare the parameters which were to be calculated with the code packages. There are several parameters that must be calculated by the code packages and they relate to: the safeness of the design, the ability of the design to produce the rated power for the defined length of time (cycle-length), and the economy of the design. These parameters may be divided into two sets. The first set can be calculated by scoping or level II code packages involving two dimensional calculations, whereas the second set involves three dimensional level III code packages. Simple thermal feedback techniques not involving voids can be used and therefore the majority of the required parameters can be determined using 2-D calculations.

Once the benchmark specifications and parameters were available each code package could be used by any participating Institute in the CRP to perform in-core fuel management calculations. However, it was important to compare the results calculated for these benchmark problems by the different computer code packages. Such results include more data than the parameters required for benchmark calculations. For example such data are the k_{inf} of each fuel assembly in the core at various times during the core depletion, BOC homogenized number densities, selected reaction rates, etc. The code packages available to IAEA member states can also be used to calculate different types of parameters useful in physics start-up tests, various accident analyses, etc. that are not identified as part of the in-core fuel management required parameters.

The benchmark specifications and parameters include best estimate design data which are available in the open literature. The co-operation of the related industries and utilities with this programme add significantly and in fact are essential to its success.

2. BENCHMARK PROBLEM DEFINITION

The purpose of Benchmark calculations is to obtain well defined test cases for verifying the code packages of both levels.

All of the needed geometry and material compositions were given at room temperature (20°C) and at zero burnup. Some of the needed parameters are given schematically in figures, like loading patterns or control rod positions, thus being more helpful.

All the values are needed for both levels II and III previously defined for code packages, namely concerning in-core fuel management (level II) and safety and operational conditions (level III) respectively.

In order to validate the results of benchmark calculations it was also necessary to obtain measured quantities from a utility. These values were chosen in order to obtain relevant, realistic data to be used for verification of code packages and establishing the reference solutions.

The Polytechnical University of Madrid in collaboration with the utility which operates one of the PWR plants in Spain (C.N. Almaraz) has contributed to the IAEA and the contribution was mainly devoted to:

- Prepare and supply the Technical Data and Specifications of the selected PWR Benchmark in the established format.

- Select and present the measurements obtained during the operation of the first two cycles of the NPP Almaraz unit II (the start-up test and HZP conditions, the power following and HFP conditions) in order to be used as a reference.

    - Issue a document containing the previous information to be used for the validation of the results obtained by the different IFM code packages.

2.1 DESIGN PARAMETERS

The required data for the Benchmark problem definition include the reactor core description, and the nuclear design parameters for the first two cycles of unit II of the NPP Almaraz. These data show that there is similarity with the fuel assembly data in the Westinghouse RESAR document, although the core has a smaller number of fuel assemblies.

The design data in this document were extracted from the public documents, open literature, and open NPP Almaraz files[6-11].

1. CORE DESCRIPTION

		Reference
Rated thermal power	2686 MW	(7)
Number of loops	3	(7)
Heat generated in fuel	97.4%	(6)
Coolant:		
Nominal pressure	155.137 bar	(6)
Core flow	1.38×10^4 kg/s	(7)
HFP inlet temperature	291.4°C	(7)
HFP average core outlet temp.	326°C	(6)
HFP average moderator temp.	309.9°C	(6)
HFP average fuel cladding temp.	340°C	(12)
HFP average fuel temperature	654°C	(12)
HFP effective fuel temperature (BOL & HFP)	640°C	(12)
Core:		
Total fuel loading in the core (UO_2)	81856×10^3 g	(7)
Geometry	Fig. 2.1	(9)
Number of batches for initial core	3	(7)
Number and type of fuel assemblies in each batch as to enrichment		

	Cycle 1	Cycle 2	
L	53(2.1%)	9(2.1%)	
M	52(2.6%)	52(2.6%)	(7,10,11)
N	52(3.1%)	52(3.1%)	
P		44(3.15%)	

Loading patterns for cycles 1 and 2, showing position of each type fuel assembly and burnable poisons	Figs. 2.2, 2.3	
Core radius	152 cm	(7)
Location of control rod clusters in core	Fig. 3	(7)
Reflector:		
Geometry	Fig. 2.1	(9)
Water temperature	291.4°C	
Water pressure	155 bar	(7)
Material of core baffle	SS-304	(9)
Thickness of core baffle	2.857 cm	(6)
Effective reflector thickness		
radial	25.2 cm	(6)
axial	38 cm	(6)

2. FUEL ASSEMBLY DATA

Number	157	(7)
Rod array	17 x 17	(6)
Geometry	Fig. 2.5	(6)
Number of fuel rods per fuel assembly	264	(6)

Control rod guide thimbles:

Material	Zircaloy-4	(6)
Density	6.55 g/cc	(8)
Number	24	(6)
Outer radius:		
Upper region	0.612 cm	(6)
Dashpot region (51.0 cm)	0.545 cm	(6)
Wall thickness	0.0406 cm	(6)

Spacer grid:

Material	INC 718	(6)
Number, location, axial dimensions	Fig. 2.6	(7)
Mass of material in one spacer grid	611.4 g	(6)

Sleeves:

Material	SS-304	(7)
Mass	neglect	

Movable detector thimble:

Material	Zircaloy-4	
Density	6.55 g/cc	(8)
Outer radius	0.612 cm	(6)
Thickness	0.0406 cm	(6)
Location in core	Fig. 2.7	(6)

Cladding:

Material	Zircaloy-4	(6)
Density	6.55 g/cc	(8)
Outer radius	0.4750 cm	(6)
Inner radius	0.4179 cm	(6)
Zircaloy weight (clad + guide tubes)	17320×10^3 g	(7)

Pellet:

Material	UO_2 Sintered	(6)
Density (percent of theoretical)	95%	(6)
Radius	0.4096 cm	(6)
Pellet length	1.346 cm	(6)
Height of UO_2 in rod	365.76 cm	(6)
Initial He pressure (Typ)	450 psig	(6)

Burnable Poison Rod (BPR):

Geometry	Fig. 2.8	(6)
Material to hold absorber	Pyrex-glass	(6)
Fraction of B in material (B_2O_3 in glass)	12.5 w/o	(6)
Mass of B-10 per unit length of rod	0.006234 g/cm	(6)
Active length	359.562 cm	(6)

Location of BPR in fuel assembly	Fig. 2.9	(6)
Outside radius	0.48387 cm	(6)
Clad thickness	0.04699 cm	(6)
Clad material	SS-304	(6)
Inner Tube material	SS-304	(6)
Inner Tube outside radius	0.2305 cm	(6)
Inner Tube thickness	0.01651 cm	(8)
Control rods (CR):		
Materials:		
Absorber	Ag(80%)-In(15%) -Cd(5%)	(6)
Cladding	SS-304	(6)
Absorber material:		
Density	10.1564 g/cc	(6)
Radius	0.43307 cm	(6)
Active length	360.7 cm	(7)
Cladding:		
Outer radius	0.48387 cm	(7)
Thickness	0.04699 cm	(6)
Number of control pins/ cluster	24	(6)

Note: Some of the figures in the benchmark definition, contain dimensions in inches units, as in the RESAR reference document.

2.2 OPERATING CONDITIONS AND MEASURED QUANTITIES

With the collaboration of NPP Almaraz the set of results for the required measurements was prepared for two cycles (1 and 2) at HZP condition and during the operation at HFP. The reported measured data have been extracted from direct measurements in the power plant, and are presented in figures and tables, after some processing by specific NPP Almaraz codes.

a) BOC-HZP measurements

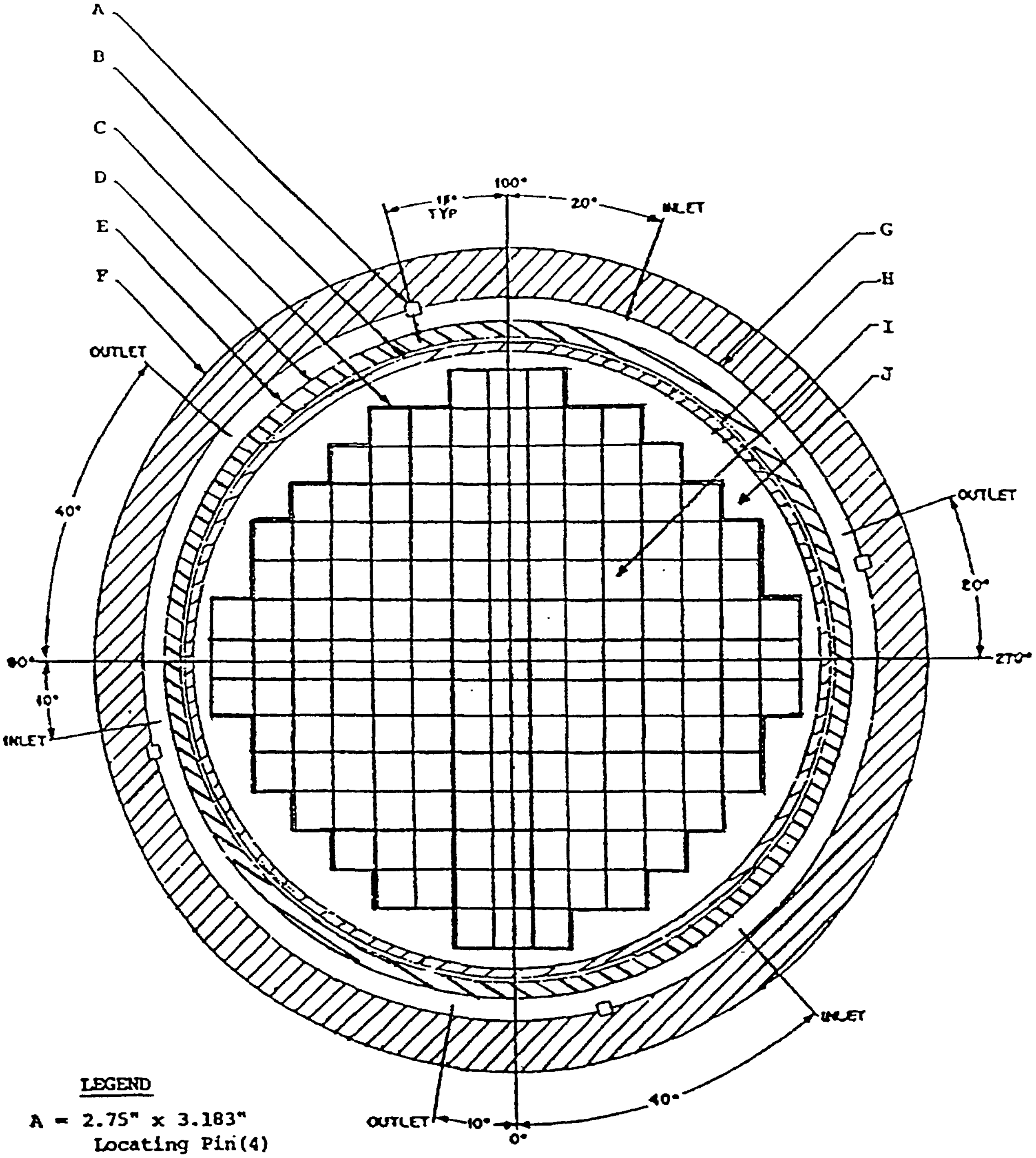
At the beginning of cycle, hot zero power condition, for the ARO and different control rods banks fully inserted, the following measurements have been extracted:

- End-point boron concentrations
- Control rod banks worths
- Isothermal reactivity coeffficients
- Power peaking factor ($F^N_{\Delta H}$)
- Boron worth calculated from previous data

b) HFP measurements

Some real operating conditions have been selected along the cycle burnup of both cycles, the conditions (Burnup, power level, critical boron concentration, coolant inlet temperature, effective flow rate, control bank position, maximum fuel assembly normalized power and maximum pin normalized power) for the selected situations are included. (It should be noted that the power values are the measured values averaged for an octant core.)

Text cont. on p. 20.



LEGEND

A = 2.75" x 3.183" Locating Pin(4)
B = 133.875" I.D. x 2.00" Wall
C = CORE BAFFLE
D = 142.625" I.D. x 2.687" Wall
E = THERMAL SHIELD
F = REACTOR VESSEL
G = 155.50" I.D. VESSEL
H = CORE BARREL
I = FUEL ASSEMBLY
J = Intra baffle-barrel area occupied by water at system pressure and temperature

(Dimensions in inches)

Fig. 2.1: NPP Almaraz II core layout.

ASSEMBLY-ID
PREVIOUS LOCATION OR *BP NO.*
BOC-BURNUP (MWD/T)

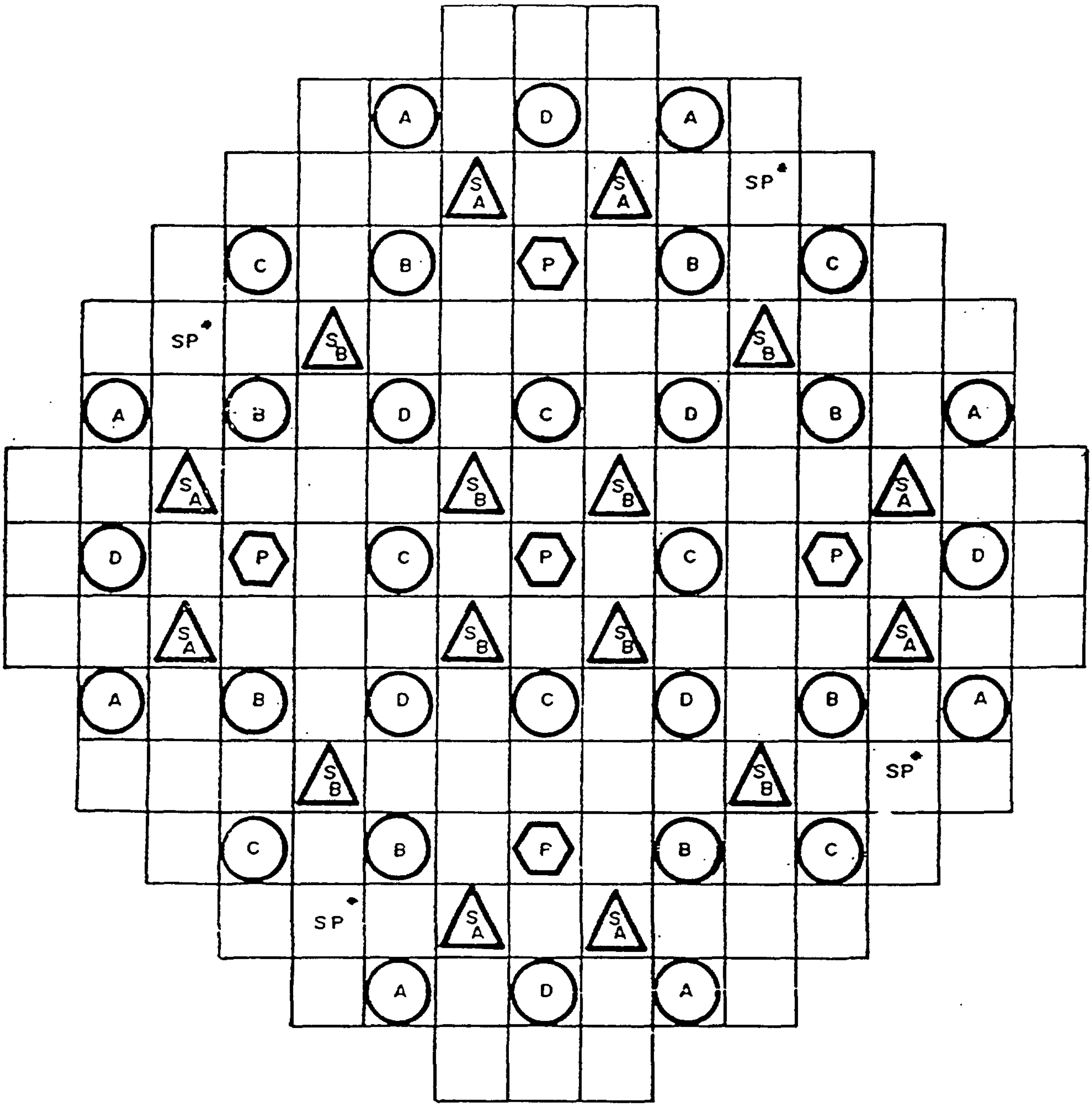
	R-	P-	N-	M-	L-	K-	J-	H-	G-	F-	E	D-	C-	B-	A-
1							N32	N22	N05						
2					N13	N36	N40 *16*	L18	N52 *16*	N07	N48				
3				N30	N15 *12*	M17 *16*	L27	M24 *12*	L36	M50 *16*	N47 *12*	N23			
4			N20	L26	M15 *16*	L06	M51 *16*	L10	M33 *16*	L05	M37 *16*	L51	N38		
5		N27	N09 *12*	M07 *16*	L32	M16 *16*	L02	M38 *20*	L40	M18 *16*	L42	M39 *16*	N18 *12*	N51	
6		N45	M45 *16*	L24	M22 *16*	L44	M09 *16*	L21	M31 *16*	L13	M23 *16*	L38	M02 *16*	N17	
7	N43	N04 *16*	L50	M05 *16*	L19	M06 *16*	L48	M43 *20*	L14	M47 *16*	L30	M12 *16*	L04	N06 *16*	N28
8	N39	L43	M27 *12*	L25	M41 *20*	L08	M35 *20*	L11	M14 *20*	L20	M03 *20*	L49	M08 *12*	L34	N41
9	N14	N26 *16*	L46	M36 *16*	L09	M21 *16*	L12	M30 *20*	L39	M49 *16*	L37	M32 *16*	L03	N50 *16*	N49
10		N21	M20 *16*	L23	M52 *16*	L15	M11 *16*	L47	M34 *16*	L16	M04 *16*	L29	M28 *16*	N03	
11		N42	N16 *12*	M48 *16*	L53	M10 *16*	L33	M25 *20*	L45	M01 *16*	L07	M42 *16*	N34 *12*	N12	
12			N37	L31	M40 *16*	L41	M13 *16*	L52	M26 *16*	L17	M29 *16*	L01	N24		
13				N29	N35 *12*	M46 *16*	L28	M44 *12*	L22	M19 *16*	N01 *12*	N11			
14					N44	N08	N46 *16*	L35	N33 *16*	N19	N10				
15							N02	N31	N25						

Fig. 2.2: NPP Almaraz II loading pattern for cycle 1.

ASSEMBLY-ID
PREVIOUS LOCATION OR *BP NO.*
BOC-BURNUP (MWD/T)

	R-	P-	N-	M-	L-	K-	J-	H-	G-	F-	E-	D-	C-	B-	A-
1							P03	P16	P19						
2					P31	P33	P02	M43 H-07 18352	P41	P08	P26				
3				P27	N32 J-01 8915	M09 J-06 18837	L02 J-05 17994	M44 H-13 17423	L40 G-05 17998	M31 G-06 18836	N05 G-01 8802	P23			
4			P24	N20 N-04 9853	M16 K-05 17895	N48 E-02 9192	N52 G-02 14817	M38 H-05 18296	N40 J-02 14922	N13 L-02 9201	M18 F-05 18145	N38 C-04 10019	P15		
5		P18	N43 R-07 9075	M22 L-06 17798	N30 M-03 9805	M15 L-04 16044	N08 K-14 13356	M51 J-04 17993	N19 F-14 12723	M37 E-04 16398	N23 D-03 10168	M23 E-06 18140	N28 A-07 8687	P01	
6		P30	M06 K-07 18477	N42 P-11 9096	M07 M-05 15942	N09 N-05 14196	M17 K-03 15680	N31 H-15 11047	M50 F-03 15858	N18 C-05 14531	M39 D-05 16219	N12 B-11 9178	M47 F-07 18758	P14	
7	P10	P38	L19 L-07 17477	N26 P-09 14973	N17 B-06 12797	M45 N-06 15731	N15 L-03 14550	M33 G-04 18126	N47 E-03 14767	M02 C-06 15613	N45 P-06 12952	N50 B-09 14909	L30 E-07 17860	P36	P29
8	P44	M35 J-08 18193	M08 C-08 17620	M41 L-08 18029	M36 M-09 17881	N41 A-08 10803	M05 M-07 17769	L17 F-12 16749	M32 D-09 17924	N39 R-08 11409	M12 D-07 17767	M03 E-08 17897	M27 N-08 17549	M14 G-08 18131	P28
9	P25	P35	L09 L-09 17918	N04 P-07 14956	N03 B-10 12963	M20 N-10 15494	N35 L-13 14793	M13 J-12 17696	N01 E-13 14545	M28 C-10 15846	N21 P-10 12745	N06 B-07 14661	L37 E-09 17818	P09	P40
10		P07	M21 K-09 18551	N27 P-05 8887	M48 M-11 16304	N16 N-11 14632	M46 K-13 15677	N22 H-01 11110	M19 F-13 15466	N34 C-11 14776	M42 D-11 16407	N51 B-05 9132	M49 F-09 18595	P17	
11		P34	N14 R-09 9011	M52 L-10 18184	N29 M-13 10000	M40 L-12 16232	N36 K-02 13154	M26 G-12 17823	N07 F-02 12925	M29 E-12 16212	N11 D-13 10029	M04 E-10 17967	N49 A-09 8736	P22	
12			P37	N37 N-12 10058	M10 K-11 17947	N10 E-14 8863	N33 G-14 14678	M25 H-11 17731	N46 J-14 15103	N44 L-14 9199	M01 F-11 18039	N24 C-12 10067	P39		
13				P43	N02 J-15 9110	M11 J-10 18355	L33 J-11 17498	M24 H-03 17770	L45 G-11 17638	M34 G-10 18510	N25 G-15 8596	P04			
14					P42	P05	P12	M30 H-09 18066	P06	P13	P21				
15							P20	P11	P32						

Fig. 2.3: NPP Almaraz II loading pattern for cycle 2.



CONTROL BANKS A, B, C, D

SHUTDOWN BANKS SA, SB

Fig. 2.4: NPP Almaraz II rod cluster control assembly pattern.

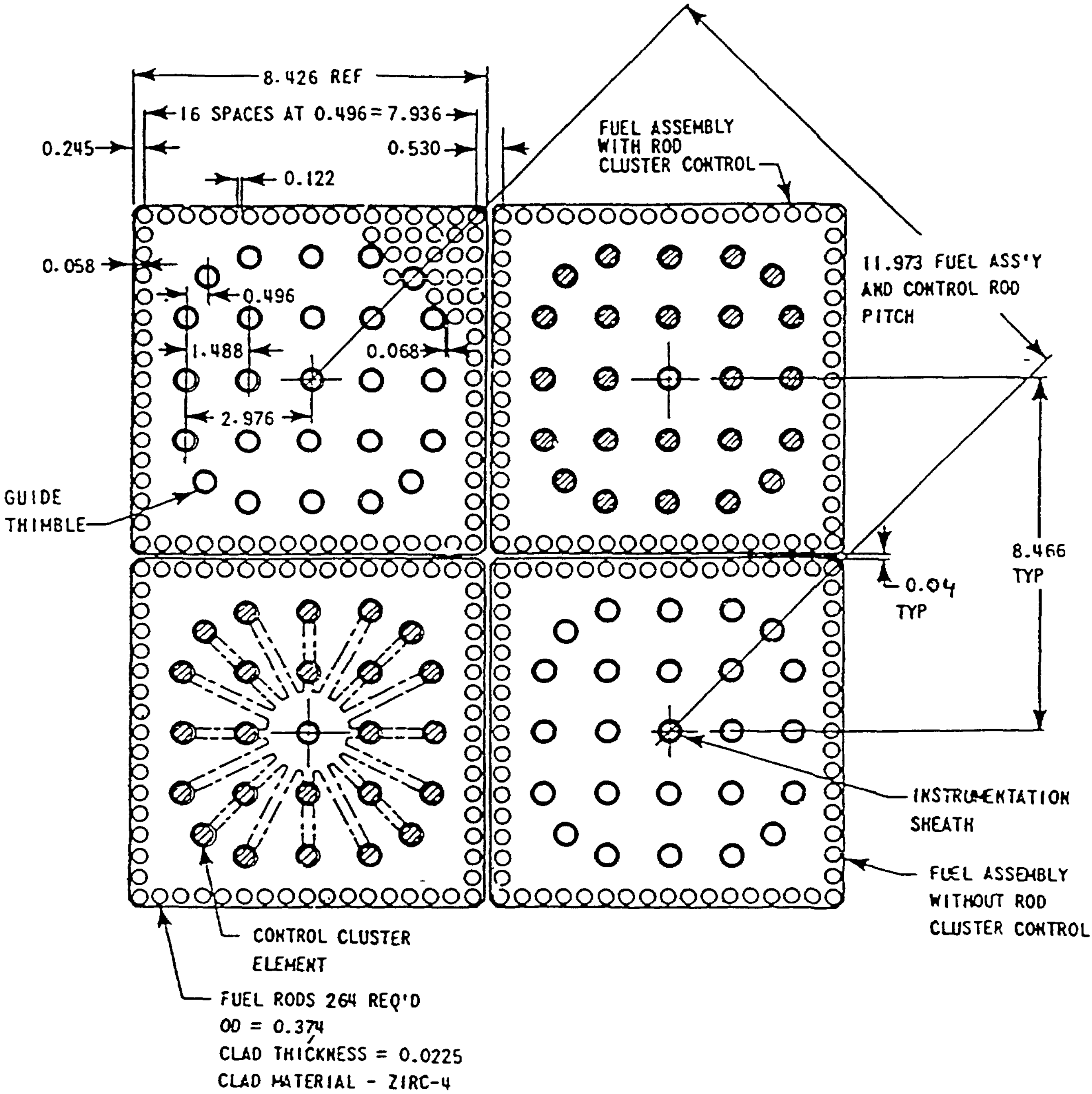


Fig. 2.5: NPP Almaraz II fuel assembly cross-section 17 × 17.

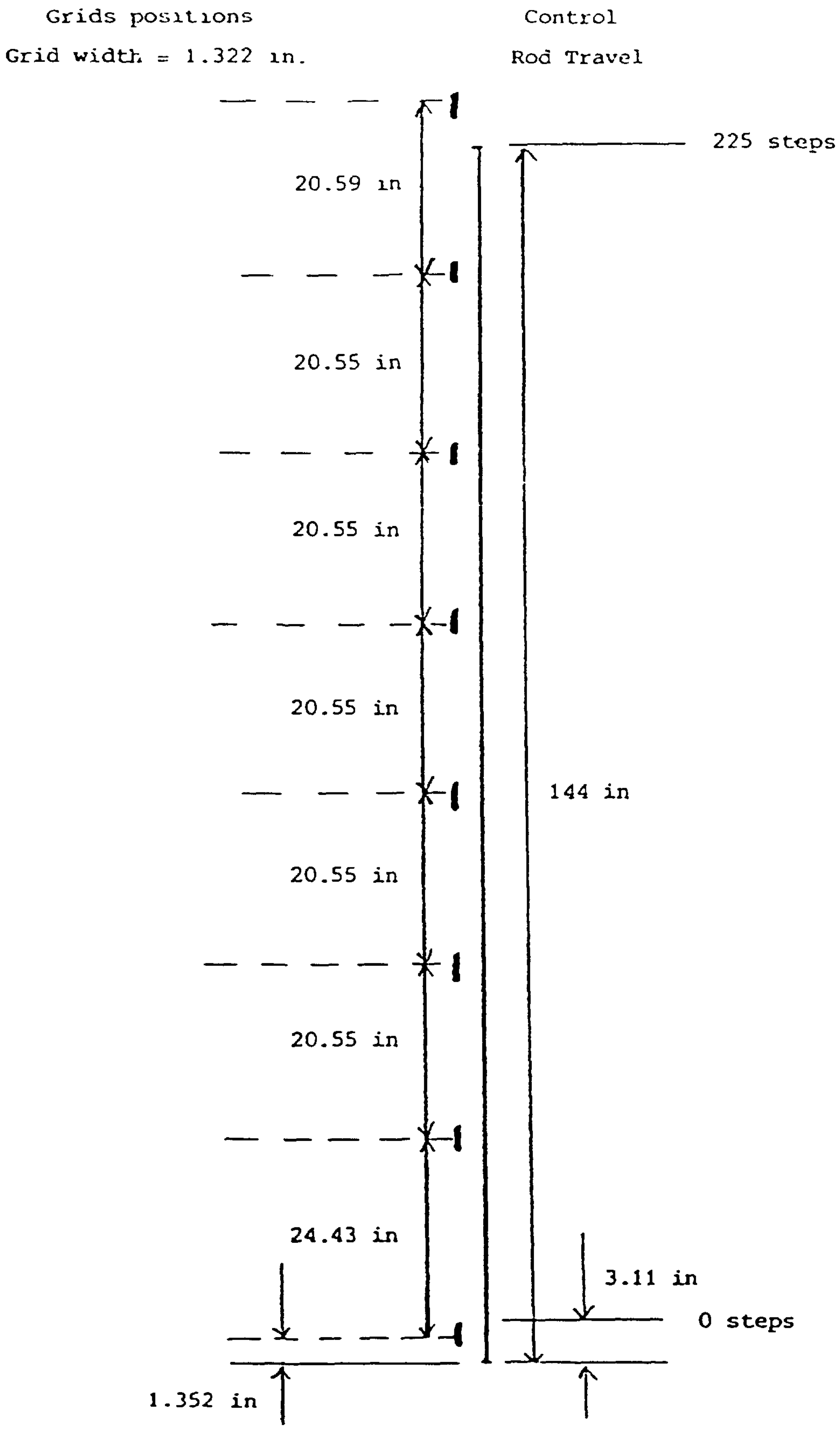


Fig. 2.6: NPP Almaraz II active fuel height, control rod travel and grid positions.

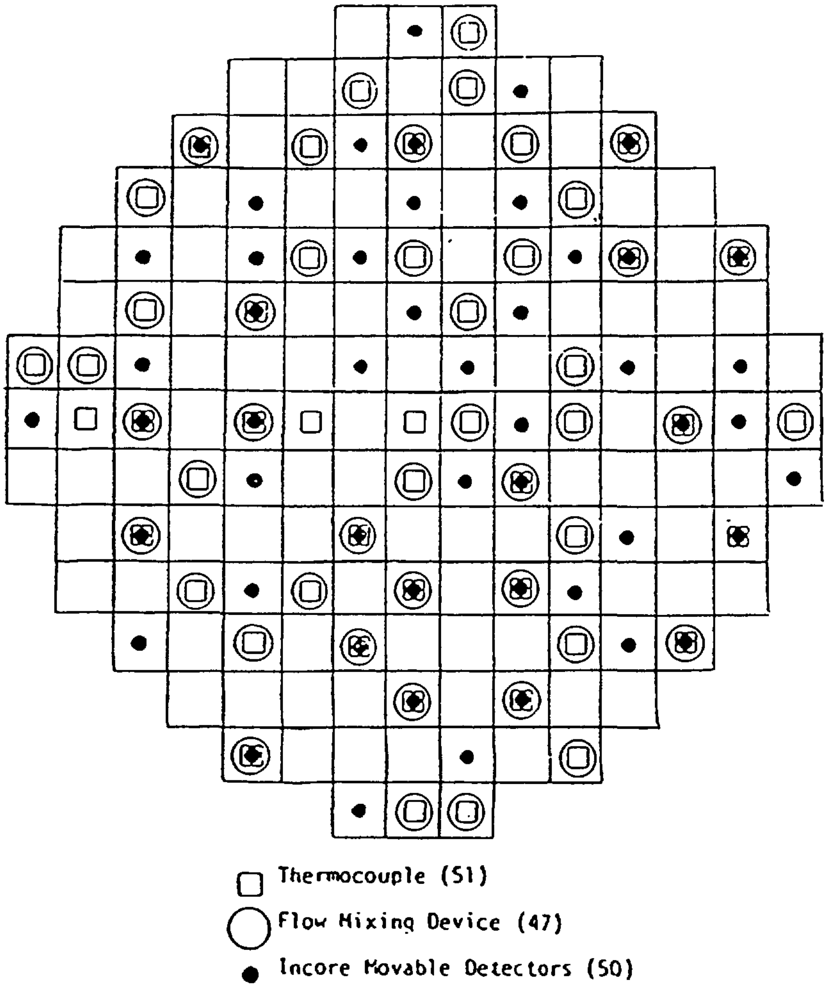


Fig. 2.7: NPP Almaraz II flow mixing thermocouples and in-core movable detector locations.

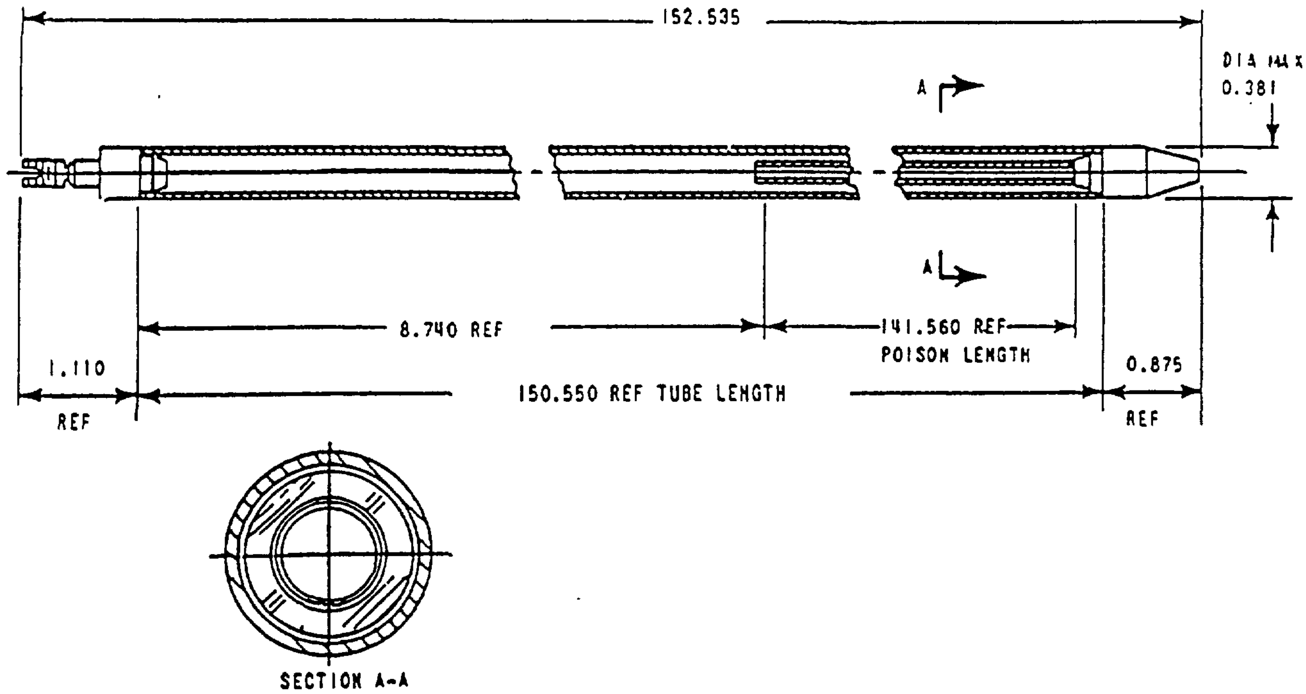


Fig. 2.8: NPP Almaraz II burnable poison rod cross-section.

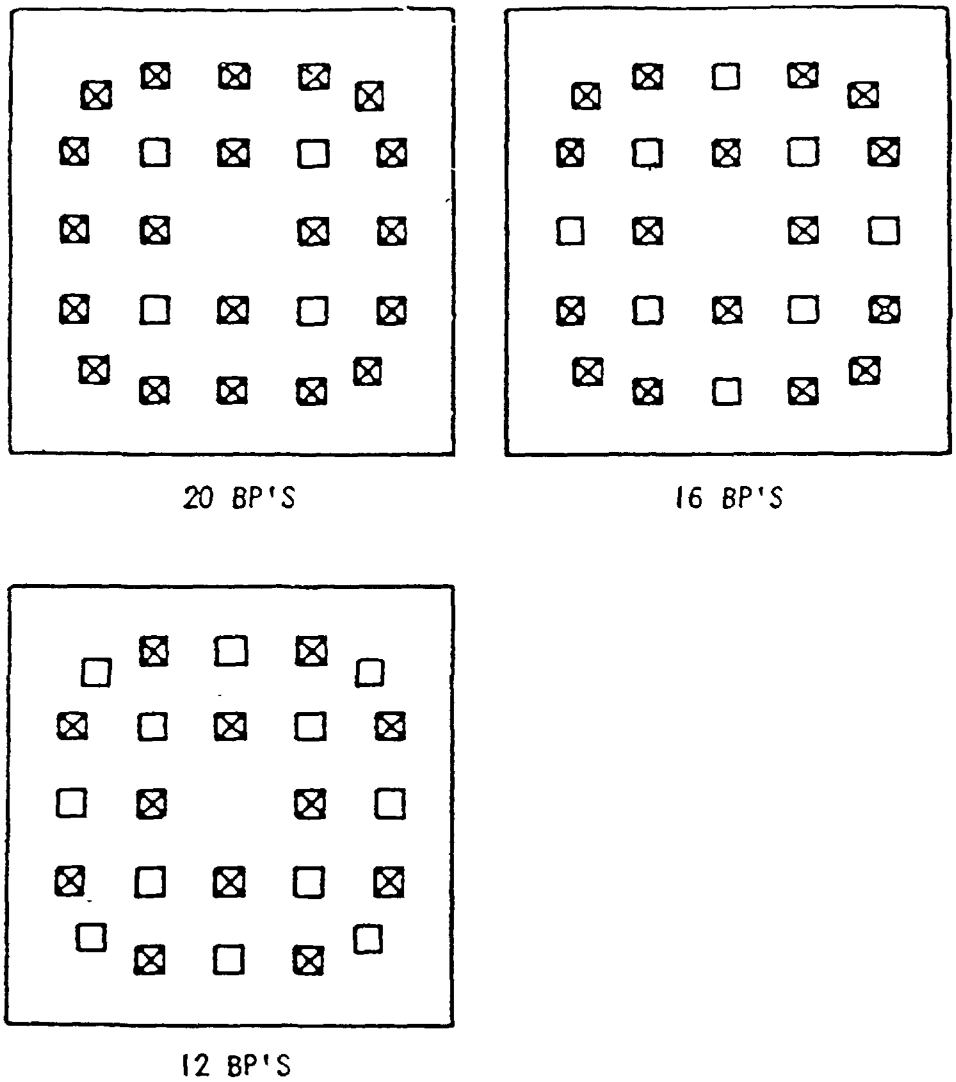


Fig. 2.9: NPP Almaraz II burnable poison rod arrangement within an assembly.

The measured axial off-set data are also included for each condition, as well as the flux map number processed by INCORE[13] code and then by JEN-UPM code package[14].

The summary of the INCORE and JEN-UPM code package outputs for each flux map are provided (in computer listing, and optionally in PC compatible diskette) including:

- assembly normalized power distribution, peak assembly normalized power distribution, and assembly burnup distribution;

- critical boron concentrations and critical boron concentrations corrected for HFP, ARO conditions;

- axial offset;

- axial normalized power distribution;

- power peaking factor, $F^N_{\Delta H}$.

In particular the measured data that have been provided are included in the following list.

List of measured data

Normal power operation:

	Cycle 1	Cycle 2
Operating conditions data	Table 2.1	Table 2.2
x-y fuel assembly power distribution	Tables 2.3	Tables 2.5
x-y power peaking factors	Tables 2.3	Tables 2.5
Axial core power distribution	Figs. 2.10	Figs. 2.11
Critical boron concentration	Table 2.1	Table 2.2
BOC Fuel assembly burnup distribution	Table 2.3.1	Table 2.5.1
EOC Fuel assembly burnup distribution	Table 2.4	Table 2.6

Low power startup tests:

Critical boron concentration	Table 2.7	Table 2.8
Differential and integral control rod worths	Figs. 2.12	NA
Integral control rod worths	Table 2.7	Table 2.8
Moderator isothermal reactivity coefficient	Table 2.7	Table 2.8
Moderator temperature reactivity coefficient	Table 2.7	Table 2.8
x-y fuel assembly power distribution	Table 2.3.1	Table 2.5.1
x-y power peaking factors	Table 2.3.1	Table 2.5.1
Axial core power distribution	Fig. 2.10.1	Fig. 2.11.1

Table 2.1
OPERATING CONDITIONS DATA AND MEASURED DATA
CYCLE 1

Flux Map (N.)	Burnup (MWd/t)	Power level (%)	Inlet Temperature (°C)	Control Bank D (Steps out)	Measured Boron Concentration (ppm)	A.O.	Pass	$F^N_{\Delta H}$	Corrected Boron Concentration (ppm)
201-01	0	3	291.4	228	1280	-4.4	1.200	1.376	1175
	25	30	" "	202	1074				
	159	49	" "	206	1003				890
201-12	715	99	" "	201	883	-12.6	1.237	1.334	875
201-15	1940	99	" "	207	856	-9.8	1.246	1.342	860
	3000	89	289.8	204	863				830
201-20	4500	92	" "	205	805	-5.3	1.247	1.332	770
201-23	6146	100	" "	221	663	-3.2	1.245	1.316	660
201-26	8200	101	" "	218	534	-4.2	1.233	1.288	530
201-28	9912	102	" "	215	399	-1.6	1.215	1.261	400
	11500	100	" "	220	284				260
201-31	13250	100	" "	222	148	-1.6	1.178	1.214	120
201-34	15100	92	" "	207	12	-3.3	1.156	1.191	-10
	15323	56	" "	186	10				

Effective flow rate for heat transfer = 1.38×10^4 Kg/sec

Table 2.2
OPERATING CONDITIONS DATA AND MEASURED DATA
CYCLE 2

Flux Map (N.)	Burnup (MWd/t)	Power level (%)	Control Bank D (Steps out)	Measured Boron Concentration (ppm)	A.O.	Pass	$F^N_{\Delta H}$	Corrected Boron Concentration (ppm)
202-01	0	3	228	1212	58.1	1.331	1.463	1075
	0	60	219					
	178	100	219	774				775
202-07	212	100	219	771	3.7	1.255	1.367	772
	745	100	221	708				720
202-09	1863	101	224	616	-1.9	1.272	1.380	595
	3000	100	223	499				500
202-13	4461	100	225	363	-3.3	1.249	1.350	350
	5540	100	224	258				260
202-15	6589	100	225	155	-4.3	1.212	1.311	160
	7617	101	226	64				60
202-17	8436	89	217	14	-1.8	1.192	1.287	-20
	8826	81	228	4				-50
	9551	63	228	4				

Coolant Inlet Temperature = 289.8°C
Effective flow rate for heat transfer = 1.29×10^4 Kg/sec

TABLE 2.3.1 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 201-01 ALMARAZ-II CYCLE 1

ALMARAZ-II CYCLE 1 INCORE

0 MWD/TMU 3 % POWER LEVEL
1280 PPM 3 % XENON
1.376 PEAK FDH

R AP PP BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

1 1.138 1.212 0				
2 1.061 1.245 0	1 1.157 1.244 0			
1 1.176 1.255 0	2 1.142 1.285 0	1 1.200 1.276 0		
2 1.078 1.260 0	1 1.178 1.254 0	2 1.127 1.280 0	1 1.120 1.221 0	
1 1.192 1.275 0	2 1.126 1.291 0	1 1.123 1.221 0	2 0.977 1.190 0	1 0.855 1.004 0
2 1.189 1.303 0	1 1.143 1.248 0	2 0.989 1.202 0	3 0.913 1.187 0	3 0.630 1.023 0
1 1.082 1.201 0	3 1.022 1.376 0	3 0.911 1.214 0	3 0.593 1.006 0	
3 0.843 1.196 0	3 0.633 1.065 0			

ZONE	POWER	BURNUP
1	1.129	0
2	1.081	0
3	0.788	0

TABLE 2.3.2 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 201-12 ALMARAZ-II CYCLE 1

ALMARAZ-II CYCLE 1 INCORE

715 MWD/TMU 99 % POWER LEVEL
883 PPM 99 % XENON
1.334 PEAK FDH

R AP PP BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

1 1.206 1.284 838				
2 1.137 1.315 786	1 1.230 1.315 853			
1 1.236 1.321 862	2 1.202 1.334 838	1 1.233 1.313 869		
2 1.131 1.298 790	1 1.215 1.295 855	2 1.148 1.316 813	1 1.127 1.230 803	
1 1.201 1.281 856	2 1.143 1.286 811	1 1.122 1.224 803	2 0.980 1.194 700	1 0.859 1.014 613
2 1.156 1.279 839	1 1.116 1.223 808	2 0.965 1.189 699	3 0.895 1.162 646	3 0.633 1.003 451
1 1.018 1.141 751	3 0.963 1.300 710	3 0.862 1.141 634	3 0.585 0.949 421	
3 0.771 1.095 577	3 0.595 0.979 439			

ZONE	POWER	BURNUP
1	1.141	811
2	1.100	780
3	0.757	552

TABLE 2.3.3 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 201-15 ALMARAZ-II CYCLE 1

ALMARAZ-II CYCLE 1 INCORE

1940 MWD/TMU 99 % POWER LEVEL
856 PPM 99 % XENON
1.342 PEAK FDH

1 1.236 1.313 2334			R AP PP BU	
2 1.178 1.329 2203	1 1.245 1.327 2369			
1 1.243 1.324 2381	2 1.225 1.342 2325	1 1.230 1.306 2378		
2 1.154 1.314 2189	1 1.218 1.296 2346	2 1.174 1.320 2235	1 1.135 1.238 2189	
1 1.196 1.272 2324	2 1.157 1.290 2220	1 1.128 1.231 2181	2 0.996 1.207 1910	1 0.857 1.015 1664
2 1.156 1.273 2255	1 1.105 1.215 2168	2 0.972 1.191 1885	3 0.892 1.161 1741	3 0.621 0.994 1219
1 0.981 1.103 1976	3 0.946 1.267 1879	3 0.841 1.117 1677	3 0.568 0.931 1127	
3 0.738 1.043 1502	3 0.573 0.938 1154			

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

ZONE	POWER	BURNUP
1	1.139	2208
2	1.118	2138
3	0.740	1469

TABLE 2.3.4 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 201-20 ALMARAZ-II CYCLE 1

ALMARAZ-II CYCLE 1 INCORE

4500 MWD/TMU 92 % POWER LEVEL
805 PPM 92 % XENON
1.332 PEAK FDH

1 1.225 1.296 5484			R AP PP BU	
2 1.216 1.328 5269	1 1.235 1.309 5544			
1 1.232 1.304 5550	2 1.247 1.332 5489	1 1.200 1.274 5488		
2 1.190 1.307 5188	1 1.203 1.281 5444	2 1.186 1.301 5256	1 1.125 1.217 5083	
1 1.173 1.250 5356	2 1.171 1.280 5199	1 1.111 1.209 5047	2 1.030 1.202 4503	1 0.874 1.033 3879
2 1.145 1.249 5201	1 1.077 1.185 4960	2 0.986 1.178 4391	3 0.919 1.166 4059	3 0.635 1.001 2826
1 0.944 1.061 4440	3 0.937 1.217 4288	3 0.825 1.089 3809	3 0.574 0.925 2588	
3 0.700 0.986 3343	3 0.554 0.893 2597			

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

ZONE	POWER	BURNUP
1	1.122	5103
2	1.138	5026
3	0.737	3360

TABLE 2.3.5 POWER AND BURNUP DISTRIBUTIONS INCORE MAP 201-23 ALMARAZ-II CYCLE 1

ALMARAZ-II CYCLE 1 INCORE

6146 MWD/TMU 100 % POWER LEVEL
663 PPM 100 % XENON
1.316 PEAK FDH

1 1.209 1.276 7487				
2 1.220 1.310 7275	1 1.214 1.285 7560			
1 1.209 1.277 7559	2 1.245 1.316 7539	1 1.195 1.271 7459		
2 1.193 1.288 7149	1 1.185 1.259 7410	2 1.191 1.285 7212	1 1.115 1.208 6927	
1 1.152 1.226 7269	2 1.172 1.259 7127	1 1.105 1.198 6871	2 1.043 1.194 6209	1 0.870 1.031 5315
2 1.141 1.227 7083	1 1.064 1.167 6722	2 1.006 1.169 6031	3 0.934 1.166 5584	3 0.636 0.999 3872
1 0.950 1.069 5999	3 0.946 1.207 5837	3 0.827 1.080 5169	3 0.576 0.929 3534	
3 0.708 0.988 4502	3 0.560 0.893 3514			

R
AP
PP
BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

ZONE	POWER	BURNUP
1	1.111	6941
2	1.144	6903
3	0.744	4579

TABLE 2.3.6 POWER AND BURNUP DISTRIBUTIONS INCORE MAP 201-26 ALMARAZ-II CYCLE 1

ALMARAZ-II CYCLE 1 INCORE

8200 MWD/TMU 101 % POWER LEVEL
534 PPM 101 % XENON
1.288 PEAK FDH

1 1.186 1.249 9947				
2 1.221 1.280 9782	1 1.182 1.250 10021			
1 1.179 1.243 10013	2 1.233 1.288 10085	1 1.166 1.236 9883		
2 1.196 1.258 9603	1 1.158 1.228 9816	2 1.192 1.254 9660	1 1.106 1.191 9208	
1 1.136 1.207 9619	2 1.178 1.245 9540	1 1.097 1.182 9132	2 1.066 1.186 8375	1 0.879 1.038 7112
2 1.142 1.214 9428	1 1.057 1.153 8900	2 1.025 1.164 8117	3 0.952 1.170 7521	3 0.645 1.004 5187
1 0.945 1.061 7946	3 0.960 1.194 7795	3 0.830 1.077 6870	3 0.586 0.931 4727	
3 0.709 0.975 5958	3 0.569 0.890 4673			

R
AP
PP
BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

ZONE	POWER	BURNUP
1	1.095	9206
2	1.150	9259
3	0.753	6116

TABLE 2.3.7 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 201-28 ALMARAZ-II CYCLE 1

ALMARAZ-II CYCLE 1 INCORE

9912 MWD/TMU 102 % POWER LEVEL
399 PPM 102 % XENON
1.261 PEAK FDH

1 1.149 1.210 11945				
2 1.199 1.249 11854	1 1.157 1.220 12023			
1 1.148 1.210 12005	2 1.215 1.261 12180	1 1.140 1.210 11857		
2 1.184 1.231 11640	1 1.140 1.204 11783	2 1.182 1.234 11692	1 1.098 1.173 11094	
1 1.119 1.189 11549	2 1.175 1.232 11554	1 1.095 1.171 11008	2 1.081 1.179 10212	1 0.886 1.042 8623
2 1.144 1.202 11385	1 1.057 1.147 10709	2 1.048 1.165 9892	3 0.979 1.179 9174	3 0.650 1.012 6296
1 0.948 1.061 9566	3 0.974 1.190 9450	3 0.846 1.093 8305	3 0.600 0.946 5742	
3 0.710 0.976 7172	3 0.573 0.894 5650			

R AP PP BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

ZONE	POWER	BURNUP
1	1.084	11072
2	1.148	11226
3	0.766	7416

TABLE 2.3.8 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 201-31 ALMARAZ-II CYCLE 1

ALMARAZ-II CYCLE 1 INCORE

13250 MWD/TMU 100 % POWER LEVEL
148 PPM 100 % XENON
1.213 PEAK FDH

1 1.115 1.173 15724				
2 1.171 1.209 15810	1 1.114 1.174 15812			
1 1.114 1.172 15781	2 1.178 1.213 16174	1 1.104 1.162 15603		
2 1.169 1.207 15567	1 1.107 1.170 15533	2 1.163 1.200 15605	1 1.087 1.151 14742	
1 1.104 1.165 15258	2 1.167 1.208 15464	1 1.081 1.150 14639	2 1.101 1.176 13853	1 0.907 1.059 11616
2 1.145 1.198 15205	1 1.058 1.139 14239	2 1.065 1.156 13419	3 1.005 1.180 12485	3 0.677 1.027 8511
1 0.961 1.071 12752	3 1.004 1.189 12752	3 0.859 1.097 11152	3 0.620 0.958 7777	
3 0.731 0.992 9577	3 0.598 0.913 7605			

R AP PP BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

ZONE	POWER	BURNUP
1	1.069	14665
2	1.141	15047
3	0.789	10011

TABLE 2.3.9 POWER AND BURNUP DISTRIBUTIONS INCORE MAP 201-34 ALMARAZ-II CYCLE 1

ALMARAZ-II CYCLE 1 INCORE

15100 MWD/TMU
12 PPM
1.191 PEAK FDH

88 % POWER LEVEL
88 % XENON

R AP PP BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

1 1.100 1.157 17773				
2 1.148 1.184 17956	1 1.091 1.155 17852			
1 1.091 1.149 17821	2 1.155 1.186 18332	1 1.089 1.144 17631		
2 1.140 1.175 17702	1 1.087 1.149 17563	2 1.152 1.184 17746	1 1.081 1.146 16748	
1 1.089 1.147 17286	2 1.156 1.191 17612	1 1.080 1.140 16638	2 1.109 1.173 15898	1 0.919 1.067 13304
2 1.142 1.189 17320	1 1.058 1.133 16196	2 1.073 1.153 15397	3 1.017 1.177 14356	3 0.691 1.033 9776
1 0.976 1.080 14544	3 1.027 1.189 14631	3 0.876 1.108 12757	3 0.636 0.966 8939	
3 0.750 1.011 10947	3 0.614 0.930 8726			

ZONE	POWER	BURNUP
1	1.061	16636
2	1.132	17150
3	0.805	11486

TABLE 2.4 EOC BURNUP DISTRIBUTIONS ALMARAZ-II CYCLE 1

ALMARAZ-II CYCLE 1 INCORE

15.323 MWD/TU
10 PPM

R BU

R-REGION
BU-ASS. BURNUP

1 17.963				
2 18.186	1 18.046			
1 17.992	2 18.615	1 17.770		
2 17.988	1 17.775	2 18.015	1 16.938	
1 17.474	2 17.872	1 16.833	2 16.220	1 13.579
2 17.590	1 16.387	2 15.671	3 14.599	3 10.000
1 14.727	3 14.877	3 12.952	3 9.094	
3 11.091	3 8.867			

ZONE	BURNUP
1	16.833
2	17.426
3	11.682

TABLE 2.5.1 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 202-01 ALMARAZ-II CYCLE 2

ALMARAZ-II CYCLE 2 INCORE

0 MWD/TMU — 3 % POWER LEVEL
1212 PPM — 3 % XENON
1.463 PEAK FDH

R AP PP BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

1 0.728 0.765 16749				
2 0.907 1.016 17879	3 1.067 1.191 14664			
3 1.172 1.250 11092	2 1.056 1.150 15671	3 1.160 1.240 14534		
2 0.987 1.058 17867	3 1.163 1.288 12952	2 1.063 1.135 16220	3 1.200 1.285 10001	
2 0.898 0.961 17988	3 1.081 1.195 14878	3 1.195 1.302 9094	2 0.967 1.060 18015	3 1.002 1.078 9999
2 0.877 0.936 17591	1 0.827 0.918 17775	2 0.951 1.019 18615	3 1.015 1.109 8867	4 0.729 1.080 0
2 1.007 1.085 18186	4 1.331 1.463 0	4 1.056 1.349 0	4 0.695 1.086 0	
4 0.958 1.272 0	4 0.788 1.242 0			

ZONE	POWER	BURNUP
1	0.816	17661
2	0.981	17427
3	1.116	11682
4	0.923	0

TABLE 2.5.2 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 202-07 ALMARAZ-II CYCLE 2

ALMARAZ-II CYCLE 2 INCORE

212 MWD/TMU — 100 % POWER LEVEL
771 PPM — 100 % XENON
1.367 PEAK FDH

R AP PP BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

1 0.789 0.831 16910				
2 0.958 1.061 18077	3 1.109 1.215 14895			
3 1.185 1.267 11342	2 1.080 1.163 15897	3 1.161 1.242 14780		
2 1.010 1.086 18079	3 1.170 1.277 13199	2 1.069 1.139 16446	3 1.193 1.268 10255	
2 0.928 1.005 18182	3 1.090 1.185 15108	3 1.176 1.270 9345	2 0.973 1.064 18221	3 1.000 1.080 10211
2 0.904 0.952 17780	1 0.850 0.919 17953	2 0.954 1.015 18817	3 1.007 1.087 9081	4 0.741 1.075 156
2 0.985 1.044 18397	4 1.255 1.367 274	4 1.020 1.283 220	4 0.695 1.060 147	
4 0.925 1.195 200	4 0.766 1.169 165			

ZONE	POWER	BURNUP
1	0.843	17837
2	0.995	17637
3	1.118	11919
4	0.898	193

TABLE 2.5.3 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 202-09 ALMARAZ-II CYCLE 2

ALMARAZ-II CYCLE 2 INCORE

1863 MWD/TMU 101 % POWER LEVEL
616 PPM 101 % XENON
1.379 PEAK FDH

1 0.798 0.841 18220			R AP PP BU	
2 0.949 1.041 19651	3 1.086 1.185 16707			
3 1.156 1.232 13275	2 1.048 1.129 17654	3 1.145 1.222 16684		
2 0.990 1.063 19730	3 1.132 1.237 15100	2 1.056 1.125 18201	3 1.174 1.253 12208	
2 0.935 1.006 19720	3 1.085 1.166 16903	3 1.170 1.256 11282	2 0.974 1.063 19828	3 1.003 1.081 11865
2 0.922 0.979 19287	1 0.863 0.927 19367	2 0.960 1.016 20397	3 1.016 1.102 10751	4 0.754 1.087 1390
2 1.011 1.071 20045	4 1.271 1.379 2360	4 1.033 1.296 1915	4 0.703 1.070 1302	
4 0.953 1.237 1750	4 0.794 1.188 1453			

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

ZONE	POWER	BURNUP
1	0.856	19239
2	0.991	19276
3	1.106	13755
4	0.915	1690

TABLE 2.5.4 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 202-13 ALMARAZ-II CYCLE 2

ALMARAZ-II CYCLE 2 INCORE

4461 MWD/TMU 100 % POWER LEVEL
363 PPM 100 % XENON
1.350 PEAK FDH

1 0.823 0.864 20326			R AP PP BU	
2 0.960 1.049 22131	3 1.097 1.187 19542			
3 1.155 1.229 16277	2 1.053 1.132 20383	3 1.135 1.205 19646		
2 1.001 1.069 22316	3 1.141 1.234 18053	2 1.049 1.116 20935	3 1.162 1.235 15243	
2 0.950 1.017 22168	3 1.093 1.168 19732	3 1.160 1.245 14308	2 0.974 1.057 22360	3 1.009 1.083 14479
2 0.936 0.983 21701	1 0.876 0.940 21626	2 0.957 1.020 22888	3 1.016 1.097 13392	4 0.770 1.097 3370
2 0.994 1.053 22649	4 1.249 1.350 5634	4 1.019 1.267 4582	4 0.718 1.069 3147	
4 0.935 1.204 4204	4 0.781 1.166 3498			

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

ZONE	POWER	BURNUP
1	0.870	21481
2	0.993	21854
3	1.106	16627
4	0.910	4061

TABLE 2.5.5 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 202-15 ALMARAZ-II CYCLE 2

ALMARAZ-II CYCLE 2 INCORE

6589 MWD/TMU 100 % POWER LEVEL
155 PPM 100 % XENON
1.311 PEAK FDH

R AP PP BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

1 0.848 0.889 22103				
2 0.976 1.063 24191	3 1.108 1.192 21887			
3 1.160 1.233 18740	2 1.058 1.135 22629	3 1.134 1.200 22060		
2 1.008 1.077 24454	3 1.142 1.232 20482	2 1.050 1.116 23168	3 1.160 1.233 17713	
2 0.960 1.030 24200	3 1.095 1.168 22060	3 1.160 1.244 16777	2 0.981 1.060 24440	3 1.016 1.091 16633
2 0.945 0.987 23702	1 0.885 0.942 23499	2 0.962 1.025 24930	3 1.021 1.100 15559	4 0.781 1.101 5021
2 0.978 1.033 24747	4 1.212 1.311 8253	4 1.007 1.244 6738	4 0.724 1.068 4682	
4 0.913 1.169 6171	4 0.764 1.131 5141			

ZONE	POWER	BURNUP
1	0.881	23344
2	0.997	23971
3	1.109	18984
4	0.899	5985

TABLE 2.5.6 POWER AND BURNUP DISTRIBUTIONS
INCORE MAP 202-17 ALMARAZ-II CYCLE 2

ALMARAZ-II CYCLE 2 INCORE

8436 MWD/TMU 89 % POWER LEVEL
14 PPM 89 % XENON
1.287 PEAK FDH

R AP PP BU

R-REGION
AP-ASS. POWER
PP-PEAK PIN POWER
BU-ASS. BURNUP

1 0.861 0.908 23682				
2 0.984 1.067 26000	3 1.107 1.191 23932			
3 1.162 1.234 20883	2 1.053 1.129 24579	3 1.128 1.192 24149		
2 1.013 1.079 26321	3 1.138 1.227 22588	2 1.046 1.113 25104	3 1.159 1.232 19855	
2 0.969 1.034 25982	3 1.097 1.170 24084	3 1.160 1.246 18920	2 0.986 1.064 26256	3 1.024 1.098 18518
2 0.946 0.989 25448	1 0.886 0.941 25134	2 0.967 1.033 26711	3 1.029 1.109 17452	4 0.792 1.110 6474
2 0.968 1.025 26543	4 1.192 1.287 10473	4 1.003 1.233 8593	4 0.731 1.070 6026	
4 0.901 1.151 7846	4 0.756 1.111 6544			

ZONE	POWER	BURNUP
1	0.883	24973
2	0.999	25815
3	1.110	21033
4	0.895	7642

TABLE 2.6 EOC BURNUP DISTRIBUTIONS
ALMARAZ-II CYCLE 2

ALMARAZ-II CYCLE 2 INCORE

9.551 MWD/TU
4 PPM

1 24.689				
2 27.080	3 25.119			
3 22.147	2 25.740	3 25.365		
2 27.444	3 23.850	2 26.282	3 21.120	
2 27.086	3 25.322	3 20.184	2 27.366	3 19.712
2 26.535	1 26.157	2 27.819	3 18.605	4 7.387
2 27.571	4 11.771	4 9.686	4 6.892	
4 8.812	4 7.378			

R BU

R-REGION
BU-ASS. BURNUP

ZONE	BURNUP
1	25.994
2	26.932
3	22.260
4	8.640

Table 2.7.
PWR BENCHMARK HZP TEST
CYCLE 1

Control Bank IN	Boron end point (ppm)	Control Bank Worth* (pcm)	Isothermal Coefficient (pcm/°C)	$F^N_{\Delta H}$
ARO	1332.5		-1.9	1.4339
D(Ref.)	1178.0	1394	-8.15	1.4525
C(D-IN)	1059.7	1192	NA	NA
B(D + C-IN)	866.7	1964	-25.0	NA
A (D + C + B-IN)	758.8	1253	NA	NA
SB (D + C + B + A-IN)	NA	1022	NA	NA
All but H-14	574.3	7697	NA	NA

ARO Calculated Boron Worth (pcm/ppm) = -10.11
ARO moderator coefficient (pcm/°C) = 2.05
ARO Doppler coefficient (pcm/°C) = -3.95

*Boron dilution method

Table 2.8.

PWR BENCHMARK HZP TEST
CYCLE 2

Control Bank IN	Boron end point (ppm)	Control Bank Worth* (pcm)	Isothermal Coefficient (pcm/°C)	$F^N_{\Delta H}$
ARO	1261.0		-9.1	1.56
B (Ref.)	1127.0	1203	-13.1	NA
D	NA	1184	NA	NA
SB	NA	995	NA	NA
C	NA	939	NA	NA
SA	NA	747	NA	NA
A	NA	613	NA	NA
All	NA	5681	NA	NA

ARO Calculated Boron Worth (pcm/ppm) = -8.98
ARO moderator coefficient (pcm/°C) = -6.4
ARO Doppler coefficient (pcm/°C) = -2.7

Rod Swap method, except Bank B (Boron dilution)

TABLE 2.9 AXIAL POWER DISTRIBUTION
INCORE MAPS ALMARAZ II CYCLE 1

AXIAL HEIGHT (%)	AXIAL POWER MAP-01	AXIAL POWER MAP-12	AXIAL POWER MAP-31
0.0000	0.181	0.305	0.488
1.7544	0.203	0.356	0.578
3.5088	0.295	0.490	0.759
5.2631	0.386	0.614	0.871
7.0175	0.472	0.725	0.975
8.7719	0.550	0.822	1.054
10.5263	0.631	0.906	1.097
12.2806	0.705	0.978	1.125
14.0350	0.772	1.036	1.134
15.7894	0.823	1.070	1.106
17.5438	0.836	1.052	1.029
19.2982	0.962	1.178	1.116
21.0525	1.048	1.242	1.125
22.8069	1.113	1.283	1.117
24.5613	1.171	1.313	1.116
26.3157	1.222	1.334	1.105
28.0700	1.260	1.343	1.090
29.8244	1.279	1.333	1.057
31.5788	1.227	1.245	0.967
33.3332	1.353	1.350	1.037
35.0876	1.419	1.386	1.055
36.8420	1.460	1.396	1.048
38.5964	1.491	1.400	1.052
40.3507	1.508	1.395	1.048
42.1051	1.514	1.383	1.040
43.8595	1.496	1.355	1.019
45.6139	1.403	1.247	0.938
47.3682	1.500	1.321	1.006
49.1226	1.543	1.347	1.035
50.8770	1.550	1.343	1.036
52.6314	1.547	1.331	1.049
54.3857	1.531	1.312	1.051
56.1401	1.504	1.286	1.050
57.8945	1.454	1.248	1.039
59.6489	1.330	1.144	0.966
61.4033	1.383	1.180	1.018
63.1577	1.391	1.193	1.066
64.9120	1.363	1.175	1.072
66.6664	1.325	1.150	1.091
68.4208	1.279	1.119	1.098
70.1752	1.223	1.083	1.102
71.9296	1.150	1.034	1.095
73.6839	1.015	0.938	1.028
75.4383	1.015	0.927	1.061
77.1927	0.984	0.924	1.117
78.9471	0.927	0.885	1.121
80.7015	0.863	0.839	1.126
82.4558	0.792	0.787	1.117
84.2102	0.713	0.727	1.098
85.9646	0.626	0.656	1.061
87.7190	0.512	0.558	0.966
89.4734	0.459	0.498	0.913
91.2277	0.395	0.449	0.898
92.9821	0.319	0.380	0.812
94.7365	0.248	0.307	0.709
96.4909	0.182	0.235	0.588
98.2453	0.135	0.176	0.489
100.0000	0.100	0.127	0.442

TABLE 2.10 AXIAL POWER DISTRIBUTION
INCORE MAPS ALMARAZ II CYCLE 2

AXIAL HEIGHT (%)	AXIAL POWER MAP-01	AXIAL POWER MAP-07	AXIAL POWER MAP-17
0.0000	0.070	0.425	0.593
1.7544	0.099	0.468	0.574
3.5088	0.113	0.631	0.771
5.2631	0.154	0.756	0.907
7.0175	0.188	0.849	0.996
8.7719	0.216	0.917	1.054
10.5263	0.238	0.963	1.087
12.2806	0.259	0.992	1.104
14.0350	0.278	1.008	1.105
15.7894	0.292	0.995	1.084
17.5438	0.303	0.927	0.972
19.2982	0.300	1.015	1.058
21.0525	0.335	1.040	1.092
22.8069	0.361	1.048	1.093
24.5613	0.384	1.050	1.090
26.3157	0.406	1.050	1.085
28.0700	0.428	1.046	1.077
29.8244	0.451	1.029	1.055
31.5788	0.467	0.939	0.945
33.3332	0.471	1.030	1.045
35.0876	0.531	1.055	1.076
36.8420	0.578	1.062	1.081
38.5964	0.617	1.065	1.081
40.3507	0.657	1.066	1.078
42.1051	0.699	1.063	1.071
43.8595	0.738	1.046	1.050
45.6139	0.762	0.959	0.948
47.3682	0.773	1.057	1.044
49.1226	0.868	1.084	1.075
50.8770	0.945	1.093	1.082
52.6314	1.004	1.098	1.084
54.3857	1.065	1.102	1.082
56.1401	1.124	1.101	1.077
57.8945	1.178	1.086	1.051
59.6489	1.218	1.001	0.946
61.4033	1.204	1.099	1.052
63.1577	1.358	1.131	1.079
64.9120	1.462	1.144	1.085
66.6664	1.544	1.153	1.087
68.4208	1.617	1.158	1.087
70.1752	1.690	1.161	1.083
71.9296	1.753	1.150	1.060
73.6839	1.792	1.059	0.959
75.4383	1.731	1.161	1.065
77.1927	1.920	1.193	1.097
78.9471	2.029	1.201	1.101
80.7015	2.088	1.201	1.101
82.4558	2.127	1.189	1.091
84.2102	2.142	1.166	1.074
85.9646	2.134	1.121	1.035
87.7190	2.066	0.992	0.907
89.4734	1.869	1.014	0.947
91.2277	1.878	0.961	0.913
92.9821	1.776	0.863	0.824
94.7365	1.575	0.729	0.701
96.4909	1.298	0.571	0.570
98.2453	0.997	0.479	0.524
100.0000	0.839	0.395	0.479

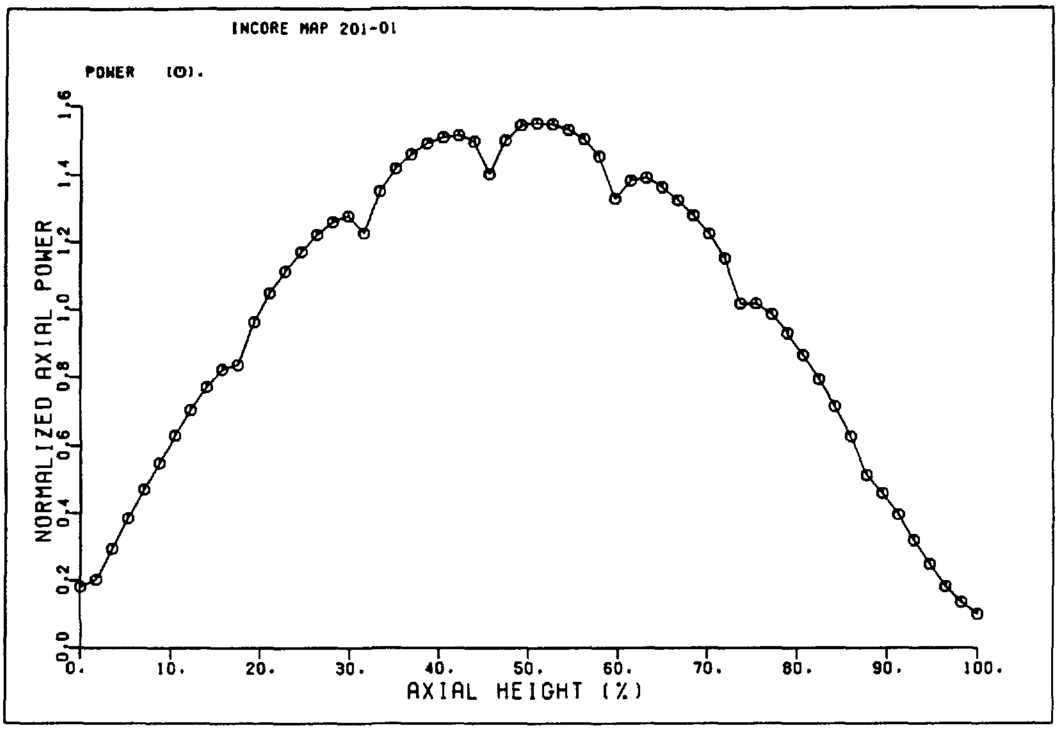


FIG. 2.10.1 AXIAL POWER DISTRIBUTION ALMARAZ II
CYCLE 1 INCORE MAP 201-01

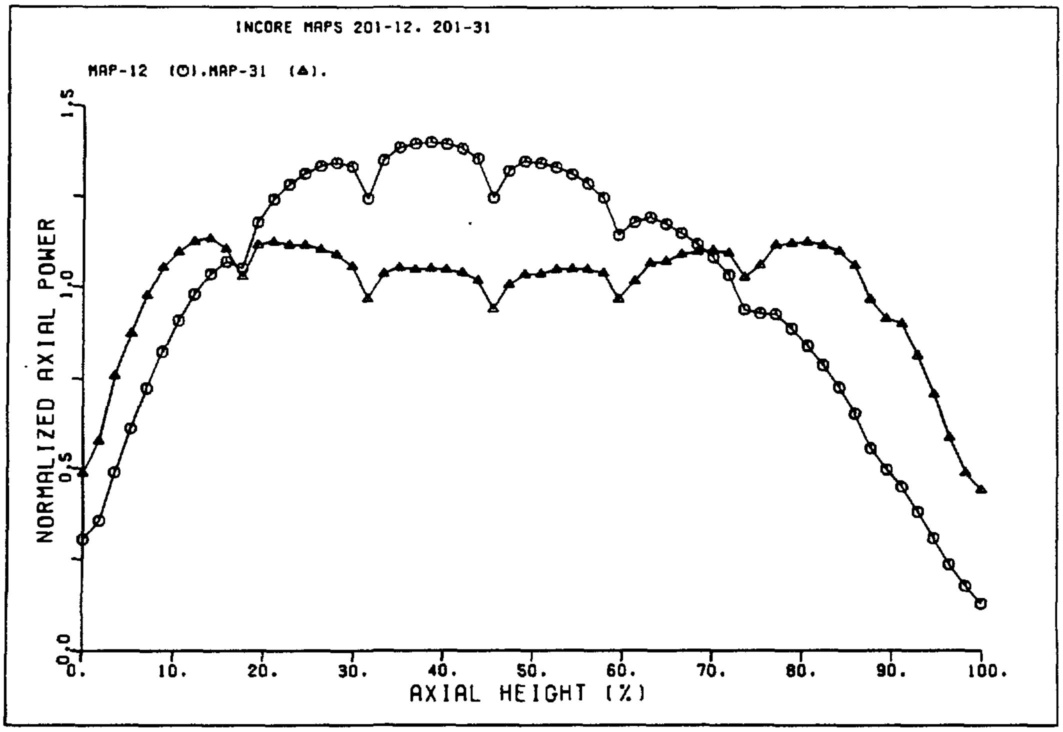


FIG. 2.10.1 AXIAL POWER DISTRIBUTION ALMARAZ II
CYCLE 1 INCORE MAPS 201-12 201-31

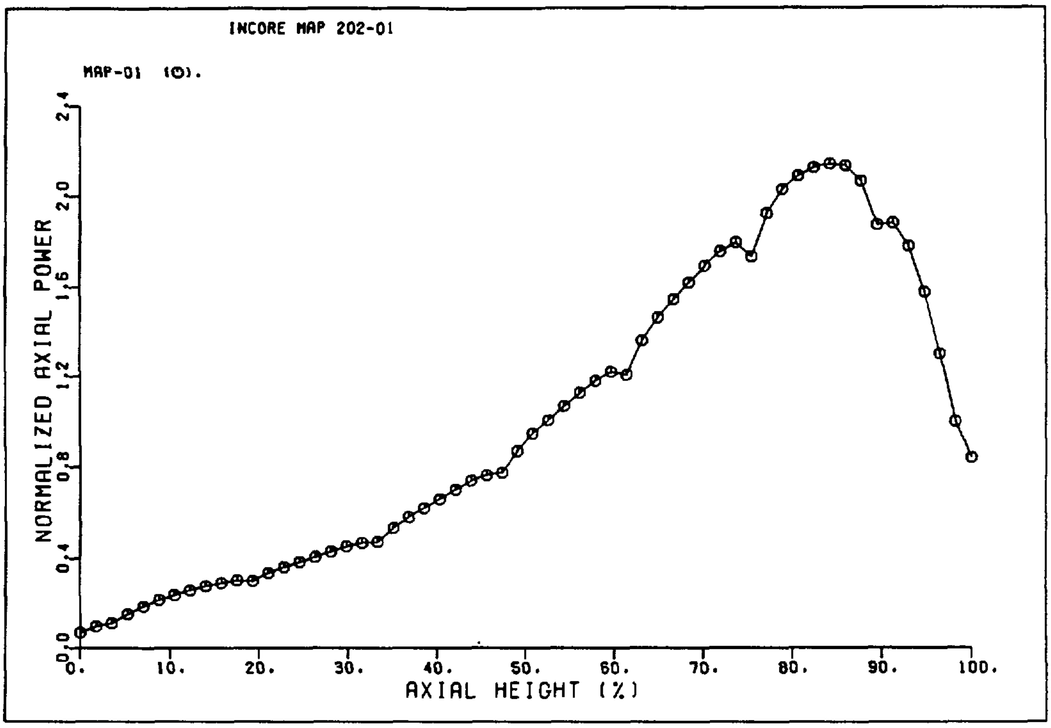


FIG. 2.11.1 AXIAL POWER DISTRIBUTION ALMARAZ II
CYCLE 2 INCORE MAP 202-01

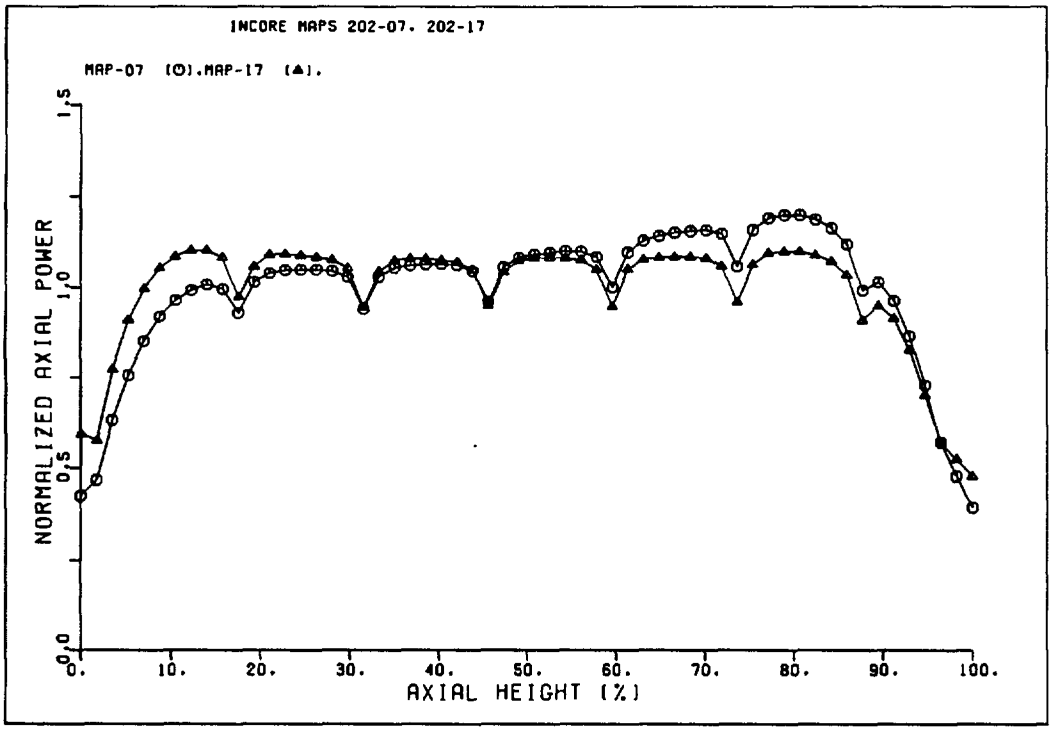


FIG. 2.11.2 AXIAL POWER DISTRIBUTION ALMARAZ II
CYCLE 2 INCORE MAPS 202-07 202-17

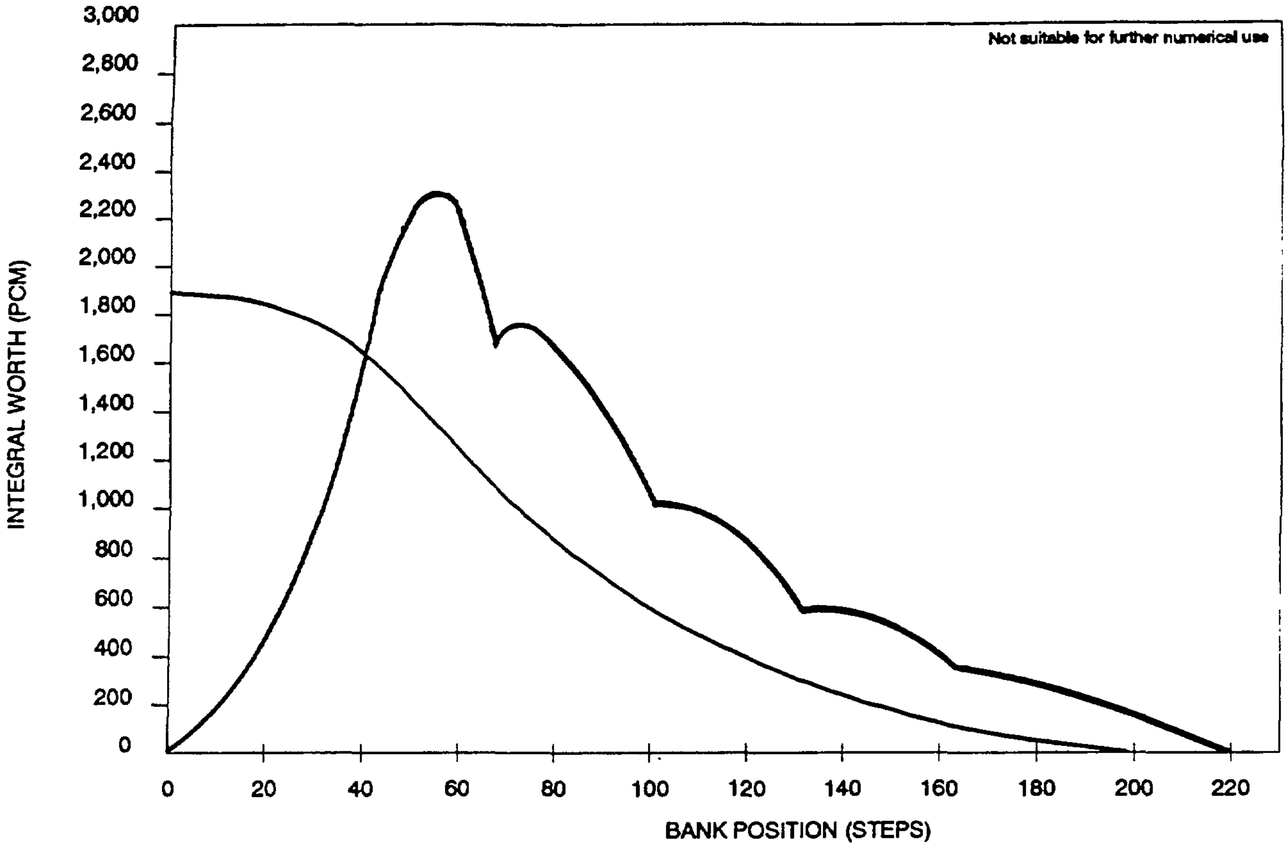


Fig. 2.12.1: CYCLE 1: *Measured differential & integral worth control bank B*

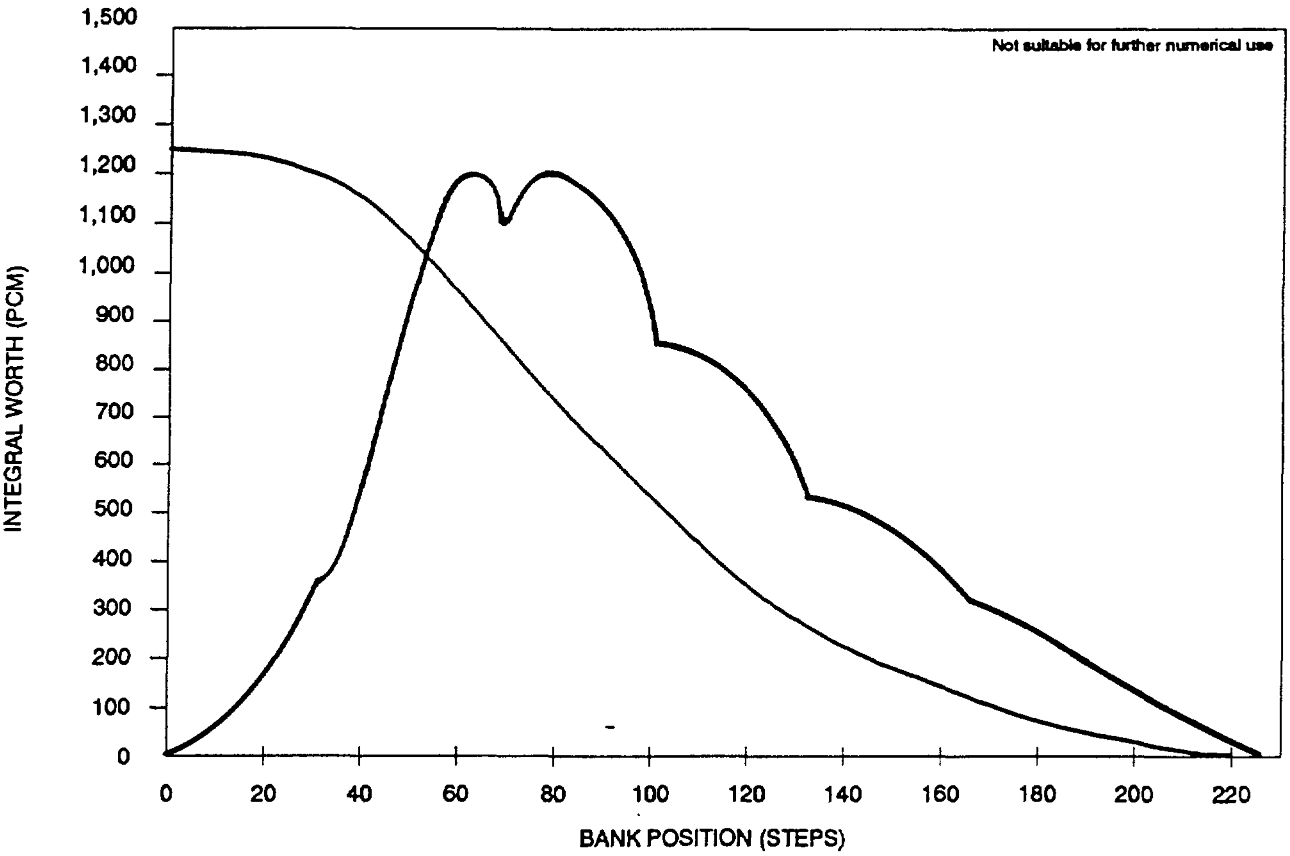


Fig. 2.12.2: CYCLE 1: *Measured differential & integral worth control bank A*

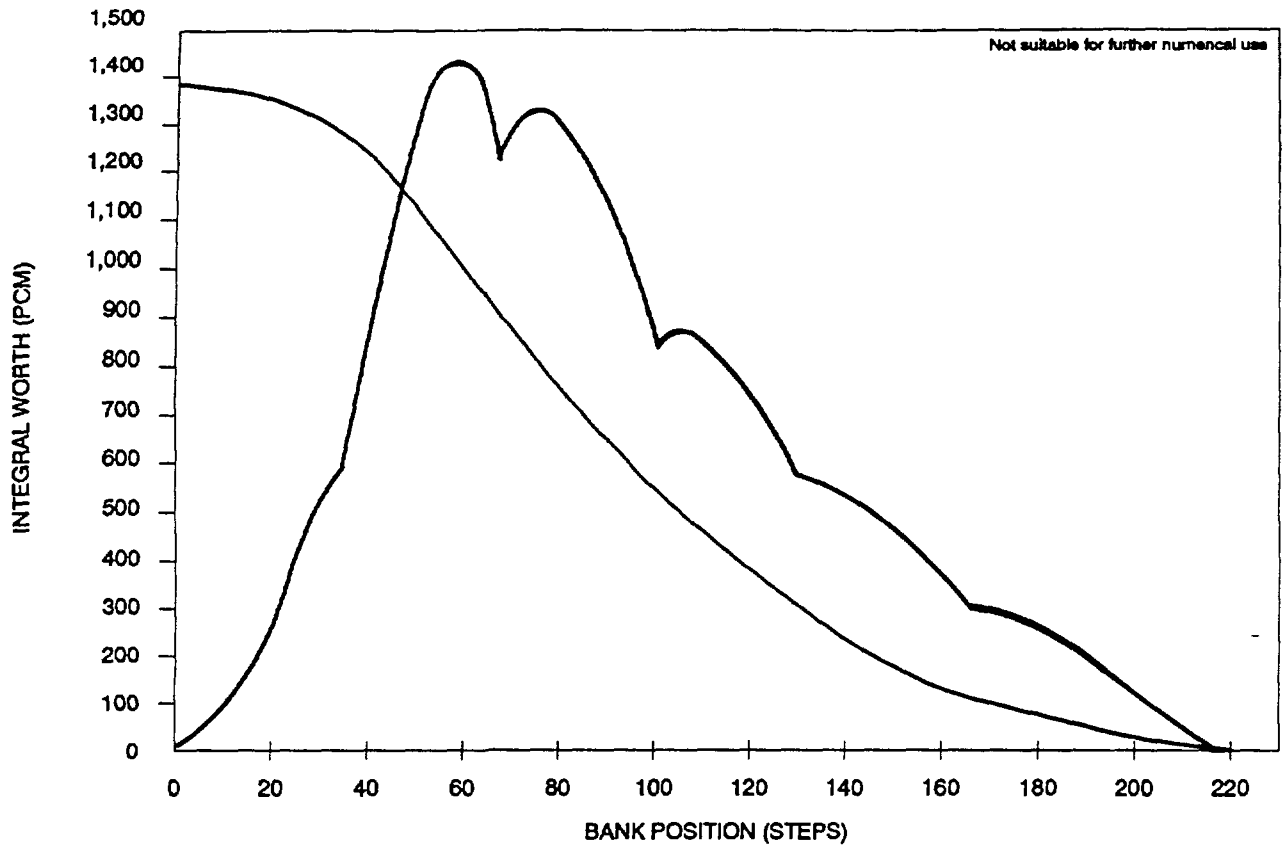


Fig. 2.12.3: CYCLE 1: Measured differential & integral worth control bank D

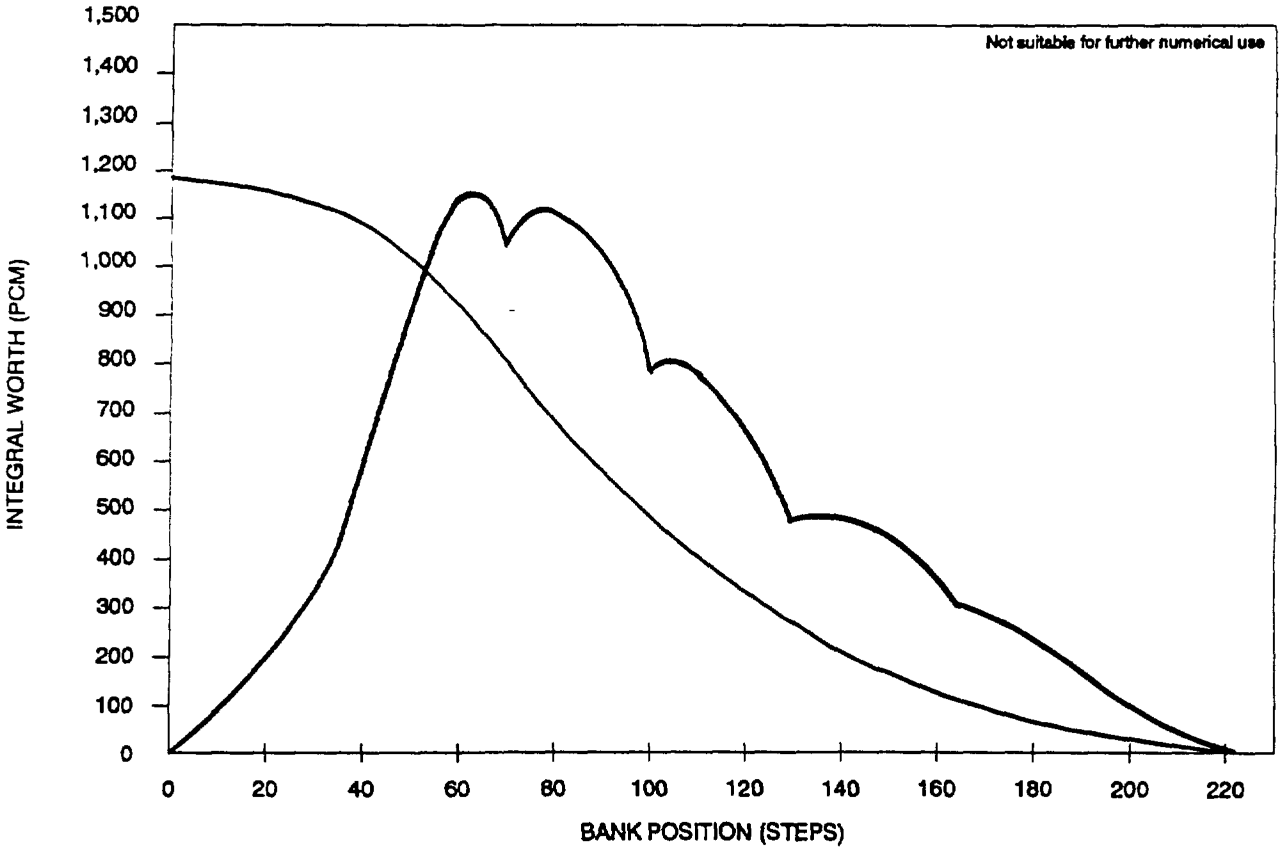


Fig. 2.12.4: CYCLE 1: Measured differential & integral worth control bank C

3. METHODS AND CALCULATING PROCEDURES

In this chapter will be included a brief description of the methods and calculating procedures used by each participant to get the results of the proposed benchmark. All of the participants (India, Spain, Turkey, Croatia, South Africa and Serbia) provided results for level II, and 1 participant (Spain) provided results for level III. The participants who have generated results for level III, use a 3D core calculation code which can simulate partial power level and partial control rods inserted.

3.1 BHABHA ATOMIC RESEARCH CENTRE (INDIA)

The code package used is the SUPERB-AKHILESH[15,16]. For the lattice calculations the SUPERB lattice code was used, and the global core analysis has been performed with a new one-group, two dimensional code AKHILESH. The block diagram of the code package is given in Figure 3.1.

The basic nuclear data is the 69 group WIMS library of U.K. whose group structure is sufficiently fine for the important resonances of Pu isotopes in the thermal energy range. The cross sections are condensed to 28 groups with the spectrum of

<u>Nuclear Data</u>
WIMS-69 (UKNDL) condensed to
28 groups using a typical PWR spectrum

<u>SUPERB</u>
Fuel assembly homogenization

1-D transport single pin (28 groups)
1-D transport supercell for BA (28 groups)
1-D transport supercell for FA (28 groups)

2-D homogenized single pin (5 groups)
2-D diffusion for FA (5 groups)

k_{inf}&M^2, (BU, BC, T_f, T_m, P, p_m)

<u>AKHILESH</u>
Core calculation

2-D one group nodal
Constant axial buckling
Albedo treatment for reflector
Depletion with critical BC search

FIGURE 3.1
Block diagram of SUPERB-AKHILESH code package

a typical PWR lattice pincell. The 69 group spectra for collapsing are obtained by MURLI[17] which uses the interface current approach (J±) to solve the integral transport equation for a pincell. This 28 group library is found to nearly reproduce the 69-group results. This 28 group library has been used for all of the PWR lattice analyses presented here.

The SUPERB code treats the fuel-assembly unit cell as if it were part of an infinite lattice. Since for an assembly consisting of various heterogeneities like water rod, cluster control assembly, burnable absorber etc., a transport theory solution with exact 2-D geometrical treatment would require large computer time and memory, we essentially perform a series of 1-D transport calculations in 28 groups using an interface current approach. Then the multigroup neutron spectrum at any point in the 2-D lattice is obtained as a superimposition of various 1-D transport solutions.

The fuel pins in an assembly are categorized into several fuel pincell types depending on the layer count from the water gap and its location in the layer. Appropriate Dancoff factors and resonance self-shielded cross sections are evaluated. The pincells, consisting of the fuel rod, clad and associated coolant in one square pitch area are analyzed in 28 groups by J± formalism. J± method has been found to be quite accurate in cylindrical geometry despite the use of cosine current approximation[18].

The infinite lattice assumption of the pincell calculations is corrected by performing a cylindrical supercell calculation. In the uncontrolled PWR fuel assembly water rods appear in a cluster form and give rise to softening of the spectra in the surrounding fuel layers. In order to consider this effect we perform this supercell simulation in an artificial 1-D geometry wherein a single water rod is considered at the centre, surrounded by several paste regions of various pincells. The supercell calculation is done in 28 groups by the J± formalism. The ratio of the supercell spectrum to the pincell average spectrum serves as the correction factor which accounts for the softening effect of the water rod. In this cylindrical representation the presence, if any, of poisoned pins, control absorbers are ignored.

Control absorber rods (RCCA and burnable absorber) are treated by a special mini-supercell calculation in 28 groups by J± formalism where the typical control absorber pin with its fine structure is at the centre, surrounded by rings of homogeneous fuel pastes of the surrounding pincells.

Using the appropriate supercell 28 group spectra, the fuel pincell and other material cross sections are condensed to few groups, typically 5. The control absorber cell (of equivalent one square pitch area) is homogenized by simple flux and volume weighting procedure using the spectra of control supercell calculation.

The fuel assembly is then analyzed in the proper 2-D geometry by solving the few group diffusion equation in

Cartesian geometry using the five point centre-mesh finite difference (FD) scheme. One mesh per fuel pincell region is considered. We obtain K-inf, power distribution and flux and volume weighted one or two group homogenized assembly parameters from this calculation.

One group reaction rates are obtained from the few group diffusion theory spectra which can be optionally adjusted for criticality.

The equations of depletion/build-up of fuel isotopes are solved for a number of fuel pins, termed as the burnup zone. The fission products are lumped into a few pseudo fission products groups which are recommended in LWR-WIMS[19]. The burnup integration is done by the trapezoidal rule and a variable integration step size is chosen by the code such that the concentration of any isotope does not change by more than 5% in one step. From the average change in number density of a burnup zone, the change in each fuel pin number density is obtained by using the linear relationship between average burnup zone power and pin power. The calculation proceeds in the same manner for subsequent burnup steps.

The depletion of boron-10 in burnable absorber pins is calculated considering only one zone for the entire cluster. In order to determine the absolute flux for this zone, the depletion calculation is linked with a surrounding fuel burnup zone where the flux is known from the specified heat rating.

The supercell spectra are updated at coarser burnup levels and diffusion calculations are performed at intermediate fine burnup steps.

AKHILESH essentially solves a one group two dimensional diffusion equation by a finite difference method. It solves for neutron source distribution instead of flux distribution as is done in COMETG[16] or TACHY[20]. The mesh size is uniformly a quarter of an assembly. This mesh size was found to significantly improve the power distribution compared to a one mesh per assembly solution. Albedo parameters are used at the core reflector interface. These albedoes were chosen by simple numerical tuning of the power distribution of the peripheral fuel assemblies against measured for the nominal power condition at BOC-1. The albedoes are not varied as a function of burnup, boron, or the power level. This is considered to be one of the major deficiencies of the present model. When the analytical methods for the proper representation of reflector and other outer layers out to the pressure vessel are fully developed, we will reevaluate the albedo parameters theoretically. The axial leakage is included by means of an axial buckling which is assumed to be constant during the cycle.

The nominal fuel temperature (T_f) was assumed to be 704/C and the nominal coolant temperature (T_C) was 310/C. In a mesh the mean temperature of fuel was deduced by assuming a linear variation of (T_f-T_C) with the power in the mesh relative to the nominal average value. $\Delta K/K$ due to fuel temperature is then applied by interpolation of the tabular values evaluated as a function of burnup for each fuel type.

The $\Delta K/K$ due to xenon is evaluated as a function of burnup, boron, and power rating for each fuel type. The $\Delta K/K$ is interpolated as a function of relative mesh power from,

$$\Delta K/K = \frac{P\ (1+X_2)\ X_1}{P + X_2} - X_1$$

where X_1 is the $\Delta K/K$ due to xenon at average power of $P = 1.0$. X_1 is evaluated as a function of burnup and boron for each fuel type. X_2 is evaluated for different heat rating values from SUPERB for fresh fuel without boron.

The mean coolant temperature in a mesh is assumed to be the addition of the inlet temperature and $\Delta T/2$ where ΔT is proportional to the power in that mesh. Both K_{inf} and M^2 are perturbed due to T_C.

The presence of control rods (RCCAs) in a fuel assembly is determined by using burnup dependent worths of these RCCAs. For fractional control some weighted $\Delta K/K$ is used in an approximate manner.

The change in reactivity due to the difference in the instantaneous critical boron at a given cycle burnup and the average boron (history) that was present up to that burnup is also considered. This effect was found to be very important when predicting the cycle length as is shown by the results presented in the next section.

The flow of calculations in the code AKHILESH is as follows. We start with the initial burnup profile of a given cycle. An initial flat guess for source distribution and unit eigenvalue are assumed. The innermost loop updates the eigenvalue and source distribution. Power dependent feedbacks are applied after every sixth iteraction. After convergence of source and eigenvalue the boron concentration is varied such that a required K-effective or eigenvalue can be met. When the critical boron is evaluated and the burnup profile is determined at the given burnup step, the calculations are then repeated as before. Finally the cycle calculations are terminated either when the critical boron becomes negative or when all burnup steps are completed. The burnup profile for the next cycle can be reconstituted with the help of assembly identification numbers or simply specified by input. A boron history profile is also followed up and reconstituted for the next cycle. The next cycle calculation is done in a similar way. The typical running time on an ND-570 computer for a one cycle followup (14 cases) is about 5 min.

3.2 UNIVERSIDAD POLITECNICA DE MADRID (SPAIN)

The code package used is the last version (SEANAP) of the JEN-UPM system[14,21,22], which is running on different computers and workstations (CONVEX, CRAY, SUN,...), has been developed from our previous PWR core analysis system[23]. This last version has incorporated improvements in accuracy and efficiency into the previous codes and procedures, as well as

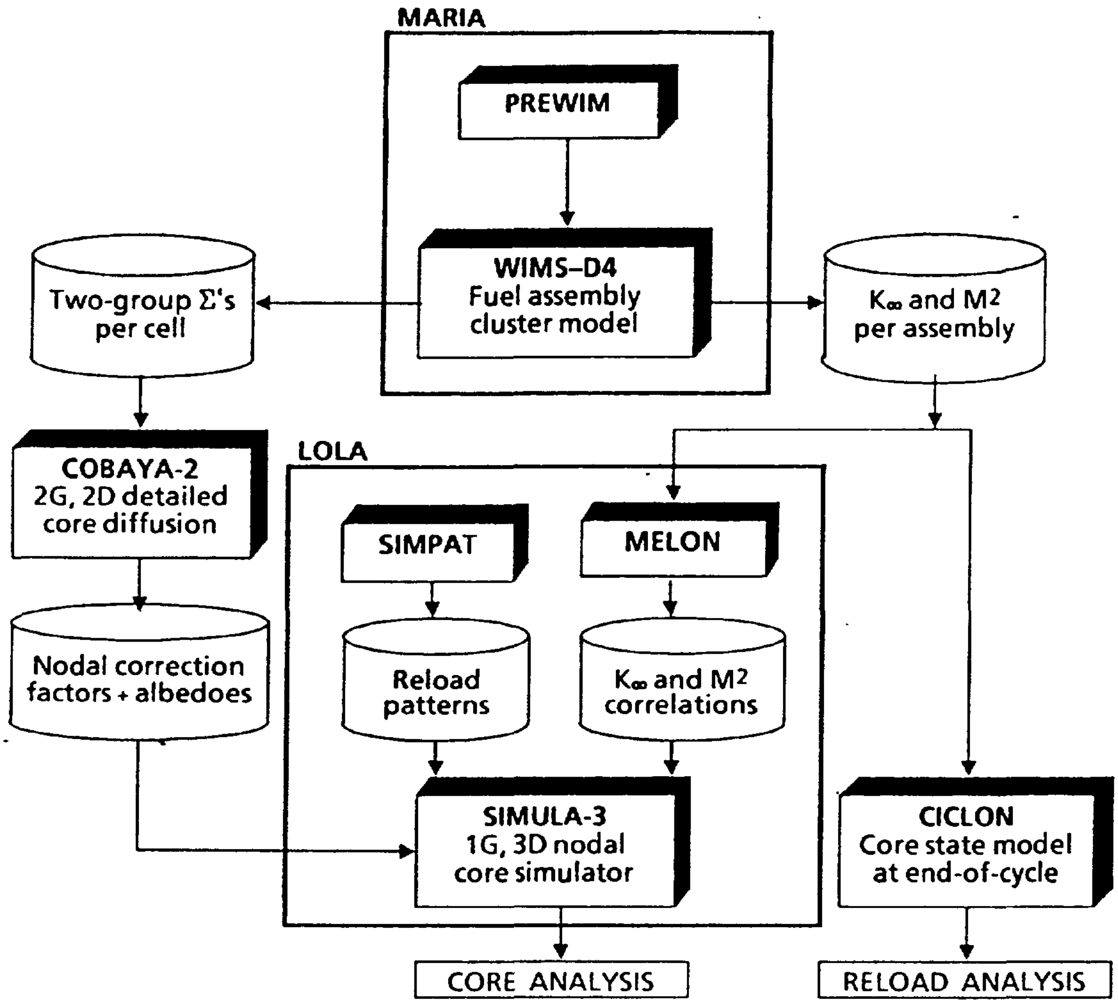


Fig. 3.2 Scheme of the PWR Core Analysis System SEANAP

introduced new advanced codes and methodologies[24], by a merging of the co-ordinated disciplinary development work, application experience and validation results.

The SEANAP system is integrated by four interconnected subsystems or codes (Fig. 3.2) the MARIA subsystem[23] for fuel assembly calculations; the COBAYA-2 code[24] or CARMEN code for detailed (pin-by-pin) core calculations at reference conditions; the LOLA subsystem[23] for three-dimensional one-group corrected-nodal core simulation; and the CICLON code[25] for fuel management analysis.

The MARIA subsystem is integrated by the PREWIM and WIMS-D4 codes. The PREWIM code produces the full input data files required by the WIMS-D4 code[26], in a consistent and efficient way, for all the sets of fuel assembly calculations covering the parameter space of the local physical variables (water density, fuel temperature, xenon concentration, boron concentration, burnup and control) along each cycle of reload and operation. A cylindrical model of the equivalent fraction of each fuel assembly type is constructed by PREWIM, where a central detailed cell (with water, control or burnable absorber, according to the assembly kind) is surrounded by several annulus with fuel rods and the corresponding fractions of water cells and structural material, forming an ordered cluster. This model provides an efficient and accurate treatment of the PWR fuel assemblies with regularly distributed fuel rods, water tubes, and control rods or burnable absorber tubes (gas filled or wet).

Among the new capabilities introduced in the last PREWIM version are: variation of the effective fuel temperature with the local power density and burnup, through input correlations fitted to the results obtained by the thermo-mechanical fuel rod code GAPCON-THERMAL-3[14] with a revised fuel cracking model that enhances early pellet-clad contact; restarts with isotopic concentrations in burnable materials from the end of the previous irradiation cycle and changes in the local conditions and burnup history; automated reconfiguration of the fuel cluster models after removal of burnable absorber clusters from previous cycles or insertion of control rod clusters; and procedures to produce the complete set of cases required for each fuel assembly type in each cycle on a single computer run.

The last WIMS-D4 version includes several minor modifications in the original and previous versions, as well as the use of options with improved efficiency and accuracy, such as: the continuous change in the Pu-240 selfshielding with burnup; input Dancoff factors for fuel rods in a regular lattice and in locations close to vacant cells or assembly borders; and saving of isotopic material composition for continuation cases in next cycles.

The COBAYA-2 code performs the detailed (pin-by-pin) two-group two-dimensional core diffusion calculations along each cycle, including several unrodded and rodded configurations at hot-zero-power (HZP) and hot-full-power (HFP), at beginning and end-of-cycle (BOC and EOC), and at several steps along the nominal burnup. The full core or a half, quarter or octant, according to the actual symmetries, is represented. The detailed core-shroud (steel plate) and reflector (borated water) is included in the fine-mesh grid. Variable axial leakage is included through group dependent bucklings obtained by axial one-dimensional diffusion calculations of the averaged core.

COBAYA-2 includes the following main extensions: feedback on the cross sections at the fuel pin level of the local burnup, xenon concentration, fuel temperature, water density and boron concentration, optimized acceleration by the synthetic one-group corrected diffusion method of the two-group local (by cells) and corrected global (by nodes) two-dimensional diffusion solutions; and extended options for output of the explicitly calculated spectral and transport correction factors (per fuel assembly kind and per node), average and relative albedoes at the core boundary and hot-pin to node average power ratios (per node), in data files formatted to be input directly to the core simulator SIMULA-3[23,24].

The LOLA subsystem for PWR core simulation includes the extended one-group three-dimensional nodal code SIMULA-3 and several auxiliary codes, where the more relevant ones are the MELON and SIMPAT codes.

The MELON code has been extended to generate more accurate correlations of k-infinity, including the cross-effects of boron concentration on xenon worth and burnup on Doppler worth, as well as to autocheck the fits of the correlations for all input values and conditions. A new auxiliary code, PREMEL, has been developed for the automated preparation of the complete data sets to be input to MELON for all the fuel types in each cycle, with very low overall preparation effort, computing time and error chance.

The SIMPAT code generates the formatted data sets to be input to the core simulator for defining the fuel type per node (quarters of assemblies), and the shuffling of fuel from previous cycles, also at the node level. The fuel loading pattern, for the whole core in each cycle, is input to SIMPAT by fuel assembly identifications. The code searches the positions in previous cycles and gives the maps of types and identifications per node, taking into account the core fraction considered in the simulator for each cycle and the eventual node rotations that can result when a fuel assembly is changed in core half, quadrant or octant.

SIMPAT also prepares a formatted file with the burnup values by fuel pin after shuffling from the previous cycle, taking into account the eventual fuel assembly rotations.

The last SIMULA version of the PWR core simulator includes extensions and improvements such as: extended correlations of the nodal k-infinity; variation of the spectral and transport factors by fuel type with local burnup; variation of the average albedoes with burnup and water density; calculation of hot-pin powers per node by superposition, with input ratios per node taken from the COBAYA produced files at selected core conditions and burnups; restart and selected output options, including channel outlet coolant temperatures and averages per assembly, quadrant and octant of the nodal variables (power, burnup, water density, xenon and iodine concentrations); and automated data input directly from the formatted files produced by the other codes of the system, including MELON (correlations), COBAYA (hot-pin ratios, correction factors and relative albedoes per node), SIMPAT (node types and identifications for reload) and SIMULA itself (node burnups at the end of previous cycles).

The SEANAP system provides a rather simple, reliable, systematic and efficient capability to perform the neutronic calculations required for the extensive analysis of the design, tests, and operation of PWR cores. For each cycle, an expert can complete the preparation of all the data files required by the core simulator (including the MARIA and COBAYA calculations for all fuel assembly types and reference core conditions), in one or two weeks with a medium computer (1-4 Mips, 100-200 Kwords). The calculations for the analysis of the startup tests and nominal design of one cycle can be completed in another week or two, because the SIMULA-3 core simulator is rather fast and simple. Then, the detailed follow of the actual core operation along the cycle can be done rather easily, analyzing the deviations and actualizing the previsions, as well as the modifications during the fuel reload. The system provides also the tools for the analysis of fuel reload strategies with alternative loading patterns and fuel or absorber designs and management, using the CICLON code or the two-dimensional option of the core simulator SIMULA.

3.3 CEKMECE NUCLEAR RESEARCH AND TRAINING CENTRE (TURKEY)

The code package used is the GELS-GEREBUS in-core fuel management modular system (Fig. 3.3). The GELS-GEREBUS code system consists of one dimensional integral transport theory lattice and multigroup cross section generating spectral code GELS[27] and a 2D diffusion code GEREBUS[28]. The two codes are linked by the microscopic cross section library, generated by GELS for each fuel type and represented as polynomials depending on burnup values.

GELS is a cross section generation and cell depletion code using a 45 group library. The code produces group constants for the static PWR design of whatever fuel cycle (Uranium, Thorium, or Plutonium). The whole complete range of temperatures is covered and the treatment of strong lumped absorbers as control or burnable poison pins is included. The code solves the one dimensional transport equation in integral transport theory formalism and uses the first collision probability technique. The whole cell can be divided into several regions with different or same compositions. GELS calculates in each region 45 group fluxes and by using this space dependent spectrum, homogenization and group collapsing are performed.

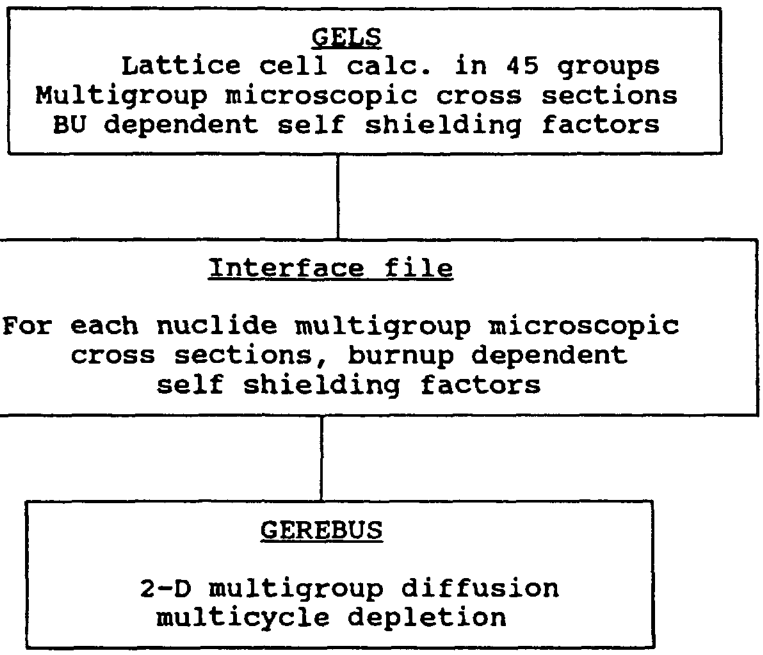


FIGURE 3.3
Block diagram of GELS-GEREBUS code system

GELS produces in different format homogenized microscopic cross sections, number densities, and burnup dependent self shielding factors in polynomial forms. There are 15 fuel isotopes in the burnup chain, 6 nonsaturating pseudo fission products, 25 fission products in 3 chains, 12 nonburnable isotopes and 8 lumped absorbers. Group condensation can be performed in any number of groups. The cross-section library consists of 30 thermal and 15 fast energy groups which is condensed from 200 groups by means of a sophisticated zero dimensional spectral code GGC-4[29].

This 45 group structure was chosen in such a way as to reflect the differences of different PWR lattices in the condensed group constants. This was accomplished by choosing appropriate group boundaries in the fast and thermal energy ranges. The partitioning in the fast energy range was made according to the physical effects prevailing in the individual sub-ranges.

The space dependence of the group constants of the epithermal resonance absorbers is taken into account for the special design of different lattice geometries used in the PWR's. The thermal groups have been selected according to the potential spectral shape which is greatly influenced by the thermal resonance absorbers. Care has been taken to provide sufficient representation of this species of cross-sections, so that this part of the spectrum is free of the resonance formalism of the epithermal energy range.

Cross-sections that are directly dependent upon fuel or moderator temperature will be supplied for the actual case by the square LAGRANGE interpolation of the data prepared for the temperatures:

T_{Fuel} : 300, 373, 473, 593, 900, 1200 °K
T_{Mod} : 300, 373, 473, 593 °K

The well known chains for heavy metals, short and truncated fission products, and rare earth elements were used for the burnup dependent cross-section calculations.

A fixed cross section library must incorporate fission products to permit depletion calculations. To avoid using several pseudo fission products having different saturation behaviour, the number of fission products has to be optimized (minimized) to the smallest number possible, i.e. that which gives good results. This allows a good calculation of the burnup while the number of heavy metals is fixed in some measure by the planned application. Moreover, the structure of the chains should be simple. The points of view of abbreviating the chains are the following:

1. The yields of precursors with half lifes below the order of magnitude of hours are cumulated to that of the next longer living successor.
2. Low yield nuclides (yield <<1%) without strong fission product parents are omitted even if their absorption cross-sections are high.

3. Unstable nuclides of a sufficient lifetime are taken into account, even if their absorption is small, with regard to burnup effects caused by power cycling.

The code GEREBUS is the GKSS version of the 2D multigroup, diffusion depletion code EREBUS. GEREBUS requires for each nuclide in each fuel type a multigroup microscopic cross section library and multigroup burnup dependent self shielding factors in polynomial form. The cross sections themselves belong to beginning of cycle (BOC). The burnup dependencies are handled by means of burnup dependent self shielding factors. By using these cross sections, self shielding factors and number densities, GEREBUS calculates macroscopic cross sections and reaction rates. Some outstanding features of GEREBUS are:

- several sets of cross-section libraries and self-shielding factors,
- the burnup dependence of the group-constants were simplified by polynomials,
- 3 types of criticality searches (by uniform variation of a control isotope, by regionwise variation of a control isotope, and by boundary search), in addition to the straight burnup calculation,
- possibilities of changing sets of data at prefixed time-steps,
- arbitrary isotopic chains,
- automatic fuel shuffling,
- 2 types of restart of interrupted problems,
- possibilities of giving one buckling for the whole reactor, or per group, or per composition and per group, or per region and per group,
- the burnup dependence of the axial buckling of a PWR was represented by simple polynomials.

3.4 RUDER BOSKOVIC INSTITUTE AND UNIVERSITY OF ZAGREB (CROATIA)

The code package used is the Penn State Fuel Management Package (PFMP). The Penn State Fuel Management Package consists of the PSU-LEOPARD[30] code (Penn State University LEOPARD) and MCRAC[31] code (Multiple Cycle Reactor Analysis Code). PSU-LEOPARD is basically the LEOPARD code with the additional option to generate the cross section data in the form compatible with the MCRAC code. MCRAC is a global core calculation model incorporating the common options generally found in the core model such as the critical boron search, the macroscopic depletion of the fuel assemblies, and the power-dependent xenon correction. The two energy group solution of the neutron diffusion equation in the two-dimensional form is obtained through the EXTERMINATOR-II finite difference algorithm.

This code system possesses such modern features as the automatic data transfer from the cross section generation model to the global core model amd the multicycle simulation. The data transfer is done by means of a computer file containing the so-called ADD(Assembly Data Descriptions)

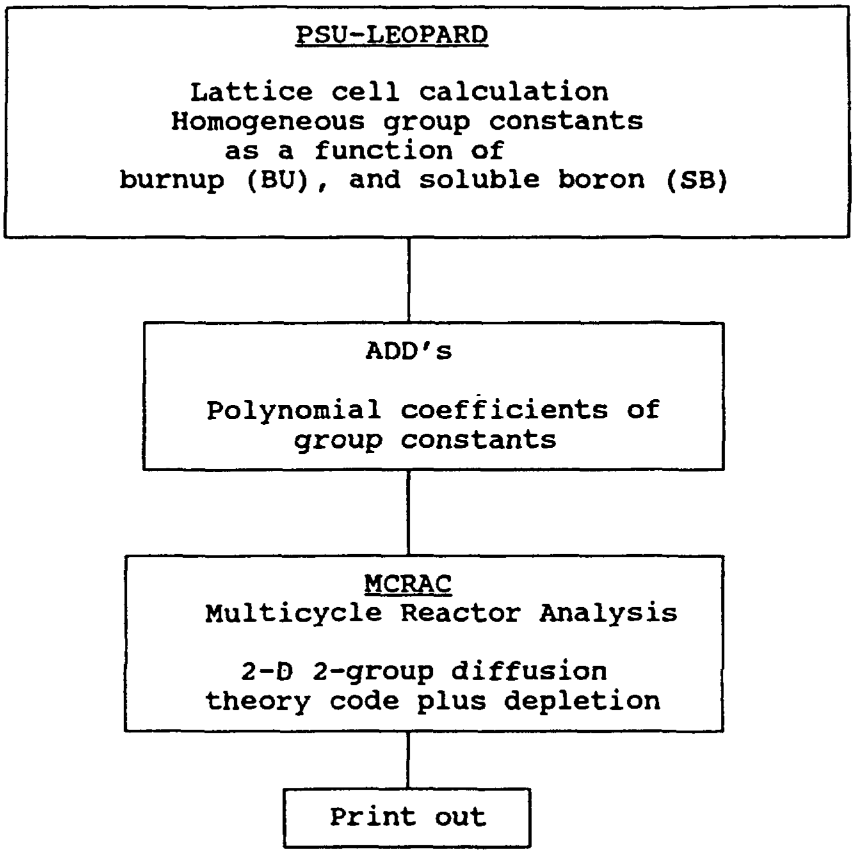


Figure 3.4
Block Diagram of the Penn State Fuel Management Package

decks. The ADD is a collection of the polynomial coefficients that represent the macroscopic cross sections as functions of burnup. It also contains the polynomial coefficients for the boron and xenon corrections and the fissile atom inventory calculation. PSU-LEOPARD has the option to prepare the ADD deck automatically. The structure of the PFMP is depicted in Figure 3.4.

The PFMP version obtained from the Penn State University has been further developed at the Rugjer Bošković Institute (RBI). Improvements which are incorporated into a new version developed at RBI (PFMP/RBI)[32,33] are the following:

- modelling of burnable poison rods and integral fuel burnable absorbers (IFBA);
- fast and convenient fuel assembly interchange option for loading pattern search;
- local maximum power calculation;
- improved core map printout;
- automated mesh definition;
- core modelling by following separately quarter fuel assembly burnups;
- pin-power reconstruction.

Additionally, the PFMP has been converted for operation on the personal computer (IBM-PC or compatible). The PC version of PFMP has been used at the IAEA co-sponsored workshop

"Reactor Physics Calculations for Applications in Nuclear Technology"[34,35], which has been held at International Centre for Theoretical Physics, Trieste, Italy, in year 1990.

3.5 ATOMIC ENERGY CORPORATION OF SOUTH AFRICA LTD. (SOUTH AFRICA)

The methods used in the Reactor Theory Division of the AEC of South Africa for PWR in-core calculations is based on a microscopic core depletion model. The global reactor calculations are performed with a two-dimensional two-group nodal diffusion code. The two-group homogenized assembly microscopic cross section data required for these core depletion calculations are prepared with a one-dimensional multigroup assembly depletion code package.

a) Lattice cell calculations methods

The lattice cell code (assembly) package consists of several interconnected codes each performing a specific task. The geometric model used to represent a two-dimensional fuel assembly is based on a simplified one-dimensional cylindrical model similar to that used by the Spanish group in their MARIA package[23]. In fact, much of our procedure resembles that used by the Spanish. The lattice cell code package consists of four main modules:

A preprocessor code based on a modification of the PREWIM code[36] to set up a string of input data required by all of the other modules in the package. In particular, the modified PREWIM generates WIMS-D/4.1[36] input data for both the so-called base depletion and off-base non-depletion calculations, the latter of which includes independent variations in state parameters (soluble boron concentration, moderator density and fuel temperature) at predetermined exposure points. Additional input data is also generated to simulate control rod insertion and/or burnable poison rod extraction at the selected exposure points (this includes automatic reconfiguration of the cylindrical assembly model). Furthermore, a correlative thermal hydraulics module (called TABASCO[37]) has been added so as to supply data such as moderator and fuel temperatures at nominal power. The variation of fuel temperature with exposure is also accounted for by this method and an effective fuel temperature is computed from the physical value to account for the Doppler broadening effect on cross sections. The same module also provides the power levels corresponding to off-base fuel temperature variations in order to adjust (within WIMS-D/4.1) equilibrium Xe number densities. The Dancoff factor calculation in PREWIM has also been modified to accomodate group dependent total cross sections for the non-fuel materials. In the case of assemblies with burnable poison rods, the more efficient POISON depletion option in WIMS-D/4.1 is activated. It should be noted that a zero buckling is used in all lattice calculations and that no critical buckling search is attempted (although this option is available in WIMS-D/4.1).

WIMS-D/4.1[36] performs a 24-group lattice depletion calculations. This particular version of the WIMS-D/4[26] code includes improved resonance integral interpolation, explicit treatment of I-135 and Pm-149 in the burnup chains, and an infinite lattice treatment of fuel clusters as required for PWR assembly calculations (the cluster treatment in WIMS-D/4 is based on an isolated cluster model which may be more appropriate for Gas-cooled Reactor type fuel assemblies).

WEDRO-1.1[38] post-processes (group collapses, homogenizes, sets up depletion chains for those isotopes selected for microscopic treatment) the WIMS-E files produced by WIMS-D/4.1. This code checks the specified WIMS-E files for variations in state parameters for each exposure interval (i.e. it checks for off-base calculations) and produces files in a specific format required by the polynomial fitting module CLIPAR.

CLIPAR is used to parametrize the two-group dataproduced by WEDRO-1.1 as functions of exposure, soluble boron concentration (ppm), moderator density and fuel temperature by means of a least squares quadratic polynomial fitting procedure. The resultant polynomial library reduces computer storage requirements considerably and is used directly in the global reactor calculations.

In addition to this package, which is used to prepare two-group data for fuel assemblies, an independent package is used for the generation of reflector data. The radial reflector data for this project was generated by means of the NGET-RM procedure[39] and the method proposed in Ref. 40 was used to diagonalize the resultant diffusion coefficient matrix. The one-dimensional (slab) geometric model used for this purpose includes only the core baffle (2.8575 cm) in the water reflector (18.7505 cm), thus ignoring the barrel and neutron pads. The two-group data generated in this manner were parameterized as a function of soluble boron concentration (water density being fixed at the core inlet value at nominal operating conditions). The code CLIPAR was also used to obtain a quadratic polynomial fit to this data.

The above is a description of the procedure followed to generate the two-group polynomial library used in the global core calculations. However, for the auxiliary lattice benchmark test calculations, some of the features of the overall lattice cell calculational package were deliberately deactivated to comply with the requirements of this benchmark test. These include the skipping of the thermal hydraulics (TABASCO) calculations and specification of the recommended fixed temperatures, skipping of off-base perturbed lattice calculations, and the use of two fixed soluble boron concentrations (0 and 1000 ppm) for base depletion calculations.

It must be noted that the specifications for the sleeves of the benchmark assemblies were not available. Instead of simply neglecting the effects of the sleeves in the lattice calculations, we have used a typical mass of 820 grams per fuel assembly for these structures (consisting of SS-304).

b) Core calculation methods

The core fuel cycle calculations for the benchmark have been done using a Level II code package which uses the BOLD-VENTURE code system[41] from Oak Ridge as a basis for data communication. Additional locally developed modules have been added to provide the core cycle analysis capability and this modified system is currently known as OSCAR-2.

The actual static reactor core flux calculations were performed with a two-dimensional code based on the two-group analytic nodal diffusion method[42]. For these calculations each fuel and reflector assembly is divided into four nodes. For thermal hydraulic feedback the same method as used in the cross section generation phase (i.e. the TABASCO method) is used to obtain moderator densities and fuel temperatures (which vary with exposure) per node. These nodewise state parameters (together with exposure and ppm) are used to reconstruct two-group cross sections from the polynomial data library generated by means of the lattice cell package described earlier. Local depletion calculations are performed on an assembly-wise basis (not nodewise) using the BURNER module of the original BOLD-VENTURE code system. The U-235, U-238, Pu-239, Pu-240, Pu-241, Pu-242 isotopes as well I-135, Xe-135, Pm-149, Sm-149 and the B-10 of the burnable poison rods are explicitly treated.

In completing the calculations for this project, certain assumptions and modelling decisions were made: The reflector regions in the core are modelled using an homogenized baffle/reflector node treatment which is consistent with the use of coarse mesh nodal methods. All calculations were based on 2-D models of the reactor. The axial effects were approximately taken into account by using a constant, group and assembly independent geometric buckling factor. The same axial buckling was used for both cycles. The reactor core calculation for cyle 2 was based on a quarter core configuration representing reflective (white) symmetry across the horizontal and vertical axes. All our calculations were done at 100% reactor power (no core follow - Level II code) and EOC time points were taken as those specified in the benchmark data rather than those usually defined as the zero ppm points.

3.6 BORIS KIDRIČ INSTITUTE OF NUCLEAR SCIENCES (YUGOSLAVIA)

Two fundamental types of computer programs are normally used for detailed in-core fuel management neutronic analysis: a code which describes the neutronic characteristics of a fuel assembly as depletion progresses (assembly depletion code), and a code which mocks up the operation of the reactor core (2- or 3- dimensional) simulator). The simulator code needs as input the neutronic data derived from the assembly depletion code, as well as data which define the core configuration and thermal-hydraulic conditions.

In the present research project, the previously adopted and verified calculational scheme has been used for calculating reactivity and power density distribution in a reactor core versus nuclear fuel burnup. This scheme consists of the WIMSD4 code[26] for pin cell and fuel assembly treatment and the code VAMPIR[43] for over-all reactor core calculations. WIMSD4 code provides the group values of fuel assembly averaged cross sections for specified burnup values. These are used as input data for calculating the global reactor core parameters versus burnup. According to the specification given above, this scheme can be considered as a level 2 scheme.

The group values of effective fuel assembly physical parameters versus burnup have been calculated using the "cluster" option of the WIMSD4 code. In order to simplify preparation of input data for the WIMS code a relatively simple algorithm for representing the standard PWR fuel assembly in the form appropriate for application of WIMSD4 "cluster" option has been programmed for a personal computer following the general idea of the PREWIM code[23].

All the pin cell, supercell, and fuel assembly calculations were performed using different options of the WIMSD4 code in 40 energy groups. This number of groups was adopted as optimal from both the accuracy and the calculating time point of view.

The group values of effective fuel assembly physical parameters versus burnup have been calculated using the "cluster" option of the WIMSD4 code. Following the general idea of the PREWIM code, the 1/24 part of the fuel assembly, i.e. the portion of the fuel assembly assigned to one control rod guide thimble, has been modeled as a cylindrical multizone supercell. Two central zones represent the control rod and its cladding, or moderator if the control rod is not present in the channel. The next four annular zones represent moderator, control rod guide thimble, structural materials of the control rod and the corresponding part of the instrumentation channel, and moderator, respectively. The seventh zone contains four fuel rods which are closest to the control rod. The moderator again occupies the zone number eight. The zone number nine contains 1/24 part of fuel pins having no contact with the control rod, while the zone number ten contains 1/24 part of the rest of the fuel rods. Finally, the zone number eleven contains the corresponding part of the fuel assembly construction material.

The results of the fuel assembly calculations performed by the WIMS code, namely the tabulated values of the two group assembly averaged effective cross sections versus burnup, are used as input data for the overall reactor core calculations in x-y geometry. The 1/8 part of the reactor core, is modeled for the global reactor core calculations.

4. BENCHMARK RESULTS

The goal of Benchmark calculations is not only to compare results obtained by participants and to verify computer code packages but also to provide the reference solutions, relevant for in-core fuel management, that enable the participants to adjust their codes for certain reactor types. For that reason quantities which are results of benchmark calculations are given and compared in this chapter. They are presented in two parts, one part concerning cell calculations and the other global calculculations. Results of the global calculations are divided into two groups according to a code package level (level II and level III). The participants have provided either main or auxillary results, depending on their code packages.

The auxilliary quantities are given separately to help explain the possible discrepancies that may appear in deriving the main results. Thus the strong and weak points of the applied computational approaches can be identified and specified more closely. Hopefully, improvements to codes and preferred packages for specific problems will be suggested in the future.

The Rugjer Boskovic Institute from Zagreb, Croatia collected the calculated data from the participating groups, and with a software developed for this application, has generated comparison tables. These tables include absolute values of quantities obtained from all participants for cell calculations and global calculations, as well as comparison of the global calculation results against the reference data (measurements).

4.1 Lattice cell calculations

4.1.1 Static lattice cell calculations

Lattice cell calculations were performed by all participants to obtain data for k_{inf}, uranium and plutonium isotopic inventory, and boron remaining in burnable absorber rods with the assumption of zero leakage. The infinite multiplication factors obtained by static cell calculations for 2.1% enriched fuel, 3.1% enriched fuel, and 2.6% enriched fuel (containing 0, 12, 16, and 20BPRs) are summarized in Tables 4.1 - 4.6. The static cell calculations have been performed at 0 MWd/tU burnup at 0 ppm and 1000 ppm boron concentrations for the following prescribed temperature combinations:

Case	T_{mod} (C)	T_{clad} (C)	$T_{fuel,avrg}$ (C)	$T_{fuel,eff}$ (C)
A	20.	20.	20.	20.
B	291.4	291.4-	291.4	291.4
C	309.9	340.	704.	640.
D	309.9	340.	904.	840.
E	279.9	340.	704.	640.

The results match quite well for lattice cells without burnable absorbers, but for lattice cells with burnable absorbers the deviations of results are higher. This is because there are different levels of sophistication in the modeling of the burnable absorbers.

4.1.2 Burnup lattice cell calculations

The burnup lattice calculations were performed for the following conditions: T_{mod}=309.9 C

T_{clad}=340 C

$T_{fuel,avrg}$=704 C

$T_{fuel,eff}$=640 C

HFP

with the assumptions of no Xe at burnup 0 MWd/tU, and equilibrium Xe thereafter. Results are to be given for the following burnup values (MWd/tU):
0, 150, 2000, 4000, 6000, 8000, 10000, 14000, 18000, 22000, 26000, 30000, 34000, 38000, 42000, 46000, 50000.

The infinite multiplication factors obtained by burnup lattice cell calculations for 2.1% enriched fuel, 3.1% enriched fuel, and 2.6% enriched fuel (containing 0, 12, 16, and 20BPRs) are summarized in Tables 4.7 - 4.12 using 0 ppm boron concentration. The same quantities for boron concentration of 1000 ppm are given in Tables 4.13 - 4.18. Tables 4.19 - 4.21 contain burnable boron fraction left versus burnup for 2.6% enriched fuel without soluble boron, with 12 BPR, 16 BPR, and 20 BPR, respectively. The same quantities for boron concentration of 1000 ppm are given in Tables 4.22 - 4.24.

The isotopic composition versus burnup for 2.1% enriched fuel, 3.1% enriched fuel, and 2.6% enriched fuel (containing 0, 12, 16, and 20 BPRs) without soluble boron is presented in Tables 4.25 - 4.66. The same quantities for boron concentration of 1000 ppm are given in Tables 4.67 - 4.108.

4.2 Global calculations

The results of benchmark global calculations were provided for Cycle 1 and Cycle 2 of the NPP Almaraz. The results were classified into two groups according to level of codes used:

A) level II code results

B) level III code results

4.2.1 Level II code results

The following results were given for HFP conditions:

- critical boron concentration versus core burnup

- average fuel assembly power distribution versus core burnup

- peak fuel assembly power distribution versus core burnup

- fuel assembly burnup distribution versus core burnup

- batch averaged isotopic composition at the end of cycles

Octant normalized power distribution and assembly burnup distributions are provided for the following core burnups:

Cycle 1: 0 MWd/tU, 715 MWd/tU, 1940 MWd/tU, 4500 MWd/tU, 6146 MWd/tU, 8200 MWd/tU, 9912 MWd/tU, 13250 MWd/tU and 15100 MWd/tU

Cycle 2: 0 MWd/tU, 212 MWd/tU, 1863 MWd/tU, 4461 MWd/tU, 6589 MWd/tU, and 8436 MWd/tU

The results provided by all participants are compared and given in Tables 4.109-4.188 and Figures 4.1-4.4.

4.2.2 Level III code results

The following level III code results were given for actual NPP Almaraz operating conditions:

- critical boron concentration versus core burnup

- average fuel assembly power distribution versus core burnup

- peak fuel assembly power distribution versus core burnup

- fuel assembly burnup distribution versus core burnup

- batch averaged isotopic composition at the end of cycles

- axial core power distribution and axial offset

- differential and integral worths of control banks

- reactivity coefficients

Octant normalized power distribution and assembly burnup distributions are provided for the following core burnups:

Cycle 1: 0 MWd/tU, 715 MWd/tU, 1940 MWd/tU, 4500 MWd/tU, 6146 MWd/tU, 8200 MWd/tU, 9912 MWd/tU, 13250 MWd/tU and 15100 MWd/tU;
Cycle 2: 0 MWd/tU, 212 MWd/tU, 1863 MWd/tU, 4461 MWd/tU, 6589 MWd/tU, and 8436 MWd/tU

The results provided by level III code participants are compared and given in Tables 4.189-4.245.

4.3 Comparison of results

In order to understand the results of the different participants some remarks have to be made, as: the conditions at which calculations have been made are sometimes different from prescribed conditions due to each particular method and procedure used; as well as the particular characteristics of the nodalization of each code package.

4.3.1 Comments on Bhabha Atomic Research Centre (India) results

In reference to the results for lattice cell and core calculations, the following comments may be made about their results when compared to those by other participants. First we will consider the results for lattice cell calculations. The infinite multiplication factors for lattices without burnable poison rods (BPRs) are overpredicted by as much as 1000 to 1500 pcm which improves with burnup and diminishes to above 500 pcm at 50 GWd/tU. The situation is much better in the case of lattices with burnable poison rods where the prediction does not exceed 500 pcm throughout the burnup when compared with Spanish results. The reasons for the lattice discrepancies with the fuel assemblies that do not contain burnable boron are not yet clear. The SUPERB code has been validated against many LWR benchmarks and it is succesfuly used for the fuel management of BWRs. But, now, in light of the PWR benchmark results it is still worthwhile to look once more into the methodology and nuclear data used by the code. The results show that SUPERB code calculates the burnable absorber depletion slightly slower than other participants codes. Similarly, U-235 and U-238 depletion is also slightly slower. Plutonium isotopic concentrations are within 2-3 % of other participants.

For the core calculation results it should be mentioned here that we have used only a 2-D code which cannot model some effects like partial control rod insertion, but in PWRs the control is done by using soluble boron. Therefore, a 3-D code is not required here. The reflector has been treated using albedos which have been adjusted using the power distribution at BOC of cycle 1. The critical boron concentrations for cycle 1 hot full power conditions are overpredicted by an average of 20 ppm, with the maximum of 45 ppm, except at 0 MWd/tU. Translated in terms of reactivity there is a difference of about 200-500 pcm. The difference at BOC conditions seems to be quite large, mainly due to the interpretation of the BOC conditions. It was assumed that in this condition the equilibrium xenon is there right from the beginning, whereas for other participants there is no xenon at 0 MWd/tU. For cycle 2 the differences are much lower except at the point of 0 GWd/tU, due to the same reasons given for the cycle 1.

Similar deviations are obtained when modelling actual power operating conditions. The deviations for power distribution and burnup distribution are within 5% for cycle 1 and cycle 2.

4.3.2 Comments on Universidad Politecnica de Madrid (Spain) results

In the burnup lattice cell calculations a $T_{fuel,eff}$ dependence with power density and burnup was considered. The correlation used has been determined by GAPCON-THERMAL[14] thermo-mechanical calculations and is incorporated in the PREWIM code[23]. This could be a reason for the difference with some other participants in the k_{inf} dependence vs. burnup.

When burnable poison rods are inserted into a fuel assembly, the model used by WIMS is a cylindrical representation of the burnable absorber, which is surrounded with several annuli with fuel rods and the corresponding fractions of water cells and structural material, as a geometrical fraction the whole fuel assembly. This can be the reason for differences with those participants that used a different fuel assembly model.

For global calculations the measured BOC burnup distribution per assembly for cycle 2 has been considered instead of the one corresponding to the EOC burnup distribution calculated for cycle 1. Thus, this will produce a small difference with other participants.

The critical boron concentration has a deviation with respect to the reference, which at BOC is about ±10 ppm, at MOC about -20 ppm and at EOC about -50 ppm for cycle 1, and -25 ppm for cycle 2. These are the deviations for the HFP cases and for the actual operating condition cases. The deviations in assembly power distrbutions, peak assembly power distributions and assembly burnup distributions were obtained at actual operating conditions. The deviations for these distributions are always less than 4%, and typicaly less than 2% in all other fuel assemblies.

It seems that at EOC the power distribution is a little shifted to the periphery of the core, but the assembly burnup distribution at EOC is in a good agreement with the reference. This means that the integrated power produced by the fuel assembly is also in a good agreement with the reference (within ±1.5 % in an average). The isotopic composition at EOC is not provided because the code for core calculations doesn't use these quantities in its calculational procedure.

4.3.3 Comments on Cekmece Nuclear Research and Training Centre (Turkey) results

Calculated values are compared against corrected CB values (HFP and ARO conditions). But because the whole core calculation are done with partial power simulation, calculated CB values correspond to these conditions. Therefore, the errors in the above mentioned tables seems to be higher especially at the beginning of cycles. When the calculated values are compared with actual measured values the relative difference is lower.

In the first cycle the biggest differences occur at zero and 159 MWd/tU, because for these burnups the power levels were 3% and 49% of full power, respectively, so that absolute differences are -44 ppm and -23 ppm instead of 58 ppm and 100 ppm respectively. Towards the end of cycle, the absolute differences in critical boron concentrations are -35 ppm, -52 ppm and -69 ppm, instead of -19 ppm, -24 ppm, and -47 ppm for burnups 11500 MWd/tU, 13250 MWd/tU and 15100 MWd/tU, respectively.

In the second cycle at BOC conditions where power level is 3%, the absolute error is 2 ppm instead of 101 ppm. At the EOC condition where power level is 89%, absolute error changes from 58 ppm to 24 ppm.

Errors in burnup and normalized power values are higher for the fuel assemblies adjacent to the reflector, most probably due to approximate modelling of reflector. In general errors for cycle 1 are higher than for cycle 2 due to heavy loading of BPRs and their modelling.

4.3.4 Comments on Ruder Boskovic Institute and University of Zagreb (Croatia) results

The differences between calculated and measured boron concentrations are within 100 ppm. The biggest difference is at the beginning of the first cycle (-92 ppm), due to the heavy loading of BPRs. However, the length of the cycle is predicted rather well for the code system classified as the level II code system. Calculated normalized power distribution is closer to the measured one for the second cycle than for the first cycle due to the approximate BPR modelling. Maximum difference is about 10%, but on the average differences are much lower. For both cycles calculated power on the periphery is generaly higher than measured, and opposite is the case for the inner core positions. The explanation for these deviations is approximate modelling of reflector region. Bigger differences in normalized power distributions at BOC and EOC condition are due to comparison of calculated power distribution at HFP conditions against measured power distribution at lower power levels.

4.3.5 Comments on Atomic Energy Corporation (South Africa) results

The calculated critical boron concentrations remain within 50 ppm of the measured values for the duration of the cycle 1. For the cycle 2 calculated critical boron concentrations are within 70 ppm of the measured values for the duration of the cycle. The maximum assembly normalized power error (compared with the measured results) is about 10% at the beginning of the first cycle, reducing to about 2% at the end of the first cycle. For the second cycle the maximum assembly normalized power error is about 5% near the beginning of the cycle, reducing to about 3% at the end of the cycle. Comparison between calculated and measured assembly burnup values showed that maximum error is within 5%.

The 2-D calculations performed with the OSCAR-2 system could probably be improved by incorporating more consistent axial leakage method such as group and space dependent axial bucklings which are also exposure dependent. However, at present the system is rather rigid and it is difficult to streamline the calculational route such that a 1-D axial calculational module could for instance be used for this purpose. One definite improvement which can be made concerns the modelling of radial reflector. It is expected that reflector data which include the effects of the core barrel and neutron pads could effect the 2-D power distributions quite significantly, and that such data should thus be used in the global reactor calculations. Unfortunately, the code package again has a limitation in this regard since it allows only one type of reflector node.

4.3.6 Comments on Boris Kidric Institute of Nuclear Sciences (Serbia) results

The calculated critical boron concentrations remain within 100 ppm of the measured values, for both cycles, except for BOC conditions, where errors are up to 260 ppm. Such big differences are probably due to the different BOC assumptions made for this operational point. The maximum assembly normalized power error (compared with the measured results) is within 6% for both cycles. The same holds also for the assembly burnup distribution. The following directions for further improvements are identified:

- Improving modelling, particularly with regard to phenomena at sharp interfaces, such as absorber regions (control rods, burnable absorbers) and water regions inside and outside the fuel rod array;
- Updating cross-section libraries and use of a finer energy mesh for more accuracy;
- Improving user friendliness in input preparation;
- Extensive interfacing or linkage between the assembly depletion codes and the overall reactor core simulation codes;
- Improving thermal-hydraulic modelling in order to increase the accuracy of power distribution calculations.

TABLE 4.1
Infinite multiplication factors for 2.1% enriched fuel

ppm	T	SPA	IND	SAF	TUR	CRO
0	A	1.28558	1.29692	1.28750	1.28451	1.28805
0	B	1.24877	1.26303	1.25050	1.24599	1.24984
0	C	1.22941	1.24416	1.23194	1.22536	1.23193
0	D	1.22279	1.23751	1.22479	1.21988	1.22641
0	E	1.23841	1.25250	1.24062	1.23939	1.24178
1000	A	1.06973	1.07791	1.06694	1.07010	1.07723
1000	B	1.08552	1.09911	1.08770	1.08621	1.09074
1000	C	1.07630	1.09001	1.07868	1.07568	1.08219
1000	D	1.07033	1.08414	1.07258	1.07089	1.07717
1000	E	1.07268	1.08564	1.07553	1.07656	1.07971

TABLE 4.2
Infinite multiplication factors for 3.1% enriched fuel

ppm	T	SPA	IND	SAF	TUR	CRO
0	A	1.39370	1.40536	1.39642	1.39108	1.39383
0	B	1.34785	1.36244	1.34922	1.34273	1.34570
0	C	1.32603	1.34131	1.32848	1.31962	1.32527
0	D	1.31903	1.33434	1.32066	1.31390	1.31950
0	E	1.33761	1.35216	1.33940	1.33655	1.33803
1000	A	1.20457	1.21416	1.20261	1.20467	1.21076
1000	B	1.20902	1.22383	1.21077	1.20802	1.21170
1000	C	1.19641	1.21152	1.19871	1.19399	1.19971
1000	D	1.18996	1.20519	1.19180	1.18882	1.19433
1000	E	1.19634	1.21065	1.19866	1.19891	1.20116

TABLE 4.3
Infinite multiplication factors for 2.6% enriched fuel

ppm	T	SPA	IND	SAF	TUR	CRO
0	A	1.34788	1.35929	1.35022	1.34600	1.34916
0	B	1.30594	1.32024	1.30743	1.30190	1.30532
0	C	1.28513	1.30003	1.28762	1.27981	1.28594
0	D	1.27829	1.29317	1.28006	1.27417	1.28025
0	E	1.29562	1.30982	1.29755	1.29551	1.29745
1000	A	1.14592	1.15480	1.14353	1.14619	1.15282
1000	B	1.15566	1.16982	1.15756	1.15545	1.15957
1000	C	1.14454	1.15645	1.14688	1.14295	1.14910
1000	D	1.13829	1.15892	1.14028	1.13794	1.14387
1000	E	1.14285	1.15276	1.14537	1.14605	1.14877

TABLE 4.4
Infinite multiplication factors for 2.6% enriched fuel (12 BPR)

ppm	T	SPA	IND	SAF	TUR	CRO
0	A	1.22020	1.22202	1.22315	1.20708	1.20511
0	B	1.15389	1.15674	1.15439	1.14686	1.13413
0	C	1.13261	1.13576	1.13409	1.12649	1.11450
0	D	1.12638	1.12955	1.12715	1.12177	1.10926
0	E	1.14575	1.14884	1.14695	1.14256	1.12826
1000	A	1.05986	1.06018	1.05874	1.04052	1.05029
1000	B	1.04098	1.04479	1.04179	1.03034	1.02686
1000	C	1.02775	1.03157	1.02900	1.01810	1.01458
1000	D	1.02200	1.02592	1.02290	1.01378	1.00973
1000	E	1.03072	1.03436	1.03226	1.02333	1.01858

TABLE 4.5
Infinite multiplication factors for 2.6% enriched fuel (16 BPR)

ppm	T	SPA	IND	SAF	TUR	CRO
0	A	1.17835	1.18324	1.18143	1.16374	1.15765
0	B	1.10748	1.11264	1.10772	1.09980	1.08247
0	C	1.08642	1.09214	1.08760	1.08004	1.06325
0	D	1.08039	1.08612	1.08089	1.07558	1.05817
0	E	1.09988	1.10579	1.10087	1.09605	1.07705
1000	A	1.02992	1.03279	1.02907	1.00686	1.01549
1000	B	1.00473	1.01026	1.00522	.99168	.98573
1000	C	.99118	.99702	.99213	.97960	.97335
1000	D	.98560	.99153	.98619	.97551	.96862
1000	E	.99513	1.00097	.99639	.98533	.97801

TABLE 4.6
Infinite multiplication factors for 2.6% enriched fuel (20 BPR)

ppm	T	SPA	IND	SAF	TUR	CRO
0	A	1.13789	1.14225	1.14090	1.12183	1.11232
0	B	1.06375	1.06768	1.06365	1.05495	1.03465
0	C	1.04300	1.04696	1.04381	1.03583	1.01588
0	D	1.03717	1.04114	1.03732	1.03162	1.01094
0	E	1.05661	1.06093	1.05733	1.05169	1.02956
1000	A	1.00056	1.00350	.99987	.97410	.98184
1000	B	.97018	.97472	.97029	.95459	.94717
1000	C	.95644	.96081	.95701	.94271	.93474
1000	D	.95103	.95549	.95124	.93883	.93015
1000	E	.96116	.96573	.96208	.94884	.94002

TABLE 4.7
Infinite multiplication factors vs. burnup for 2.1% enriched fuel
(0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.22941	1.24416	1.23193	1.23194	1.22536	1.24186
0.15	1.18279	1.19366	1.18763	1.18635	1.18002	1.19471
2.00	1.16302	1.16702	1.16245	1.16209	1.15552	1.17470
4.00	1.13696	1.13987	1.13413	1.13486	1.12758	1.14838
6.00	1.10999	1.11233	1.10582	1.10771	1.10009	1.12114
8.00	1.08430	1.08655	1.07913	1.08231	1.07486	1.09519
10.00	1.06042	1.06306	1.05436	1.05874	1.05184	1.07107
14.00	1.01711	1.02108	1.01021	1.01710	1.01064	1.02732
18.00	.97871	.98443	.97185	.98001	.97461	.98854
22.00	.94440	.95185	.93805	.94671	.94260	.95388
26.00	.91390	.92291	.90812	.91694	.91408	.92308
30.00	.88714	.89666	.88157	.89064	.88877	.89605
34.00	.86403	.87337	.85808	.86774	.86647	.87271
38.00	.84437	.85282	.83747	.84807	.84696	.85285
42.00	.82786	.83465	.81961	.83138	.83015	.83617
46.00	.81409	.81881	.80439	.81737	.81530	.82227
50.00	.80266	.80489	.79174	.80559	.80257	.81072

TABLE 4.8
Infinite multiplication factors vs. burnup for 3.1% enriched fuel
(0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.32603	1.34131	1.32527	1.32848	1.31962	1.33951
0.15	1.27682	1.28800	1.27813	1.27995	1.27247	1.28975
2.00	1.25373	1.25827	1.24959	1.25248	1.24512	1.26639
4.00	1.22891	1.23065	1.22290	1.22648	1.21884	1.24132
6.00	1.20308	1.20346	1.19625	1.20035	1.19249	1.21523
8.00	1.17810	1.17818	1.17079	1.17546	1.16755	1.18999
10.00	1.15453	1.15466	1.14678	1.15207	1.14425	1.16619
14.00	1.11108	1.11174	1.10308	1.10977	1.10192	1.12230
18.00	1.07153	1.07342	1.06388	1.07138	1.06381	1.08235
22.00	1.03478	1.03839	1.02805	1.03579	1.02880	1.04523
26.00	1.00023	1.00597	.99484	1.00242	.99618	1.01033
30.00	.96778	.97532	.96383	.97103	.96563	.97755
34.00	.93750	.94671	.93479	.94165	.93703	.94696
38.00	.90955	.91994	.90772	.91440	.91039	.91873
42.00	.88413	.89493	.88275	.88941	.88578	.89306
46.00	.86142	.87187	.86001	.86684	.86327	.87012
50.00	.84148	.85070	.83983	.84676	.84293	.84997

TABLE 4.9
Infinite multiplication factors vs. burnup for 2.6% enriched uel
(0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.28513	1.30003	1.28594	1.28762	1.27981	1.29817
0.15	1.23653	1.24747	1.23954	1.23989	1.23305	1.24902
2.00	1.21424	1.21808	1.21184	1.21315	1.20629	1.22646
4.00	1.18838	1.19032	1.18400	1.18610	1.17876	1.20034
6.00	1.16161	1.16221	1.15621	1.15910	1.15146	1.17330
8.00	1.13592	1.13637	1.12986	1.13358	1.12595	1.14736
10.00	1.11185	1.11255	1.10518	1.10976	1.10236	1.12304
14.00	1.06778	1.06951	1.06059	1.06706	1.05978	1.07853
18.00	1.02798	1.03138	1.02104	1.02854	1.02192	1.03833
22.00	.99144	.99679	.98537	.99320	.98752	1.00142
26.00	.95782	.96526	.95283	.96061	.95600	.96746
30.00	.92708	.93595	.92304	.93071	.92710	.93641
34.00	.89932	.90914	.89581	.90353	.90073	.90837
38.00	.87465	.88471	.87112	.87920	.87687	.88346
42.00	.85311	.86249	.84897	.85772	.85550	.86170
46.00	.83460	.84261	.82951	.83905	.83656	.84300
50.00	.81891	.82486	.81283	.82304	.81989	.82715

TABLE 4.10
Infinite multiplication factors vs. burnup for 2.6% enriched fuel
(12 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.13261	1.13576	1.11452	1.13409	1.12222	1.14546
0.15	1.09618	1.09694	1.08218	1.09831	1.08744	1.10857
2.00	1.09922	1.09687	1.08688	1.09782	1.08782	1.11161
4.00	1.09725	1.09772	1.08739	1.09479	1.08560	1.10961
6.00	1.09201	1.09331	1.08342	1.08933	1.08070	1.10431
8.00	1.08492	1.08576	1.07642	1.08226	1.07411	1.09714
10.00	1.07588	1.07764	1.06681	1.07320	1.06544	1.08800
14.00	1.05071	1.05363	1.04131	1.04893	1.04155	1.06255
18.00	1.01947	1.02363	1.01113	1.01873	1.01196	1.03096
22.00	.98673	.99240	.98006	.98711	.98128	.99785
26.00	.95527	.96258	.95014	.95668	.95187	.96603
30.00	.92614	.93455	.92222	.92841	.92452	.93658
34.00	.89967	.90878	.89650	.90258	.89942	.90981
38.00	.87602	.88519	.87306	.87933	.87660	.88589
42.00	.85521	.86363	.85194	.85870	.85601	.86485
46.00	.83715	.84422	.83322	.84059	.83759	.84658
50.00	.82167	.82675	.81700	.82490	.82124	.83093

TABLE 4.11
Infinite multiplication factors vs. burnup for 2.6% enriched fuel
(16 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.08642	1.09214	1.06326	1.08760	1.07605	1.09918
0.15	1.05350	1.05580	1.03485	1.05528	1.04447	1.06583
2.00	1.06429	1.06279	1.04930	1.06286	1.05268	1.07671
4.00	1.06961	1.07068	1.05833	1.06720	1.05768	1.08209
6.00	1.07089	1.07231	1.06151	1.06822	1.05913	1.08338
8.00	1.06938	1.06969	1.06026	1.06667	1.05792	1.08186
10.00	1.06483	1.06604	1.05512	1.06197	1.05359	1.07725
14.00	1.04532	1.04798	1.03525	1.04319	1.03526	1.05752
18.00	1.01670	1.02081	1.00791	1.01552	1.00839	1.02856
22.00	.98515	.99080	.97830	.98507	.97898	.99664
26.00	.95438	.96158	.94922	.95533	.95032	.96552
30.00	.92574	.93400	.92191	.92756	.92350	.93654
34.00	.89968	.90858	.89669	.90215	.89883	.91018
38.00	.87635	.88528	.87369	.87925	.87636	.88658
42.00	.85577	.86395	.85290	.85888	.85606	.86575
46.00	.83786	.84470	.83444	.84097	.83786	.84764
50.00	.82245	.82734	.81841	.82539	.82165	.83205

TABLE 4.12
Infinite multiplication factors vs. burnup for 2.6% enriched fuel
(20 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.04300	1.04696	1.01524	1.04381	1.03287	1.05567
0.15	1.01329	1.01396	.99037	1.01466	1.00418	1.02555
2.00	1.03127	1.02885	1.01377	1.02979	1.01962	1.04372
4.00	1.04336	1.04476	1.03073	1.04097	1.03128	1.05595
6.00	1.05069	1.05276	1.04060	1.04806	1.03856	1.06337
8.00	1.05440	1.05509	1.04488	1.05165	1.04232	1.06712
10.00	1.05406	1.05567	1.04398	1.05107	1.04201	1.06678
14.00	1.03995	1.04288	1.02953	1.03749	1.02901	1.05250
18.00	1.01389	1.01813	1.00487	1.01229	1.00478	1.02613
22.00	.98354	.98922	.97658	.98302	.97666	.99541
26.00	.95346	.96058	.94832	.95395	.94874	.96497
30.00	.92532	.93344	.92159	.92668	.92245	.93649
34.00	.89965	.90837	.89686	.90169	.89822	.91051
38.00	.87664	.88537	.87427	.87914	.87611	.88722
42.00	.85629	.86428	.85383	.85903	.85610	.86662
46.00	.83854	.84522	.83566	.84131	.83812	.84866
50.00	.82323	.82799	.81983	.82586	.82158	.83316

TABLE 4.13
Infinite multiplication factors vs. burnup for 2.1% enriched fuel
(1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.07630	1.09001	1.08219	1.07868	1.07568	1.08720
0.15	1.04163	1.05207	1.04930	1.04471	1.04062	1.05213
2.00	1.03382	1.03866	1.03699	1.03307	1.02830	1.04420
4.00	1.01710	1.02112	1.01828	1.01520	1.00988	1.01177
6.00	.99792	1.00130	.99787	.99586	.99040	1.00794
8.00	.97898	.98201	.97798	.97721	.97195	.98881
10.00	.96107	.96438	.95915	.95960	.95479	.97072
14.00	.92807	.93239	.92507	.92806	.92378	.93739
18.00	.89850	.90410	.89516	.89958	.89631	.90752
22.00	.87191	.87873	.86877	.87381	.87168	.88067
26.00	.84812	.85602	.84529	.85059	.84955	.85664
30.00	.82704	.83523	.82436	.82989	.82972	.83535
34.00	.80859	.81657	.80570	.81163	.81201	.81671
38.00	.79263	.79985	.78913	.79569	.79627	.80059
42.00	.77894	.78483	.77456	.78189	.78233	.78676
46.00	.76728	.77148	.76189	.77003	.77002	.77499
50.00	.75740	.75953	.75110	.75986	.75914	.76501

TABLE 4.14
Infinite multiplication factors vs. burnup for 3.1% enriched fuel
(1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.19641	1.21152	1.19971	1.19871	1.19399	1.20858
0.15	1.15679	1.16830	1.16172	1.15959	1.15525	1.16851
2.00	1.14043	1.14617	1.14084	1.13941	1.13474	1.15195
4.00	1.12088	1.12434	1.11983	1.11873	1.11368	1.13220
6.00	1.09967	1.10190	1.09800	1.09727	1.09194	1.11077
8.00	1.07882	1.08064	1.07679	1.07655	1.07112	1.08971
10.00	1.05900	1.06087	1.05659	1.05692	1.05154	1.06969
14.00	1.02224	1.02456	1.01949	1.02124	1.01576	1.03256
18.00	.98869	.99200	.98605	.98873	.98367	.99867
22.00	.95753	.96218	.95549	.95855	.95394	.96720
26.00	.92835	.93461	.92723	.93032	.92632	.93772
30.00	.90104	.90855	.90096	.90388	.90052	.91014
34.00	.87566	.88428	.87649	.87921	.87644	.88450
38.00	.85229	.86160	.85372	.85634	.85406	.86090
42.00	.83101	.84041	.83268	.83537	.83338	.83940
46.00	.81189	.82081	.81349	.81635	.81441	.82009
50.00	.79495	.80272	.79629	.79929	.79714	.80298

TABLE 4.15
Infinite multiplication factors vs. burnup for 2.6% enriched fuel
(1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.14454	1.15645	1.14910	1.14688	1.14295	1.15616
0.15	1.10664	1.11758	1.11293	1.10958	1.10550	1.11782
2.00	1.09312	1.09821	1.09496	1.09222	1.08767	1.10413
4.00	1.07418	1.07779	1.07442	1.07216	1.06711	1.08500
6.00	1.05335	1.05576	1.05276	1.05115	1.04581	1.06396
8.00	1.03292	1.03497	1.03174	1.03091	1.02558	1.04332
10.00	1.01358	1.01583	1.01178	1.01182	1.00688	1.02379
14.00	.97787	.98090	.97541	.97732	.97238	.98772
18.00	.94547	.94978	.94289	.94602	.94150	.95499
22.00	.91568	.92143	.91356	.91721	.91360	.92490
26.00	.88832	.89556	.88692	.89069	.88797	.89727
30.00	.86331	.87146	.86254	.86632	.86446	.87200
34.00	.84068	.84939	.84025	.84414	.84295	.84915
38.00	.82044	.82916	.81998	.82417	.82341	.82870
42.00	.80259	.81064	.80168	.80639	.80575	.81067
46.00	.78703	.79389	.78543	.79071	.78989	.79496
50.00	.77360	.77873	.77124	.77701	.77574	.78139

TABLE 4.16
Infinite multiplication factors vs. burnup for 2.6% enriched fuel
(12 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.02775	1.03157	1.01460	1.02900	1.02084	1.03941
0.15	.99856	1.00022	.98871	1.00032	.99242	1.00985
2.00	1.00604	1.00499	.99745	1.00476	.99705	1.01738
4.00	1.00673	1.00824	1.00018	1.00452	.99736	1.01808
6.00	1.00331	1.00536	.99791	1.00095	.99424	1.01462
8.00	.99769	.99920	.99257	.99542	.98915	1.00893
10.00	.99020	.99243	.98480	.98798	.98210	1.00136
14.00	.96934	.97247	.96382	.96804	.96253	.98026
18.00	.94371	.94775	.93899	.94330	.93829	.95435
22.00	.91687	.92201	.91338	.91740	.91317	.92720
26.00	.89106	.89738	.88875	.89242	.88905	.90110
30.00	.86713	.87417	.86574	.86915	.86656	.87690
34.00	.84534	.85278	.84455	.84785	.84587	.85487
38.00	.82578	.83310	.82514	.82861	.82698	.83509
42.00	.80842	.81501	.80759	.81138	.80983	.81753
46.00	.79318	.79858	.79185	.79611	.79434	.80212
50.00	.77994	.78363	.77806	.78269	.78041	.78873

TABLE 4.17
Infinite multiplication factors vs. burnup for 2.6% enriched fuel (16 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.99118	.99702	.97332	.99213	.98404	1.00283
0.15	.96461	.96740	.95040	.96602	.95801	.97590
2.00	.97865	.97819	.96744	.97732	.96935	.99007
4.00	.98548	.98723	.97742	.98327	.97581	.99698
6.00	.98745	.98948	.98115	.98510	.97801	.99897
8.00	.98640	.98742	.98058	.98409	.97737	.99791
10.00	.98254	.98435	.97651	.98019	.97385	.99401
14.00	.96626	.96925	.96020	.96467	.95869	.97754
18.00	.94275	.94684	.93769	.94200	.93666	.95375
22.00	.91687	.92208	.91325	.91703	.91255	.92757
26.00	.89158	.89791	.88927	.89257	.88898	.90198
30.00	.86801	.87501	.86675	.86967	.86689	.87814
34.00	.84650	.85385	.84590	.84867	.84651	.85638
38.00	.82716	.83436	.82683	.82967	.82788	.83681
42.00	.80996	.81643	.80952	.81264	.81092	.81941
46.00	.79484	.80012	.79399	.79752	.79559	.80412
50.00	.78167	.78525	.78032	.78419	.78178	.79079

TABLE 4.18
Infinite multiplication factors vs. burnup for 2.6% enriched fuel (20 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.95644	.96081	.93419	.95701	.94927	.96826
0.15	.93228	.93371	.91402	.93330	.92543	.94356
2.00	.95250	.95127	.93880	.95106	.94305	.96400
4.00	.96508	.96689	.95556	.96285	.95524	.97673
6.00	.97213	.97454	.96502	.96978	.96240	.98386
8.00	.97540	.97664	.96911	.97304	.96591	.98717
10.00	.97499	.97711	.96859	.97252	.96572	.98676
14.00	.96312	.96641	.95681	.96129	.95495	.97474
18.00	.94171	.94602	.93653	.94062	.93545	.95308
22.00	.91680	.92216	.91317	.91660	.91224	.92787
26.00	.89203	.89842	.88981	.89266	.88917	.90280
30.00	.86882	.87583	.86773	.87012	.86738	.87931
34.00	.84759	.85491	.84723	.84943	.84727	.85782
38.00	.82847	.83561	.82846	.83067	.82884	.83847
42.00	.81145	.81784	.81140	.81383	.81207	.82124
46.00	.79645	.80165	.79608	.79886	.79689	.80606
50.00	.78335	.78687	.78257	.78563	.78319	.79281

TABLE 4.19
Burnable boron fraction left vs. burnup for 2.6% enriched fuel
(12 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
.15	.97781	.97670	.97632	.97775	.97719	.96676
2.00	.73581	.71647	.72269	.73043	.73027	.72752
4.00	.52292	.49502	.51068	.51625	.51510	.51703
6.00	.35636	.32702	.35149	.35001	.34915	.35234
8.00	.23212	.21040	.23542	.22704	.22698	.22950
10.00	.14452	.12877	.15357	.14105	.14169	.14289
14.00	.05040	.04416	.06157	.04918	.04970	.04983
18.00	.01549	.01358	.02282	.01533	.01570	.01532
22.00	.00436	.00389	.00795	.00442	.00461	.00431
26.00	.00115	.00105	.00263	.00120	.00128	.00114
30.00	.00028	.00027	.00083	.00031	.00034	.00028
34.00	.00007	.00006	.00025	.00007	.00008	.00007
38.00	.00001	.00002	.00007	.00002	.00002	.00001
42.00	.00000	.00000	.00002	.00000	.00000	.00000
46.00	.00000	.00000	.00001	.00000	.00000	.00000
50.00	.00000	.00000	.00000	.00000	.00000	.00000

TABLE 4.20
Burnable boron fraction left vs. burnup for 2.6% enriched fuel
(16 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
.15	.97744	.97741	.97589	.97737	.97700	.96600
2.00	.73244	.72308	.71869	.72695	.72869	.72389
4.00	.51855	.50350	.50571	.51169	.51365	.51250
6.00	.35239	.33440	.34708	.34590	.34853	.34828
8.00	.22918	.21544	.23214	.22405	.22724	.22651
10.00	.14270	.13136	.15143	.13922	.14252	.14104
14.00	.04998	.04406	.06093	.04878	.05069	.04940
18.00	.01551	.01298	.02276	.01536	.01631	.01533
22.00	.00443	.00351	.00802	.00449	.00489	.00438
26.00	.00118	.00088	.00269	.00124	.00139	.00117
30.00	.00030	.00021	.00086	.00032	.00037	.00030
34.00	.00007	.00005	.00026	.00008	.00010	.00007
38.00	.00002	.00001	.00008	.00002	.00002	.00002
42.00	.00000	.00000	.00002	.00000	.00001	.00000
46.00	.00000	.00000	.00001	.00000	.00000	.00000
50.00	.00000	.00000	.00000	.00000	.00000	.00000

TABLE 4.21
Burnable boron fraction left vs. burnup for 2.6% enriched fuel
(20 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
.15	.97713	.97656	.97555	.97705	.97682	.96531
2.00	.72977	.71594	.71557	.72406	.72728	.72096
4.00	.51528	.49309	.50168	.50808	.51247	.50906
6.00	.34960	.32722	.34324	.34283	.34819	.34538
8.00	.22732	.21205	.22897	.22198	.22773	.22458
10.00	.14172	.13111	.14902	.13810	.14353	.14001
14.00	.04996	.04618	.05972	.04869	.05178	.04936
18.00	.01568	.01467	.02222	.01551	.01696	.01549
22.00	.00454	.00436	.00778	.00460	.00519	.00449
26.00	.00123	.00122	.00259	.00129	.00150	.00122
30.00	.00032	.00033	.00082	.00034	.00042	.00032
34.00	.00008	.00008	.00025	.00009	.00011	.00008
38.00	.00002	.00002	.00007	.00002	.00003	.00002
42.00	.00000	.00000	.00002	.00000	.00001	.00000
46.00	.00000	.00000	.00001	.00000	.00000	.00000
50.00	.00000	.00000	.00000	.00000	.00000	.00000

TABLE 4.22
Burnable boron fraction left vs. burnup for 2.6% enriched fuel
(12 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
.15	.97771	.97656	.97642	.97765	.97712	.96666
2.00	.73585	.71623	.72419	.73047	.73016	.72756
4.00	.52478	.49389	.51426	.51803	.51665	.51887
6.00	.36040	.32858	.35682	.35393	.35270	.35634
8.00	.23779	.21387	.24173	.23255	.23203	.23511
10.00	.15084	.13316	.16004	.14716	.14731	.14914
14.00	.05551	.04797	.06665	.05405	.05426	.05488
18.00	.01838	.01578	.02598	.01808	.01833	.01817
22.00	.00568	.00491	.00963	.00569	.00585	.00562
26.00	.00167	.00146	.00343	.00171	.00179	.00165
30.00	.00047	.00042	.00118	.00049	.00053	.00046
34.00	.00013	.00012	.00039	.00014	.00015	.00013
38.00	.00003	.00003	.00013	.00004	.00004	.00003
42.00	.00001	.00001	.00004	.00001	.00001	.00001
46.00	.00000	.00000	.00001	.00000	.00000	.00000
50.00	.00000	.00000	.00000	.00000	.00000	.00000

TABLE 4.23
Burnable boron fraction left vs. burnup for 2.6% enriched fuel
(16 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
.15	.97736	.97722	.97599	.97729	.97694	.96592
2.00	.73270	.72231	.72029	.72723	.72871	.72415
4.00	.52071	.50419	.50938	.51379	.51535	.51463
6.00	.35669	.33716	.35241	.35010	.35220	.35253
8.00	.23502	.21976	.23836	.22973	.23232	.23228
10.00	.14907	.13640	.15776	.14541	.14814	.14733
14.00	.05504	.04818	.06586	.05361	.05525	.05440
18.00	.01837	.01527	.02583	.01809	.01895	.01816
22.00	.00574	.00452	.00966	.00576	.00615	.00567
26.00	.00171	.00127	.00348	.00176	.00192	.00169
30.00	.00049	.00034	.00121	.00051	.00058	.00048
34.00	.00013	.00009	.00041	.00015	.00017	.00013
38.00	.00004	.00002	.00013	.00004	.00005	.00004
42.00	.00001	.00001	.00004	.00001	.00001	.00001
46.00	.00000	.00000	.00001	.00000	.00000	.00000
50.00	.00000	.00000	.00000	.00000	.00000	.00000

TABLE 4.24
Burnable boron fraction left vs. burnup for 2.6% enriched fuel
(20 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	1.00000	1.00000	1.00000	1.00000	1.00000	1.00000
.15	.97707	.97642	.97566	.97699	.97678	.96524
2.00	.73020	.71574	.71721	.72452	.72742	.72139
4.00	.51765	.49711	.50533	.51043	.51429	.51140
6.00	.35408	.33246	.34847	.34722	.35193	.34981
8.00	.23324	.21803	.23500	.22776	.23283	.23042
10.00	.14810	.13712	.15511	.14430	.14912	.14631
14.00	.05498	.05062	.06441	.05348	.05632	.05432
18.00	.01852	.01714	.02512	.01821	.01964	.01830
22.00	.00585	.00550	.00933	.00587	.00650	.00578
26.00	.00176	.00169	.00332	.00181	.00206	.00174
30.00	.00051	.00050	.00114	.00054	.00063	.00050
34.00	.00014	.00014	.00038	.00015	.00019	.00014
38.00	.00004	.00004	.00012	.00004	.00005	.00004
42.00	.00001	.00001	.00004	.00001	.00002	.00001
46.00	.00000	.00000	.00001	.00000	.00000	.00000
50.00	.00000	.00000	.00000	.00000	.00000	.00000

TABLE 4.25
Mass of U-235 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	21.000	21.000	20.999	21.000	20.998	21.000
0.15	20.819	20.820	20.818	20.820	20.816	20.977
2.00	18.747	18.770	18.727	18.742	18.759	18.938
4.00	16.774	16.860	16.749	16.763	16.797	16.938
6.00	15.012	15.140	14.992	15.000	15.050	15.161
8.00	13.426	13.600	13.417	13.416	13.480	13.565
10.00	11.991	12.210	11.995	11.985	12.062	12.110
14.00	9.511	9.788	9.553	9.523	9.618	9.606
18.00	7.475	7.792	7.551	7.505	7.613	7.555
22.00	5.815	6.152	5.918	5.858	5.976	5.868
26.00	4.475	4.842	4.596	4.528	4.650	4.525
30.00	3.410	3.752	3.537	3.464	3.587	3.444
34.00	2.574	2.883	2.699	2.627	2.745	2.596
38.00	1.928	2.197	2.043	1.975	2.085	1.949
42.00	1.435	1.661	1.536	1.474	1.573	1.444
46.00	1.063	1.249	1.148	1.094	1.181	1.071
50.00	.784	.934	.853	.808	.883	.788

TABLE 4.26
Mass of U-236 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.032	.031	.032	.032	.033	.030
2.00	.400	.393	.394	.400	.406	.396
4.00	.747	.730	.735	.748	.760	.742
6.00	1.055	1.028	1.036	1.056	1.071	1.039
8.00	1.328	1.294	1.302	1.328	1.347	1.317
10.00	1.572	1.532	1.539	1.571	1.591	1.554
14.00	1.981	1.935	1.934	1.975	1.997	1.960
18.00	2.301	2.254	2.240	2.290	2.308	2.277
22.00	2.544	2.502	2.472	2.528	2.539	2.514
26.00	2.722	2.683	2.641	2.702	2.701	2.693
30.00	2.843	2.821	2.756	2.820	2.807	2.811
34.00	2.917	2.914	2.827	2.893	2.866	2.891
38.00	2.953	2.970	2.861	2.927	2.886	2.920
42.00	2.958	2.996	2.866	2.932	2.875	2.930
46.00	2.940	2.997	2.849	2.912	2.841	2.910
50.00	2.904	2.981	2.814	2.875	2.788	2.871

TABLE 4.27
Mass of U-238 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	979.00	979.00	979.00	979.00	979.00	979.00
0.15	978.89	978.90	978.87	978.95	978.90	978.90
2.00	977.47	977.50	977.45	977.53	977.54	977.45
4.00	975.93	975.90	975.89	975.97	976.01	975.93
6.00	974.35	974.30	974.34	974.39	974.46	974.37
8.00	972.74	972.70	972.74	972.76	972.89	972.77
10.00	971.09	971.10	971.10	971.10	971.26	971.14
14.00	967.67	967.70	967.72	967.68	967.91	967.75
18.00	964.10	964.20	964.26	964.10	964.42	964.20
22.00	960.38	960.60	960.66	960.38	960.78	960.49
26.00	956.51	956.90	956.97	956.51	957.00	956.63
30.00	952.50	953.05	953.16	952.51	953.12	952.63
34.00	948.36	949.10	949.20	948.39	949.11	948.50
38.00	944.11	945.05	945.21	944.16	945.02	944.26
42.00	939.78	940.90	941.12	939.83	940.85	939.93
46.00	935.36	936.70	936.95	935.43	936.60	935.51
50.00	930.89	932.45	932.77	930.98	932.28	931.04

TABLE 4.28
Mass of Pu-239 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.103	.103	.103	.102	.043	.099
2.00	1.178	1.191	1.178	1.176	1.093	1.168
4.00	2.033	2.051	2.033	2.033	1.961	2.010
6.00	2.672	2.699	2.673	2.678	2.621	2.643
8.00	3.160	3.195	3.159	3.173	3.130	3.128
10.00	3.534	3.580	3.531	3.556	3.526	3.495
14.00	4.043	4.108	4.025	4.074	4.077	3.999
18.00	4.340	4.424	4.314	4.386	4.411	4.296
22.00	4.509	4.606	4.475	4.567	4.609	4.465
26.00	4.601	4.696	4.558	4.668	4.723	4.554
30.00	4.648	4.744	4.594	4.719	4.783	4.603
34.00	4.670	4.759	4.601	4.742	4.812	4.623
38.00	4.682	4.757	4.593	4.750	4.824	4.633
42.00	4.689	4.746	4.578	4.749	4.825	4.643
46.00	4.697	4.732	4.561	4.745	4.822	4.653
50.00	4.705	4.717	4.542	4.740	4.817	4.663

TABLE 4.29
Mass of Pu-240 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.001	.000	.000	.000	.000	.000
2.00	.070	.071	.070	.069	.063	.069
4.00	.223	.222	.223	.220	.207	.218
6.00	.413	.408	.412	.405	.388	.406
8.00	.618	.608	.615	.605	.584	.614
10.00	.829	.811	.821	.809	.785	.822
14.00	1.242	1.204	1.211	1.197	1.180	1.228
18.00	1.624	1.562	1.559	1.558	1.547	1.604
22.00	1.962	1.877	1.854	1.880	1.874	1.940
26.00	2.250	2.140	2.097	2.160	2.156	2.227
30.00	2.490	2.365	2.291	2.396	2.392	2.465
34.00	2.684	2.547	2.441	2.591	2.586	2.653
38.00	2.839	2.693	2.554	2.749	2.742	2.811
42.00	2.959	2.808	2.636	2.875	2.866	2.930
46.00	3.051	2.897	2.695	2.972	2.962	3.019
50.00	3.122	2.965	2.735	3.048	3.035	3.089

TABLE 4.30
Mass of Pu-241 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.008	.008	.007	.008	.007	.010
4.00	.046	.046	.042	.047	.046	.049
6.00	.115	.116	.107	.119	.116	.119
8.00	.207	.210	.196	.214	.213	.208
10.00	.313	.319	.299	.322	.324	.307
14.00	.537	.554	.528	.560	.557	.535
18.00	.751	.780	.751	.778	.779	.742
22.00	.940	.978	.947	.966	.976	.931
26.00	1.097	1.140	1.111	1.120	1.140	1.089
30.00	1.224	1.273	1.242	1.243	1.273	1.208
34.00	1.325	1.376	1.343	1.340	1.378	1.307
38.00	1.403	1.454	1.418	1.415	1.460	1.386
42.00	1.464	1.511	1.473	1.473	1.523	1.445
46.00	1.512	1.554	1.512	1.517	1.571	1.495
50.00	1.549	1.585	1.538	1.551	1.607	1.534

TABLE 4.31
Mass of Pu-242 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.002	.002	.002	.002	.002	.000
6.00	.009	.009	.008	.010	.010	.010
8.00	.023	.023	.021	.024	.024	.020
10.00	.046	.044	.041	.047	.047	.049
14.00	.118	.115	.108	.121	.122	.119
18.00	.227	.222	.211	.231	.233	.228
22.00	.368	.359	.345	.373	.375	.366
26.00	.533	.524	.506	.539	.542	.525
30.00	.717	.703	.688	.721	.726	.713
34.00	.911	.894	.886	.912	.920	.901
38.00	1.108	1.089	1.094	1.107	1.117	1.099
42.00	1.305	1.285	1.306	1.301	1.313	1.297
46.00	1.496	1.475	1.519	1.489	1.503	1.485
50.00	1.679	1.657	1.730	1.670	1.684	1.663

TABLE 4.32
Mass of U-235 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	31.000	31.000	30.999	31.000	30.999	31.000
0.15	30.816	30.820	30.814	30.817	30.816	30.910
2.00	28.647	28.700	28.628	28.646	28.676	28.939
4.00	26.480	26.530	26.455	26.478	26.530	26.747
6.00	24.466	24.530	24.444	24.466	24.536	24.717
8.00	22.585	22.710	22.572	22.589	22.677	22.818
10.00	20.823	21.000	20.823	20.832	20.936	21.030
14.00	17.621	17.900	17.665	17.651	17.772	17.798
18.00	14.800	15.160	14.894	14.853	14.990	14.949
22.00	12.322	12.750	12.466	12.398	12.548	12.444
26.00	10.157	10.670	10.348	10.254	10.416	10.263
30.00	8.285	8.821	8.514	8.396	8.567	8.364
34.00	6.682	7.222	6.937	6.802	6.977	6.747
38.00	5.328	5.855	5.597	5.449	5.626	5.384
42.00	4.201	4.696	4.470	4.317	4.490	4.242
46.00	3.277	3.728	3.534	3.383	3.548	3.313
50.00	2.531	2.930	2.766	2.623	2.776	2.556

TABLE 4.33
Mass of U-236 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.034	.033	.034	.034	.035	.030
2.00	.433	.421	.429	.433	.443	.426
4.00	.830	.815	.821	.829	.849	.822
6.00	1.195	1.176	1.180	1.193	1.222	1.188
8.00	1.534	1.503	1.512	1.531	1.567	1.515
10.00	1.847	1.806	1.819	1.842	1.885	1.831
14.00	2.406	2.350	2.360	2.395	2.448	2.386
18.00	2.883	2.816	2.818	2.866	2.920	2.851
22.00	3.285	3.214	3.202	3.262	3.311	3.257
26.00	3.619	3.542	3.516	3.589	3.628	3.583
30.00	3.887	3.819	3.768	3.854	3.876	3.851
34.00	4.097	4.041	3.963	4.061	4.061	4.059
38.00	4.251	4.214	4.106	4.214	4.191	4.207
42.00	4.357	4.342	4.202	4.320	4.270	4.316
46.00	4.418	4.430	4.258	4.383	4.304	4.375
50.00	4.442	4.481	4.278	4.409	4.300	4.395

TABLE 4.34
Mass of U-238 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	969.00	969.00	969.00	969.00	969.00	969.00
0.15	968.91	968.90	968.87	968.97	968.90	969.12
2.00	967.72	967.70	967.67	967.77	967.76	967.73
4.00	966.42	966.40	966.38	966.47	966.50	966.46
6.00	965.10	965.00	965.00	965.13	965.22	965.15
8.00	963.75	963.70	963.67	963.77	963.90	963.82
10.00	962.37	962.30	962.25	962.38	962.54	962.45
14.00	959.52	959.40	959.41	959.51	959.75	959.64
18.00	956.53	956.50	956.48	956.51	956.83	956.67
22.00	953.42	953.40	953.41	953.39	953.80	953.59
26.00	950.17	950.20	950.21	950.14	950.64	950.36
30.00	946.78	946.95	946.97	946.76	947.35	946.98
34.00	943.24	943.55	943.60	943.24	943.93	943.46
38.00	939.57	940.00	940.09	939.59	940.39	939.80
42.00	935.75	936.35	936.49	935.80	936.74	935.99
46.00	931.81	932.60	932.80	931.90	932.98	932.06
50.00	927.74	928.80	928.98	927.87	929.09	927.99

TABLE 4.35
Mass of Pu-239 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.085	.085	.087	.085	.035	.089
2.00	1.023	1.029	1.037	1.021	.940	1.010
4.00	1.835	1.871	1.862	1.835	1.755	1.821
6.00	2.490	2.550	2.528	2.496	2.422	2.465
8.00	3.025	3.090	3.071	3.038	2.973	2.990
10.00	3.462	3.537	3.514	3.483	3.428	3.425
14.00	4.113	4.205	4.163	4.144	4.117	4.069
18.00	4.543	4.654	4.591	4.588	4.583	4.494
22.00	4.817	4.944	4.863	4.876	4.891	4.771
26.00	4.980	5.110	5.023	5.051	5.082	4.930
30.00	5.065	5.206	5.104	5.147	5.190	5.019
34.00	5.098	5.241	5.128	5.186	5.239	5.049
38.00	5.098	5.236	5.115	5.186	5.247	5.049
42.00	5.078	5.204	5.077	5.162	5.228	5.029
46.00	5.048	5.156	5.023	5.124	5.193	4.999
50.00	5.016	5.099	4.960	5.078	5.150	4.969

TABLE 4.36
Mass of Pu-240 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.045	.044	.045	.044	.039	.040
4.00	.149	.150	.150	.147	.136	.148
6.00	.286	.289	.288	.282	.265	.287
8.00	.442	.442	.444	.434	.411	.436
10.00	.608	.603	.610	.596	.567	.604
14.00	.953	.933	.943	.922	.891	.940
18.00	1.295	1.255	1.264	1.246	1.215	1.277
22.00	1.621	1.559	1.560	1.556	1.525	1.604
26.00	1.922	1.835	1.825	1.844	1.813	1.901
30.00	2.193	2.085	2.054	2.106	2.074	2.168
34.00	2.432	2.304	2.248	2.339	2.305	2.405
38.00	2.635	2.493	2.408	2.541	2.505	2.613
42.00	2.806	2.652	2.536	2.713	2.675	2.782
46.00	2.945	2.784	2.635	2.855	2.815	2.910
50.00	3.055	2.890	2.710	2.970	2.928	3.029

TABLE 4.37
Mass of Pu-241 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.004	.004	.004	.004	.004	.000
4.00	.027	.028	.025	.028	.027	.030
6.00	.074	.076	.069	.075	.074	.069
8.00	.141	.145	.134	.144	.143	.139
10.00	.223	.230	.214	.229	.228	.218
14.00	.415	.431	.409	.432	.428	.406
18.00	.619	.646	.621	.643	.639	.614
22.00	.817	.854	.828	.844	.844	.812
26.00	.996	1.042	1.018	1.023	1.030	.990
30.00	1.152	1.207	1.185	1.178	1.193	1.138
34.00	1.283	1.345	1.323	1.306	1.330	1.267
38.00	1.390	1.456	1.434	1.410	1.442	1.376
42.00	1.474	1.540	1.519	1.491	1.530	1.455
46.00	1.540	1.603	1.581	1.553	1.597	1.524
50.00	1.590	1.647	1.623	1.599	1.648	1.574

TABLE 4.38
Mass of Pu-242 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.001	.001	.001	.001	.001	.000
6.00	.004	.004	.004	.004	.004	.000
8.00	.011	.011	.010	.011	.011	.010
10.00	.022	.022	.020	.023	.022	.020
14.00	.063	.062	.057	.064	.063	.059
18.00	.128	.127	.118	.131	.129	.129
22.00	.220	.217	.204	.223	.220	.218
26.00	.336	.333	.314	.340	.336	.337
30.00	.473	.467	.446	.476	.472	.465
34.00	.627	.618	.598	.629	.625	.624
38.00	.796	.783	.766	.795	.791	.792
42.00	.973	.957	.948	.970	.966	.960
46.00	1.156	1.136	1.139	1.150	1.146	1.148
50.00	1.340	1.317	1.337	1.330	1.327	1.326

TABLE 4.39
Mass of U-235 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	26.000	26.000	25.999	26.000	25.997	26.000
0.15	25.817	25.820	25.816	25.818	25.815	26.081
2.00	23.688	23.710	23.669	23.686	23.708	23.929
4.00	21.601	21.660	21.578	21.596	21.641	21.817
6.00	19.693	19.760	19.674	19.688	19.750	19.888
8.00	17.937	18.060	17.929	17.935	18.013	18.121
10.00	16.316	16.490	16.321	16.317	16.411	16.484
14.00	13.428	13.690	13.477	13.449	13.561	13.565
18.00	10.955	11.280	11.049	10.998	11.126	11.070
22.00	8.849	9.228	8.984	8.912	9.051	8.939
26.00	7.070	7.510	7.238	7.148	7.296	7.141
30.00	5.585	6.025	5.776	5.672	5.824	5.646
34.00	4.363	4.786	4.563	4.451	4.604	4.404
38.00	3.371	3.765	3.570	3.456	3.604	3.404
42.00	2.580	2.932	2.766	2.656	2.796	2.606
46.00	1.957	2.263	2.124	2.023	2.151	1.980
50.00	1.474	1.731	1.618	1.528	1.642	1.485

TABLE 4.40
Mass of U-236 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.033	.032	.033	.033	.034	.030
2.00	.418	.411	.413	.418	.425	.416
4.00	.793	.779	.782	.793	.808	.782
6.00	1.133	1.117	1.116	1.133	1.154	1.119
8.00	1.443	1.416	1.418	1.441	1.468	1.426
10.00	1.725	1.689	1.693	1.722	1.752	1.713
14.00	2.217	2.168	2.168	2.208	2.244	2.198
18.00	2.622	2.567	2.556	2.607	2.641	2.594
22.00	2.950	2.894	2.868	2.929	2.956	2.920
26.00	3.208	3.151	3.112	3.182	3.198	3.178
30.00	3.403	3.359	3.296	3.374	3.374	3.366
34.00	3.543	3.515	3.427	3.512	3.494	3.504
38.00	3.634	3.626	3.512	3.602	3.564	3.593
42.00	3.683	3.698	3.557	3.651	3.592	3.643
46.00	3.698	3.737	3.570	3.666	3.585	3.663
50.00	3.684	3.747	3.556	3.653	3.549	3.643

TABLE 4.41
Mass of U-238 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	974.00	974.00	974.00	974.00	974.00	974.00
0.15	973.90	973.90	973.87	973.96	973.90	973.94
2.00	972.62	972.60	972.58	972.67	972.66	972.68
4.00	971.22	971.20	971.16	971.26	971.30	971.30
6.00	969.79	969.70	969.74	969.82	969.89	969.89
8.00	968.33	968.20	968.27	968.34	968.47	968.45
10.00	966.83	966.70	966.76	966.84	967.00	966.96
14.00	963.73	963.70	963.70	963.73	963.96	963.89
18.00	960.49	960.50	960.50	960.48	960.78	960.67
22.00	957.10	957.20	957.21	957.09	957.48	957.30
26.00	953.56	953.70	953.79	953.56	954.03	953.78
30.00	949.88	950.15	950.29	949.89	950.46	950.11
34.00	946.05	946.45	946.64	946.07	946.76	946.29
38.00	942.09	942.70	942.87	942.13	942.96	942.34
42.00	938.00	938.80	939.05	938.08	939.03	938.26
46.00	933.80	934.80	935.10	933.91	935.01	934.06
50.00	929.51	930.75	931.10	929.64	930.90	929.77

TABLE 4.42
Mass of Pu-239 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.093	.093	.093	.092	.038	.089
2.00	1.089	1.107	1.098	1.087	1.005	1.079
4.00	1.923	1.957	1.939	1.922	1.847	1.901
6.00	2.574	2.632	2.596	2.580	2.514	2.544
8.00	3.090	3.152	3.116	3.103	3.049	3.059
10.00	3.500	3.571	3.528	3.522	3.479	3.465
14.00	4.087	4.174	4.107	4.119	4.106	4.049
18.00	4.453	4.556	4.467	4.498	4.510	4.405
22.00	4.671	4.789	4.681	4.731	4.761	4.623
26.00	4.793	4.911	4.798	4.864	4.908	4.742
30.00	4.852	4.975	4.849	4.931	4.986	4.801
34.00	4.872	4.993	4.857	4.954	5.018	4.821
38.00	4.872	4.982	4.840	4.952	5.021	4.821
42.00	4.861	4.955	4.808	4.934	5.007	4.811
46.00	4.847	4.918	4.767	4.910	4.985	4.801
50.00	4.835	4.880	4.725	4.884	4.959	4.791

TABLE 4.43
Mass of Pu-240 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.055	.055	.055	.054	.048	.049
4.00	.179	.181	.179	.177	.165	.178
6.00	.339	.342	.339	.333	.315	.337
8.00	.517	.516	.517	.506	.483	.515
10.00	.703	.697	.701	.687	.660	.693
14.00	1.081	1.057	1.062	1.044	1.018	1.069
18.00	1.445	1.399	1.399	1.388	1.366	1.426
22.00	1.781	1.712	1.699	1.707	1.688	1.762
26.00	2.081	1.985	1.958	1.996	1.977	2.059
30.00	2.342	2.227	2.174	2.250	2.231	2.316
34.00	2.562	2.431	2.349	2.468	2.448	2.534
38.00	2.744	2.601	2.488	2.651	2.629	2.712
42.00	2.891	2.740	2.594	2.801	2.778	2.861
46.00	3.006	2.849	2.672	2.921	2.896	2.980
50.00	3.095	2.935	2.729	3.015	2.989	3.059

TABLE 4.44
Mass of Pu-241 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.006	.006	.005	.006	.005	.010
4.00	.035	.035	.032	.035	.035	.030
6.00	.091	.094	.085	.093	.092	.089
8.00	.169	.174	.160	.173	.173	.168
10.00	.262	.271	.251	.269	.269	.257
14.00	.470	.489	.463	.490	.485	.465
18.00	.681	.712	.682	.707	.704	.673
22.00	.877	.918	.887	.904	.908	.871
26.00	1.047	1.095	1.067	1.073	1.086	1.039
30.00	1.190	1.245	1.217	1.213	1.235	1.178
34.00	1.306	1.366	1.338	1.326	1.357	1.297
38.00	1.398	1.460	1.430	1.415	1.453	1.386
42.00	1.470	1.529	1.499	1.483	1.528	1.455
46.00	1.525	1.579	1.547	1.534	1.584	1.515
50.00	1.567	1.615	1.579	1.573	1.626	1.554

TABLE 4.45
Mass of Pu-242 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.001	.001	.001	.001	.001	.000
6.00	.006	.006	.005	.006	.006	.010
8.00	.016	.016	.014	.016	.016	.020
10.00	.031	.031	.028	.032	.032	.030
14.00	.085	.084	.077	.086	.086	.079
18.00	.169	.166	.155	.172	.171	.168
22.00	.282	.278	.262	.286	.285	.277
26.00	.421	.417	.395	.425	.424	.416
30.00	.580	.573	.551	.584	.584	.574
34.00	.756	.745	.726	.757	.758	.752
38.00	.941	.927	.915	.940	.942	.931
42.00	1.131	1.114	1.114	1.127	1.130	1.119
46.00	1.321	1.302	1.319	1.314	1.318	1.307
50.00	1.508	1.486	1.527	1.497	1.502	1.495

TABLE 4.46
Mass of U-235 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	25.998	26.000	25.999	26.000	25.996	26.000
0.15	25.816	25.820	25.817	25.819	25.815	25.870
2.00	23.707	23.730	23.694	23.705	23.721	23.977
4.00	21.653	21.700	21.639	21.647	21.680	21.894
6.00	19.782	19.840	19.776	19.778	19.827	20.003
8.00	18.065	18.180	18.070	18.064	18.128	18.263
10.00	16.480	16.640	16.499	16.484	16.562	16.666
14.00	13.654	13.900	13.715	13.679	13.777	13.804
18.00	11.227	11.540	11.330	11.274	11.389	11.357
22.00	9.149	9.511	9.291	9.217	9.345	9.253
26.00	7.385	7.805	7.558	7.469	7.606	7.463
30.00	5.902	6.323	6.096	5.995	6.138	5.966
34.00	4.671	5.078	4.875	4.767	4.911	4.723
38.00	3.662	4.042	3.865	3.755	3.896	3.701
42.00	2.846	3.189	3.038	2.932	3.067	2.882
46.00	2.196	2.496	2.370	2.271	2.395	2.225
50.00	1.683	1.938	1.834	1.746	1.859	1.699

TABLE 4.47
Mass of U-236 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.034	.033	.033	.034	.035	.030
2.00	.424	.416	.419	.424	.435	.415
4.00	.800	.785	.790	.801	.821	.791
6.00	1.139	1.121	1.123	1.140	1.168	1.127
8.00	1.446	1.418	1.424	1.446	1.480	1.434
10.00	1.726	1.689	1.697	1.725	1.762	1.711
14.00	2.212	2.162	2.168	2.205	2.248	2.185
18.00	2.613	2.557	2.553	2.600	2.642	2.581
22.00	2.940	2.882	2.864	2.920	2.955	2.907
26.00	3.198	3.140	3.109	3.174	3.197	3.164
30.00	3.396	3.349	3.295	3.368	3.375	3.362
34.00	3.539	3.509	3.430	3.509	3.498	3.500
38.00	3.635	3.624	3.520	3.603	3.572	3.589
42.00	3.689	3.701	3.571	3.658	3.605	3.648
46.00	3.710	3.745	3.589	3.678	3.603	3.668
50.00	3.701	3.760	3.581	3.670	3.572	3.658

TABLE 4.48
Mass of U-238 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	973.94	974.00	974.00	974.00	974.00	973.94
0.15	973.83	973.90	973.87	973.95	973.89	973.93
2.00	972.43	972.50	972.45	972.54	972.53	972.46
4.00	970.91	970.90	970.94	971.01	971.04	970.96
6.00	969.39	969.40	969.43	969.47	969.55	969.46
8.00	967.85	967.90	967.87	967.92	968.03	967.95
10.00	966.30	966.30	966.32	966.34	966.50	966.41
14.00	963.12	963.20	963.16	963.14	963.38	963.26
18.00	959.82	959.90	959.92	959.83	960.16	959.98
22.00	956.39	956.60	956.59	956.39	956.81	956.58
26.00	952.83	953.15	953.13	952.83	953.35	953.03
30.00	949.13	949.55	949.62	949.13	949.76	949.34
34.00	945.29	945.85	945.93	945.31	946.05	945.52
38.00	941.32	942.10	942.20	941.36	942.23	941.56
42.00	937.24	938.25	938.34	937.30	938.31	937.49
46.00	933.05	934.25	934.43	933.14	934.29	933.31
50.00	928.77	930.15	930.43	928.89	930.19	929.03

TABLE 4.49
Mass of Pu-239 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.102	.101	.102	.102	.043	.099
2.00	1.191	1.200	1.197	1.192	1.106	1.177
4.00	2.089	2.113	2.098	2.094	2.018	2.066
6.00	2.781	2.826	2.793	2.794	2.728	2.749
8.00	3.322	3.370	3.335	3.343	3.288	3.283
10.00	3.745	3.801	3.760	3.775	3.732	3.698
14.00	4.338	4.407	4.351	4.381	4.364	4.291
18.00	4.703	4.784	4.715	4.761	4.764	4.647
22.00	4.923	5.014	4.932	4.994	5.015	4.865
26.00	5.049	5.137	5.053	5.133	5.166	4.993
30.00	5.116	5.205	5.110	5.207	5.250	5.062
34.00	5.145	5.228	5.125	5.239	5.290	5.082
38.00	5.152	5.222	5.114	5.244	5.300	5.092
42.00	5.147	5.200	5.086	5.234	5.293	5.092
46.00	5.139	5.167	5.049	5.214	5.275	5.082
50.00	5.131	5.132	5.007	5.191	5.252	5.072

TABLE 4.50
Mass of Pu-240 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.060	.060	.060	.059	.053	.059
4.00	.192	.191	.193	.190	.177	.188
6.00	.358	.359	.359	.354	.335	.356
8.00	.541	.537	.541	.533	.507	.534
10.00	.732	.720	.729	.718	.687	.722
14.00	1.116	1.083	1.094	1.079	1.049	1.107
18.00	1.483	1.426	1.432	1.426	1.396	1.463
22.00	1.819	1.739	1.733	1.746	1.715	1.799
26.00	2.118	2.011	1.991	2.034	2.002	2.096
30.00	2.377	2.252	2.207	2.287	2.254	2.353
34.00	2.597	2.457	2.383	2.505	2.470	2.571
38.00	2.780	2.628	2.523	2.689	2.652	2.749
42.00	2.928	2.768	2.631	2.841	2.803	2.897
46.00	3.047	2.881	2.712	2.964	2.925	3.016
50.00	3.139	2.970	2.772	3.063	3.023	3.105

TABLE 4.51
Mass of Pu-241 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.007	.007	.006	.007	.006	.010
4.00	.040	.041	.038	.042	.041	.040
6.00	.103	.106	.097	.107	.106	.099
8.00	.188	.193	.179	.195	.196	.188
10.00	.287	.296	.277	.298	.300	.287
14.00	.506	.524	.500	.531	.528	.504
18.00	.725	.753	.726	.756	.755	.712
22.00	.927	.963	.938	.959	.964	.920
26.00	1.105	1.145	1.124	1.135	1.147	1.088
30.00	1.254	1.299	1.280	1.281	1.302	1.236
34.00	1.377	1.425	1.407	1.401	1.428	1.364
38.00	1.475	1.524	1.506	1.496	1.529	1.463
42.00	1.553	1.598	1.580	1.570	1.608	1.533
46.00	1.613	1.653	1.634	1.627	1.669	1.592
50.00	1.660	1.692	1.670	1.670	1.715	1.641

TABLE 4.52
Mass of Pu-242 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.002	.002	.002	.002	.002	.000
6.00	.007	.007	.006	.007	.007	.010
8.00	.017	.017	.015	.018	.017	.020
10.00	.034	.033	.031	.035	.035	.030
14.00	.089	.088	.082	.092	.091	.089
18.00	.175	.172	.161	.179	.178	.168
22.00	.288	.284	.269	.294	.293	.287
26.00	.427	.422	.401	.433	.432	.425
30.00	.585	.577	.555	.591	.589	.583
34.00	.758	.746	.728	.762	.760	.751
38.00	.940	.925	.913	.941	.939	.929
42.00	1.126	1.108	1.109	1.124	1.123	1.117
46.00	1.312	1.292	1.310	1.307	1.305	1.295
50.00	1.494	1.473	1.514	1.487	1.484	1.473

TABLE 4.53
Mass of U-235 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	25.998	26.000	25.999	26.000	25.996	26.000
0.15	25.816	25.820	25.818	25.820	25.815	25.870
2.00	23.714	23.740	23.702	23.712	23.725	23.977
4.00	21.671	21.720	21.660	21.666	21.694	21.914
6.00	19.814	19.870	19.812	19.809	19.853	20.033
8.00	18.109	18.220	18.119	18.108	18.167	18.314
10.00	16.536	16.690	16.560	16.540	16.614	16.726
14.00	13.731	13.970	13.796	13.756	13.850	13.885
18.00	11.318	11.630	11.426	11.367	11.477	11.448
22.00	9.249	9.603	9.397	9.319	9.444	9.354
26.00	7.490	7.900	7.668	7.576	7.711	7.574
30.00	6.008	6.419	6.207	6.103	6.246	6.078
34.00	4.774	5.172	4.983	4.872	5.017	4.824
38.00	3.760	4.131	3.967	3.855	3.998	3.802
42.00	2.936	3.272	3.134	3.025	3.162	2.973
46.00	2.277	2.570	2.456	2.355	2.482	2.306
50.00	1.754	2.004	1.912	1.820	1.936	1.770

TABLE 4.54
Mass of U-236 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.034	.033	.033	.034	.035	.030
2.00	.426	.417	.422	.426	.438	.425
4.00	.803	.787	.793	.804	.826	.791
6.00	1.141	1.123	1.126	1.142	1.172	1.127
8.00	1.447	1.418	1.426	1.448	1.484	1.434
10.00	1.726	1.688	1.698	1.725	1.766	1.711
14.00	2.210	2.160	2.168	2.204	2.250	2.185
18.00	2.611	2.554	2.552	2.598	2.643	2.581
22.00	2.937	2.879	2.863	2.918	2.955	2.907
26.00	3.195	3.137	3.108	3.171	3.197	3.164
30.00	3.393	3.347	3.296	3.366	3.376	3.352
34.00	3.538	3.508	3.432	3.508	3.499	3.500
38.00	3.635	3.624	3.523	3.604	3.575	3.599
42.00	3.692	3.703	3.576	3.660	3.609	3.648
46.00	3.714	3.748	3.596	3.683	3.609	3.668
50.00	3.708	3.766	3.589	3.677	3.580	3.668

TABLE 4.55
Mass of U-238 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	973.92	974.00	974.00	974.00	974.00	973.94
0.15	973.81	973.90	973.87	973.95	973.89	973.91
2.00	972.36	972.40	972.40	972.48	972.48	972.39
4.00	970.81	970.90	970.85	970.92	970.95	970.86
6.00	969.26	969.30	969.29	969.35	969.42	969.33
8.00	967.69	967.70	967.74	967.77	967.88	967.78
10.00	966.12	966.20	966.14	966.18	966.33	966.23
14.00	962.91	963.00	962.99	962.94	963.18	963.05
18.00	959.60	959.70	959.70	959.61	959.93	959.76
22.00	956.16	956.40	956.37	956.17	956.57	956.35
26.00	952.58	952.90	952.91	952.59	953.09	952.78
30.00	948.87	949.30	949.35	948.89	949.50	949.09
34.00	945.03	945.65	945.71	945.06	945.78	945.26
38.00	941.07	941.90	941.94	941.11	941.96	941.30
42.00	936.98	938.00	938.12	937.05	938.04	937.23
46.00	932.80	934.00	934.16	932.89	934.03	933.05
50.00	928.52	929.95	930.17	928.64	929.93	928.78

TABLE 4.56
Mass of Pu-239 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.106	.104	.106	.105	.044	.109
2.00	1.227	1.233	1.233	1.229	1.143	1.216
4.00	2.147	2.164	2.156	2.154	2.079	2.126
6.00	2.853	2.892	2.864	2.869	2.805	2.818
8.00	3.401	3.445	3.413	3.426	3.374	3.362
10.00	3.829	3.882	3.843	3.862	3.823	3.787
14.00	4.424	4.491	4.438	4.471	4.458	4.370
18.00	4.788	4.868	4.803	4.850	4.858	4.736
22.00	5.009	5.097	5.021	5.085	5.109	4.954
26.00	5.137	5.222	5.144	5.224	5.262	5.082
30.00	5.205	5.291	5.204	5.301	5.349	5.151
34.00	5.237	5.316	5.221	5.336	5.392	5.181
38.00	5.247	5.313	5.212	5.344	5.405	5.191
42.00	5.245	5.292	5.186	5.335	5.400	5.181
46.00	5.238	5.261	5.150	5.318	5.384	5.181
50.00	5.231	5.227	5.110	5.296	5.363	5.171

TABLE 4.57
Mass of Pu-240 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.061	.061	.062	.061	.055	.059
4.00	.196	.194	.197	.195	.182	.198
6.00	.365	.364	.366	.361	.341	.356
8.00	.550	.543	.550	.542	.516	.544
10.00	.742	.727	.738	.728	.697	.732
14.00	1.128	1.092	1.105	1.092	1.060	1.117
18.00	1.495	1.436	1.444	1.439	1.408	1.483
22.00	1.832	1.749	1.744	1.760	1.728	1.809
26.00	2.131	2.022	2.003	2.048	2.015	2.106
30.00	2.391	2.262	2.219	2.302	2.266	2.363
34.00	2.611	2.466	2.395	2.520	2.483	2.581
38.00	2.795	2.637	2.535	2.706	2.666	2.759
42.00	2.945	2.779	2.644	2.859	2.819	2.907
46.00	3.065	2.892	2.727	2.984	2.943	3.026
50.00	3.159	2.983	2.787	3.084	3.043	3.124

TABLE 4.58
Mass of Pu-241 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.007	.007	.007	.007	.007	.010
4.00	.042	.042	.040	.044	.043	.040
6.00	.107	.109	.102	.112	.111	.109
8.00	.194	.199	.187	.202	.203	.188
10.00	.296	.304	.286	.308	.310	.297
14.00	.518	.535	.513	.544	.542	.514
18.00	.739	.766	.742	.772	.772	.732
22.00	.943	.978	.955	.977	.983	.929
26.00	1.123	1.161	1.144	1.154	1.168	1.107
30.00	1.274	1.318	1.303	1.303	1.325	1.256
34.00	1.399	1.447	1.432	1.424	1.453	1.384
38.00	1.499	1.546	1.533	1.521	1.556	1.483
42.00	1.579	1.622	1.609	1.597	1.637	1.562
46.00	1.641	1.679	1.665	1.656	1.699	1.622
50.00	1.690	1.720	1.703	1.701	1.747	1.671

TABLE 4.59
Mass of Pu-242 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.002	.002	.002	.002	.002	.000
6.00	.007	.007	.006	.007	.007	.010
8.00	.018	.017	.016	.018	.018	.020
10.00	.035	.034	.032	.036	.036	.030
14.00	.091	.089	.083	.093	.093	.089
18.00	.177	.174	.163	.181	.180	.178
22.00	.290	.286	.271	.297	.295	.287
26.00	.429	.424	.403	.436	.434	.425
30.00	.586	.578	.557	.592	.590	.583
34.00	.758	.746	.728	.762	.760	.751
38.00	.938	.924	.913	.940	.938	.929
42.00	1.123	1.106	1.107	1.122	1.119	1.107
46.00	1.308	1.289	1.307	1.304	1.300	1.295
50.00	1.489	1.469	1.510	1.482	1.477	1.473

TABLE 4.60
Mass of U-235 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	25.997	26.000	25.999	26.000	25.996	26.000
0.15	25.816	25.820	25.818	25.820	25.815	25.870
2.00	23.721	23.740	23.711	23.720	23.729	23.987
4.00	21.690	21.730	21.683	21.684	21.708	21.934
6.00	19.845	19.890	19.848	19.841	19.879	20.074
8.00	18.154	18.260	18.169	18.153	18.206	18.355
10.00	16.593	16.740	16.623	16.598	16.665	16.777
14.00	13.807	14.040	13.879	13.834	13.923	13.966
18.00	11.409	11.710	11.523	11.459	11.567	11.539
22.00	9.350	9.697	9.503	9.422	9.545	9.455
26.00	7.596	7.999	7.779	7.683	7.818	7.686
30.00	6.115	6.521	6.319	6.212	6.355	6.179
34.00	4.878	5.272	5.092	4.979	5.125	4.935
38.00	3.859	4.227	4.072	3.957	4.102	3.903
42.00	3.028	3.363	3.231	3.119	3.259	3.064
46.00	2.360	2.655	2.545	2.440	2.571	2.387
50.00	1.828	2.081	1.992	1.897	2.015	1.851

TABLE 4.61
Mass of U-236 (kg/tU) vs. burnup for 2.6% enriched fuel (20 BPR, 0 ppm boron concentration).

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.034	.033	.034	.034	.035	.030
2.00	.428	.419	.424	.428	.441	.425
4.00	.805	.790	.796	.807	.830	.791
6.00	1.143	1.126	1.129	1.145	1.177	1.127
8.00	1.449	1.421	1.429	1.450	1.489	1.434
10.00	1.726	1.689	1.700	1.726	1.770	1.711
14.00	2.209	2.159	2.168	2.203	2.252	2.185
18.00	2.608	2.551	2.552	2.596	2.643	2.581
22.00	2.933	2.876	2.862	2.915	2.955	2.897
26.00	3.192	3.134	3.108	3.169	3.197	3.154
30.00	3.391	3.344	3.296	3.364	3.376	3.352
34.00	3.537	3.505	3.433	3.508	3.501	3.500
38.00	3.636	3.624	3.526	3.605	3.578	3.599
42.00	3.694	3.704	3.581	3.663	3.614	3.648
46.00	3.718	3.751	3.603	3.687	3.615	3.678
50.00	3.714	3.770	3.598	3.683	3.588	3.668

TABLE 4.62
Mass of U-238 (kg/tU) vs. burnup for 2.6% enriched fuel (20 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	973.90	974.00	974.00	974.00	974.00	973.94
0.15	973.78	973.90	973.87	973.94	973.89	973.88
2.00	972.29	972.40	972.36	972.43	972.43	972.32
4.00	970.70	970.80	970.76	970.82	970.86	970.75
6.00	969.12	969.20	969.16	969.23	969.29	969.19
8.00	967.53	967.60	967.61	967.62	967.73	967.62
10.00	965.94	966.00	966.01	966.01	966.15	966.05
14.00	962.70	962.80	962.81	962.74	962.97	962.84
18.00	959.37	959.50	959.52	959.39	959.70	959.53
22.00	955.91	956.20	956.15	955.92	956.33	956.10
26.00	952.33	952.65	952.68	952.33	952.84	952.53
30.00	948.61	949.10	949.13	948.62	949.23	948.84
34.00	944.77	945.45	945.45	944.78	945.51	945.00
38.00	940.80	941.65	941.71	940.83	941.69	941.04
42.00	936.72	937.75	937.85	936.77	937.76	936.97
46.00	932.53	933.80	933.94	932.61	933.75	932.79
50.00	928.26	929.75	929.95	928.36	929.67	928.52

TABLE 4.63
Mass of Pu-239 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.109	.107	.109	.109	.046	.109
2.00	1.264	1.267	1.271	1.266	1.180	1.246
4.00	2.207	2.225	2.216	2.216	2.141	2.185
6.00	2.927	2.964	2.937	2.945	2.883	2.897
8.00	3.483	3.524	3.495	3.510	3.462	3.441
10.00	3.915	3.965	3.928	3.951	3.916	3.866
14.00	4.512	4.575	4.528	4.564	4.555	4.459
18.00	4.877	4.950	4.894	4.943	4.955	4.825
22.00	5.097	5.178	5.113	5.177	5.207	5.043
26.00	5.227	5.303	5.238	5.319	5.362	5.171
30.00	5.298	5.374	5.300	5.397	5.452	5.240
34.00	5.332	5.401	5.321	5.435	5.497	5.270
38.00	5.344	5.399	5.314	5.445	5.514	5.280
42.00	5.345	5.381	5.290	5.439	5.511	5.280
46.00	5.340	5.352	5.256	5.424	5.498	5.280
50.00	5.335	5.318	5.216	5.404	5.469	5.270

TABLE 4.64
Mass of Pu-240 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.063	.062	.064	.063	.056	.059
4.00	.200	.199	.202	.200	.186	.198
6.00	.371	.370	.373	.368	.348	.366
8.00	.558	.551	.558	.550	.524	.554
10.00	.751	.735	.748	.739	.706	.742
14.00	1.139	1.102	1.116	1.104	1.072	1.127
18.00	1.508	1.446	1.456	1.453	1.420	1.493
22.00	1.845	1.759	1.757	1.774	1.741	1.819
26.00	2.145	2.031	2.015	2.063	2.027	2.116
30.00	2.405	2.271	2.231	2.318	2.279	2.373
34.00	2.626	2.476	2.407	2.537	2.497	2.600
38.00	2.811	2.647	2.548	2.724	2.681	2.778
42.00	2.963	2.788	2.658	2.879	2.836	2.927
46.00	3.085	2.903	2.741	3.006	2.962	3.045
50.00	3.181	2.995	2.803	3.108	3.066	3.144

TABLE 4.65
Mass of Pu-241 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.007	.007	.007	.008	.007	.010
4.00	.044	.045	.042	.046	.045	.040
6.00	.111	.114	.107	.116	.117	.109
8.00	.201	.206	.194	.210	.211	.198
10.00	.305	.313	.296	.317	.321	.297
14.00	.530	.548	.526	.558	.557	.524
18.00	.754	.781	.758	.788	.789	.742
22.00	.960	.995	.974	.995	1.003	.949
26.00	1.141	1.180	1.164	1.174	1.190	1.127
30.00	1.295	1.339	1.325	1.325	1.348	1.275
34.00	1.421	1.468	1.457	1.448	1.479	1.404
38.00	1.524	1.569	1.560	1.547	1.583	1.503
42.00	1.605	1.647	1.639	1.625	1.666	1.592
46.00	1.669	1.705	1.697	1.686	1.731	1.651
50.00	1.720	1.747	1.737	1.732	1.776	1.701

TABLE 4.66
Mass of Pu-242 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 0 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.002	.002	.002	.002	.002	.000
6.00	.007	.007	.007	.007	.007	.010
8.00	.018	.018	.016	.019	.019	.020
10.00	.035	.035	.032	.037	.037	.040
14.00	.092	.091	.085	.095	.096	.089
18.00	.178	.176	.165	.184	.184	.178
22.00	.292	.288	.273	.299	.298	.287
26.00	.430	.426	.405	.438	.436	.425
30.00	.587	.579	.558	.594	.592	.583
34.00	.757	.747	.728	.763	.760	.751
38.00	.937	.924	.912	.940	.936	.929
42.00	1.120	1.105	1.105	1.120	1.116	1.107
46.00	1.303	1.287	1.304	1.300	1.295	1.285
50.00	1.483	1.465	1.505	1.477	1.471	1.463

TABLE 4.67
Mass of U-235 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	21.000	21.000	20.999	21.000	20.998	21.000
0.15	20.820	20.820	20.819	20.821	20.819	20.977
2.00	18.772	18.800	18.750	18.766	18.773	18.959
4.00	16.839	16.910	16.808	16.824	16.843	17.009
6.00	15.125	15.240	15.094	15.107	15.136	15.282
8.00	13.589	13.740	13.561	13.570	13.611	13.726
10.00	12.203	12.390	12.182	12.188	12.239	12.323
14.00	9.815	10.050	9.813	9.812	9.880	9.909
18.00	7.854	8.128	7.873	7.866	7.948	7.929
22.00	6.246	6.540	6.283	6.272	6.364	6.313
26.00	4.936	5.260	4.986	4.970	5.070	4.990
30.00	3.877	4.185	3.935	3.916	4.020	3.919
34.00	3.028	3.313	3.088	3.067	3.171	3.060
38.00	2.354	2.609	2.411	2.390	2.491	2.374
42.00	1.822	2.046	1.874	1.855	1.949	1.838
46.00	1.406	1.598	1.450	1.434	1.520	1.424
50.00	1.083	1.243	1.118	1.105	1.182	1.091

TABLE 4.68
Mass of U-236 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.033	.032	.032	.033	.033	.030
2.00	.403	.396	.397	.404	.412	.396
4.00	.750	.732	.738	.752	.767	.742
6.00	1.055	1.028	1.037	1.057	1.078	1.039
8.00	1.325	1.291	1.301	1.326	1.352	1.307
10.00	1.564	1.525	1.535	1.565	1.593	1.544
14.00	1.966	1.921	1.924	1.962	1.991	1.950
18.00	2.279	2.234	2.226	2.270	2.296	2.257
22.00	2.518	2.478	2.455	2.504	2.522	2.495
26.00	2.694	2.659	2.623	2.676	2.683	2.663
30.00	2.818	2.797	2.740	2.796	2.790	2.792
34.00	2.897	2.892	2.815	2.872	2.851	2.871
38.00	2.940	2.953	2.854	2.913	2.876	2.910
42.00	2.953	2.986	2.866	2.924	2.872	2.920
46.00	2.943	2.995	2.854	2.913	2.844	2.910
50.00	2.914	2.985	2.825	2.882	2.798	2.881

TABLE 4.69
Mass of U-238 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	979.00	979.00	979.00	979.00	979.00	979.00
0.15	978.88	978.90	978.87	978.94	978.90	978.89
2.00	977.34	977.30	977.36	977.40	977.39	977.32
4.00	975.68	975.70	975.71	975.72	975.76	975.68
6.00	973.99	974.00	974.07	974.02	974.11	974.01
8.00	972.27	972.30	972.38	972.29	972.41	972.30
10.00	970.52	970.60	970.65	970.53	970.70	970.56
14.00	966.93	967.10	967.19	966.91	967.17	967.00
18.00	963.20	963.40	963.59	963.17	963.51	963.29
22.00	959.35	959.70	959.91	959.31	959.73	959.45
26.00	955.37	955.85	956.13	955.33	955.87	955.48
30.00	951.28	951.90	952.22	951.25	951.88	951.41
34.00	947.10	947.90	948.27	947.07	947.83	947.23
38.00	942.82	943.80	944.23	942.80	943.70	942.96
42.00	938.46	939.60	940.14	938.45	939.51	938.60
46.00	934.04	935.40	936.01	934.04	935.25	934.18
50.00	929.56	931.15	931.84	929.58	930.94	929.71

TABLE 4.70
Mass of Pu-239 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.112	.111	.110	.111	.047	.109
2.00	1.273	1.276	1.250	1.270	1.182	1.257
4.00	2.192	2.194	2.155	2.192	2.118	2.168
6.00	2.883	2.889	2.834	2.889	2.829	2.851
8.00	3.413	3.425	3.354	3.428	3.382	3.376
10.00	3.826	3.847	3.756	3.849	3.817	3.792
14.00	4.404	4.442	4.305	4.435	4.437	4.356
18.00	4.763	4.819	4.644	4.807	4.833	4.712
22.00	4.987	5.056	4.850	5.043	5.086	4.940
26.00	5.126	5.198	4.974	5.191	5.247	5.078
30.00	5.214	5.290	5.044	5.284	5.349	5.158
34.00	5.271	5.344	5.081	5.342	5.413	5.217
38.00	5.309	5.373	5.097	5.377	5.452	5.257
42.00	5.338	5.389	5.101	5.398	5.476	5.286
46.00	5.362	5.395	5.097	5.411	5.490	5.306
50.00	5.385	5.397	5.088	5.419	5.498	5.326

TABLE 4.71
Mass of Pu-240 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.001	.000	.001	.001	.000	.000
2.00	.076	.076	.074	.075	.068	.079
4.00	.236	.233	.233	.233	.220	.238
6.00	.432	.424	.426	.424	.406	.426
8.00	.641	.627	.631	.628	.605	.634
10.00	.854	.830	.837	.834	.808	.841
14.00	1.267	1.220	1.224	1.221	1.202	1.257
18.00	1.647	1.573	1.564	1.579	1.565	1.633
22.00	1.982	1.883	1.853	1.899	1.888	1.960
26.00	2.271	2.143	2.090	2.178	2.166	2.247
30.00	2.514	2.366	2.281	2.417	2.402	2.485
34.00	2.714	2.551	2.430	2.617	2.599	2.683
38.00	2.877	2.702	2.545	2.782	2.760	2.851
42.00	3.008	2.825	2.631	2.917	2.891	2.980
46.00	3.113	2.922	2.694	3.026	2.995	3.079
50.00	3.195	2.999	2.740	3.113	3.078	3.158

TABLE 4.72
Mass of Pu-241 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.009	.009	.008	.009	.009	.010
4.00	.053	.053	.048	.055	.054	.049
6.00	.131	.131	.120	.136	.135	.129
8.00	.234	.235	.218	.242	.242	.228
10.00	.350	.354	.331	.361	.363	.346
14.00	.595	.611	.579	.622	.618	.594
18.00	.830	.858	.820	.862	.862	.822
22.00	1.040	1.076	1.036	1.070	1.079	1.030
26.00	1.217	1.258	1.218	1.244	1.264	1.208
30.00	1.365	1.413	1.367	1.387	1.417	1.346
34.00	1.484	1.536	1.485	1.502	1.541	1.465
38.00	1.580	1.632	1.576	1.595	1.640	1.564
42.00	1.658	1.707	1.645	1.668	1.720	1.643
46.00	1.720	1.764	1.696	1.726	1.782	1.703
50.00	1.770	1.808	1.733	1.772	1.830	1.752

TABLE 4.73
Mass of Pu-242 (kg/tU) vs. burnup for 2.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.003	.003	.002	.003	.003	.000
6.00	.010	.010	.009	.011	.011	.010
8.00	.026	.025	.023	.026	.026	.030
10.00	.049	.048	.044	.051	.051	.049
14.00	.124	.121	.113	.128	.128	.119
18.00	.234	.229	.216	.240	.240	.228
22.00	.373	.366	.349	.381	.380	.366
26.00	.535	.527	.507	.543	.542	.525
30.00	.711	.700	.684	.719	.718	.703
34.00	.897	.883	.874	.903	.902	.891
38.00	1.085	1.070	1.073	1.089	1.089	1.079
42.00	1.272	1.255	1.276	1.273	1.273	1.257
46.00	1.453	1.436	1.480	1.452	1.452	1.435
50.00	1.627	1.609	1.682	1.624	1.622	1.614

TABLE 4.74
Mass of U-235 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	31.000	31.000	30.999	31.000	30.999	31.000
0.15	30.816	30.820	30.815	30.818	30.816	31.132
2.00	28.660	28.690	28.641	28.659	28.680	28.949
4.00	26.517	26.550	26.491	26.513	26.552	26.788
6.00	24.534	24.580	24.508	24.530	24.584	24.778
8.00	22.689	22.790	22.667	22.687	22.754	22.919
10.00	20.965	21.120	20.952	20.967	21.046	21.182
14.00	17.844	18.090	17.862	17.863	17.953	18.020
18.00	15.105	15.420	15.158	15.143	15.246	15.263
22.00	12.704	13.080	12.793	12.761	12.875	12.828
26.00	10.607	11.060	10.730	10.681	10.807	10.717
30.00	8.788	9.265	8.939	8.876	9.010	8.879
34.00	7.223	7.708	7.395	7.319	7.460	7.293
38.00	5.889	6.366	6.072	5.988	6.133	5.949
42.00	4.765	5.220	4.950	4.861	5.007	4.808
46.00	3.826	4.250	4.005	3.916	4.058	3.869
50.00	3.052	3.436	3.218	3.132	3.268	3.081

TABLE 4.75
Mass of U-236 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.034	.033	.034	.034	.035	.030
2.00	.438	.428	.434	.438	.450	.436
4.00	.837	.824	.828	.837	.861	.832
6.00	1.204	1.186	1.188	1.202	1.237	1.188
8.00	1.541	1.512	1.520	1.539	1.583	1.524
10.00	1.853	1.814	1.826	1.849	1.901	1.831
14.00	2.407	2.352	2.364	2.398	2.461	2.386
18.00	2.877	2.813	2.818	2.862	2.928	2.851
22.00	3.273	3.205	3.196	3.252	3.313	3.237
26.00	3.600	3.527	3.507	3.573	3.623	3.564
30.00	3.865	3.799	3.756	3.833	3.866	3.821
34.00	4.072	4.019	3.949	4.037	4.048	4.029
38.00	4.227	4.191	4.092	4.191	4.175	4.187
42.00	4.335	4.321	4.190	4.298	4.255	4.286
46.00	4.402	4.411	4.249	4.366	4.292	4.356
50.00	4.432	4.468	4.274	4.397	4.292	4.385

TABLE 4.76
Mass of U-238 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	969.00	969.00	969.00	969.00	969.00	969.00
0.15	968.90	968.90	968.87	968.96	968.90	968.89
2.00	967.63	967.60	967.62	967.68	967.68	967.64
4.00	966.24	966.20	966.20	966.29	966.34	966.27
6.00	964.83	964.80	964.83	964.86	964.95	964.88
8.00	963.40	963.30	963.36	963.41	963.55	963.47
10.00	961.93	961.90	961.94	961.94	962.12	962.01
14.00	958.91	958.90	958.96	958.90	959.17	959.02
18.00	955.77	955.80	955.90	955.74	956.09	955.91
22.00	952.51	952.60	952.70	952.47	952.91	952.67
26.00	949.12	949.25	949.46	949.08	949.63	949.30
30.00	945.61	945.85	946.08	945.57	946.22	945.81
34.00	941.97	942.35	942.62	941.94	942.69	942.18
38.00	938.21	938.75	939.07	938.19	939.07	938.43
42.00	934.33	935.05	935.42	934.34	935.33	934.56
46.00	930.34	931.25	931.69	930.37	931.51	930.58
50.00	926.25	927.35	927.87	926.32	927.61	926.50

TABLE 4.77
Mass of Pu-239 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.092	.091	.091	.091	.038	.089
2.00	1.094	1.100	1.092	1.091	1.004	1.079
4.00	1.960	1.990	1.959	1.959	1.874	1.940
6.00	2.659	2.709	2.660	2.665	2.585	2.633
8.00	3.231	3.283	3.232	3.245	3.173	3.197
10.00	3.703	3.761	3.701	3.724	3.663	3.663
14.00	4.415	4.485	4.397	4.445	4.412	4.365
18.00	4.899	4.985	4.868	4.942	4.932	4.851
22.00	5.223	5.325	5.182	5.280	5.289	5.167
26.00	5.434	5.537	5.381	5.503	5.527	5.375
30.00	5.564	5.679	5.499	5.643	5.679	5.504
34.00	5.639	5.757	5.558	5.723	5.768	5.583
38.00	5.677	5.792	5.577	5.761	5.814	5.623
42.00	5.690	5.796	5.567	5.770	5.829	5.633
46.00	5.690	5.780	5.537	5.761	5.823	5.633
50.00	5.683	5.751	5.496	5.739	5.803	5.623

TABLE 4.78
Mass of Pu-240 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.048	.048	.047	.047	.042	.049
4.00	.158	.159	.157	.156	.144	.158
6.00	.301	.303	.299	.296	.277	.297
8.00	.461	.459	.459	.453	.428	.455
10.00	.631	.623	.626	.618	.587	.624
14.00	.980	.954	.961	.949	.915	.970
18.00	1.325	1.276	1.280	1.274	1.240	1.307
22.00	1.651	1.578	1.572	1.584	1.549	1.633
26.00	1.952	1.850	1.831	1.872	1.835	1.930
30.00	2.223	2.097	2.056	2.134	2.094	2.198
34.00	2.462	2.315	2.246	2.368	2.324	2.435
38.00	2.669	2.504	2.404	2.572	2.524	2.643
42.00	2.845	2.665	2.531	2.748	2.695	2.811
46.00	2.991	2.800	2.632	2.897	2.839	2.960
50.00	3.110	2.912	2.709	3.020	2.957	3.079

TABLE 4.79
Mass of Pu-241 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.005	.005	.004	.005	.005	.000
4.00	.031	.032	.029	.032	.031	.030
6.00	.083	.086	.077	.085	.084	.079
8.00	.157	.161	.147	.161	.160	.158
10.00	.247	.254	.235	.254	.253	.247
14.00	.456	.472	.445	.476	.469	.455
18.00	.678	.704	.673	.705	.703	.673
22.00	.893	.930	.896	.923	.924	.881
26.00	1.090	1.135	1.102	1.120	1.127	1.079
30.00	1.264	1.318	1.284	1.292	1.307	1.247
34.00	1.413	1.474	1.439	1.439	1.461	1.396
38.00	1.538	1.602	1.566	1.560	1.591	1.524
42.00	1.640	1.704	1.667	1.659	1.696	1.623
46.00	1.723	1.785	1.743	1.737	1.780	1.703
50.00	1.789	1.846	1.800	1.799	1.846	1.772

TABLE 4.80
Mass of Pu-242 (kg/tU) vs. burnup for 3.1% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.001	.001	.001	.001	.001	.000
6.00	.005	.005	.004	.005	.005	.000
8.00	.012	.012	.011	.012	.012	.010
10.00	.024	.024	.022	.025	.024	.020
14.00	.067	.066	.060	.068	.067	.069
18.00	.135	.133	.123	.138	.132	.129
22.00	.228	.225	.210	.233	.226	.228
26.00	.344	.342	.320	.349	.341	.337
30.00	.480	.475	.451	.485	.476	.475
34.00	.631	.623	.600	.636	.625	.624
38.00	.794	.784	.764	.797	.786	.782
42.00	.964	.952	.940	.965	.953	.950
46.00	1.139	1.124	1.125	1.137	1.123	1.128
50.00	1.313	1.296	1.315	1.309	1.294	1.297

TABLE 4.81
Mass of U-235 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	26.000	26.000	25.999	26.000	25.997	26.000
0.15	25.818	25.820	25.817	25.819	25.815	26.081
2.00	23.706	23.730	23.687	23.703	23.719	23.949
4.00	21.650	21.700	21.624	21.642	21.672	21.868
6.00	19.780	19.830	19.755	19.770	19.814	19.979
8.00	18.067	18.170	18.046	18.058	18.114	18.252
10.00	16.490	16.640	16.477	16.483	16.551	16.656
14.00	13.692	13.920	13.706	13.700	13.782	13.828
18.00	11.303	11.590	11.346	11.329	11.423	11.414
22.00	9.267	9.601	9.339	9.310	9.415	9.363
26.00	7.542	7.933	7.637	7.598	7.713	7.616
30.00	6.092	6.486	6.204	6.157	6.278	6.151
34.00	4.883	5.267	5.005	4.952	5.077	4.929
38.00	3.887	4.250	4.010	3.955	4.080	3.929
42.00	3.074	3.407	3.191	3.137	3.259	3.101
46.00	2.417	2.714	2.524	2.473	2.589	2.444
50.00	1.891	2.151	1.985	1.939	2.046	1.909

TABLE 4.82
Mass of U-236 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.034	.032	.033	.034	.034	.030
2.00	.423	.415	.417	.423	.432	.416
4.00	.799	.784	.787	.799	.818	.792
6.00	1.138	1.121	1.121	1.138	1.166	1.129
8.00	1.445	1.418	1.422	1.445	1.479	1.435
10.00	1.725	1.689	1.695	1.723	1.762	1.703
14.00	2.209	2.162	2.166	2.203	2.248	2.188
18.00	2.607	2.554	2.549	2.595	2.639	2.584
22.00	2.929	2.876	2.856	2.910	2.948	2.900
26.00	3.183	3.128	3.097	3.159	3.184	3.148
30.00	3.376	3.334	3.280	3.349	3.358	3.346
34.00	3.517	3.490	3.411	3.487	3.477	3.485
38.00	3.612	3.604	3.499	3.580	3.549	3.574
42.00	3.668	3.681	3.549	3.635	3.580	3.633
46.00	3.690	3.725	3.568	3.656	3.579	3.653
50.00	3.685	3.743	3.560	3.650	3.550	3.643

TABLE 4.83
Mass of U-238 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	974.00	974.00	974.00	974.00	974.00	974.00
0.15	973.89	973.90	973.87	973.95	973.88	973.93
2.00	972.51	972.50	972.49	972.56	972.56	972.57
4.00	971.01	971.00	971.03	971.05	971.09	971.09
6.00	969.48	969.40	969.52	969.51	969.58	969.58
8.00	967.92	967.90	967.96	967.94	968.05	968.03
10.00	966.33	966.30	966.41	966.33	966.51	966.46
14.00	963.05	963.10	963.21	963.04	963.28	963.21
18.00	959.65	959.70	959.88	959.62	959.96	959.83
22.00	956.12	956.30	956.46	956.08	956.51	956.32
26.00	952.45	952.70	952.95	952.42	952.96	952.66
30.00	948.67	949.05	949.35	948.63	949.26	948.90
34.00	944.76	945.30	945.67	944.73	945.48	945.00
38.00	940.74	941.45	941.89	940.72	941.62	940.98
42.00	936.61	937.50	938.03	936.61	937.63	936.86
46.00	932.39	933.50	934.08	932.41	933.58	932.65
50.00	928.09	929.40	930.03	928.14	929.47	928.35

TABLE 4.84
Mass of Pu-239 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.100	.099	.099	.099	.041	.099
2.00	1.170	1.180	1.160	1.168	1.080	1.158
4.00	2.063	2.084	2.047	2.062	1.982	2.039
6.00	2.762	2.803	2.741	2.767	2.697	2.732
8.00	3.318	3.361	3.292	3.331	3.273	3.287
10.00	3.765	3.814	3.733	3.786	3.740	3.722
14.00	4.416	4.477	4.362	4.447	4.431	4.375
18.00	4.839	4.916	4.768	4.883	4.888	4.791
22.00	5.112	5.203	5.026	5.169	5.193	5.059
26.00	5.282	5.374	5.184	5.351	5.390	5.227
30.00	5.386	5.485	5.272	5.462	5.512	5.336
34.00	5.446	5.545	5.314	5.525	5.584	5.395
38.00	5.479	5.572	5.326	5.557	5.622	5.425
42.00	5.497	5.577	5.318	5.568	5.637	5.445
46.00	5.506	5.568	5.298	5.567	5.637	5.455
50.00	5.513	5.552	5.270	5.558	5.630	5.455

TABLE 4.85
Mass of Pu-240 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.059	.059	.058	.058	.052	.059
4.00	.190	.190	.188	.188	.175	.188
6.00	.356	.357	.352	.350	.331	.356
8.00	.538	.534	.532	.527	.503	.535
10.00	.727	.716	.718	.711	.682	.723
14.00	1.108	1.076	1.079	1.070	1.042	1.099
18.00	1.472	1.416	1.411	1.414	1.389	1.455
22.00	1.807	1.725	1.706	1.732	1.708	1.792
26.00	2.107	1.994	1.958	2.020	1.994	2.089
30.00	2.368	2.233	2.170	2.274	2.246	2.346
34.00	2.592	2.438	2.343	2.494	2.463	2.564
38.00	2.779	2.610	2.480	2.682	2.646	2.752
42.00	2.933	2.753	2.588	2.838	2.798	2.900
46.00	3.058	2.869	2.669	2.967	2.923	3.029
50.00	3.158	2.963	2.730	3.072	3.023	3.128

TABLE 4.86
Mass of Pu-241 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.007	.007	.006	.007	.006	.010
4.00	.040	.040	.036	.041	.040	.040
6.00	.103	.105	.095	.106	.105	.099
8.00	.189	.194	.177	.195	.194	.188
10.00	.291	.299	.276	.300	.300	.287
14.00	.519	.537	.506	.542	.536	.515
18.00	.749	.779	.742	.779	.774	.742
22.00	.964	1.003	.964	.995	.998	.950
26.00	1.154	1.199	1.162	1.183	1.195	1.138
30.00	1.316	1.369	1.329	1.342	1.363	1.307
34.00	1.451	1.509	1.466	1.473	1.504	1.435
38.00	1.561	1.621	1.575	1.580	1.618	1.544
42.00	1.651	1.709	1.659	1.665	1.710	1.633
46.00	1.722	1.776	1.722	1.733	1.781	1.703
50.00	1.779	1.827	1.766	1.785	1.838	1.762

TABLE 4.87
Mass of Pu-242 (kg/tU) vs. burnup for 2.6% enriched fuel
(0 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.002	.002	.001	.002	.002	.000
6.00	.007	.007	.006	.007	.007	.010
8.00	.017	.017	.015	.017	.017	.020
10.00	.034	.034	.030	.035	.034	.030
14.00	.090	.089	.081	.092	.091	.089
18.00	.176	.174	.161	.180	.178	.178
22.00	.290	.286	.268	.295	.292	.287
26.00	.427	.424	.401	.434	.430	.426
30.00	.583	.577	.554	.590	.585	.574
34.00	.753	.743	.723	.758	.752	.742
38.00	.930	.919	.906	.933	.927	.921
42.00	1.111	1.097	1.097	1.112	1.105	1.099
46.00	1.292	1.276	1.294	1.290	1.283	1.277
50.00	1.468	1.451	1.492	1.464	1.455	1.455

TABLE 4.88
Mass of U-235 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	25.998	26.000	25.999	26.000	25.996	26.000
0.15	25.817	25.820	25.818	25.820	25.815	25.870
2.00	23.724	23.750	23.711	23.721	23.730	23.987
4.00	21.698	21.740	21.683	21.690	21.711	21.945
6.00	19.862	19.910	19.852	19.853	19.886	20.084
8.00	18.183	18.280	18.180	18.176	18.220	18.385
10.00	16.639	16.780	16.645	16.635	16.690	16.828
14.00	13.894	14.120	13.929	13.907	13.978	14.047
18.00	11.544	11.830	11.608	11.575	11.662	11.670
22.00	9.533	9.859	9.624	9.582	9.681	9.637
26.00	7.821	8.201	7.934	7.884	7.993	7.908
30.00	6.373	6.756	6.502	6.445	6.562	6.442
34.00	5.159	5.533	5.296	5.235	5.357	5.218
38.00	4.150	4.505	4.287	4.226	4.348	4.197
42.00	3.319	3.647	3.451	3.390	3.511	3.357
46.00	2.641	2.937	2.762	2.706	2.820	2.670
50.00	2.093	2.352	2.199	2.148	2.255	2.114

TABLE 4.89
Mass of U-236 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.034	.033	.034	.034	.035	.030
2.00	.428	.419	.423	.429	.441	.425
4.00	.806	.790	.795	.807	.831	.801
6.00	1.144	1.126	1.128	1.145	1.179	1.127
8.00	1.449	1.421	1.428	1.450	1.491	1.434
10.00	1.727	1.689	1.699	1.726	1.772	1.711
14.00	2.206	2.157	2.166	2.201	2.253	2.185
18.00	2.601	2.546	2.547	2.590	2.641	2.571
22.00	2.922	2.866	2.854	2.904	2.948	2.887
26.00	3.176	3.119	3.096	3.154	3.185	3.144
30.00	3.372	3.327	3.281	3.345	3.361	3.332
34.00	3.516	3.487	3.417	3.487	3.483	3.480
38.00	3.615	3.603	3.509	3.583	3.558	3.569
42.00	3.675	3.684	3.564	3.642	3.594	3.629
46.00	3.701	3.733	3.587	3.668	3.597	3.658
50.00	3.701	3.755	3.584	3.667	3.572	3.658

TABLE 4.90
Mass of U-238 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	973.94	974.00	974.00	974.00	974.00	973.94
0.15	973.82	973.90	973.87	973.94	973.89	973.92
2.00	972.32	972.40	972.36	972.43	972.43	972.35
4.00	970.71	970.80	970.76	970.80	970.85	970.76
6.00	969.10	969.10	969.16	969.17	969.26	969.17
8.00	967.47	967.50	967.56	967.53	967.66	967.56
10.00	965.83	965.90	965.96	965.87	966.04	965.94
14.00	962.48	962.60	962.68	962.49	962.75	962.62
18.00	959.02	959.20	959.30	959.02	959.37	959.18
22.00	955.46	955.70	955.88	955.44	955.89	955.64
26.00	951.77	952.15	952.33	951.75	952.30	951.97
30.00	947.96	948.45	948.69	947.94	948.60	948.17
34.00	944.04	944.70	945.00	944.02	944.81	944.27
38.00	940.01	940.85	941.18	940.01	940.92	940.25
42.00	935.88	936.95	937.32	935.89	936.95	936.12
46.00	931.66	932.95	933.37	931.70	932.90	931.91
50.00	927.36	928.85	929.37	927.42	928.78	927.62

TABLE 4.91
Mass of Pu-239 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.109	.107	.108	.109	.045	.109
2.00	1.269	1.271	1.258	1.269	1.178	1.256
4.00	2.223	2.237	2.204	2.228	2.147	2.195
6.00	2.961	2.993	2.936	2.974	2.903	2.927
8.00	3.541	3.573	3.510	3.563	3.504	3.500
10.00	4.001	4.038	3.964	4.031	3.983	3.955
14.00	4.659	4.706	4.606	4.702	4.681	4.607
18.00	5.083	5.141	5.017	5.139	5.139	5.023
22.00	5.357	5.424	5.278	5.426	5.443	5.300
26.00	5.532	5.597	5.441	5.613	5.643	5.468
30.00	5.643	5.711	5.535	5.731	5.772	5.576
34.00	5.711	5.777	5.584	5.802	5.851	5.646
38.00	5.753	5.809	5.602	5.842	5.896	5.685
42.00	5.778	5.819	5.600	5.861	5.919	5.715
46.00	5.795	5.816	5.584	5.867	5.926	5.725
50.00	5.807	5.803	5.559	5.864	5.923	5.745

TABLE 4.92
Mass of Pu-240 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.063	.063	.063	.063	.056	.059
4.00	.202	.200	.201	.200	.186	.198
6.00	.373	.372	.371	.369	.348	.366
8.00	.560	.553	.555	.551	.524	.554
10.00	.754	.737	.744	.739	.706	.742
14.00	1.141	1.101	1.108	1.103	1.070	1.127
18.00	1.508	1.442	1.443	1.450	1.416	1.493
22.00	1.844	1.751	1.738	1.769	1.734	1.819
26.00	2.143	2.021	1.992	2.057	2.018	2.116
30.00	2.403	2.260	2.204	2.311	2.268	2.373
34.00	2.627	2.464	2.378	2.532	2.485	2.600
38.00	2.815	2.636	2.517	2.720	2.670	2.778
42.00	2.971	2.782	2.627	2.879	2.825	2.937
46.00	3.099	2.900	2.712	3.011	2.953	3.065
50.00	3.202	2.998	2.775	3.119	3.058	3.164

TABLE 4.93
Mass of Pu-241 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.008	.008	.007	.008	.007	.010
4.00	.045	.045	.042	.047	.046	.049
6.00	.114	.117	.107	.119	.118	.109
8.00	.207	.212	.196	.216	.216	.208
10.00	.315	.323	.302	.327	.329	.316
14.00	.552	.570	.542	.580	.577	.544
18.00	.790	.817	.785	.825	.823	.781
22.00	1.011	1.046	1.014	1.047	1.051	.999
26.00	1.208	1.246	1.217	1.241	1.253	1.196
30.00	1.376	1.421	1.390	1.406	1.426	1.364
34.00	1.517	1.566	1.534	1.544	1.571	1.503
38.00	1.634	1.682	1.649	1.657	1.690	1.612
42.00	1.729	1.774	1.739	1.748	1.786	1.711
46.00	1.806	1.846	1.807	1.820	1.863	1.790
50.00	1.868	1.901	1.857	1.878	1.923	1.849

TABLE 4.94
Mass of Pu-242 (kg/tU) vs. burnup for 2.6% enriched fuel
(12 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.002	.002	.002	.002	.002	.000
6.00	.007	.007	.007	.008	.007	.010
8.00	.018	.018	.017	.019	.019	.020
10.00	.036	.036	.032	.037	.037	.040
14.00	.094	.092	.085	.097	.095	.089
18.00	.181	.178	.166	.186	.184	.178
22.00	.295	.291	.274	.302	.298	.297
26.00	.432	.428	.405	.440	.435	.425
30.00	.587	.579	.557	.595	.588	.583
34.00	.754	.744	.724	.761	.753	.742
38.00	.929	.916	.904	.934	.924	.920
42.00	1.107	1.092	1.092	1.110	1.098	1.097
46.00	1.284	1.267	1.286	1.285	1.271	1.266
50.00	1.458	1.440	1.481	1.456	1.440	1.444

TABLE 4.95
Mass of U-235 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	25.998	26.000	25.999	26.000	25.996	26.000
0.15	25.817	25.820	25.819	25.820	25.815	25.870
2.00	23.730	23.750	23.719	23.728	23.734	24.007
4.00	21.715	21.760	21.704	21.707	21.724	21.973
6.00	19.892	19.940	19.886	19.882	19.910	20.122
8.00	18.224	18.320	18.227	18.217	18.256	18.433
10.00	16.690	16.830	16.703	16.687	16.738	16.885
14.00	13.964	14.180	14.005	13.978	14.045	14.123
18.00	11.627	11.900	11.697	11.659	11.742	11.766
22.00	9.623	9.943	9.721	9.674	9.770	9.732
26.00	7.916	8.288	8.036	7.981	8.088	8.012
30.00	6.469	6.845	6.604	6.543	6.659	6.546
34.00	5.253	5.620	5.396	5.331	5.452	5.311
38.00	4.240	4.589	4.384	4.318	4.440	4.289
42.00	3.404	3.725	3.541	3.477	3.598	3.440
46.00	2.719	3.008	2.846	2.786	2.901	2.752
50.00	2.163	2.417	2.275	2.221	2.330	2.185

TABLE 4.96
Mass of U-236 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.034	.033	.034	.034	.036	.030
2.00	.430	.421	.425	.431	.444	.425
4.00	.808	.791	.798	.810	.835	.801
6.00	1.146	1.127	1.131	1.148	1.183	1.137
8.00	1.451	1.421	1.430	1.452	1.495	1.433
10.00	1.727	1.689	1.701	1.727	1.776	1.710
14.00	2.205	2.156	2.167	2.201	2.255	2.184
18.00	2.599	2.544	2.547	2.588	2.642	2.570
22.00	2.919	2.864	2.854	2.902	2.949	2.886
26.00	3.174	3.117	3.096	3.152	3.186	3.133
30.00	3.370	3.326	3.282	3.344	3.362	3.331
34.00	3.516	3.486	3.419	3.486	3.485	3.479
38.00	3.616	3.604	3.512	3.585	3.561	3.578
42.00	3.677	3.686	3.569	3.645	3.599	3.637
46.00	3.706	3.737	3.593	3.673	3.603	3.667
50.00	3.707	3.760	3.592	3.673	3.579	3.667

TABLE 4.97
Mass of U-238 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	973.92	974.00	974.00	974.00	974.00	973.94
0.15	973.80	973.90	973.87	973.94	973.88	973.91
2.00	972.26	972.30	972.31	972.38	972.38	972.28
4.00	970.61	970.70	970.71	970.72	970.76	970.65
6.00	968.97	969.00	969.07	969.05	969.14	969.03
8.00	967.32	967.40	967.43	967.38	967.51	967.40
10.00	965.66	965.70	965.78	965.70	965.87	965.76
14.00	962.28	962.40	962.50	962.30	962.56	962.41
18.00	958.81	959.00	959.12	958.82	959.16	958.97
22.00	955.23	955.50	955.66	955.22	955.66	955.41
26.00	951.53	951.95	952.11	951.52	952.06	951.72
30.00	947.72	948.25	948.46	947.70	948.36	947.93
34.00	943.79	944.50	944.73	943.78	944.56	944.01
38.00	939.76	940.65	940.96	939.76	940.66	939.99
42.00	935.63	936.70	937.10	935.64	936.69	935.87
46.00	931.41	932.70	933.14	931.44	932.64	931.66
50.00	927.11	928.65	929.15	927.17	928.52	927.36

TABLE 4.98
Mass of Pu-239 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.113	.110	.111	.112	.047	.109
2.00	1.303	1.303	1.294	1.305	1.214	1.285
4.00	2.279	2.286	2.262	2.286	2.206	2.253
6.00	3.031	3.057	3.006	3.046	2.978	2.995
8.00	3.619	3.646	3.587	3.643	3.587	3.578
10.00	4.083	4.117	4.046	4.116	4.072	4.032
14.00	4.744	4.789	4.693	4.790	4.773	4.685
18.00	5.168	5.223	5.106	5.228	5.232	5.110
22.00	5.442	5.506	5.369	5.516	5.536	5.377
26.00	5.619	5.680	5.532	5.704	5.738	5.554
30.00	5.732	5.796	5.629	5.825	5.869	5.663
34.00	5.804	5.863	5.681	5.899	5.952	5.732
38.00	5.848	5.898	5.701	5.942	6.000	5.782
42.00	5.876	5.910	5.701	5.963	6.026	5.811
46.00	5.895	5.908	5.687	5.971	6.035	5.821
50.00	5.909	5.898	5.664	5.970	6.035	5.841

TABLE 4.99
Mass of Pu-240 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.065	.064	.065	.065	.058	.059
4.00	.205	.203	.205	.204	.190	.208
6.00	.379	.376	.377	.375	.354	.376
8.00	.568	.558	.563	.559	.532	.563
10.00	.763	.744	.753	.749	.715	.751
14.00	1.151	1.109	1.119	1.114	1.080	1.137
18.00	1.520	1.451	1.454	1.462	1.427	1.502
22.00	1.856	1.761	1.750	1.783	1.746	1.838
26.00	2.155	2.031	2.004	2.071	2.031	2.135
30.00	2.417	2.269	2.216	2.326	2.281	2.392
34.00	2.641	2.474	2.390	2.547	2.499	2.609
38.00	2.830	2.647	2.531	2.737	2.685	2.797
42.00	2.988	2.792	2.641	2.898	2.841	2.955
46.00	3.117	2.912	2.726	3.031	2.972	3.084
50.00	3.222	3.011	2.791	3.141	3.078	3.182

TABLE 4.100
Mass of Pu-241 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.008	.008	.007	.008	.008	.010
4.00	.047	.047	.044	.049	.048	.049
6.00	.118	.120	.112	.124	.123	.119
8.00	.213	.218	.203	.223	.223	.208
10.00	.324	.331	.311	.337	.339	.316
14.00	.564	.580	.555	.593	.588	.553
18.00	.804	.830	.801	.840	.837	.791
22.00	1.027	1.061	1.031	1.064	1.068	1.018
26.00	1.225	1.263	1.236	1.260	1.272	1.206
30.00	1.395	1.438	1.412	1.427	1.447	1.384
34.00	1.538	1.585	1.558	1.566	1.594	1.522
38.00	1.657	1.704	1.675	1.681	1.715	1.641
42.00	1.754	1.798	1.768	1.774	1.813	1.730
46.00	1.833	1.871	1.838	1.849	1.891	1.809
50.00	1.897	1.928	1.890	1.908	1.954	1.878

TABLE 4.101
Mass of Pu-242 (kg/tU) vs. burnup for 2.6% enriched fuel
(16 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.002	.002	.002	.002	.002	.000
6.00	.008	.008	.007	.008	.008	.010
8.00	.019	.019	.017	.020	.019	.020
10.00	.037	.036	.033	.038	.038	.040
14.00	.095	.094	.086	.098	.098	.099
18.00	.182	.180	.168	.188	.186	.178
22.00	.297	.292	.276	.304	.301	.296
26.00	.433	.429	.407	.442	.437	.425
30.00	.587	.580	.558	.596	.589	.583
34.00	.754	.744	.724	.761	.753	.741
38.00	.927	.916	.903	.933	.923	.919
42.00	1.104	1.091	1.090	1.108	1.095	1.087
46.00	1.281	1.265	1.283	1.282	1.266	1.265
50.00	1.453	1.436	1.477	1.452	1.433	1.433

TABLE 4.102
Mass of U-235 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	25.997	26.000	25.999	26.000	25.996	26.000
0.15	25.817	25.820	25.819	25.820	25.815	25.870
2.00	23.737	23.760	23.728	23.735	23.738	24.027
4.00	21.733	21.780	21.725	21.725	21.737	21.992
6.00	19.921	19.970	19.920	19.912	19.935	20.160
8.00	18.265	18.360	18.274	18.259	18.292	18.491
10.00	16.743	16.890	16.762	16.740	16.785	16.942
14.00	14.034	14.250	14.082	14.049	14.112	14.199
18.00	11.710	11.990	11.787	11.744	11.825	11.851
22.00	9.715	10.030	9.820	9.767	9.865	9.827
26.00	8.011	8.383	8.138	8.078	8.188	8.107
30.00	6.566	6.941	6.708	6.642	6.761	6.649
34.00	5.348	5.716	5.498	5.429	5.554	5.415
38.00	4.331	4.681	4.481	4.411	4.539	4.382
42.00	3.489	3.813	3.634	3.565	3.691	3.532
46.00	2.798	3.090	2.931	2.867	2.988	2.834
50.00	2.235	2.492	2.353	2.295	2.409	2.257

TABLE 4.103
Mass of U-236 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.035	.033	.034	.035	.036	.030
2.00	.432	.423	.428	.433	.448	.425
4.00	.810	.793	.802	.812	.840	.800
6.00	1.148	1.128	1.134	1.150	1.188	1.136
8.00	1.452	1.422	1.433	1.454	1.500	1.432
10.00	1.727	1.689	1.703	1.728	1.780	1.709
14.00	2.204	2.154	2.167	2.200	2.258	2.173
18.00	2.597	2.541	2.547	2.587	2.643	2.569
22.00	2.917	2.860	2.854	2.901	2.949	2.885
26.00	3.172	3.115	3.096	3.150	3.187	3.132
30.00	3.369	3.322	3.283	3.343	3.363	3.329
34.00	3.515	3.484	3.421	3.486	3.487	3.478
38.00	3.617	3.603	3.516	3.586	3.564	3.576
42.00	3.680	3.687	3.574	3.648	3.603	3.636
46.00	3.710	3.739	3.600	3.677	3.609	3.665
50.00	3.713	3.764	3.601	3.679	3.587	3.665

TABLE 4.104
Mass of U-238 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	973.90	974.00	974.00	974.00	974.00	973.94
0.15	973.77	973.90	973.87	973.94	973.88	973.87
2.00	972.19	972.30	972.27	972.34	972.33	972.20
4.00	970.51	970.60	970.63	970.63	970.67	970.55
6.00	968.84	968.90	968.94	968.94	969.01	968.90
8.00	967.16	967.30	967.29	967.25	967.36	967.24
10.00	965.48	965.60	965.65	965.55	965.70	965.57
14.00	962.08	962.20	962.32	962.12	962.36	962.20
18.00	958.59	958.80	958.90	958.61	958.94	958.74
22.00	955.00	955.30	955.44	955.00	955.43	955.17
26.00	951.29	951.75	951.88	951.29	951.82	951.49
30.00	947.47	948.05	948.24	947.47	948.11	947.68
34.00	943.54	944.30	944.51	943.54	944.30	943.76
38.00	939.51	940.45	940.69	939.51	940.41	939.74
42.00	935.38	936.50	936.83	935.39	936.43	935.62
46.00	931.16	932.50	932.88	931.19	932.38	931.41
50.00	926.86	928.45	928.88	926.91	928.26	927.11

TABLE 4.105
Mass of Pu-239 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.116	.113	.115	.115	.048	.119
2.00	1.339	1.337	1.332	1.342	1.250	1.324
4.00	2.337	2.341	2.321	2.346	2.267	2.312
6.00	3.102	3.124	3.078	3.120	3.054	3.063
8.00	3.698	3.721	3.668	3.726	3.672	3.655
10.00	4.166	4.196	4.131	4.203	4.163	4.120
14.00	4.831	4.870	4.783	4.881	4.868	4.772
18.00	5.255	5.304	5.197	5.320	5.328	5.197
22.00	5.530	5.585	5.461	5.608	5.635	5.463
26.00	5.709	5.760	5.627	5.798	5.839	5.641
30.00	5.825	5.878	5.727	5.921	5.973	5.750
34.00	5.899	5.947	5.781	5.999	6.058	5.829
38.00	5.946	5.983	5.804	6.044	6.110	5.878
42.00	5.977	5.998	5.806	6.068	6.138	5.908
46.00	5.998	5.997	5.794	6.079	6.151	5.928
50.00	6.015	5.988	5.773	6.079	6.152	5.937

TABLE 4.106
Mass of Pu-240 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.066	.066	.067	.066	.060	.069
4.00	.209	.206	.209	.209	.195	.207
6.00	.385	.382	.384	.381	.360	.375
8.00	.575	.564	.571	.567	.540	.573
10.00	.771	.751	.762	.758	.724	.761
14.00	1.162	1.117	1.129	1.126	1.091	1.146
18.00	1.531	1.459	1.465	1.475	1.439	1.512
22.00	1.869	1.769	1.762	1.797	1.757	1.847
26.00	2.169	2.039	2.016	2.086	2.043	2.144
30.00	2.431	2.278	2.229	2.342	2.294	2.401
34.00	2.656	2.483	2.403	2.565	2.512	2.628
38.00	2.847	2.656	2.544	2.756	2.700	2.816
42.00	3.006	2.803	2.655	2.918	2.858	2.974
46.00	3.137	2.923	2.742	3.053	2.990	3.102
50.00	3.244	3.023	2.807	3.165	3.100	3.201

TABLE 4.107
Mass of Pu-241 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.008	.008	.008	.009	.008	.010
4.00	.049	.049	.046	.051	.050	.049
6.00	.122	.125	.117	.128	.128	.119
8.00	.220	.224	.211	.230	.231	.217
10.00	.332	.339	.320	.346	.349	.326
14.00	.575	.592	.568	.605	.603	.573
18.00	.817	.843	.816	.855	.864	.810
22.00	1.042	1.076	1.049	1.080	1.093	1.027
26.00	1.242	1.279	1.256	1.278	1.296	1.225
30.00	1.414	1.457	1.434	1.447	1.472	1.393
34.00	1.560	1.605	1.582	1.589	1.620	1.541
38.00	1.680	1.725	1.702	1.706	1.742	1.660
42.00	1.779	1.820	1.797	1.801	1.841	1.759
46.00	1.860	1.895	1.869	1.877	1.922	1.838
50.00	1.926	1.954	1.923	1.939	1.986	1.907

TABLE 4.108
Mass of Pu-242 (kg/tU) vs. burnup for 2.6% enriched fuel
(20 BPR, 1000 ppm boron concentration)

BURNUP GWd/tU	SPA	IND	CRO	SAF	TUR	SER
0.00	.000	.000	.000	.000	.000	.000
0.15	.000	.000	.000	.000	.000	.000
2.00	.000	.000	.000	.000	.000	.000
4.00	.002	.002	.002	.002	.002	.000
6.00	.008	.008	.007	.008	.008	.010
8.00	.019	.019	.017	.020	.020	.020
10.00	.038	.037	.034	.039	.039	.040
14.00	.096	.095	.088	.099	.099	.099
18.00	.184	.181	.169	.190	.188	.178
22.00	.298	.294	.277	.306	.304	.296
26.00	.434	.430	.408	.443	.440	.425
30.00	.588	.581	.558	.597	.591	.583
34.00	.753	.744	.724	.761	.754	.741
38.00	.926	.914	.902	.932	.922	.919
42.00	1.102	1.089	1.088	1.106	1.093	1.087
46.00	1.277	1.262	1.280	1.278	1.263	1.265
50.00	1.448	1.432	1.473	1.447	1.428	1.432

TABLE 4.109
NPP ALMARAZ Cycle 1, Critical boron concentration comparison
Absolute error for Boron conc. (ppm)

BURNUP (MWd/tU)	REF	SPA	IND	CRO	SAF	TUR	SER
0.	1178.	8.	-248.x	-63.	6.	58.y	172.
159.	890.	6.	36.	-92.	-	100.z	260.
715.	875.	15.	24.	-52.	12.	46.	70.
1940.	860.	2.	14.	-22.	17.	63.	66.
3000.	830.	-12.	11.	-11.	-	59.	66.
4500.	770.	-34.	-2.	-10.	-12.	26.	40.
6146.	660.	-32.	15.	5.	8.	14.	13.
8200.	530.	-49.	12.	-10.	12.	-9.	8.
9912.	400.	-49.	24.	-15.	27.	-19.	-8.
11500.	260.	-36.	45.	-4.	-	-19.	17.
13250.	120.	-36.	43.	-9.	55.	-24.	7.
15100.	-10.	-58.	18.	-34.	29.	-47.	31.

x - equilibrium Xe
y - 3% of nominal power
z - 49% of nominal power

TABLE 4.110
NPP ALMARAZ Cycle 1, Power peaking factor comparison
Relative error for $F_{\Delta H}$ (%)

BURNUP (MWd/tU)	REF *	SPA *	CRO	TUR +
0.	1.376	0.36	5.01	-4.29
159.	1.354	-2.07	4.21	-4.43
715.	1.334	-1.12	3.07	0.67
1940.	1.342	0.00	2.61	1.56
3000.	1.337	1.57	4.49	0.07
4500.	1.332	-0.15	4.50	-2.40
6146.	1.316	-2.12	3.42	-4.10
8200.	1.288	-3.26	1.55	-6.13
9912.	1.261	-3.80	1.98	-6.74
11500.	1.235	-2.83	5.26	-6.72
13250.	1.214	-2.80	8.15	-4.86
15100.	1.191	-0.50	11.42	-0.84

* - actual operating conditions
+ - actual power level

TABLE 4.111
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 0 MWd/tU

REF SPA IND CRO SAF TUR SER

1.138 1.104 1.228 1.020 1.035 1.127 1.111				
1.061 1.062 1.049 1.025 1.002 1.109 1.034	1.157 1.148 1.261 1.077 1.081 1.182 1.129			
1.176 1.156 1.262 1.092 1.094 1.190 1.147	1.142 1.155 1.135 1.136 1.098 1.212 1.102	1.200 1.182 1.273 1.135 1.131 1.220 1.146		
1.078 1.094 1.053 1.089 1.052 1.143 1.052	1.178 1.171 1.256 1.128 1.125 1.203 1.110	1.127 1.133 1.094 1.136 1.101 1.176 1.067	1.120 1.094 1.162 1.063 1.077 1.088 1.084	
1.192 1.186 1.247 1.169 1.157 1.216 1.209	1.126 1.144 1.088 1.161 1.121 1.184 1.075	1.123 1.105 1.160 1.075 1.091 1.105 1.086	.977 .972 .928 .974 .980 .959 1.007	.855 .835 .878 .834 .873 .791 .883
1.189 1.195 1.127 1.251 1.206 1.240 1.125	1.143 1.132 1.163 1.129 1.135 1.134 1.157	.989 .993 .932 .995 1.007 .977 1.051	.913 .924 .881 .915 .958 .873 .937	.630 .646 .653 .684 .690 .612 .645
1.082 1.048 1.068 1.076 1.088 1.028 1.119	1.022 1.028 .938 1.068 1.064 1.007 1.068	.911 .929 .912 .936 .962 .902 .943	.593 .607 .620 .630 .651 .565 .630	
.843 .830 .831 .887 .895 .768 .888	.633 .632 .636 .680 .684 .585 .662			

TABLE 4.112
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 0 MWd/tU

1.212 1.173 - 1.122 - 1.220 -				REF SPA IND CRO SAF TUR SER
1.245 1.245 - 1.175 - 1.168 -	1.244 1.232 - 1.188 - 1.285 -			
1.255 1.231 - 1.204 - 1.286 -	1.285 1.290 - 1.256 - 1.241 -	1.276 1.257 - 1.250 - 1.317 -		
1.260 1.266 - 1.233 - 1.184 -	1.254 1.247 - 1.244 - 1.300 -	1.280 1.290 - 1.256 - 1.234 -	1.221 1.187 - 1.171 - 1.200 -	
1.275 1.267 - 1.284 - 1.313 -	1.291 1.302 - 1.323 - 1.233 -	1.221 1.197 - 1.187 - 1.208 -	1.190 1.196 - 1.179 - 1.101 -	1.004 .975 - .970 - .961 -
1.303 1.314 - 1.367 - 1.279 -	1.248 1.231 - 1.259 - 1.245 -	1.202 1.220 - 1.217 - 1.123 -	1.187 1.198 - 1.176 - 1.014 -	1.023 1.028 - 1.085 - .902 -
1.201 1.165 - 1.217 - 1.175 -	1.376 1.381 - 1.445 - 1.101 -	1.214 1.229 - 1.264 - 1.122 -	1.006 1.011 - 1.022 - .929 -	
1.196 1.188 - 1.344 - 1.059 -	1.065 1.065 - 1.171 - .971 -			

TABLE 4.113
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle.1 burnup = 0 MWd/tU

0. 0. 0. 0. 0. 0. 0.				REF SPA IND CRO SAF TUR SER
0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.			
0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.		
0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	
0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.
0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.	
0. 0. 0. 0. 0. 0. 0.	0. 0. 0. 0. 0. 0. 0.			

TABLE 4.114
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 715 MWd/tU

1.206 1.190 1.250 1.111 1.111 1.181 1.175				REF SPA IND CRO SAF TUR SER
1.137 1.128 1.081 1.116 1.073 1.162 1.110	1.230 1.220 1.278 1.157 1.150 1.227 1.197			
1.236 1.222 1.277 1.164 1.156 1.229 1.204	1.202 1.194 1.159 1.210 1.156 1.249 1.163	1.233 1.207 1.281 1.190 1.180 1.246 1.176		
1.131 1.132 1.076 1.146 1.098 1.171 1.101	1.215 1.215 1.263 1.173 1.168 1.223 1.147	1.148 1.155 1.110 1.178 1.136 1.195 1.083	1.127 1.129 1.163 1.084 1.101 1.110 1.094	
1.201 1.206 1.244 1.182 1.176 1.215 1.220	1.143 1.150 1.099 1.179 1.139 1.187 1.097	1.122 1.128 1.159 1.084 1.104 1.108 1.088	.980 .984 .935 .979 .985 .965 1.014	.859 .862 .872 .825 .866 .796 .889
1.156 1.160 1.122 1.220 1.187 1.211 1.098	1.116 1.119 1.150 1.100 1.120 1.111 1.131	.965 .974 .932 .975 .990 .963 1.017	.895 .896 .875 .887 .929 .861 .917	.633 .644 .643 .664 .665 .616 .648
1.018 .990 1.043 1.012 1.042 .986 1.057	.963 .960 .922 1.004 1.011 .966 .994	.862 .870 .888 .879 .906 .872 .895	.585 .586 .605 .598 .615 .559 .621	
.771 .763 .798 .807 .825 .726 .812	.595 .592 .613 .626 .633 .562 .624			

TABLE 4.115
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 715 MWd/tU

1.284 1.267 - 1.219 - 1.275 -				REF SPA IND CRO SAF TUR SER
1.315 1.297 - 1.266 - 1.216 -	1.315 1.304 - 1.274 - 1.328 -			
1.321 1.302 - 1.279 - 1.323 -	1.334 1.319 - 1.326 - 1.279 -	1.313 1.288 - 1.307 - 1.343 -		
1.298 1.298 - 1.278 - 1.218 -	1.295 1.297 - 1.290 - 1.320 -	1.316 1.307 - 1.316 - 1.259 -	1.230 1.228 - 1.198 - 1.211 -	
1.281 1.284 - 1.293 - 1.306 -	1.286 1.288 - 1.315 - 1.225 -	1.224 1.227 - 1.198 - 1.210 -	1.194 1.207 - 1.201 - 1.111 -	1.014 1.009 - .967 - .969 -
1.279 1.285 - 1.355 - 1.259 -	1.223 1.226 - 1.225 - 1.223 -	1.189 1.204 - 1.211 - 1.114 -	1.162 1.164 - 1.159 - 1.006 -	1.003 1.009 - 1.055 - .896 -
1.141 1.109 - 1.151 - 1.134 -	1.300 1.289 - 1.375 - 1.146 -	1.141 1.147 - 1.197 - 1.079 -	.949 .953 - .969 - .900 -	
1.095 1.086 - 1.225 - .997 -	.979 .973 - 1.072 - .918 -			

TABLE 4.116
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 715 MWd/tU

838. 814. 878. 741. 770. 833. 817.				REF SPA IND CRO SAF TUR SER
786. 774. 752. 739. 741. 820. 776.	853. 840. 901. 776. 801. 867. 844.			
862. 845. 902. 784. 808. 869. 849.	838. 831. 812. 812. 807. 884. 840.	869. 845. 909. 812. 832. 884. 866.		
790. 789. 754. 776. 769. 831. 793.	855. 850. 897. 805. 825. 869. 879.	813. 813. 782. 813. 802. 850. 841.	803. 796. 829. 768. 786. 792. 802.	
856. 854. 890. 827. 841. 866. 823.	811. 817. 778. 823. 811. 847. 832.	803. 799. 828. 772. 792. 792. 806.	700. 700. 663. 706. 707. 691. 662.	613. 615. 627. 614. 630. 572. 581.
839. 841. 805. 878. 862. 869. 865.	808. 808. 829. 798. 815. 798. 780.	699. 704. 666. 710. 718. 692. 653.	646. 653. 628. 660. 678. 620. 624.	451. 468. 466. 503. 489. 445. 447.
751. 730. 761. 760. 772. 712. 688.	710. 713. 668. 751. 747. 698. 676.	634. 647. 649. 666. 673. 631. 609.	421. 432. 441. 456. 457. 404. 397.	
577. 576. 591. 628. 623. 528. 525.	439. 443. 452. 484. 476. 408. 412.			

TABLE 4.117
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 1940 MWd/tU

1.236 1.219 1.277 1.178 1.153 1.235 1.204				REF SPA IND CRO SAF TUR SER
1.178 1.178 1.133 1.199 1.125 1.223 1.151	1.245 1.241 1.298 1.210 1.183 1.268 1.213			
1.243 1.238 1.293 1.208 1.185 1.264 1.210	1.225 1.228 1.197 1.268 1.193 1.290 1.199	1.230 1.222 1.289 1.216 1.197 1.267 1.184		
1.154 1.166 1.114 1.195 1.131 1.206 1.123	1.218 1.221 1.268 1.193 1.182 1.241 1.156	1.174 1.178 1.138 1.210 1.159 1.219 1.109	1.135 1.130 1.165 1.091 1.107 1.121 1.108	
1.196 1.199 1.238 1.175 1.174 1.212 1.226	1.157 1.163 1.117 1.193 1.151 1.197 1.111	1.128 1.124 1.156 1.083 1.106 1.112 1.093	.996 .996 .953 .991 .996 .977 1.030	.857 .854 .867 .816 .861 .794 .886
1.156 1.151 1.118 1.191 1.170 1.188 1.095	1.105 1.101 1.130 1.070 1.101 1.091 1.119	.972 .978 .939 .971 .991 .961 1.021	.892 .893 .875 .880 .925 .856 .914	.621 .632 .631 .648 .653 .602 .636
.981 .963 1.005 .955 1.003 .946 1.015	.946 .941 .903 .964 .985 .933 .977	.841 .844 .858 .843 .879 .838 .873	.568 .572 .588 .578 .600 .541 .597	
.738 .727 .752 .745 .779 .678 .770	.573 .567 .582 .586 .603 .529 .597			

TABLE 4.118
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 1940 MWd/tU

1.313 1.296 - 1.282 - 1.326 -				REF SPA IND CRO SAF TUR SER
1.329 1.333 - 1.338 - 1.268 -	1.327 1.321 - 1.320 - 1.363 -			
1.324 1.316 - 1.317 - 1.354 -	1.342 1.342 - 1.377 - 1.317 -	1.306 1.302 - 1.323 - 1.359 -		
1.314 1.324 - 1.333 - 1.256 -	1.296 1.303 - 1.301 - 1.332 -	1.320 1.322 - 1.355 - 1.286 -	1.238 1.231 - 1.205 - 1.230 -	
1.272 1.274 - 1.275 - 1.296 -	1.290 1.294 - 1.318 - 1.242 -	1.231 1.225 - 1.197 - 1.218 -	1.207 1.212 - 1.216 - 1.126 -	1.015 1.004 - .961 - .978 -
1.273 1.269 - 1.331 - 1.244 -	1.215 1.207 - 1.190 - 1.211 -	1.191 1.199 - 1.205 - 1.113 -	1.161 1.156 - 1.156 - 1.012 -	.994 .991 - 1.030 - .887 -
1.103 1.083 - 1.088 - 1.097 -	1.267 1.254 - 1.317 - 1.111 -	1.117 1.113 - 1.153 - 1.049 -	.931 .930 - .943 - .879 -	
1.043 1.032 - 1.129 - .935 -	.938 .929 - .998 - .868 -			

TABLE 4.119
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 1940 MWd/tU

2334. 2271. 2409. 2101. 2146. 2346. 2274.				REF SPA IND CRO SAF TUR SER
2203. 2156. 2076. 2107. 2069. 2318. 2154.	2369. 2334. 2467. 2194. 2227. 2421. 2338.			
2381. 2341. 2466. 2210. 2242. 2418. 2347.	2325. 2295. 2231. 2294. 2237. 2465. 2287.	2378. 2323. 2478. 2269. 2295. 2438. 2353.		
2189. 2176. 2072. 2179. 2128. 2309. 2182.	2346. 2339. 2444. 2242. 2272. 2390. 2400.	2235. 2227. 2143. 2255. 2207. 2344. 2293.	2189. 2179. 2254. 2096. 2149. 2165. 2179.	
2324. 2332. 2414. 2275. 2299. 2352. 2219.	2220. 2226. 2123. 2266. 2220. 2314. 2260.	2181. 2181. 2248. 2100. 2160. 2155. 2194.	1910. 1905. 1809. 1905. 1923. 1889. 1796.	1664. 1671. 1695. 1625. 1701. 1545. 1576.
2255. 2262. 2180. 2373. 2329. 2325. 2327.	2168. 2179. 2238. 2146. 2202. 2134. 2100.	1885. 1897. 1807. 1904. 1942. 1870. 1759.	1741. 1750. 1700. 1747. 1821. 1669. 1667.	1219. 1257. 1253. 1316. 1306. 1183. 1198.
1976. 1943. 2038. 1999. 2062. 1872. 1833.	1879. 1889. 1797. 1981. 1992. 1841. 1784.	1677. 1712. 1737. 1742. 1787. 1659. 1608.	1127. 1150. 1183. 1189. 1212. 1067. 1065.	
1502. 1511. 1568. 1616. 1637. 1358. 1411.	1154. 1167. 1203. 1251. 1254. 1057. 1092.			

TABLE 4.120
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 4500 MWd/tU

1.225 1.209 1.255 1.208 1.173 1.208 1.194				REF SPA IND CRO SAF TUR SER
1.216 1.211 1.175 1.266 1.172 1.220 1.189	1.235 1.217 1.264 1.220 1.188 1.226 1.202			
1.232 1.213 1.258 1.211 1.185 1.222 1.199	1.247 1.234 1.216 1.297 1.214 1.265 1.209	1.200 1.183 1.250 1.202 1.186 1.223 1.143		
1.190 1.190 1.149 1.233 1.161 1.204 1.158	1.203 1.194 1.234 1.181 1.171 1.205 1.136	1.186 1.190 1.163 1.231 1.176 1.214 1.119	1.125 1.122 1.153 1.089 1.106 1.120 1.095	
1.173 1.169 1.201 1.146 1.151 1.178 1.195	1.171 1.174 1.138 1.201 1.159 1.192 1.125	1.111 1.115 1.142 1.076 1.101 1.111 1.077	1.030 1.034 .998 1.023 1.026 1.019 1.065	.874 .868 .878 .823 .870 .829 .905
1.145 1.140 1.115 1.159 1.147 1.166 1.083	1.077 1.077 1.101 1.036 1.074 1.076 1.091	.986 1.006 .974 .988 1.007 .993 1.038	.919 .923 .906 .901 .944 .897 .941	.635 .644 .636 .652 .658 .631 .650
.944 .927 .969 .905 .963 .932 .979	.937 .939 .904 .943 .969 .936 .967	.825 .838 .842 .826 .862 .847 .865	.574 .580 .588 .579 .600 .563 .609	
.700 .699 .715 .700 .740 .667 .736	.554 .556 .562 .562 .583 .533 .581			

TABLE 4.121
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 4500 MWd/tU

1.296 1.278 1.308 1.293 - 1.281 -				REF SPA IND CRO SAF TUR SER
1.328 1.330 1.250 1.376 - 1.247 -	1.309 1.288 1.318 1.307 - 1.300 -			
1.304 1.283 1.312 1.297 - 1.293 -	1.332 1.318 1.274 1.392 - 1.280 -	1.274 1.255 1.303 1.286 - 1.295 -		
1.307 1.317 1.223 1.356 - 1.236 -	1.281 1.267 1.286 1.265 - 1.277 -	1.301 1.301 1.219 1.359 - 1.257 -	1.217 1.213 1.201 1.189 - 1.216 -	
1.250 1.240 1.252 1.223 - 1.246 -	1.280 1.279 1.193 1.317 - 1.224 -	1.209 1.207 1.191 1.175 - 1.205 -	1.202 1.220 1.051 1.231 - 1.141 -	1.033 1.019 .915 .968 - 1.016 -
1.249 1.238 1.154 1.288 - 1.214 -	1.185 1.176 1.148 1.141 - 1.186 -	1.178 1.198 1.025 1.203 - 1.121 -	1.166 1.172 .941 1.175 - 1.053 -	1.001 1.002 .667 1.029 - .925 -
1.061 1.043 1.010 1.026 - 1.077 -	1.217 1.218 .955 1.266 - 1.097 -	1.089 1.090 .883 1.123 - 1.054 -	.925 .933 .616 .944 - .905 -	
.986 .982 .750 1.049 - .913 -	.893 .896 .590 .943 - .860 -			

TABLE 4.122
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 4500 MWd/tU

5484. 5403. 5681. 5161. 5139. 5458. 5399.				REF SPA IND CRO SAF TUR SER
5269. 5212. 5019. 5251. 4988. 5447. 5197.	5544. 5510. 5782. 5317. 5298. 5588. 5512.			
5550. 5508. 5767. 5321. 5316. 5575. 5510.	5489. 5459. 5321. 5580. 5326. 5720. 5482.	5488. 5431. 5763. 5381. 5401. 5598. 5544.		
5188. 5189. 4957. 5281. 5062. 5395. 5190.	5444. 5454. 5677. 5296. 5338. 5499. 5612.	5256. 5258. 5078. 5378. 5208. 5457. 5413.	5083. 5068. 5230. 4889. 5021. 5035. 5070.	
5356. 5384. 5562. 5261. 5343. 5391. 5147.	5199. 5217. 5001. 5329. 5200. 5370. 5281.	5047. 5054. 5199. 4866. 5028. 5002. 5075.	4503. 4477. 4272. 4466. 4503. 4473. 4213.	3879. 3860. 3915. 3714. 3930. 3645. 3628.
5201. 5201. 5037. 5391. 5355. 5324. 5341.	4960. 4977. 5108. 4851. 5056. 4899. 4784.	4391. 4415. 4228. 4399. 4507. 4393. 4076.	4059. 4050. 3952. 4011. 4204. 3941. 3850.	2826. 2875. 2865. 2972. 2984. 2779. 2736.
4440. 4371. 4580. 4392. 4662. 4268. 4100.	4288. 4290. 4102. 4422. 4531. 4236. 4045.	3809. 3862. 3915. 3877. 4045. 3820. 3620.	2588. 2612. 2681. 2663. 2754. 2493. 2390.	
3343. 3340. 3460. 3475. 3638. 3071. 3089.	2597. 2602. 2672. 2721. 2803. 2418. 2411.			

TABLE 4.123
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 6146 MWd/tU

1.209 1.181 1.237 1.182 1.179 1.186 1.178				REF SPA IND CRO SAF TUR SER
1.220 1.202 1.193 1.258 1.197 1.213 1.192	1.214 1.188 1.240 1.187 1.187 1.198 1.177			
1.209 1.185 1.234 1.180 1.182 1.195 1.173	1.245 1.222 1.220 1.278 1.224 1.246 1.222	1.195 1.179 1.225 1.172 1.178 1.195 1.138		
1.193 1.185 1.168 1.229 1.177 1.199 1.161	1.185 1.170 1.212 1.156 1.165 1.181 1.119	1.191 1.188 1.174 1.226 1.184 1.208 1.124	1.115 1.113 1.144 1.084 1.103 1.116 1.091	
1.152 1.148 1.182 1.125 1.139 1.158 1.172	1.172 1.170 1.150 1.199 1.165 1.187 1.125	1.105 1.106 1.134 1.073 1.097 1.107 1.071	1.043 1.050 1.022 1.047 1.041 1.040 1.079	.870 .877 .882 .839 .872 .847 .902
1.141 1.139 1.115 1.152 1.137 1.154 1.078	1.064 1.068 1.088 1.029 1.061 1.068 1.078	1.006 1.020 .993 1.009 1.017 1.011 1.060	.934 .941 .923 .928 .954 .922 .957	.636 .656 .640 .669 .658 .650 .651
.950 .943 .954 .901 .944 .928 .985	.946 .951 .909 .953 .964 .942 .977	.827 .843 .837 .836 .854 .856 .858	.576 .591 .590 .594 .599 .580 .606	
.708 .709 .701 .699 .723 .667 .747	.560 .567 .557 .568 .575 .542 .587			

TABLE 4.124
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 6146 MWd/tU

1.276 1.244 1.290 1.256 - 1.251 -				REF SPA IND CRO SAF TUR SER
1.310 1.288 1.261 1.355 - 1.230 -	1.285 1.252 1.294 1.262 - 1.262 -			
1.277 1.248 1.288 1.254 - 1.256 -	1.316 1.281 1.273 1.361 - 1.254 -	1.271 1.245 1.278 1.243 - 1.256 -		
1.288 1.279 1.235 1.338 - 1.221 -	1.259 1.236 1.265 1.229 - 1.244 -	1.285 1.269 1.226 1.336 - 1.237 -	1.208 1.198 1.193 1.172 - 1.204 -	
1.226 1.213 1.233 1.193 - 1.218 -	1.259 1.248 1.201 1.302 - 1.212 -	1.198 1.190 1.183 1.160 - 1.194 -	1.194 1.202 1.069 1.237 - 1.146 -	1.031 1.026 .920 .983 - 1.034 -
1.227 1.216 1.156 1.269 - 1.197 -	1.167 1.161 1.135 1.124 - 1.172 -	1.169 1.181 1.039 1.209 - 1.124 -	1.166 1.168 .959 1.198 - 1.075 -	.999 1.008 .672 1.047 - .946 -
1.069 1.057 .995 1.015 - 1.068 -	1.207 1.206 .955 1.262 - 1.092 -	1.080 1.084 .878 1.129 - 1.059 -	.929 .939 .619 .965 - .922 -	
.988 .985 .736 1.040 - .907 -	.893 .900 .584 .944 - .861 -			

TABLE 4.125
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 6146 MWd/tU

7487. 7393. 7746. 7140. 7098. 7411. 7390.				**REF** **SPA** **IND** **CRO** **SAF** **TUR** **SER**
7275. 7205. 6953. 7334. 6946. 7445. 7187.	7560. 7513. 7863. 7313. 7281. 7561. 7545.			
7559. 7505. 7838. 7303. 7294. 7542. 7537.	7539. 7491. 7323. 7708. 7352. 7771. 7438.	7459. 7378. 7821. 7348. 7381. 7566. 7533.		
7149. 7148. 6849. 7310. 7000. 7370. 7152.	7410. 7420. 7708. 7231. 7293. 7444. 7637.	7212. 7217. 6992. 7403. 7170. 7446. 7432.	6927. 6915. 7127. 6679. 6868. 6872. 6887.	
7269. 7308. 7539. 7139. 7264. 7298. 7002.	7127. 7150. 6875. 7305. 7135. 7325. 7248.	6871. 6890. 7079. 6636. 6864. 6826. 6920.	6209. 6179. 5915. 6159. 6214. 6186. 5816.	5315. 5289. 5361. 5075. 5382. 5040. 4972.
7083. 7078. 6872. 7296. 7268. 7224. 7282.	6722. 6750. 6921. 6553. 6848. 6657. 6490.	6031. 6070. 5830. 6033. 6187. 6058. 5600.	5584. 5569. 5443. 5505. 5776. 5459. 5296.	3872. 3935. 3912. 4052. 4078. 3850. 3747.
5999. 5897. 6175. 5879. 6268. 5796. 5535.	5837. 5835. 5591. 5977. 6146. 5787. 5503.	5169. 5241. 5301. 5240. 5479. 5230. 4914.	3534. 3566. 3649. 3621. 3751. 3448. 3294.	
4502. 4491. 4636. 4625. 4869. 4170. 4143.	3514. 3516. 3598. 3647. 3773. 3310. 3259.			

TABLE 4.126
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 8200 MWd/tU

1.186 1.150 1.213 1.131 1.177 1.140 1.156				REF SPA IND CRO SAF TUR SER
1.221 1.188 1.202 1.223 1.213 1.182 1.192	1.182 1.154 1.212 1.134 1.177 1.149 1.147			
1.179 1.152 1.207 1.131 1.172 1.149 1.142	1.233 1.202 1.218 1.237 1.227 1.207 1.198	1.166 1.145 1.197 1.128 1.163 1.153 1.110		
1.196 1.177 1.178 1.209 1.189 1.179 1.164	1.158 1.144 1.187 1.120 1.153 1.146 1.093	1.192 1.180 1.179 1.211 1.190 1.191 1.125	1.106 1.104 1.131 1.077 1.099 1.108 1.079	
1.136 1.127 1.159 1.101 1.126 1.132 1.155	1.178 1.167 1.156 1.191 1.168 1.177 1.131	1.097 1.099 1.123 1.069 1.092 1.103 1.063	1.066 1.070 1.046 1.076 1.060 1.067 1.103	.879 .891 .889 .862 .876 .872 .910
1.142 1.136 1.114 1.148 1.129 1.145 1.086	1.057 1.061 1.075 1.027 1.050 1.063 1.071	1.025 1.040 1.015 1.038 1.032 1.038 1.080	.952 .968 .945 .965 .968 .957 .975	.645 .674 .648 .695 .662 .680 .660
.945 .941 .945 .908 .930 .937 .980	.960 .967 .921 .976 .964 .961 .991	.830 .854 .836 .857 .849 .878 .862	.586 .609 .597 .619 .602 .609 .621	
.709 .717 .696 .713 .710 .680 .746	.569 .580 .559 .586 .570 .563 .597			

TABLE 4.127
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 8200 MWd/tU

1.249 1.208 1.267 1.195 - 1.195 -				REF SPA IND CRO SAF TUR SER
1.280 1.246 1.263 1.308 - 1.189 -	1.250 1.212 1.266 1.198 - 1.202 -			
1.243 1.210 1.261 1.194 - 1.199 -	1.288 1.243 1.268 1.308 - 1.209 -	1.236 1.203 1.250 1.190 - 1.203 -		
1.258 1.243 1.238 1.301 - 1.188 -	1.228 1.203 1.240 1.183 - 1.198 -	1.254 1.234 1.227 1.298 - 1.203 -	1.191 1.178 1.181 1.150 - 1.181 -	
1.207 1.187 1.211 1.160 - 1.182 -	1.245 1.224 1.204 1.278 - 1.190 -	1.182 1.174 1.173 1.142 - 1.176 -	1.186 1.191 1.090 1.242 - 1.150 -	1.038 1.036 .928 1.004 - 1.056 -
1.214 1.198 1.155 1.251 - 1.178 -	1.153 1.147 1.123 1.112 - 1.156 -	1.164 1.172 1.059 1.218 - 1.131 -	1.170 1.176 .983 1.231 - 1.106 -	1.004 1.022 .680 1.079 - .975 -
1.061 1.049 .986 1.017 - 1.069 -	1.194 1.196 .964 1.273 - 1.098 -	1.077 1.089 .878 1.149 - 1.074 -	.931 .955 .627 1.000 - .951 -	
.975 .984 .731 1.051 - .913 -	.890 .905 .586 .963 - .876 -			

TABLE 4.128
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 8200 MWd/tU

9947. 9820. 10286. 9543. 9560. 9757. 9824.				REF SPA IND CRO SAF TUR SER
9782. 9673. 9403. 9903. 9444. 9874. 9656.	10021. 9954. 10410. 9725. 9759. 9922. 10002.			
10013. 9939. 10373. 9703. 9762. 9903. 9995.	10085. 10001. 9829. 10313. 9906. 10251. 10031.	9883. 9799. 10337. 9733. 9839. 9935. 10013.		
9603. 9582. 9247. 9825. 9457. 9793. 9595.	9816. 9824. 10198. 9587. 9724. 9800. 10119.	9660. 9657. 9404. 9914. 9640. 9894. 9953.	9208. 9202. 9476. 8902. 9170. 9150. 9194.	
9619. 9667. 9966. 9438. 9642. 9624. 9269.	9540. 9553. 9237. 9763. 9564. 9743. 9691.	9132. 9161. 9409. 8838. 9153. 9092. 9208.	8375. 8336. 8014. 8326. 8387. 8379. 7852.	7112. 7091. 7174. 6811. 7200. 6832. 6672.
9428. 9417. 9163. 9658. 9639. 9576. 9636.	8900. 8944. 9156. 8665. 9061. 8842. 8608.	8117. 8166. 7870. 8121. 8310. 8191. 7540.	7521. 7502. 7338. 7429. 7762. 7425. 7140.	5187. 5282. 5228. 5439. 5448. 5247. 5032.
7946. 7835. 8135. 7731. 8238. 7714. 7360.	7795. 7789. 7458. 7945. 8154. 7761. 7352.	6870. 6972. 7019. 6968. 7254. 7035. 6542.	4727. 4780. 4860. 4854. 4998. 4700. 4385.	
5958. 5947. 6076. 6067. 6373. 5566. 5499.	4673. 4681. 4742. 4822. 4967. 4467. 4342.			

TABLE 4.129
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 9912 MWd/tU

1.149 1.126 1.187 1.092 1.158 1.102 1.120				REF SPA IND CRO SAF TUR SER
1.199 1.173 1.198 1.191 1.206 1.149 1.171	1.157 1.128 1.184 1.094 1.156 1.108 1.119			
1.148 1.128 1.181 1.093 1.152 1.110 1.117	1.215 1.184 1.207 1.203 1.214 1.170 1.160	1.140 1.114 1.172 1.096 1.144 1.118 1.086		
1.184 1.168 1.179 1.189 1.186 1.157 1.153	1.140 1.124 1.166 1.093 1.137 1.117 1.076	1.182 1.172 1.178 1.195 1.186 1.172 1.115	1.098 1.097 1.123 1.070 1.094 1.099 1.120	
1.119 1.113 1.143 1.083 1.114 1.112 1.138	1.175 1.163 1.159 1.183 1.167 1.165 1.128	1.095 1.094 1.116 1.065 1.089 1.098 1.061	1.081 1.084 1.065 1.094 1.076 1.084 1.118	.886 .903 .896 .879 .885 .885 .917
1.144 1.133 1.115 1.147 1.126 1.139 1.080	1.057 1.058 1.069 1.027 1.046 1.064 1.071	1.048 1.056 1.034 1.059 1.047 1.059 1.094	.979 .989 .964 .993 .985 .984 1.003	.650 .690 .656 .716 .669 .706 .665
.948 .937 .943 .917 .930 .945 .983	.974 .980 .934 .997 .974 .982 1.005	.846 .866 .840 .876 .853 .902 .878	.600 .625 .606 .640 .610 .637 .631	
.710 .725 .697 .729 .711 .698 .745	.573 .592 .564 .604 .575 .587 .601			

TABLE 4.130
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 9912 MWd/tU

1.210 1.181 1.241 1.150 - 1.149 -				REF SPA IND CRO SAF TUR SER
1.249 1.211 1.253 1.269 - 1.151 -	1.220 1.181 1.238 1.151 - 1.154 -			
1.210 1.181 1.234 1.151 - 1.155 -	1.261 1.213 1.254 1.266 - 1.172 -	1.210 1.167 1.225 1.152 - 1.160 -		
1.231 1.211 1.234 1.269 - 1.158 -	1.204 1.178 1.219 1.150 - 1.161 -	1.234 1.208 1.225 1.267 - 1.176 -	1.173 1.163 1.174 1.132 - 1.159 -	
1.189 1.169 1.195 1.138 - 1.156 -	1.232 1.204 1.205 1.258 - 1.171 -	1.171 1.161 1.167 1.129 - 1.157 -	1.179 1.178 1.108 1.243 - 1.148 -	1.042 1.045 .935 1.020 - 1.067 -
1.202 1.182 1.156 1.239 - 1.164 -	1.147 1.136 1.118 1.104 - 1.144 -	1.165 1.162 1.077 1.225 - 1.135 -	1.179 1.179 1.003 1.256 - 1.127 -	1.012 1.034 .689 1.108 - .994 -
1.061 1.040 .985 1.023 - 1.075 -	1.190 1.185 .976 1.286 - 1.109 -	1.093 1.097 .883 1.168 - 1.090 -	.946 .968 .636 1.029 - .975 -	
.976 .985 .732 1.068 - 9.927 -	.894 .910 .592 .985 - .896 -			

TABLE 4.131
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 9912 MWd/tU

11945. 11789. 12362. 11462. 11612. 11545. 11806.				REF SPA IND CRO SAF TUR SER
11854. 11706. 11462. 11982. 11559. 11843. 11698.	12023. 11930. 12484. 11649. 11812. 11820. 12033.			
12005. 11911. 12439. 11622. 11805. 11805. 11952.	12180. 12059. 11914. 12416. 12044. 12254. 12308.	11857. 11759. 12385. 11650. 11867. 11850. 12028.		
11640. 11598. 11264. 11886. 11529. 11775. 11626.	11783. 11782. 12231. 11493. 11734. 11713. 12149.	11692. 11678. 11422. 11980. 11714. 11902. 12048.	11094. 11091. 11413. 10743. 11806. 11033. 10620.	
11549. 11596. 11951. 11314. 11605. 11529. 11130.	11554. 11550. 11217. 11799. 11600. 11738. 11729.	11008. 11042. 11331. 10665. 11056. 10972. 11112.	10212. 10167. 9804. 10176. 10234. 10235. 9587.	8623. 8617. 8696. 8295. 8727. 8349. 8116.
11385. 11361. 11071. 11623. 11606. 11528. 11714.	10709. 10761. 10997. 10424. 10891. 10665. 10367.	9892. 9947. 9609. 9907. 10108. 10004. 9292.	9174. 9159. 8956. 9093. 9447. 9110. 8726.	6296. 6436. 6337. 6639. 6598. 6456. 6137.
9566. 9445. 9752. 9289. 9858. 9333. 8880.	9450. 9443. 9035. 9625. 9833. 9444. 8923.	8305. 8434. 8451. 8443. 8730. 8586. 7922.	5742. 5823. 5883. 5923. 6046. 5790. 5393.	
7172. 7175. 7267. 7295. 7607. 6761. 6656.	5650. 5674. 5699. 5833. 5961. 5472. 5268.			

TABLE 4.132
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 13250 MWd/tU

1.115 1.084 1.127 1.031 1.111 1.024 1.086				REF SPA IND CRO SAF TUR SER
1.171 1.141 1.159 1.134 1.169 1.074 1.145	1.114 1.086 1.125 1.033 1.109 1.030 1.081			
1.114 1.087 1.125 1.037 1.108 1.036 1.079	1.178 1.152 1.164 1.146 1.174 1.093 1.147	1.104 1.089 1.124 1.046 1.105 1.052 1.051		
1.169 1.145 1.158 1.151 1.164 1.101 1.138	1.107 1.091 1.125 1.050 1.104 1.058 1.045	1.163 1.155 1.160 1.165 1.167 1.124 1.097	1.087 1.083 1.108 1.056 1.086 1.077 1.063	
1.104 1.088 1.116 1.055 1.093 1.072 1.133	1.167 1.150 1.151 1.164 1.157 1.130 1.120	1.081 1.083 1.106 1.056 1.084 1.082 1.048	1.101 1.099 1.094 1.117 1.099 1.103 1.139	.907 .919 .915 .904 .904 .921 .939
1.145 1.131 1.118 1.144 1.125 1.125 1.081	1.058 1.055 1.069 1.030 1.049 1.064 1.072	1.065 1.074 1.069 1.089 1.074 1.089 1.122	1.005 1.018 1.004 1.034 1.019 1.032 1.029	.677 .712 .678 .752 .689 .769 .693
.961 .960 .959 .939 .945 .979 .997	1.004 1.009 .974 1.036 1.004 1.029 1.036	.859 .885 .859 .907 .871 .961 .892	.620 .649 .630 .677 .631 .705 .652	
.731 .750 .719 .763 .730 .746 .770	.598 .618 .590 .642 .596 .651 .627			

TABLE 4.133
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 13250 MWd/tU

1.173 1.132 1.180 1.082 - 1.060 -				REF SPA IND CRO SAF TUR SER
1.209 1.157 1.204 1.206 - 1.071 -	1.174 1.133 1.177 1.084 - 1.070 -			
1.172 1.134 1.178 1.088 - 1.074 -	1.213 1.176 1.206 1.210 - 1.096 -	1.162 1.137 1.176 1.097 - 1.099 -		
1.207 1.163 1.204 1.226 - 1.103 -	1.170 1.140 1.177 1.102 - 1.105 -	1.200 1.179 1.202 1.226 - 1.127 -	1.151 1.139 1.160 1.111 - 1.117 -	
1.165 1.137 1.168 1.106 - 1.113 -	1.208 1.177 1.193 1.227 - 1.130 -	1.150 1.138 1.158 1.113 - 1.121 -	1.176 1.156 1.135 1.239 - 1.139 -	1.059 1.054 .957 1.042 - 1.083 -
1.198 1.170 1.158 1.220 - 1.135 -	1.139 1.122 1.119 1.097 - 1.117 -	1.156 1.147 1.109 1.232 - 1.136 -	1.180 1.173 1.045 1.291 - 1.155 -	1.027 1.042 .713 1.153 - 1.034 -
1.071 1.057 1.004 1.040 - 1.089 -	1.189 1.178 1.014 1.313 - 1.132 -	1.097 1.111 .904 1.201 - 1.119 -	.958 .980 .662 1.079 - 1.022 -	
.992 1.002 .756 1.108 - .966 -	.913 .927 .620 1.033 - .982 -			

TABLE 4.134
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 13250 MWd/tU

15724. 15509. 16271. 15036. 15561. 15130. 15566.				REF SPA IND CRO SAF TUR SER
15810. 15591. 15429. 15892. 15669. 15493. 15615.	15812. 15655. 16382. 15230. 15754. 15323. 15780.			
15781. 15637. 16329. 15208. 15732. 15325. 15777.	16174. 15982. 15906. 16367. 16715. 15967. 16046.	15603. 15460. 16253. 15252. 15766. 15418. 15850.		
15567. 15475. 15185. 15814. 15571. 15501. 15547.	15533. 15503. 16086. 15092. 15609. 15296. 16021.	15605. 15576. 15342. 15938. 15750. 15699. 16106.	14742. 14739. 15149. 14299. 14817. 14650. 14742.	
15258. 15287. 15741. 14897. 15402. 15142. 14574.	15464. 15420. 15082. 15727. 15575. 15544. 15694.	14639. 14682. 15049. 14211. 14769. 14601. 14804.	13853. 13800. 13388. 13857. 13899. 13907. 13042.	11616. 11643. 11703. 11259. 11743. 11396. 10990.
15205. 15143. 14796. 15449. 15439. 15298. 15648.	14239. 14289. 14565. 13856. 14458. 14220. 13796.	13419. 13489. 13094. 13476. 13676. 13620. 12497.	12485. 12486. 12210. 12453. 12802. 12519. 11922.	8511. 8756. 8545. 9070. 8876. 8969. 8368.
12752. 12597. 12911. 12373. 13028. 12561. 11872.	12752. 12741. 12187. 12995. 13151. 12841. 12066.	11152. 11343. 11268. 11401. 11633. 11737. 10679.	7777. 7931. 7924. 8100. 8124. 8082. 7363.	
9577. 9618. 9608. 9764. 10026. 9210. 8910.	7605. 7673. 7601. 7890. 7920. 7589. 7140.			

TABLE 4.135
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 15100 MWd/tU

1.100 1.061 1.108 1.008 1.083 .991 1.072				REF SPA IND CRO SAF TUR SER
1.148 1.121 1.143 1.110 1.142 1.038 1.122	1.091 1.059 1.105 1.010 1.081 .996 1.059			
1.091 1.063 1.107 1.015 1.082 1.003 1.058	1.155 1.127 1.147 1.122 1.148 1.956 1.120	1.089 1.039 1.107 1.027 1.084 1.021 1.050		
1.140 1.132 1.147 1.132 1.145 1.071 1.110	1.087 1.072 1.110 1.033 1.086 1.029 1.042	1.152 1.140 1.150 1.149 1.153 1.096 1.099	1.081 1.076 1.101 1.049 1.081 1.061 1.050	
1.089 1.077 1.106 1.043 1.082 1.049 1.119	1.156 1.145 1.145 1.153 1.149 1.108 1.121	1.080 1.080 1.100 1.052 1.082 1.069 1.047	1.109 1.111 1.100 1.122 1.107 1.103 1.147	.919 .935 .923 .914 .916 .937 .952
1.142 1.127 1.118 1.143 1.126 1.114 1.093	1.058 1.055 1.069 1.032 1.052 1.061 1.075	1.073 1.091 1.078 1.098 1.085 1.096 1.110	1.017 1.041 1.018 1.050 1.035 1.051 1.042	.691 .731 .689 .768 .703 .809 .707
.976 .945 .969 .951 .959 .989 1.011	1.027 1.023 .992 1.054 1.023 1.052 1.060	.876 .908 .867 .921 .884 .999 .906	.636 .669 .641 .695 .646 .750 .664	
.750 .759 .733 .783 .748 .778 .786	.614 .631 .604 .662 .614 .694 .634			

TABLE 4.136
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 15100 MWd/tU

1.157 1.108 1.161 1.058 - 1.022 -				**REF** **SPA** **IND** **CRO** **SAF** **TUR** **SER**
1.184 1.138 1.185 1.181 - 1.039 -	1.155 1.106 1.158 1.059 - 1.031 -			
1.149 1.111 1.160 1.065 - 1.037 -	1.186 1.153 1.187 1.187 - 1.058 -	1.144 1.087 1.160 1.075 - 1.067 -		
1.175 1.152 1.190 1.209 - 1.072 -	1.149 1.122 1.163 1.083 - 1.076 -	1.184 1.168 1.191 1.212 - 1.103 -	1.146 1.127 1.153 1.102 - 1.097 -	
1.147 1.125 1.159 1.093 - 1.091 -	1.191 1.171 1.186 1.214 - 1.110 -	1.140 1.130 1.153 1.107 - 1.106 -	1.173 1.163 1.140 1.234 - 1.127 -	1.067 1.065 .966 1.050 - 1.082 -
1.189 1.165 1.159 1.213 - 1.116 -	1.133 1.118 1.119 1.095 - 1.105 -	1.153 1.157 1.118 1.233 - 1.132 -	1.177 1.185 1.058 1.303 - 1.161 -	1.033 1.061 .724 1.173 - 1.048 -
1.080 1.036 1.014 1.051 - 1.092 -	1.189 1.178 1.030 1.327 - 1.139 -	1.108 1.138 .913 1.216 - 1.181 -	.966 1.001 .674 1.102 - 1.043 -	
1.011 1.007 .771 1.132 - .988 -	.930 .934 .636 1.061 - 1.082 -			

TABLE 4.137
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 15100 MWd/tU

17773. 17515. 18356. 16933. 17668. 16964. 17603.					REF SPA IND CRO SAF TUR SER
17956. 17702. 17573. 17980. 17885. 17416. 17753.	17852. 17664. 18463. 17131. 17856. 17166. 17833.				
17821. 17648. 18411. 17117. 17832. 17181. 17822.	18332. 18114. 18058. 18477. 18400. 17922. 18283.	17631. 17474. 18332. 17179. 17861. 17307. 17740.			
17702. 17593. 17326. 17935. 17776. 17483. 17699.	17563. 17521. 18167. 17027. 17702. 17201. 17891.	17746. 17713. 17489. 18087. 17961. 17728. 18156.	16748. 16742. 17198. 16249. 16875. 16614. 16870.		
17286. 17299. 17805. 16844. 17473. 17084. 16411.	17612. 17548. 17212. 17876. 17767. 17594. 17712.	16638. 16685. 17095. 16163. 16825. 16580. 16851.	15898. 15833. 15411. 15925. 15980. 15948. 14983.	13304. 13344. 13396. 12936. 13453. 13130. 12613.	
17320. 17236. 16865. 17565. 17570. 17359. 17617.	16196. 16240. 16542. 15763. 16445. 16183. 15657.	15397. 15476. 15071. 15494. 15710. 15649. 14642.	14356. 14369. 14068. 14373. 14730. 14465. 13739.	9776. 10073. 9800. 10468. 10179. 10465. 9640.	
14544. 14373. 14686. 14115. 14817. 14391. 13578.	14631. 14608. 13989. 14919. 15050. 14787. 13857.	12757. 12981. 12857. 13085. 13279. 13586. 12288.	8939. 9131. 9089. 9360. 9317. 9469. 8554.		
10947. 11005. 10938. 11184. 11406. 10649. 10267.	8726. 8817. 8691. 9086. 9047. 8873. 8364.				

TABLE 4.138
NPP ALMARAZ Cycle 1, Reference assembly power distribution and relative difference (%) distribution, Cycle 1 burnup = 0 MWd/tU

1.138 -2.99 7.91 -10.37 -9.05 -.97 -2.37				REF SPA IND CRO SAF TUR SER
1.061 .09 -1.13 -3.39 -5.56 4.52 -2.54	1.157 -.78 8.99 -6.91 -6.57 2.16 -2.42			
1.176 -1.70 7.31 -7.14 -6.97 1.19 -2.47	1.142 1.14 -.61 -.53 -3.85 6.13 -3.50	1.200 -1.50 6.08 -5.42 -5.75 1.67 -4.50		
1.078 1.48 -2.32 1.02 -2.41 6.03 -2.41	1.178 -.59 6.62 -4.24 -4.50 2.12 -5.77	1.127 .53 -2.93 .80 -2.31 4.35 -5.32	1.120 -2.32 3.75 -5.09 -3.84 -2.86 -3.21	
1.192 -.50 4.61 -1.93 -2.94 2.01 1.43	1.126 1.60 -3.37 3.11 -.44 5.15 -4.53	1.123 -1.60 3.29 -4.27 -2.85 -1.60 -3.29	.977 -.51 -5.02 -.31 .31 -1.84 3.07	.855 -2.34 2.69 -2.46 2.11 -7.49 3.27
1.189 .50 -5.21 5.21 1.43 4.29 -5.38	1.143 -.96 1.75 -1.22 -.70 -.79 1.22	.989 .40 -5.76 .61 1.82 -1.21 6.27	.913 1.20 -3.50 .22 4.93 -4.38 2.63	.630 2.54 3.65 8.57 9.52 -2.86 2.38
1.082 -3.14 -1.29 -.55 .55 -4.99 3.42	1.022 .59 -8.22 4.50 4.11 -1.47 4.50	.911 1.98 .11 2.74 5.60 -.99 3.51	.593 2.36 4.55 6.24 9.78 -4.72 6.24	
.843 -1.54 -1.42 5.22 6.17 -8.90 5.34	.633 -.16 .47 7.42 8.06 -7.58 4.58			

TABLE 4.139
NPP ALMARAZ Cycle 1, Reference peak assembly power distribution and relative difference (%) distribution, Cycle 1 burnup = 0 MWd/tU

1.212 -3.22 5.28 -7.43 - .66 -				REF SPA IND CRO SAF TUR SER
1.245 .00 -5.86 -5.62 - -6.18 -	1.244 -.96 5.39 -4.50 - 3.30 -			
1.255 -1.91 4.54 -4.06 - 2.47 -	1.285 .39 -4.67 -2.26 - -3.42 -	1.276 -1.49 3.68 -2.04 - 3.21 -		
1.260 .48 -6.59 -2.14 - -6.03 -	1.254 -.56 4.15 -.80 - 3.67 -	1.280 .78 -7.73 -1.87 - -3.59 -	1.221 -2.78 -1.15 -4.10 - -1.72 -	
1.275 -.63 1.57 .71 - 2.98 -	1.291 .85 -8.99 2.48 - -4.49 -	1.221 -1.97 -1.23 -2.78 - -1.06 -	1.190 .50 -15.80 -.92 - -7.48 -	1.004 -2.89 -9.16 -3.39 - -4.28 -
1.303 .84 -8.37 4.91 - -1.84 -	1.248 -1.36 -3.21 .88 - -.24 -	1.202 1.50 -16.31 1.25 - -6.57 -	1.187 .93 -21.99 -.93 - -14.57 -	1.023 .49 -33.14 6.06 - -11.83 -
1.201 -3.00 -7.58 1.33 - -2.16 -	1.376 .36 -26.53 5.01 - -19.99 -	1.214 1.24 -21.33 4.12 - -7.58 -	1.006 .50 -35.49 1.59 - -7.65 -	
1.196 -.67 -27.17 12.37 - -11.45 -	1.065 .00 -37.46 9.95 - -8.83 -			

TABLE 4.140
NPP ALMARAZ Cycle 1, Reference assembly power distribution and relative difference (%) distribution, Cycle 1 burnup = 8200 MWd/tU

1.186 -3.04 2.28 -4.64 -.76 -3.88 -2.53				REF SPA IND CRO SAF TUR SER
1.221 -2.70 -1.56 .16 -.66 -3.19 -2.38	1.182 -2.37 2.54 -4.06 -.42 -2.79 -2.96			
1.179 -2.29 2.37 -4.07 -.59 -2.54 -3.14	1.233 -2.51 -1.22 .32 -.49 -2.11 -2.84	1.166 -1.80 2.66 -3.26 -.26 -1.11 -4.80		
1.196 -1.59 -1.51 1.09 -.59 -1.42 -2.68	1.158 -1.21 2.50 -3.28 -.43 -1.04 -5.61	1.192 -1.01 -1.09 1.59 -.17 -.08 -5.62	1.106 -.18 2.26 -2.62 -.63 .18 -2.44	
1.136 -.79 2.02 -3.08 -.88 -.35 1.67	1.178 -.93 -1.87 1.10 -.85 -.08 -3.99	1.097 .18 2.37 -2.55 -.46 .55 -3.10	1.066 .38 -1.88 .94 -.56 .09 3.47	.879 1.37 1.14 -1.93 -.34 -.80 3.53
1.142 -.53 -2.45 .53 -1.14 .26 -4.90	1.057 .38 1.70 -2.84 -.66 .57 1.32	1.025 1.46 -.98 1.27 .68 1.27 5.37	.952 1.68 -.74 1.37 1.68 .53 2.42	.645 4.50 .47 7.75 2.64 5.43 2.33
.945 -.42 .00 -3.92 -1.59 -.85 3.70	.960 .73 -4.06 1.67 .42 .10 3.23	.830 2.89 .72 3.25 2.29 5.78 3.86	.586 3.92 1.88 5.63 2.73 3.92 5.97	
.709 1.13 -1.83 .56 .14 -4.09 5.22	.569 1.93 -1.76 2.99 .18 -1.05 4.92			

TABLE 4.141

NPP ALMARAZ Cycle 1, Reference peak assembly power distribution and relative difference (%) distribution, Cycle 1 burnup = 8200 MWd/tU

1.249 -3.28 1.44 -4.32 - -4.32 -				REF SPA IND CRO SAF TUR SER
1.280 -2.66 -1.33 2.19 - -7.11 -	1.250 -3.04 1.28 -4.16 - -3.84 -			
1.243 -2.65 1.45 -3.94 - -3.54 -	1.288 -3.49 -1.55 1.55 - -6.13 -	1.236 -2.67 1.13 -3.72 - -2.67 -		
1.258 -1.19 -1.59 3.42 - -5.56 -	1.228 -2.04 .98 -3.66 - -2.44 -	1.254 -1.59 -2.15 3.51 - -4.07 -	1.191 -1.09 -.84 -3.44 - -.84 -	
1.207 -1.66 .33 -3.89 - -2.07 -	1.245 -1.69 -3.29 2.65 - -4.42 -	1.182 -.68 -.76 -3.38 - -.51 -	1.186 .42 -8.09 4.72 - -3.04 -	1.038 -.19 -10.60 -3.28 - 1.73 -
1.214 -1.32 -4.86 3.05 - -2.97 -	1.153 -.52 -2.60 -3.56 - .26 -	1.164 .69 -9.02 4.64 - -2.84 -	1.170 .51 -15.98 5.21 - -5.47 -	1.004 1.79 -32.27 7.47 - -2.89 -
1.061 -1.13 -7.07 -4.15 - .75 -	1.194 .17 -19.26 6.62 - -8.04 -	1.077 1.11 -18.48 6.69 - -.28 -	.931 2.58 -32.65 7.41 - 2.15 -	
.975 .92 -25.03 7.79 - -6.36 -	.890 1.69 -34.16 8.20 - -1.57 -			

TABLE 4.142

NPP ALMARAZ Cycle 1, Reference assembly burnup distribution and relative difference (%) distribution, Cycle 1 burnup = 8200 MWd/tU

9947. -1.28 3.41 -4.06 -3.89 -1.91 -1.24				REF SPA IND CRO SAF TUR SER
9782. -1.11 -3.87 1.24 -3.46 .94 -1.29	10021. -.67 3.88 -2.95 -2.61 -.99 -.19			
10013. -.74 3.60 -3.10 -2.51 -1.10 -.18	10085. -.83 -2.54 2.26 -1.77 1.65 -.54	9883. -.85 4.59 -1.52 -.45 .53 1.32		
9603. -.22 -3.71 2.31 -1.52 1.98 -.08	9816. .08 3.89 -2.33 -.94 -.16 3.09	9660. -.03 -2.65 2.63 -.21 2.42 3.03	9208. -.07 2.91 -3.32 -.41 -.63 -.15	
9619. .50 3.61 -1.88 .24 .05 -3.64	9540. .14 -3.18 2.34 .25 2.13 1.58	9132. .32 3.03 -3.22 .23 -.44 .83	8375. -.47 -4.31 -.59 .14 .05 -6.24	7112. -.30 .87 -4.23 1.24 -3.94 -6.19
9428. -.12 -2.81 2.44 2.24 1.57 2.21	8900. .49 2.88 -2.64 1.81 -.65 -3.28	8117. .60 -3.04 .05 2.38 .91 -7.11	7521. -.25 -2.43 -1.22 3.20 -1.28 -5.07	5187. 1.83 .79 4.86 5.03 1.16 -2.99
7946. -1.40 2.38 -2.71 3.67 -2.92 -7.37	7795. -.08 -4.32 1.92 4.61 -.44 -5.68	6870. 1.48 2.17 1.43 5.59 2.40 -4.77	4727. 1.12 2.81 2.69 5.73 -.57 -7.24	
5958. -.18 1.98 1.83 6.97 -6.58 -7.70	4673. .17 1.48 3.19 6.29 -4.41 -7.08			

TABLE 4.143
NPP ALMARAZ Cycle 1, Reference assembly power distribution and relative difference (%) distribution, Cycle 1 burnup = 15100 MWd/tU

1.100 -3.55 .73 -8.36 -1.55 -9.91 -2.55				REF SPA IND CRO SAF TUR SER
1.148 -2.35 -.44 -3.31 -.52 -9.58 -2.26	1.091 -2.93 1.28 -7.42 -.92 -8.71 -2.93			
1.091 -2.57 1.47 -6.97 -.82 -8.07 -3.02	1.155 -2.42 -.69 -2.86 -.61 69.35 -3.03	1.089 -4.59 1.65 -5.69 -.46 -6.24 -3.58		
1.140 -.70 .61 -.70 .44 -6.05 -2.63	1.087 -1.38 2.12 -4.97 -.09 -5.34 -4.14	1.152 -1.04 -.17 -.26 .09 -4.86 -4.60	1.081 -.46 1.85 -2.96 .00 -1.85 -2.87	
1.089 -1.10 1.56 -4.22 -.64 -3.67 2.75	1.156 -.95 -.95 -.26 -.61 -4.15 -3.03	1.080 .00 1.85 -2.59 .19 -1.02 -3.06	1.109 .18 -.81 1.17 -.18 -.54 3.43	.919 1.74 .44 -.54 -.33 1.96 3,59
1.142 -1.31 -2.10 .09 -1.40 -2.45 -4.29	1.058 -.28 1.04 -2.46 -.57 .28 1.61	1.073 1.68 .47 2.33 1.12 2.14 3.45	1.017 2.36 .10 3.24 1.77 3.34 2.46	.691 5.79 -.29 11.14 1.74 17.08 2.32
.976 -3.18 -.72 -2.56 -1.74 1.33 3.59	1.027 -.39 -3.41 2.63 -.39 2.43 3.21	.876 3.65 -1.03 5.14 .91 14.04 3.42	.636 5.19 .79 9.28 1.57 17.92 4.40	
.750 1.20 -2.27 4.40 -.27 3.73 4.80	.614 2.77 -1.63 7.82 .00 13.03 3.26			

TABLE 4.144

NPP ALMARAZ Cycle 1, Reference peak assembly power distribution and relative difference (%) distribution, Cycle 1 burnup = 15100 MWd/tU

1.157 -4.24 .35 -8.56 - -11.67 -				REF SPA IND CRO SAF TUR SER
1.184 -3.89 .08 -.25 - -12.25 -	1.155 -4.24 .26 -8.31 - -10.74 -			
1.149 -3.31 .96 -7.31 - -9.75 -	1.186 -2.78 .08 .08 - -10.79 -	1.144 -4.98 1.40 -6.03 - -6.73 -		
1.175 -1.96 1.28 2.89 - -8.77 -	1.149 -2.35 1.22 -5.74 - -6.35 -	1.184 -1.35 .59 2.36 - -6.84 -	1.146 -1.66 .61 -3.84 - -4.28 -	
1.147 -1.92 1.05 -4.71 - -4.88 -	1.191 -1.68 -.42 1.93 - -6.80 -	1.140 -.88 1.14 -2.89 - -2.98 -	1.173 -.85 -2.81 5.20 - -3.92 -	1.067 -.19 -9.47 -1.59 - 1.41 -
1.189 -2.02 -2.52 2.02 - -6.14 -	1.133 -1.32 -1.24 -3.35 - -2.47 -	1.153 .35 -3.04 6.94 - -1.82 -	1.177 .68 -10.11 10.71 - -1.36 -	1.033 2.71 -29.91 13.55 - 1.45 -
1.080 -4.07 -6.11 -2.69 - 1.11 -	1.189 -.93 -13.37 11.61 - -4.21 -	1.108 2.71 -17.60 9.75 - 6.59 -	.966 3.62 -30.23 14.08 - 7.97 -	
1.011 -.40 -23.74 11.97 - -2.27 -	.930 .43 -31.61 14.09 - 16.34 -			

TABLE 4.145
NPP ALMARAZ Cycle 1, Reference assembly burnup distribution and relative difference (%) distribution, Cycle 1 burnup = 15100 MWd/tU

17773. -1.45 3.28 -4.73 -.59 -4.55 -.96				REF SPA IND CRO SAF TUR SER
17956. -1.41 -2.13 .13 -.40 -3.01 -1.13	17852. -1.05 3.42 -4.04 .02 -3.84 -.11			
17821. -.97 3.31 -3.95 .06 -3.59 .01	18332. -1.19 -1.49 .79 .37 -2.24 -.27	17631. -.89 3.98 -2.56 1.30 -1.84 .62		
17702. -.62 -2.12 1.32 .42 -1.24 -.02	17563. -.24 3.44 -3.05 .79 -2.06 1.87	17746. -.19 -1.45 1.92 1.21 -.10 2.31	16748. -.04 2.69 -2.98 .76 -.80 .73	
17286. .08 3.00 -2.56 1.08 -1.17 -5.06	17612. -.36 -2.27 1.50 .88 -.10 .57	16638. .28 2.75 -2.85 1.12 -.35 1.28	15898. -.41 -3.06 .17 .52 .31 -5.76	13304. .30 .69 -2.77 1.12 -1.31 -5.19
17320. -.48 -2.63 1.41 1.44 .23 1.71	16196. .27 2.14 -2.67 1.54 -.08 -3.33	15397. .51 -2.12 .63 2.03 1.64 -4.90	14356. .09 -2.01 .12 2.61 .76 -4.30	9776. 3.04 .25 7.08 4.12 7.05 -1.39
14544. -1.18 .98 -2.95 1.88 -1.05 -6.64	14631. -.16 -4.39 1.97 2.86 1.07 -5.29	12757. 1.76 .78 2.57 4.09 6.50 -3.68	8939. 2.15 1.68 4.71 4.23 5.93 -4.31	
10947. .53 -.08 2.16 4.19 -2.72 -6.21	8726. 1.04 -.40 4.13 3.68 1.68 -4.15			

TABLE 4.146
Batch averaged mass of U-235 (kg/tU)
NPP ALMARAZ Cycle-1, EOC

BAT	IND	CRO	SAF	TUR	SER
1	8.297	8.589	8.618	8.701	8.255
2	12.310	11.943	12.043	12.106	11.943
3	19.960	19.539	18.782	19.697	20.178

TABLE 4.147
Batch averaged mass of U-236 (kg/tU)
NPP ALMARAZ Cycle-1, EOC

BAT	IND	CRO	SAF	TUR	SER
1	2.189	2.103	.000	2.195	2.178
2	2.458	2.492	.000	2.566	2.508
3	2.015	2.073	.000	2.129	1.958

TABLE 4.148
Batch averaged mass of U-238 (kg/tU)
NPP ALMARAZ Cycle-1, EOC

BAT	IND	CRO	SAF	TUR	SER
1	964.40	965.63	964.24	966.05	956.49
2	960.17	959.99	959.53	960.43	960.43
3	960.77	960.56	958.92	961.18	961.75

TABLE 4.149
Batch averaged mass of Pu-239 (kg/tU)
NPP ALMARAZ Cycle-1, EOC

BAT	IND	CRO	SAF	TUR	SER
1	4.560	4.306	4.599	4.627	4.227
2	4.959	4.872	4.859	4.839	4.704
3	3.986	3.992	4.247	3.719	3.570

TABLE 4.150
Batch averaged mass of Pu-240 (kg/tU)
NPP ALMARAZ Cycle-1, EOC

BAT	IND	CRO	SAF	TUR	SER
1	1.507	1.426	1.459	1.447	1.467
2	1.363	1.413	1.404	1.314	1.404
3	.751	.789	.900	.709	.681

TABLE 4.151
Batch averaged mass of Pu-241 (kg/tU)
NPP ALMARAZ Cycle-1, EOC

BAT	IND	CRO	SAF	TUR	SER
1	.778	.666	.752	.785	.670
2	.741	.721	.743	.783	.883
3	.337	.326	.438	.358	.267

TABLE 4.152
Batch averaged mass of Pu-242 (kg/tU)
NPP ALMARAZ Cycle-1, EOC

BAT	IND	CRO	SAF	TUR	SER
1	.208	.162	.199	.199	.187
2	.156	.151	.169	.171	.155
3	.042	.039	.067	.047	.034

TABLE 4.153
NPP ALMARAZ Cycle 2, Critical boron concentration comparison
Absolute error for Boron conc. (ppm)

BURNUP (MWd/tU)	REF	SPA	IND	CRO	SAF	TUR	SER
0.	1075.	23.	-276.x	60.	66.	101.y	235.
212.	772.	-9.	2.	18.	69.	129.	84.
1863.	595.	-6.	2.	26.	73.	105.	63.
4461.	350.	-20.	-10.	8.	61.	82.	48.
6589.	160.	-36.	-25.	-10.	44.	52.	20.
8436.	-20.	-26.	-19.	-4.	50.	58.	54.

x - equilibrium Xe
y - 3% of nominal power

TABLE 4.154
NPP ALMARAZ Cycle 2, Power peaking factor comparison
Relative error for $F_{\Delta H}$ (%)

BURNUP (MWd/tU)	REF *	SPA *	CRO	TUR +
0.	1.463	-4.37	-6.43	1.64
212.	1.367	0.29	-2.93	4.39
1863.	1.380	-1.45	-1.45	5.72
4461.	1.350	-0.96	-1.26	2.07
6589.	1.311	0.08	0.23	1.83
8436.	1.287	0.54	1.40	1.63

* - actual operating conditions
+ - actual power level

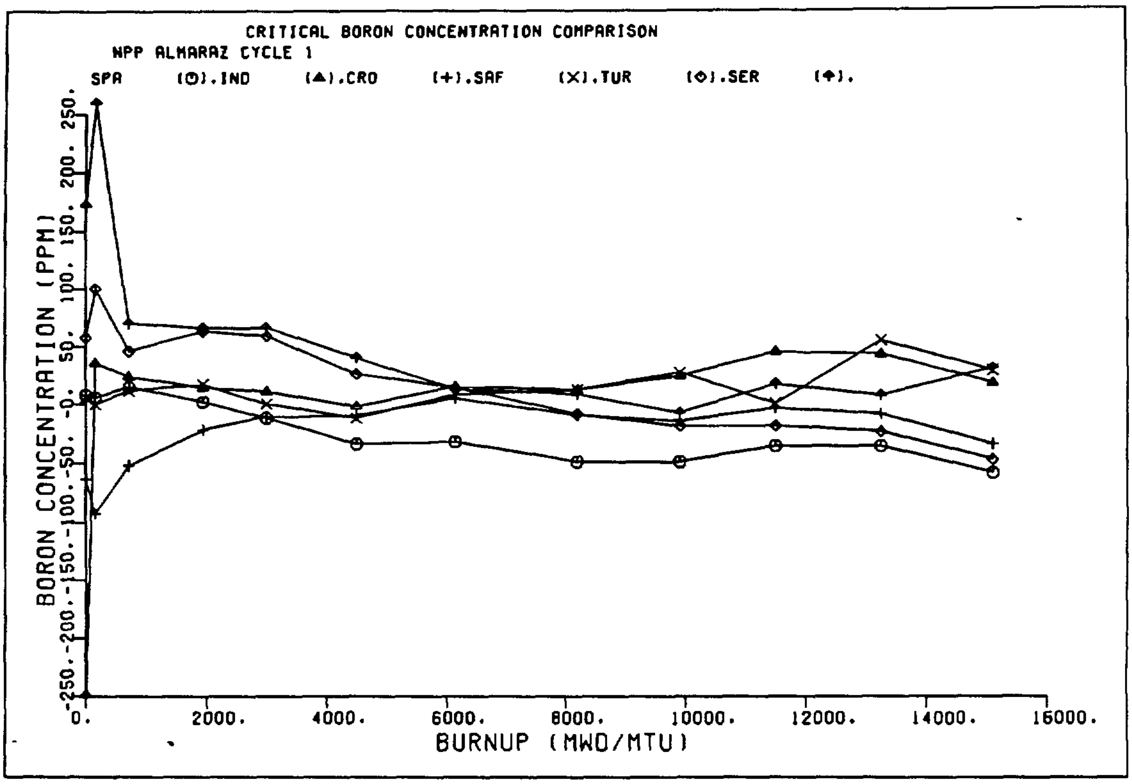


FIGURE 4.1 NPP ALMARAZ CYCLE 1, Critical boron concentration comparison

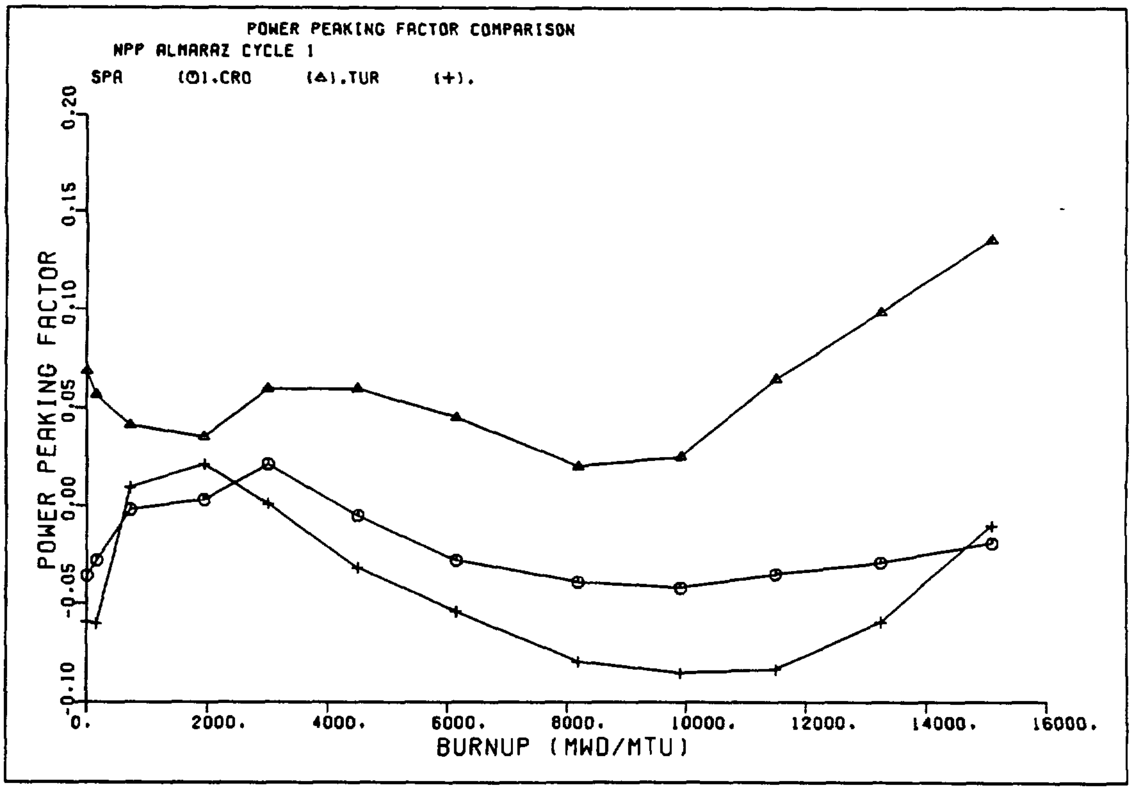


FIGURE 4.2 NPP ALMARAZ CYCLE 1, Power peaking factor comparison

TABLE 4.155
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup =   0 MWd/tU

.728 .760 .772 .746 .716 .784 .735				REF SPA IND CRO SAF TUR SER
.907 .934 .906 .924 .857 .899 .916	1.067 1.092 1.043 1.095 1.015 1.043 1.081			
1.172 1.180 1.147 1.184 1.098 1.211 1.208	1.056 1.074 1.029 1.055 .983 1.036 1.070	1.160 1.190 1.125 1.199 1.111 1.151 1.171		
.987 .995 .985 .997 .929 .994 .997	1.163 1.172 1.153 1.175 1.108 1.194 1.242	1.063 1.090 1.067 1.088 1.028 1.105 1.093	1.200 1.222 1.215 1.247 1.191 1.275 1.204	
.898 .922 .927 .911 .883 .889 .849	1.081 1.094 1.085 1.100 1.058 1.086 1.096	1.195 1.203 1.218 1.215 1.193 1.271 1.192	.967 .977 .980 .981 .956 .993 .925	1.002 1.003 1.010 1.014 1.023 .974 .990
.877 .873 .901 .858 .879 .889 .897	.827 .813 .879 .787 .837 .909 .778	.951 .936 .949 .923 .949 .966 .994	1.015 1.004 1.034 1.012 1.044 1.003 1.004	.729 .743 .769 .768 .791 .665 .753
1.007 .970 .997 .942 1.006 .981 .966	1.331 1.277 1.345 1.258 1.373 1.337 1.267	1.056 1.038 1.088 1.043 1.115 1.057 1.091	.695 .690 .742 .708 .753 .630 .730	
.958 .928 1.005 .911 1.019 .840 .994	.788 .764 .828 .779 .846 .702 .812			

TABLE 4.156
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 0 MWd/tU

.765 .785 .808 .764 - .839 -				REF SPA IND CRO SAF TUR SER
1.016 1.037 .953 .999 - 1.035 -	1.191 1.206 1.100 1.187 - 1.093 -			
1.250 1.252 1.207 1.216 - 1.277 -	1.150 1.167 1.082 1.087 - 1.134 -	1.240 1.273 1.185 1.255 - 1.189 -		
1.058 1.072 1.036 1.042 - 1.116 -	1.288 1.283 1.215 1.223 - 1.254 -	1.135 1.160 1.122 1.115 - 1.206 -	1.285 1.291 1.278 1.288 - 1.352 -	
.961 .997 .976 .983 - .985 -	1.195 1.206 1.143 1.234 - 1.228 -	1.302 1.288 1.281 1.283 - 1.358 -	1.060 1.078 1.031 1.076 - 1.176 -	1.078 1.085 1.063 1.172 - 1.113 -
.936 .918 .947 .955 - .979 -	.918 .879 .921 .873 - 1.107 -	1.019 1.003 .999 1.018 - 1.094 -	1.109 1.085 1.087 1.152 - 1.145 -	1.080 1.100 .806 1.120 - 1.042 -
1.085 1.033 1.049 1.032 - 1.108 -	1.463 1.399 1.411 1.369 - 1.487 -	1.349 1.321 1.141 1.315 - 1.377 -	1.086 1.077 .779 1.114 - 1.075 -	
1.272 1.216 1.054 1.211 - 1.150 -	1.242 1.198 .868 1.232 - 1.201 -			

TABLE 4.157
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 0 MWd/tU

<table>
<tr><td>16749.
16749.
16749.
16749.
16376.
16820.
16916.</td><td></td><td></td><td></td><td>REF
SPA
IND
CRO
SAF
TUR
SER</td></tr>
<tr><td>17879.
17879.
17696.
17879.
17767.
17812.
18034.</td><td>14664.
14664.
14545.
14664.
14730.
14700.
14056.</td><td></td><td></td><td></td></tr>
<tr><td>11092.
11092.
11110.
11092.
11406.
10823.
11437.</td><td>15671.
15671.
15466.
15671.
15710.
15894.
15985.</td><td>14534.
14534.
14776.
14534.
14730.
14700.
14669.</td><td></td><td></td></tr>
<tr><td>17867.
17867.
17823.
17867.
17767.
17842.
18055.</td><td>12952.
12952.
12925.
12952.
13279.
13809.
13038.</td><td>16220.
16220.
16212.
16220.
15980.
16195.
16682.</td><td>10001.
10001.
10029.
10001.
10180.
10645.
100037.</td><td></td></tr>
<tr><td>17988.
17988.
17731.
17988.
17776.
17724.
16988.</td><td>14878.
14878.
15103.
14878.
15050.
15022.
15086.</td><td>9094.
9094.
9199.
9094.
9317.
9636.
9072.</td><td>18015.
18015.
18039.
18015.
17961.
17975.
17230.</td><td>9999.
9999.
10067.
9999.
10180.
10645.
9086.</td></tr>
<tr><td>17591.
17591.
17770.
17591.
17570.
17608.
17992.</td><td>17775.
17775.
17638.
17775.
17702.
17432.
16692.</td><td>18615.
18615.
18510.
18615.
18400.
18161.
17342.</td><td>8867.
8867.
8596.
8867.
9047.
9028.
8767.</td><td>0.
0.
0.
0.
0.
0.
0.</td></tr>
<tr><td>18186.
18186.
18066.
18186.
17885.
17652.
17451.</td><td>0.
0.
0.
0.
0.
0.
0.</td><td>0.
0.
0.
0.
0.
0.
0.</td><td>0.
0.
0.
0.
0.
0.
0.</td><td></td></tr>
<tr><td>0.
0.
0.
0.
0.
0.
0.</td><td>0.
0.
0.
0.
0.
0.
0.</td><td></td><td></td><td></td></tr>
</table>

TABLE 4.158
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 212 MWd/tU

.789 .791 .781 .773 .778 .817 .778				REF SPA IND CRO SAF TUR SER
.958 .943 .915 .945 .919 .927 .945	1.109 1.084 1.052 1.113 1.075 1.069 1.087			
1.185 1.163 1.154 1.197 1.153 1.232 1.162	1.080 1.058 1.036 1.065 1.032 1.055 1.054	1.161 1.152 1.130 1.204 1.152 1.166 1.125		
1.010 .991 .991 1.006 .969 1.011 .991	1.170 1.151 1.157 1.183 1.144 1.207 1.142	1.069 1.073 1.072 1.095 1.057 1.114 1.033	1.193 1.204 1.218 1.248 1.209 1.279 1.169	
.928 .930 .931 .918 .908 .900 .949	1.090 1.085 1.087 1.103 1.076 1.092 1.044	1.176 1.192 1.219 1.219 1.203 1.270 1.140	.973 .982 .982 .982 .964 .997 1.006	1.000 1.018 1.012 1.016 1.019 .978 1.048
.904 .895 .899 .860 .879 .888 .876	.850 .839 .877 .791 .836 .906 .871	.954 .949 .948 .925 .940 .961 1.007	1.007 1.020 1.032 1.010 1.029 1.000 1.033	.741 .767 .769 .773 .776 .675 .767
.985 .963 .989 .927 .963 .954 1.020	1.255 1.258 1.331 1.227 1.299 1.289 1.272	1.020 1.036 1.079 1.028 1.062 1.036 1.060	.695 .713 .740 .707 .726 .632 .738	
.925 .923 .993 .885 .949 .809 .976	.766 .770 .818 .759 .788 .683 .804			

TABLE 4.159
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 212 MWd/tU

.831 .820 .818 .792 - .871 -				**REF** **SPA** **IND** **CRO** **SAF** **TUR** **SER**
1.061 1.039 .962 1.014 - 1.060 -	1.215 1.187 1.108 1.197 - 1.115 -			
1.267 1.235 1.215 1.229 - 1.297 -	1.163 1.146 1.089 1.096 - 1.152 -	1.242 1.232 1.191 1.261 - 1.200 -		
1.086 1.066 1.042 1.052 - 1.134 -	1.277 1.254 1.220 1.232 - 1.264 -	1.139 1.146 1.127 1.118 - 1.279 -	1.268 1.276 1.281 1.290 - 1.354 -	
1.005 1.000 .979 .989 - .997 -	1.185 1.180 1.146 1.239 - 1.233 -	1.270 1.271 1.282 1.290 - 1.357 -	1.064 1.076 1.033 1.079 - 1.179 -	1.080 1.091 1.064 1.173 - 1.117 -
.952 .937 .946 .947 - .965 -	.919 .898 .919 .862 - 1.087 -	1.015 1.015 .997 1.006 - 1.075 -	1.087 1.094 1.086 1.156 - 1.141 -	1.075 1.108 .806 1.118 - 1.043 -
1.044 1.023 1.041 1.006 - 1.074 -	1.367 1.371 1.396 1.327 - 1.427 -	1.283 1.297 1.132 1.286 - 1.333 -	1.060 1.084 .775 1.105 - 1.060 -	
1.195 1.194 1.041 1.175 - 1.104 -	1.169 1.176 .858 1.189 - 1.151 -			

TABLE 4.160
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 212 MWd/tU

16910. 16913. 16913. 16869. 16531. 16992. 17117.				**REF** **SPA** **IND** **CRO** **SAF** **TUR** **SER**
18077. 18077. 17888. 18027. 18034. 18007. 18274.	14895. 14893. 14766. 14840. 14951. 14925. 15151.			
11342. 11338. 11353. 11287. 11643. 11082. 11490.	15897. 15895. 15684. 15846. 15923. 16117. 16219.	14780. 14778. 15015. 14738. 14971. 14946. 15185.		
18079. 18076. 18032. 18042. 17888. 18055. 18363.	13199. 13196. 13170. 13159. 13519. 14064. 13449.	16446. 16448. 16438. 16415. 16203. 16431. 16945.	10255. 10257. 10287. 10232. 10437. 10916. 10394.	
18182. 18184. 17928. 18166. 17968. 17914. 17758.	15108. 15108. 15333. 15092. 15280. 15253. 15684.	9345. 9347. 9457. 9331. 9575. 9905. 9562.	18221. 18223. 18247. 18210. 18169. 18186. 17547.	10211. 10215. 10281. 10209. 10400. 10852. 9673.
17780. 17779. 17961. 17793. 17761. 17796. 18290.	17953. 17951. 17824. 17961. 17885. 17624. 17476.	18817. 18816. 18711. 18825. 18607. 18365. 17726.	9081. 9084. 8815. 9091. 9272. 9241. 8800.	156. 162. 163. 173. 169. 144. 119.
18397. 18390. 18277. 18447. 18104. 17856. 17689.	274. 269. 285. 356. 293. 275. 188.	220. 221. 230. 282. 238. 221. 155.	147. 151. 157. 180. 161. 135. 108.	
200. 197. 213. 281. 218. 173. 138.	165. 164. 175. 240. 181. 196. 118.			

TABLE 4.161
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 1863 MWd/tU

.798 .804 .812 .758 .787 .810 .780				REF SPA IND CRO SAF TUR SER
.949 .947 .936 .915 .917 .910 .929	1.086 1.083 1.067 1.070 1.066 1.043 1.058			
1.156 1.157 1.158 1.150 1.140 1.188 1.129	1.048 1.055 1.044 1.025 1.022 1.026 1.029	1.145 1.150 1.130 1.156 1.135 1.129 1.090		
.990 .991 .996 .979 .968 .987 .965	1.132 1.144 1.154 1.145 1.133 1.169 1.088	1.056 1.066 1.068 1.060 1.047 1.081 1.008	1.174 1.194 1.204 1.215 1.194 1.237 1.153	
.935 .938 .937 .916 .917 .901 .965	1.085 1.085 1.084 1.090 1.076 1.079 1.047	1.170 1.185 1.203 1.198 1.193 1.240 1.127	.974 .980 .979 .975 .965 .983 1.016	1.003 1.018 1.007 1.019 1.018 .977 1.047
.922 .907 .901 .885 .897 .908 .881	.863 .849 .877 .812 .851 .922 .896	.960 .951 .943 .938 .946 .968 1.011	1.016 1.021 1.024 1.022 1.031 1.006 1.053	.754 .775 .771 .794 .780 .698 .783
1.011 .968 .972 .962 .973 .986 1.054	1.271 1.251 1.293 1.268 1.300 1.328 1.307	1.033 1.034 1.058 1.062 1.065 1.075 1.070	.703 .719 .737 .735 .733 .662 .745	
.953 .923 .969 .937 .960 .856 1.009	.794 .770 .800 .804 .795 .726 .834			

TABLE 4.162
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 1863 MWd/tU

.841 .834 .851 .776 - .860 -				REF SPA IND CRO SAF TUR SER
1.041 1.038 .985 .975 - 1.031 -	1.185 1.183 1.125 1.150 - 1.085 -			
1.232 1.228 1.220 1.183 - 1.244 -	1.129 1.141 1.098 1.055 - 1.114 -	1.222 1.228 1.191 1.215 - 1.160 -		
1.063 1.062 1.048 1.013 - 1.097 -	1.237 1.244 1.216 1.196 - 1.220 -	1.125 1.139 1.124 1.084 - 1.172 -	1.253 1.266 1.268 1.249 - 1.301 -	
1.006 1.006 .986 .971 - .983 -	1.166 1.172 1.143 1.205 - 1.199 -	1.256 1.264 1.267 1.257 - 1.313 -	1.063 1.070 1.030 1.052 - 1.145 -	1.081 1.089 1.061 1.164 - 1.105 -
.979 .949 .948 .975 - .991 -	.927 .904 .920 .880 - 1.110 -	1.016 1.015 .992 1.020 - 1.095 -	1.102 1.094 1.077 1.159 - 1.138 -	1.087 1.111 .809 1.143 - 1.049 -
1.071 1.025 1.023 1.030 - 1.108 -	1.379 1.359 1.357 1.360 - 1.459 -	1.296 1.289 1.110 1.316 - 1.363 -	1.070 1.085 .773 1.142 - 1.085 -	
1.237 1.190 1.016 1.234 - 1.154 -	1.188 1.165 .840 1.241 - 1.200 -			

TABLE 4.163
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 1863 MWd/tU

18220. 18224. 18217. 18143. 17845. 18331. 18633.				REF SPA IND CRO SAF TUR SER
19651. 19635. 19409. 19585. 19584. 19514. 19987.	16707. 16682. 16512. 16674. 16761. 16655. 17024.			
13275. 13258. 13263. 13259. 13579. 13057. 13433.	17654. 17642. 17401. 17602. 17662. 17820. 17844.	16684. 16681. 16883. 16722. 16910. 16820. 17319.		
19730. 19713. 19672. 19700. 19525. 19691. 20156.	15100. 15095. 15081. 15108. 15443. 16005. 15561.	18201. 18217. 18208. 18219. 17984. 18224. 18919.	12208. 12242. 12294. 12289. 12464. 12971. 12270.	
19720. 19723. 19467. 19680. 19501. 19402. 19037.	16903. 16901. 17127. 16910. 17090. 17040. 17393.	11282. 11313. 11464. 11340. 11591. 11962. 11548.	19828. 19843. 19868. 19828. 19798. 19814. 18905.	11865. 11896. 11950. 11884. 12109. 12466. 11272.
19287. 19261. 19445. 19211. 19245. 19291. 20107.	19367. 19340. 19271. 19264. 19298. 19143. 18590.	20397. 20383. 20273. 20350. 20195. 19962. 19251.	10751. 10768. 10516. 10756. 10996. 10901. 10284.	1390. 1431. 1433. 1448. 1467. 1288. 1311.
20045. 19981. 19900. 19974. 19729. 19476. 19075.	2360. 2343. 2462. 2377. 2469. 2461. 2077.	1915. 1930. 2000. 1977. 2017. 1986. 1725.	1302. 1329. 1375. 1345. 1375. 1018. 1195.	
1750. 1720. 1837. 1740. 1806. 1574. 1532.	1453. 1434. 1515. 1491. 1499. 1332. 1293.			

TABLE 4.164
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 4461 MWd/tU

.823 .824 .855 .775 .832 .855 .805				REF SPA IND CRO SAF TUR SER
.960 .954 .966 .917 .953 .944 .939	1.097 1.082 1.087 1.061 1.094 1.070 1.073			
1.155 1.147 1.165 1.132 1.161 1.197 1.119	1.053 1.047 1.055 1.009 1.041 1.043 1.069	1.135 1.138 1.131 1.130 1.145 1.133 1.081		
1.001 .989 1.009 .972 .989 .998 .974	1.141 1.132 1.152 1.126 1.143 1.167 1.089	1.049 1.055 1.067 1.039 1.055 1.078 .990	1.162 1.179 1.190 1.190 1.193 1.222 1.134	
.950 .946 .951 .923 .935 .915 .973	1.093 1.084 1.083 1.083 1.083 1.079 1.046	1.160 1.174 1.188 1.181 1.189 1.222 1.136	.974 .980 .981 .973 .972 .985 1.008	1.009 1.022 1.007 1.025 1.024 .991 1.045
.936 .922 .907 .903 .903 .907 .894	.876 .861 .882 .829 .856 .917 .895	.957 .955 .941 .943 .944 .960 1.010	1.016 1.026 1.018 1.030 1.029 1.012 1.051	.770 .791 .777 .820 .789 .735 .789
.994 .969 .952 .966 .948 .956 1.042	1.249 1.236 1.237 1.260 1.245 1.267 1.292	1.019 1.033 1.028 1.069 1.036 1.060 1.059	.718 .735 .735 .760 .733 .687 .760	
.935 .926 .935 .952 .926 .840 .985	.781 .776 .777 .821 .769 .720 .814			

TABLE 4.165
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 4461 MWd/tU

.864 .854 .896 .794 - .901 -				REF SPA IND CRO SAF TUR SER
1.049 1.039 1.017 .967 - 1.055 -	1.187 1.174 1.148 1.132 - 1.106 -			
1.229 1.217 1.228 1.165 - 1.246 -	1.132 1.129 1.110 1.038 - 1.121 -	1.205 1.211 1.194 1.185 - 1.157 -		
1.069 1.056 1.062 .998 - 1.104 -	1.234 1.226 1.216 1.175 - 1.211 -	1.116 1.126 1.123 1.064 - 1.159 -	1.235 1.251 1.255 1.222 - 1.278 -	
1.017 1.010 1.001 .971 - .994 -	1.168 1.161 1.144 1.180 - 1.188 -	1.245 1.252 1.253 1.234 - 1.287 -	1.057 1.064 1.034 1.034 - 1.134 -	1.083 1.088 1.062 1.162 - 1.111 -
.983 .962 .955 .981 - .973 -	.940 .914 .925 .880 - 1.080 -	1.020 1.018 .991 1.011 - 1.070 -	1.097 1.098 1.072 1.162 - 1.135 -	1.097 1.116 .816 1.171 - 1.068 -
1.053 1.025 1.003 1.017 - 1.067 -	1.350 1.337 1.300 1.333 - 1.378 -	1.267 1.273 1.080 1.303 - 1.308 -	1.069 1.090 .772 1.168 - 1.084 -	
1.204 1.183 .982 1.243 - 1.117 -	1.166 1.154 .815 1.245 - 1.154 -			

TABLE 4.166
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 4461 MWd/tU

20326. 20323. 20350. 20119. 19944. 20529. 20812.				REF SPA IND CRO SAF TUR SER
22131. 22097. 21856. 21954. 22027. 21950. 22550.	19542. 19492. 19291. 19436. 19587. 19424. 19857.			
16277. 16254. 16270. 16220. 16596. 16166. 16637.	20383. 20373. 20115. 20241. 20377. 20523. 19948.	19646. 19655. 19814. 19693. 19918. 19765. 20403.		
22316. 22284. 22264. 22231. 22104. 22280. 22829.	18053. 18057. 18072. 18059. 18443. 19040. 18749.	20935. 20978. 20978. 20949. 20767. 21030. 21988.	15243. 15333. 15408. 15417. 15621. 16157. 15444.	
22168. 22164. 21907. 22063. 21943. 21772. 21608.	19732. 19720. 19939. 19733. 19944. 19844. 20488.	14308. 14384. 14578. 14435. 14744. 15149. 14446.	22360. 22391. 22411. 22358. 22367. 22373. 21518.	14479. 14547. 14566. 14536. 14801. 15032. 13920.
21701. 21628. 21789. 21529. 21632. 21647. 22468.	21626. 21554. 21554. 21392. 21569. 21528. 21136.	22888. 22859. 22721. 22793. 22715. 22461. 21549.	13392. 13427. 13172. 13420. 13719. 13526. 12854.	3370. 3456. 3440. 3535. 3529. 3173. 3289.
22649. 22496. 22416. 22485. 22319. 21978. 21390.	5634. 5586. 5790. 5679. 5900. 5792. 5187.	4582. 4618. 4733. 4751. 4828. 4748. 4247.	3147. 3209. 3290. 3281. 3311. 2986. 2963.	
4204. 4122. 4338. 4200. 4340. 3767. 3810.	3498. 3440. 3584. 3605. 3599. 3205. 3226.			

TABLE 4.167
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 6589 MWd/tU

.848 .844 .892 .805 .854 .876 .828				REF SPA IND CRO SAF TUR SER
.976 .963 .993 .937 .966 .956 .954	1.108 1.085 1.108 1.074 1.100 1.073 1.080			
1.160 1.144 1.176 1.137 1.162 1.187 1.136	1.058 1.045 1.071 1.016 1.045 1.042 1.045	1.134 1.132 1.139 1.128 1.142 1.124 1.094		
1.008 .992 1.023 .979 .997 .999 .986	1.142 1.126 1.157 1.125 1.144 1.155 1.094	1.050 1.050 1.073 1.036 1.055 1.070 1.007	1.160 1.170 1.186 1.181 1.188 1.206 1.135	
.960 .955 .965 .934 .948 .924 .988	1.095 1.085 1.089 1.084 1.088 1.075 1.050	1.160 1.167 1.183 1.173 1.186 1.207 1.124	.981 .981 .986 .974 .977 .987 1.022	1.016 1.025 1.008 1.028 1.025 1.002 1.052
.945 .932 .915 .912 .916 .910 .914	.885 .870 .888 .838 .867 .919 .906	.962 .957 .941 .944 .948 .960 .992	1.021 1.028 1.013 1.031 1.030 1.018 1.056	.781 .803 .779 .834 .793 .768 .809
.978 .965 .937 .955 .945 .945 1.016	1.212 1.218 1.192 1.231 1.223 1.235 1.254	1.007 1.026 1.001 1.056 1.023 1.059 1.046	.724 .744 .731 .769 .735 .713 .763	
.913 .922 .906 .939 .916 .836 .958	.764 .776 .755 .813 .762 .727 .792			

TABLE 4.168
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 6589 MWd/tU

.889 .874 .936 .823 - .918 -				REF SPA IND CRO SAF TUR SER
1.063 1.044 1.047 .979 - 1.056 -	1.192 1.171 1.170 1.138 - 1.104 -			
1.233 1.213 1.242 1.170 - 1.231 -	1.135 1.123 1.128 1.043 - 1.114 -	1.200 1.201 1.203 1.178 - 1.143 -		
1.077 1.056 1.079 1.006 - 1.097 -	1.232 1.216 1.222 1.171 - 1.195 -	1.116 1.119 1.131 1.060 - 1.145 -	1.233 1.241 1.252 1.214 - 1.254 -	
1.030 1.016 1.017 .981 - .996 -	1.168 1.155 1.151 1.174 - 1.174 -	1.244 1.244 1.248 1.227 - 1.266 -	1.060 1.061 1.039 1.029 - 1.122 -	1.091 1.087 1.063 1.165 - 1.114 -
.987 .970 .964 .975 - .967 -	.942 .919 .932 .878 - 1.066 -	1.025 1.019 .992 .994 - 1.058 -	1.100 1.098 1.068 1.165 - 1.134 -	1.101 1.117 .819 1.188 - 1.081 -
1.033 1.021 .988 .993 - 1.047 -	1.311 1.312 1.255 1.314 - 1.335 -	1.244 1.253 1.053 1.294 - 1.276 -	1.068 1.088 .768 1.175 - 1.087 -	
1.169 1.168 .952 1.221 - 1.098 -	1.131 1.137 .794 1.227 - 1.132 -			

TABLE 4.169
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 6589 MWd/tU

22103. 22085. 22191. 21786. 21770. 22384. 22668.				REF SPA IND CRO SAF TUR SER
24191. 24130. 23928. 23918. 24117. 23981. 24673.	21887. 21792. 21617. 21702. 21977. 21710. 22328.			
18740. 18692. 18756. 18632. 19123. 18701. 19002.	22629. 22597. 22371. 22393. 22656. 22745. 22796.	22060. 22069. 22226. 22097. 22420. 22164. 22678.		
24454. 24389. 24418. 24303. 24273. 24407. 24932.	20482. 20460. 20527. 20454. 20939. 21507. 21215.	23168. 23219. 23252. 23159. 23077. 23314. 24011.	17713. 17835. 17939. 17944. 18217. 18733. 17939.	
24200. 24182. 23939. 24032. 23993. 23735. 23480.	22060. 22026. 22248. 22037. 22311. 22135. 22885.	16777. 16879. 17103. 16943. 17332. 17728. 17154.	24440. 24477. 24501. 24428. 24502. 24474. 23344.	16633. 16724. 16710. 16720. 17031. 17158. 16014.
23702. 23596. 23723. 23455. 23613. 23583. 24455.	23499. 23392. 23434. 23160. 23450. 23483. 22929.	24930. 24891. 24723. 24801. 24788. 24504. 24094.	15559. 15611. 15334. 15613. 15959. 15689. 14956.	5021. 5148. 5095. 5288. 5238. 4789. 4846.
24747. 24556. 24433. 24535. 24399. 23994. 23618.	8253. 8209. 8397. 8344. 8596. 8435. 7730.	6738. 6817. 6906. 7019. 7071. 7001. 6332.	4682. 4780. 4852. 4904. 4898. 4488. 4432.	
6171. 6095. 6311. 6219. 6347. 5546. 5702.	5141. 5094. 5224. 5347. 5266. 4746. 4834.			

TABLE 4.170
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 8436 MWd/tU

.861 .858 .914 .829 .874 .887 .845				REF SPA IND CRO SAF TUR SER
.994 .971 1.008 .953 .978 .959 .964	1.107 1.088 1.115 1.084 1.106 1.069 1.084			
1.162 1.143 1.178 1.141 1.164 1.174 1.136	1.053 1.043 1.076 1.021 1.049 1.037 1.033	1.128 1.113 1.139 1.127 1.141 1.110 1.092		
1.013 .995 1.032 .986 1.004 .995 .988	1.138 1.124 1.158 1.125 1.144 1.142 1.102	1.046 1.047 1.075 1.034 1.055 1.060 1.003	1.159 1.167 1.181 1.173 1.183 1.189 1.137	
.969 .962 .978 .944 .957 .929 .987	1.097 1.087 1.093 1.086 1.090 1.069 1.060	1.160 1.166 1.178 1.168 1.181 1.192 1.125	.986 .986 .990 .975 .979 .987 1.017	1.024 1.030 1.008 1.028 1.025 1.008 1.057
.946 .937 .926 .921 .924 .914 .912	.886 .876 .898 .846 .875 .922 .908	.967 .960 .945 .945 .948 .960 .991	1.029 1.032 1.011 1.030 1.027 1.023 1.054	.792 .812 .780 .841 .793 .797 .811
.968 .948 .934 .948 .940 .941 .995	1.192 1.202 1.170 1.209 1.202 1.216 1.229	1.003 1.023 .987 1.045 1.010 1.068 1.034	.731 .752 .729 .773 .733 .741 .762	
.901 .914 .891 .929 .904 .838 .938	.756 .773 .745 .806 .753 .740 .788			

TABLE 4.171
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 8436 MWd/tU

.908 .888 .959 .848 - .925 -				REF SPA IND CRO SAF TUR SER
1.067 1.047 1.063 .989 - 1.051 -	1.191 1.168 1.179 1.143 - 1.094 -			
1.234 1.211 1.244 1.174 - 1.212 -	1.129 1.117 1.134 1.046 - 1.102 -	1.192 1.178 1.205 1.173 - 1.126 -		
1.079 1.057 1.088 1.013 - 1.086 -	1.227 1.208 1.224 1.169 - 1.177 -	1.113 1.116 1.133 1.058 - 1.129 -	1.232 1.239 1.248 1.208 - 1.232 -	
1.034 1.021 1.031 .989 - .994 -	1.170 1.153 1.156 1.170 - 1.158 -	1.246 1.242 1.244 1.221 - 1.243 -	1.064 1.062 1.044 1.026 - 1.110 -	1.098 1.091 1.064 1.166 - 1.113 -
.989 .973 .976 .975 - .966 -	.941 .922 .942 .884 - 1.059 -	1.033 1.023 .996 .992 - 1.052 -	1.109 1.101 1.067 1.167 - 1.131 -	1.110 1.120 .820 1.198 - 1.088 -
1.025 1.003 .985 .979 - 1.036 -	1.287 1.294 1.232 1.305 - 1.308 -	1.233 1.246 1.039 1.289 - 1.257 -	1.070 1.088 .767 1.179 - 1.091 -	
1.151 1.152 .938 1.209 - 1.089 -	1.111 1.120 .784 1.214 - 1.120 -			

TABLE 4.172
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 8436 MWd/tU

23682. 23651. 23849. 23284. 23399. 24017. 24111.				REF SPA IND CRO SAF TUR SER
26000. 25912. 25770. 25656. 25960. 25750. 26407.	23932. 23796. 23667. 23691. 24068. 23685. 24265.			
20883. 20803. 20930. 20735. 21325. 20974. 21172.	24579. 24526. 24351. 24271. 24646. 24661. 24900.	24149. 24155. 24330. 24181. 24592. 24220. 24730.		
26321. 26222. 26312. 26115. 26175. 26246. 26860.	22588. 22537. 22666. 22532. 23112. 23622. 23157.	25104. 25157. 25235. 25071. 25087. 25275. 26004.	19855. 19992. 20128. 20121. 20465. 20936. 20056.	
25982. 25948. 25727. 25761. 25802. 25448. 25416.	24084. 24029. 24261. 24040. 24380. 24113. 24785.	18920. 19033. 19286. 19107. 19574. 19937. 19322.	26256. 26289. 26324. 26227. 26367. 26298. 25334.	18518. 18617. 18572. 18619. 18972. 19019. 17864.
25448. 25321. 25417. 25144. 25359. 25275. 26290.	25134. 25004. 25078. 24711. 25107. 25185. 24460.	26711. 26659. 26462. 26545. 26597. 26278. 25978.	17452. 17510. 17204. 17516. 17905. 17578. 16923.	6474. 6635. 6534. 6832. 6728. 6249. 6280.
26543. 26339. 26161. 26295. 26202. 25735. 25626.	10473. 10452. 10587. 10607. 10894. 10691. 9928.	8593. 8713. 8748. 8964. 8994. 8971. 8168.	6026. 6159. 6200. 6326. 6280. 5846. 5746.	
7846. 7798. 7976. 7949. 8068. 7094. 7365.	6544. 6529. 6614. 6845. 6698. 6109. 6152.			

TABLE 4.173
NPP ALMARAZ Cycle 2, Reference assembly power distribution and relative difference (%) distribution, Cycle 2 burnup = 0 MWd/tU

.728 4.40 6.04 2.47 -1.65 7.69 .96				REF SPA IND CRO SAF TUR SER
.907 2.98 -.11 1.87 -5.51 -.88 .99	1.067 2.34 -2.25 2.62 -4.87 -2.25 1.31			
1.172 .68 -2.13 1.02 -6.31 3.33 3.07	1.056 1.70 -2.56 -.09 -6.91 -1.89 1.33	1.160 2.59 -3.02 3.36 -4.22 -.78 .95		
.987 .81 -.20 1.01 -5.88 .71 1.01	1.163 .77 -.86 1.03 -4.73 2.67 6.79	1.063 2.54 .38 2.35 -3.29 3.95 2.82	1.200 1.83 1.25 3.92 -.75 6.25 .33	
.898 2.67 3.23 1.45 -1.67 -1.00 -5.46	1.081 1.20 .37 1.76 -2.13 .46 1.39	1.195 .67 1.92 1.67 -.17 6.36 -.25	.967 1.03 1.34 1.45 -1.14 2.69 -4.34	1.002 .10 .80 1.20 2.10 -2.79 -1.20
.877 -.46 2.74 -2.17 .23 1.37 2.28	.827 -1.69 6.29 -4.84 1.21 9.92 -5.93	.951 -1.58 -.21 -2.94 -.21 1.58 4.52	1.015 -1.08 1.87 -.30 2.86 -1.18 -1.08	.729 1.92 5.49 5.35 8.50 -8.78 3.29
1.007 -3.67 -.99 -6.45 -.10 -2.58 -4.07	1.331 -4.06 1.05 -5.48 3.16 .45 -4.81	1.056 -1.70 3.03 -1.23 5.59 .09 3.31	.695 -.72 6.76 1.87 8.35 -9.35 5.04	
.958 -3.13 4.91 -4.91 6.37 -12.32 3.76	.788 -3.05 5.08 -1.14 7.36 -10.91 3.05			

TABLE 4.174
NPP ALMARAZ Cycle 2, Reference peak assembly power distribution and relative difference (%) distribution, Cycle 2 burnup = 0 MWd/tU

.765 2.61 5.62 -.13 - 9.67 -				REF SPA IND CRO SAF TUR SER
1.016 2.07 -6.20 -1.67 - 1.87 -	1.191 1.26 -7.64 -.34 - -8.23 -			
1.250 .16 -3.44 -2.72 - 2.16 -	1.150 1.48 -5.91 -5.48 - -1.39 -	1.240 2.66 -4.44 1.21 - -4.11 -		
1.058 1.32 -2.08 -1.51 - 5.48 -	1.288 -.39 -5.67 -5.05 - -2.64 -	1.135 2.20 -1.15 -1.76 - 6.26 -	1.285 .47 -.54 .23 - 5.21 -	
.961 3.75 1.56 2.29 - 2.50 -	1.195 .92 -4.35 3.26 - 2.76 -	1.302 -1.08 -1.61 -1.46 - 4.30 -	1.060 1.70 -2.74 1.51 - 10.94 -	1.078 .65 -1.39 8.72 - 3.25 -
.936 -1.92 1.18 2.03 - 4.59 -	.918 -4.25 .33 -4.90 - 20.59 -	1.019 -1.57 -1.96 -.10 - 7.36 -	1.109 -2.16 -1.98 3.88 - 3.25 -	1.080 1.85 -25.37 3.70 - -3.52 -
1.085 -4.79 -3.32 -4.88 - 2.12 -	1.463 -4.37 -3.55 -6.43 - 1.64 -	1.349 -2.08 -15.42 -2.52 - 2.08 -	1.086 -.83 -28.27 2.58 - -1.01 -	
1.272 -4.40 -17.14 -4.80 - -9.59 -	1.242 -3.54 -30.11 -.81 - -3.30 -			

TABLE 4.175
NPP ALMARAZ Cycle 2, Reference assembly burnup distribution and relative difference (%) distribution, Cycle 2 burnup = 0 MWd/tU

16749. .00 .00 .00 -2.23 .42 1.00				REF SPA IND CRO SAF TUR SER
17879. .00 -1.02 .00 -.63 -.37 .87	14664. .00 -.81 .00 .45 .25 -4.15			
11092. .00 .16 .00 2.83 -2.43 3.11	15671. .00 -1.31 .00 .25 1.42 2.00	14534. .00 1.67 .00 1.35 1.14 .93		
17867. .00 -.25 .00 -.56 -.14 1.05	12952. .00 -.21 .00 2.52 6.62 .66	16220. .00 -.05 .00 -1.48 -.15 2.85	10001. .00 .28 .00 1.79 6.44 900.27	
17988. .00 -1.43 .00 -1.18 -1.47 -5.56	14878. .00 1.51 .00 1.16 .97 1.40	9094. .00 1.15 .00 2.45 5.96 -.24	18015. .00 .13 .00 -.30 -.22 -4.36	9999. .00 .68 .00 1.81 6.46 -9.13
17591. .00 1.02 .00 -.12 .10 2.28	17775. .00 -.77 .00 -.41 -1.93 -6.09	18615. .00 -.56 .00 -1.15 -2.44 -6.84	8867. .00 -3.06 .00 2.03 1.82 -1.13	0. .00 .00 .00 .00 .00 .00
18186. .00 -.66 .00 -1.66 -2.94 -4.04	0. .00 .00 .00 .00 .00 .00	0. .00 .00 .00 .00 .00 .00	0. .00 .00 .00 .00 .00 .00	
0. .00 .00 .00 .00 .00 .00	0. .00 .00 .00 .00 .00 .00			

TABLE 4.176
NPP ALMARAZ Cycle 2, Reference assembly power distribution and relative difference (%) distribution, Cycle 2 burnup = 4461 MWd/tU

.823 .12 3.89 -5.83 1.09 3.89 -2.19				REF SPA IND CRO SAF TUR SER
.960 -.62 .63 -4.48 -.73 -1.67 -2.19	1.097 -1.37 -.91 -3.28 -.27 -2.46 -2.19			
1.155 -.69 .87 -1.99 .52 3.64 -3.12	1.053 -.57 .19 -4.18 -1.14 -.95 1.52	1.135 .26 -.35 -.44 .88 -.18 -4.76		
1.001 -1.20 .80 -2.90 -1.20 -.30 -2.70	1.141 -.79 .96 -1.31 .18 2.28 -4.56	1.049 .57 1.72 -.95 .57 2.76 -5.62	1.162 1.46 2.41 2.41 2.67 5.16 -2.41	
.950 -.42 .11 -2.84 -1.58 -3.68 2.42	1.093 -.82 -.91 -.91 -.91 -1.28 -4.30	1.160 1.21 2.41 1.81 2.50 5.34 -2.07	.974 .62 .72 -.10 -.21 1.13 3.49	1.009 1.29 -.20 1.59 1.49 -1.78 3.57
.936 -1.50 -3.10 -3.53 -3.53 -3.10 -4.49	.876 -1.71 .68 -5.37 -2.28 4.68 2.17	.957 -.21 -1.67 -1.46 -1.36 .31 5.54	1.016 .98 .20 1.38 1.28 -.39 3.44	.770 2.73 .91 6.49 2.47 -4.55 2.47
.994 -2.52 -4.23 -2.82 -4.63 -3.82 4.83	1.249 -1.04 -.96 .88 -.32 1.44 3.44	1.019 1.37 .88 4.91 1.67 4.02 3.93	.718 2.37 2.37 5.85 2.09 -4.32 5.85	
.935 -.96 .00 1.82 -.96 -10.16 5.35	.781 -.64 -.51 5.12 -1.54 -7.81 4.23			

TABLE 4.177
NPP ALMARAZ Cycle 2, Reference peak assembly power distribution and relative difference (%) distribution, Cycle 2 burnup = 4461 MWd/tU

.864 -1.16 3.70 -8.10 - 4.28 -				REF SPA IND CRO SAF TUR SER
1.049 -.95 -3.05 -7.82 - .57 -	1.187 -1.10 -3.29 -4.63 - -6.82 -			
1.229 -.98 -.08 -5.21 - 1.38 -	1.132 -.27 -1.94 -8.30 - -.97 -	1.205 .50 -.91 -1.66 - -3.98 -		
1.069 -1.22 -.65 -6.64 - 3.27 -	1.234 -.65 -1.46 -4.78 - -1.86 -	1.116 .90 .63 -4.66 - 3.85 -	1.235 1.30 1.62 -1.05 - 3.48 -	
1.017 -.69 -1.57 -4.52 - -2.26 -	1.168 -.60 -2.05 1.03 - 1.71 -	1.245 .56 .64 -.88 - 3.37 -	1.057 .66 -2.18 -2.18 - 7.28 -	1.083 .46 -1.94 7.29 - 2.59 -
.983 -2.14 -2.85 -.20 - -1.02 -	.940 -2.77 -1.60 -6.38 - 14.89 -	1.020 -.20 -2.84 -.88 - 4.90 -	1.097 .09 -2.28 5.93 - 3.46 -	1.097 1.73 -25.62 6.75 - -2.64 -
1.053 -2.66 -4.75 -3.42 - 1.33 -	1.350 -.96 -3.70 -1.26 - 2.07 -	1.267 .47 -14.76 2.84 - 3.24 -	1.069 1.96 -27.78 9.26 - 1.40 -	
1.204 -1.74 -18.44 3.24 - -7.23 -	1.166 -1.03 -30.10 6.78 - -1.03 -			

TABLE 4.178
NPP ALMARAZ Cycle 2, Reference assembly burnup distribution and relative difference (%) distribution, Cycle 2 burnup = 4461 MWd/tU

20326. -.01 .12 -1.02 -1.88 1.00 2.39				REF SPA IND CRO SAF TUR SER
22131. -.15 -1.24 -.80 -.47 -.82 1.89	19542. -.26 -1.28 -.54 .23 -.60 1.61			
16277. -.14 -.04 -.35 1.96 -.68 2.21	20383. -.05 -1.31 -.70 -.03 .69 -2.13	19646. .05 .86 .24 1.38 .61 3.85		
22316. -.14 -.23 -.38 -.95 -.16 2.30	18053. .02 .11 .03 2.16 5.47 3.86	20935. .21 .21 .07 -.80 .45 5.03	15243. .59 1.08 1.14 2.48 6.00 1.32	
22168. -.02 -1.18 -.47 -1.01 -1.79 -2.53	19732. -.06 1.05 .01 1.07 .57 3.83	14308. .53 1.89 .89 3.05 5.88 .96	22360. .14 .23 -.01 .03 .06 -3.77	14479. .47 .60 .39 2.22 3.82 -3.86
21701. -.34 .41 -.79 -.32 -.25 3.53	21626. -.33 -.33 -1.08 -.26 -.45 -2.27	22888. -.13 -.73 -.42 -.76 -1.87 -5.85	13392. .26 -1.64 .21 2.44 1.00 -4.02	3370. 2.55 2.08 4.90 4.72 -5.85 -2.40
22649. -.68 -1.03 -.72 -1.46 -2.96 -5.56	5634. -.85 2.77 .80 4.72 2.80 -7.93	4582. .79 3.30 3.69 5.37 3.62 -7.31	3147. 1.97 4.54 4.26 5.21 -5.12 -5.85	
4204. -1.95 3.19 -.10 3.24 -10.39 -9.37	3498. -1.66 2.46 3.06 2.89 -8.38 -7.78			

TABLE 4.179
NPP ALMARAZ Cycle 2, Reference assembly power distribution and relative difference (%) distribution, Cycle 2 burnup = 8436 MWd/tU

.861 -.35 6.16 -3.72 1.51 3.02 -1.86				**REF** **SPA** **IND** **CRO** **SAF** **TUR** **SER**
.994 -2.31 1.41 -4.12 -1.61 -3.52 -3.02	1.107 -1.72 .72 -2.08 -.09 -3.43 -2.08			
1.162 -1.64 1.38 -1.81 .17 1.03 -2.24	1.053 -.95 2.18 -3.04 -.38 -1.52 -1.90	1.128 -1.33 .98 -.09 1.15 -1.60 -3.19		
1.013 -1.78 1.88 -2.67 -.89 -1.78 -2.47	1.138 -1.23 1.76 -1.14 .53 .35 -3.16	1.046 .10 2.77 -1.15 .86 1.34 -4.11	1.159 .69 1.90 1.21 2.07 2.59 -1.90	
.969 -.72 .93 -2.58 -1.24 -4.13 1.86	1.097 -.91 -.36 -1.00 -.64 -2.55 -3.37	1.160 .52 1.55 .69 1.81 2.76 -3.02	.986 .00 .41 -1.12 -.71 .10 3.14	1.024 .59 -1.56 .39 .10 -1.56 3.22
.946 -.95 -2.11 -2.64 -2.33 -3.38 -3.59	.886 -1.13 1.35 -4.51 -1.24 4.06 2.48	.967 -.72 -2.28 -2.28 -1.96 -.72 2.48	1.029 .29 -1.75 .10 -.19 -.58 2.43	.792 2.53 -1.52 6.19 .13 .63 2.40
.968 -2.07 -3.51 -2.07 -2.89 -2.79 2.79	1.192 .84 -1.85 1.43 .84 2.01 3.10	1.003 1.99 -1.60 4.19 .70 6.48 3.09	.731 2.87 -.27 5.75 .27 1.37 4.24	
.901 1.44 -1.11 3.11 .33 -6.99 4.11	.756 2.25 -1.46 6.61 -.40 -2.12 4.23			

TABLE 4.180
NPP ALMARAZ Cycle 2, Reference peak assembly power distribution and relative difference (%) distribution, Cycle 2 burnup = 8436 MWd/tU

.908 -2.20 5.62 -6.61 - 1.87 -				REF SPA IND CRO SAF TUR SER
1.067 -1.87 -.37 -7.31 - -1.50 -	1.191 -1.93 -1.01 -4.03 - -8.14 -			
1.234 -1.86 .81 -4.86 - -1.78 -	1.129 -1.06 .44 -7.35 - -2.39 -	1.192 -1.17 1.09 -1.59 - -5.54 -		
1.079 -2.04 .83 -6.12 - .65 -	1.227 -1.55 -.24 -4.73 - -4.07 -	1.113 .27 1.80 -4.94 - 1.44 -	1.232 .57 1.30 -1.95 - .00 -	
1.034 -1.26 -.29 -4.35 - -3.87 -	1.170 -1.45 -1.20 .00 - -1.03 -	1.246 -.32 -.16 -2.01 - -.24 -	1.064 -.19 -1.88 -3.57 - 4.32 -	1.098 -.64 -3.10 6.19 - 1.37 -
.989 -1.62 -1.31 -1.42 - -2.33 -	.941 -2.02 .11 -6.06 - 12.54 -	1.033 -.97 -3.58 -3.97 - 1.84 -	1.109 -.72 -3.79 5.23 - 1.98 -	1.110 .90 -26.13 7.93 - -1.98 -
1.025 -2.15 -3.90 -4.49 - 1.07 -	1.287 .54 -4.27 1.40 - 1.63 -	1.233 1.05 -15.73 4.54 - 1.95 -	1.070 1.68 -28.32 10.19 - 1.96 -	
1.151 .09 -18.51 5.04 - -5.39 -	1.111 .81 -29.43 9.27 - .81 -			

TABLE 4.181
NPP ALMARAZ Cycle 2, Reference assembly burnup distribution and relative difference (%) distribution, Cycle 2 burnup = 8436 MWd/tU

23682. -.13 .71 -1.68 -1.20 1.41 1.81				REF SPA IND CRO SAF TUR SER
26000. -.34 -.88 -1.32 -.15 -.96 1.57	23932. -.57 -1.11 -1.01 .57 -1.03 1.39			
20883. -.38 .23 -.71 2.12 .44 1.38	24579. -.22 -.93 -1.25 .27 .33 1.31	24149. .02 .75 .13 1.83 .29 2.41		
26321. -.38 -.03 -.78 -.55 -.28 2.05	22588. -.23 .35 -.25 2.32 4.58 2.52	25104. .21 .52 -.13 -.07 .68 3.59	19855. .69 1.37 1.34 3.07 5.44 1.01	
25982. -.13 -.98 -.85 -.69 -2.06 -2.18	24084. -.23 .73 -.18 1.23 .12 2.91	18920. .60 1.93 .99 3.46 5.38 2.12	26256. .13 .26 -.11 .42 .16 -3.51	18518. .53 .29 .55 2.45 2.71 -3.53
25448. -.50 -.12 -1.19 -.35 -.68 3.31	25134. -.52 -.22 -1.68 -.11 .20 -2.68	26711. -.19 -.93 -.62 -.43 -1.62 -2.74	17452. .33 -1.42 .37 2.60 .72 -3.03	6474. 2.49 .93 5.53 3.92 -3.48 -3.00
26543. -.77 -1.44 -.93 -1.28 -3.04 -3.45	10473. -.20 1.09 1.28 4.02 2.08 -5.20	8593. 1.40 1.80 4.32 4.67 4.40 -4.95	6026. 2.21 2.89 4.98 4.22 -2.99 -4.65	
7846. -.61 1.66 1.31 2.83 -9.58 -6.13	6544. -.23 1.07 4.60 2.35 -6.65 -5.99			

TABLE 4.182
Batch averaged mass of U-235 (kg/tU)
NPP ALMARAZ Cycle-2, EOC

BAT	IND	CRO	SAF	TUR	SER
1	5.018	5.216	5.407	5.758	4.977
2	7.381	7.949	8.076	8.630	7.607
3	12.813	13.297	12.638	14.057	12.845
4	22.557	23.170	23.599	24.163	23.826

TABLE 4.183
Batch averaged mass of U-236 (kg/tU)
NPP ALMARAZ Cycle-2, EOC

BAT	IND	CRO	SAF	TUR	SER
1	2.674	2.582	.000	2.711	2.657
2	3.186	3.090	.000	3.222	3.181
3	3.218	3.109	.000	3.211	3.195
4	1.627	1.511	.000	1.393	1.416

TABLE 4.184
Batch averaged mass of U-238 (kg/tU)
NPP ALMARAZ Cycle-2, EOC

BAT	IND	CRO	SAF	TUR	SER
1	956.40	957.92	956.66	982.81	958.05
2	952.59	953.04	952.59	978.46	952.50
3	952.87	953.62	951.59	971.07	953.96
4	962.54	963.13	962.78	964.08	963.79

TABLE 4.185
Batch averaged mass of Pu-239 (kg/tU)
NPP ALMARAZ Cycle-2, EOC

BAT	IND	CRO	SAF	TUR	SER
1	4.913	4.695	4.951	5.253	4.568
2	5.127	5.127	5.181	5.588	5.145
3	5.080	4.965	5.132	5.087	4.742
4	3.285	3.112	3.033	2.640	2.792

TABLE 4.186
Batch averaged mass of Pu-240 (kg/tU)
NPP ALMARAZ Cycle-2, EOC

BAT	IND	CRO	SAF	TUR	SER
1	2.143	2.028	2.095	2.143	2.139
2	2.039	2.008	2.026	1.970	2.135
3	1.578	1.524	1.654	1.415	1.556
4	.506	.441	.430	.338	.380

TABLE 4.187
Batch averaged mass of Pu-241 (kg/tU)
NPP ALMARAZ Cycle-2, EOC

BAT	IND	CRO	SAF	TUR	SER
1	1.193	1.093	1.126	1.248	1.037
2	1.173	1.135	1.123	1.247	1.124
3	.892	.812	.916	.851	.778
4	.186	.134	.158	.121	.113

TABLE 4.188
Batch averaged mass of Pu-242 (kg/tU)
NPP ALMARAZ Cycle-2, EOC

BAT	IND	CRO	SAF	TUR	SER
1	.526	.449	.481	.500	.467
2	.448	.397	.415	.422	.494
3	.232	.192	.256	.202	.207
4	.017	.010	.014	.009	.008

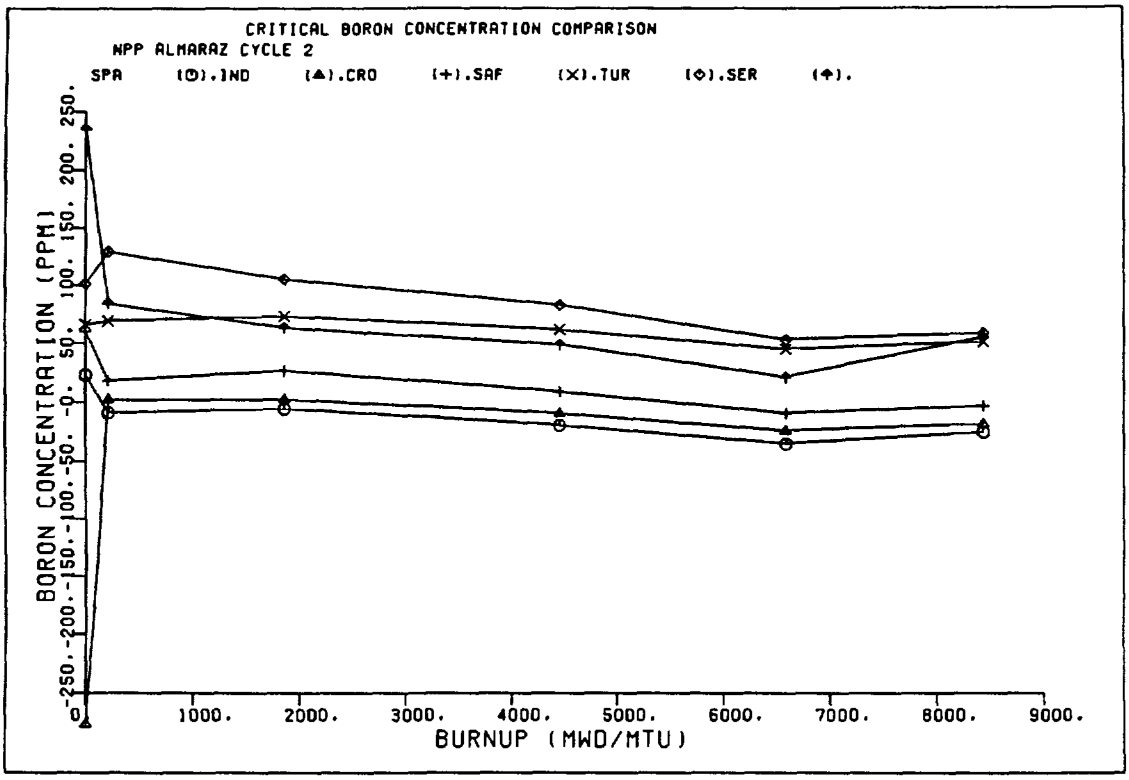


FIGURE 4.3 NPP ALMARAZ CYCLE 2, Critical boron concentration comparison

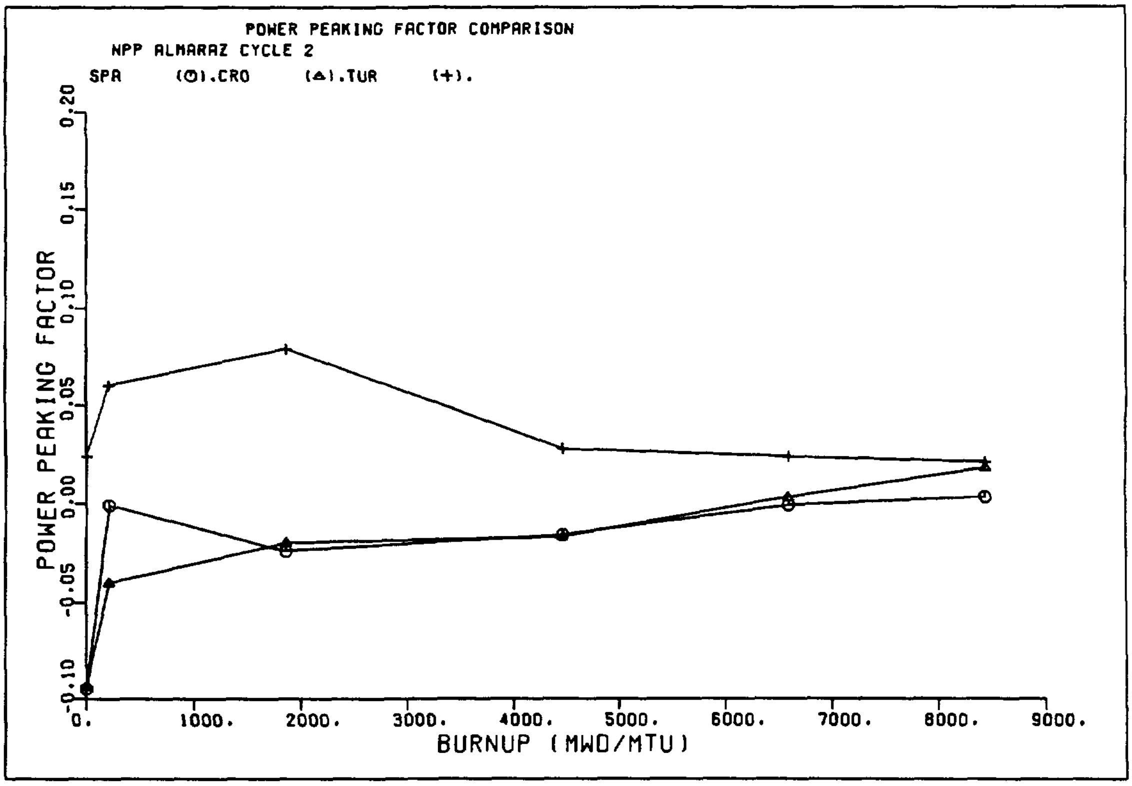


FIGURE 4.4 NPP ALMARAZ CYCLE 2, Power peaking factor comparison

TABLE 4.189
NPP ALMARAZ Cycle 1, Critical boron concentration comparison
Absolute error for boron concentration (ppm)

BURNUP (MWd/tU)	REF	SPA	IND
0.	1280.	-10.	26.
715.	883.	12.	16.
1940.	856.	11.	15.
3000.	863.	-18.	-7.
4500.	805.	-47.	-26.
6146.	663.	-24.	12.
8200.	534.	-45.	3.
9912.	399.	-44.	17.
11500.	284.	-47.	19.
13250.	148.	-53.	14.
15100.	12.	-43.	13.

TABLE 4.190
NPP ALMARAZ Cycle 1, Axial offset comparison

BURNUP (MWd/tU)	REF	SPA	IND
0.	-4.4	-.1	-
715.	-12.6	-12.5	-
1940.	-9.8	-11.4	-
3000.	-9.1	-9.1	-
4500.	-5.3	-7.4	-
6146.	-3.2	-4.2	-
8200.	-4.2	-2.6	-
9912.	-1.6	-2.4	-
11500.	.7	.7	-
13250.	-1.6	-.2	-
15100.	-3.3	.7	-

TABLE 4.191
NPP ALMARAZ Cycle 1, Maximum assembly
power comparison

BURNUP (MWD/tU)	REF	SPA	IND
0.	1.200	1.195	1.247
715.	1.237	1.222	1.279
1940.	1.246	1.241	1.302
3000.	1.241	1.241	1.298
4500.	1.247	1.234	1.267
6146.	1.245	1.222	1.242
8200.	1.233	1.202	1.218
9912.	1.215	1.184	1.207
11500.	1.168	1.168	1.186
13250.	1.178	1.155	1.165
15100.	1.156	1.145	1.150

TABLE 4.192
NPP ALMARAZ Cycle 1, Power peaking factor comparison

BURNUP (MWd/tU)	REF	SPA	IND
0.	1.376	1.381	-
715.	1.334	1.319	-
1940.	1.342	1.342	-
3000.	1.362	1.362	-
4500.	1.332	1.330	-
6146.	1.316	1.288	-
8200.	1.288	1.246	-
9912.	1.261	1.213	-
11500.	1.192	1.192	-
13250.	1.214	1.179	-
15100.	1.191	1.185	-

TABLE 4.193
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 0 MWd/tU

1.138 1.104 1.175			REF SPA IND	
1.061 1.062 1.009	1.157 1.148 1.220			
1.176 1.156 1.226	1.142 1.155 1.111	1.200 1.182 1.247		
1.078 1.094 1.032	1.178 1.171 1.234	1.127 1.133 1.081	1.120 1.094 1.140	
1.192 1.186 1.243	1.126 1.144 1.089	1.123 1.105 1.152	.977 .972 .921	.855 .835 .855
1.189 1.195 1.156	1.143 1.132 1.181	.989 .993 .950	.913 .924 .904	.630 .646 .647
1.082 1.048 1.103	1.022 1.028 .986	.911 .929 .962	.593 .607 .634	
.843 .830 .878	.633 .632 .660			

TABLE 4.194
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 0 MWd/tU

1.212 1.173 1.219			REF SPA IND	
1.245 1.245 1.124	1.244 1.232 1.266			
1.255 1.231 1.272	1.285 1.290 1.197	1.276 1.257 1.294		
1.260 1.266 1.151	1.254 1.247 1.281	1.280 1.290 1.165	1.221 1.187 1.183	
1.275 1.267 1.290	1.291 1.302 1.173	1.221 1.197 1.195	1.190 1.196 .992	1.004 .975 .888
1.303 1.314 1.223	1.248 1.231 1.226	1.202 1.220 1.024	1.187 1.198 .949	1.023 1.028 .677
1.201 1.165 1.144	1.376 1.381 1.062	1.214 1.229 1.007	1.006 1.011 .663	
1.196 1.188 .918	1.065 1.065 .690			

TABLE 4.195
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 0 MWd/tU

0. 0. 0.			REF SPA IND	
0. 0. 0.	0. 0. 0.			
0. 0. 0.	0. 0. 0.	0. 0. 0.		
0. 0. 0.	0. 0. 0.	0. 0. 0.	0. 0. 0.	
0. 0. 0.	0. 0. 0.	0. 0. 0.	0. 0. 0.	0. 0. 0.
0. 0. 0.	0. 0. 0.	0. 0. 0.	0. 0. 0.	0. 0. 0.
0. 0. 0.	0. 0. 0.	0. 0. 0.	0. 0. 0.	
0. 0. 0.	0. 0. 0.			

TABLE 4.196
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 715 MWd/tU

1.206 1.190 1.256			REF SPA IND	
1.137 1.128 1.085	1.230 1.220 1.278			
1.236 1.222 1.279	1.202 1.194 1.154	1.233 1.207 1.235		
1.131 1.132 1.081	1.215 1.215 1.265	1.148 1.155 1.108	1.127 1.129 1.167	
1.201 1.206 1.250	1.143 1.150 1.105	1.122 1.128 1.166	.980 .984 .944	.859 .862 .883
1.156 1.160 1.118	1.116 1.119 1.151	.965 .974 .939	.895 .896 .885	.633 .644 .651
1.018 .990 .998	.963 .960 .914	.862 .870 .891	.585 .586 .610	
.771 .763 .781	.595 .592 .604			

TABLE 4.197
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 715 MWd/tU

1.284 1.267 1.306			REF SPA IND	
1.315 1.297 1.198	1.315 1.304 1.329			
1.321 1.302 1.330	1.334 1.319 1.240	1.313 1.288 1.285		
1.298 1.298 1.194	1.295 1.297 1.315	1.316 1.307 1.190	1.230 1.228 1.214	
1.281 1.284 1.300	1.286 1.288 1.187	1.224 1.227 1.213	1.194 1.207 1.015	1.014 1.009 .917
1.279 1.285 1.175	1.223 1.226 1.197	1.189 1.204 1.010	1.162 1.164 .926	1.003 1.009 .681
1.141 1.109 1.038	1.300 1.289 .982	1.141 1.147 .933	.949 .953 .639	
1.095 1.086 .819	.979 .973 .633			

TABLE 4.198
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 715 MWd/tU

838. 814. 863.			REF SPA IND	
786. 774. 738.	853. 840. 885.			
862. 845. 889.	838. 831. 798.	869. 845. 869.		
790. 789. 747.	855. 850. 888.	813. 813. 774.	803. 796. 825.	
856. 854. 889.	811. 817. 779.	803. 799. 829.	700. 700. 667.	613. 615. 629.
839. 841. 808.	808. 808. 834.	699. 704. 675.	646. 653. 644.	451. 468. 472.
751. 730. 741.	710. 713. 677.	634. 647. 668.	421. 432. 451.	
577. 576. 595.	439. 443. 454.			

TABLE 4.199
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 1940 MWd/tU

1.236 1.219 1.285			REF SPA IND	
1.178 1.178 1.139	1.245 1.241 1.302			
1.243 1.238 1.298	1.225 1.228 1.196	1.230 1.222 1.257		
1.154 1.166 1.119	1.218 1.221 1.271	1.174 1.178 1.136	1.135 1.130 1.168	
1.196 1.199 1.242	1.157 1.163 1.122	1.128 1.124 1.162	.996 .996 .959	.857 .854 .874
1.156 1.151 1.114	1.105 1.101 1.130	.972 .978 .943	.892 .893 .881	.621 .632 .636
.981 .963 .972	.946 .941 .896	.841 .844 .859	.568 .572 .591	
.738 .727 .740	.573 .567 .575			

TABLE 4.200
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 1940 MWd/tU

1.313 1.296 1.337			REF SPA IND	
1.329 1.333 1.233	1.327 1.321 1.354			
1.324 1.316 1.350	1.342 1.342 1.274	1.306 1.302 1.307		
1.314 1.324 1.211	1.296 1.303 1.323	1.320 1.322 1.212	1.238 1.231 1.216	
1.272 1.274 1.292	1.290 1.294 1.196	1.231 1.225 1.208	1.207 1.212 1.024	1.015 1.004 .909
1.273 1.269 1.160	1.215 1.207 1.176	1.191 1.199 1.008	1.161 1.156 .919	.994 .991 .666
1.103 1.083 1.011	1.267 1.254 .958	1.117 1.113 .901	.931 .930 .619	
1.043 1.032 .775	.938 .929 .603			

TABLE 4.201
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 1940 MWd/tU

2334. 2271. 2401.			REF SPA IND	
2203. 2156. 2067.	2369. 2334. 2452.			
2381. 2341. 2457.	2325. 2295. 2211.	2378. 2323. 2382.		
2189. 2176. 2071.	2346. 2339. 2438.	2235. 2227. 2131.	2189. 2179. 2255.	
2324. 2332. 2421.	2220. 2226. 2132.	2181. 2181. 2258.	1910. 1905. 1824.	1664. 1671. 1710.
2255. 2262. 2178.	2168. 2179. 2244.	1885. 1897. 1825.	1741. 1750. 1727.	1219. 1257. 1269.
1976. 1943. 1963.	1879. 1889. 1796.	1677. 1712. 1759.	1127. 1150. 1199.	
1502. 1511. 1552.	1154. 1167. 1195.			

TABLE 4.202
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 4500 MWd/tU

1.225 1.209 1.261			REF SPA IND	
1.216 1.211 1.180	1.235 1.217 1.267			
1.232 1.213 1.262	1.247 1.234 1.215	1.200 1.183 1.219		
1.190 1.190 1.153	1.203 1.194 1.236	1.186 1.190 1.161	1.125 1.122 1.155	
1.173 1.169 1.205	1.171 1.174 1.143	1.111 1.115 1.147	1.030 1.034 1.004	.874 .868 .883
1.145 1.140 1.112	1.077 1.077 1.102	.986 1.006 .978	.919 .923 .912	.635 .644 .640
.944 .927 .939	.937 .939 .899	.825 .838 .844	.574 .580 .591	
.700 .699 .706	.554 .556 .557			

TABLE 4.203
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 4500 MWd/tU

1.296 1.278 1.315			REF SPA IND	
1.328 1.330 1.255	1.309 1.288 1.321			
1.304 1.283 1.316	1.332 1.318 1.273	1.274 1.255 1.271		
1.307 1.317 1.227	1.281 1.267 1.289	1.301 1.301 1.217	1.217 1.213 1.204	
1.250 1.240 1.256	1.280 1.279 1.198	1.209 1.207 1.195	1.202 1.220 1.056	1.033 1.019 .920
1.249 1.238 1.152	1.185 1.176 1.149	1.178 1.198 1.030	1.166 1.172 .947	1.001 1.002 .671
1.061 1.043 .978	1.217 1.218 .950	1.089 1.090 .885	.925 .933 .619	
.986 .982 .740	.893 .896 .585			

TABLE 4.204
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 4500 MWd/tU

5484. 5403. 5695.			REF SPA IND	
5269. 5212. 5026.	5544. 5510. 5778.			
5550. 5508. 5770.	5489. 5459. 5298.	5488. 5431. 5580.		
5188. 5189. 4967.	5444. 5454. 5678.	5256. 5258. 5062.	5083. 5068. 5238.	
5356. 5384. 5581.	5199. 5217. 5022.	5047. 5054. 5222.	4503. 4477. 4303.	3879. 3860. 3946.
5201. 5201. 5027.	4960. 4977. 5116.	4391. 4415. 4257.	4059. 4050. 3996.	2826. 2875. 2894.
4440. 4371. 4417.	4288. 4290. 4084.	3809. 3862. 3944.	2588. 2612. 2706.	
3343. 3340. 3414.	2597. 2602. 2648.			

TABLE 4.205
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 6146 MWd/tU

1.209 1.181 1.238			REF SPA IND	
1.220 1.202 1.195	1.214 1.188 1.242			
1.209 1.185 1.236	1.245 1.222 1.221	1.195 1.179 1.221		
1.193 1.185 1.169	1.185 1.170 1.213	1.191 1.188 1.175	1.115 1.113 1.144	
1.152 1.148 1.182	1.172 1.170 1.151	1.105 1.106 1.134	1.043 1.050 1.023	.870 .877 .882
1.141 1.139 1.115	1.064 1.068 1.088	1.006 1.020 .994	.934 .941 .923	.636 .656 .640
.950 .943 .950	.946 .951 .909	.827 .843 .836	.576 .591 .589	
.708 .709 .701	.560 .567 .557			

TABLE 4.206
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 6146 MWd/tU

1.276 1.244 1.292			REF SPA IND	
1.310 1.288 1.263	1.285 1.252 1.295			
1.277 1.248 1.289	1.316 1.281 1.274	1.271 1.245 1.274		
1.288 1.279 1.236	1.259 1.236 1.266	1.285 1.269 1.226	1.208 1.198 1.193	
1.226 1.213 1.233	1.259 1.248 1.202	1.198 1.190 1.183	1.194 1.202 1.069	1.031 1.026 .920
1.227 1.216 1.156	1.167 1.161 1.135	1.169 1.181 1.039	1.166 1.168 .959	.999 1.008 .671
1.069 1.057 .991	1.207 1.206 .954	1.080 1.084 .877	.929 .939 .618	
.988 .985 .736	.893 .900 .584			

TABLE 4.207
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 6146 MWd/tU

7487. 7393. 7771.			REF SPA IND	
7275. 7205. 6967.	7560. 7513. 7863.			
7559. 7505. 7847.	7539. 7491. 7298.	7459. 7378. 7586.		
7149. 7148. 6866.	7410. 7420. 7713.	7212. 7217. 6973.	6927. 6915. 7139.	
7269. 7308. 7564.	7127. 7150. 6902.	6871. 6890. 7110.	6209. 6179. 5955.	5315. 5289. 5400.
7083. 7078. 6858.	6722. 6750. 6930.	6031. 6070. 5867.	5584. 5569. 5497.	3872. 3935. 3947.
5999. 5897. 5962.	5837. 5835. 5565.	5169. 5241. 5333.	3534. 3566. 3678.	
4502. 4491. 4576.	3514. 3516. 3565.			

TABLE 4.208
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 8200 MWd/tU

1.186 1.150 1.215			REF SPA IND	
1.221 1.188 1.205	1.182 1.154 1.213			
1.179 1.152 1.208	1.233 1.202 1.218	1.166 1.145 1.189		
1.196 1.177 1.180	1.158 1.144 1.188	1.192 1.180 1.179	1.106 1.104 1.132	
1.136 1.127 1.160	1.178 1.167 1.157	1.097 1.099 1.124	1.066 1.070 1.046	.879 .891 .889
1.142 1.136 1.114	1.057 1.061 1.076	1.025 1.040 1.016	.952 .968 .945	.645 .674 .648
.945 .941 .937	.960 .967 .920	.830 .854 .836	.586 .609 .597	
.709 .717 .696	.569 .580 .559			

TABLE 4.209
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 8200 MWd/tU

1.249 1.208 1.269			REF SPA IND	
1.280 1.246 1.265	1.250 1.212 1.268			
1.243 1.210 1.262	1.288 1.243 1.268	1.236 1.203 1.242		
1.258 1.243 1.239	1.228 1.203 1.241	1.254 1.234 1.227	1.191 1.178 1.182	
1.207 1.187 1.212	1.245 1.224 1.205	1.182 1.174 1.173	1.186 1.191 1.091	1.038 1.036 .928
1.214 1.198 1.155	1.153 1.147 1.123	1.164 1.172 1.059	1.170 1.176 .983	1.004 1.022 .680
1.061 1.049 .978	1.194 1.196 .963	1.077 1.089 .878	.931 .955 .627	
.975 .984 .730	.890 .905 .587			

TABLE 4.210
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 8200 MWd/tU

9947. 9820. 10314.			REF SPA IND	
9782. 9673. 9422.	10021. 9954. 10414.			
10013. 9939. 10385.	10085. 10001. 9806.	9883. 9799. 10095.		
9603. 9582. 9267.	9816. 9824. 10205.	9660. 9657. 9386.	9208. 9202. 9489.	
9619. 9667. 9992.	9540. 9553. 9266.	9132. 9161. 9440.	8375. 8336. 8055.	7112. 7091. 7212.
9428. 9417. 9149.	8900. 8944. 9165.	8117. 8166. 7908.	7521. 7502. 7392.	5187. 5282. 5261.
7946. 7835. 7913.	7795. 7789. 7432.	6870. 6972. 7050.	4727. 4780. 4889.	
5958. 5947. 6017.	4673. 4681. 4710.			

TABLE 4.211
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 9912 MWd/tU

1.149 1.126 1.189			REF SPA IND	
1.199 1.173 1.201	1.157 1.128 1.186			
1.148 1.128 1.182	1.215 1.184 1.207	1.140 1.114 1.160		
1.184 1.168 1.181	1.140 1.124 1.167	1.182 1.172 1.178	1.098 1.097 1.124	
1.119 1.113 1.144	1.175 1.163 1.160	1.095 1.094 1.118	1.081 1.084 1.067	.886 .903 .898
1.144 1.133 1.114	1.057 1.058 1.070	1.048 1.056 1.036	.979 .989 .966	.650 .690 .657
.948 .937 .932	.974 .980 .933	.846 .866 .840	.600 .625 .606	
.710 .725 .695	.573 .592 .564			

TABLE 4.212
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 9912 MWd/tU

1.210 1.181 1.244			REF SPA IND	
1.249 1.211 1.255	1.220 1.181 1.240			
1.210 1.181 1.236	1.261 1.213 1.254	1.210 1.167 1.213		
1.231 1.211 1.235	1.204 1.178 1.220	1.234 1.208 1.224	1.173 1.163 1.175	
1.189 1.169 1.196	1.232 1.204 1.206	1.171 1.161 1.168	1.179 1.178 1.110	1.042 1.045 .937
1.202 1.182 1.155	1.147 1.136 1.118	1.165 1.162 1.078	1.179 1.179 1.004	1.012 1.034 .690
1.061 1.040 .974	1.190 1.185 .975	1.093 1.097 .883	.946 .968 .637	
.976 .985 .731	.894 .910 .592			

TABLE 4.213
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 9912 MWd/tU

11945. 11789. 12394.			REF SPA IND	
11854. 11706. 11485.	12023. 11930. 12491.			
12005. 11911. 12454.	12180. 12059. 11892.	11857. 11759. 12130.		
11640. 11598. 11286.	11783. 11782. 12239.	11692. 11678. 11404.	11094. 11091. 11427.	
11549. 11596. 11978.	11554. 11550. 11248.	11008. 11042. 11363.	10212. 10167. 9846.	8623. 8617. 8734.
11385. 11361. 11056.	10709. 10761. 11007.	9892. 9947. 9648.	9174. 9159. 9011.	6296. 6436. 6370.
9566. 9445. 9518.	9450. 9443. 9007.	8305. 8434. 8481.	5742. 5823. 5912.	
7172. 7175. 7208.	5650. 5674. 5667.			

TABLE 4.214
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 13250 MWd/tU

1.115 1.084 1.128			REF SPA IND	
1.171 1.141 1.159	1.114 1.086 1.125			
1.114 1.087 1.126	1.178 1.152 1.165	1.104 1.089 1.122		
1.169 1.145 1.158	1.107 1.091 1.125	1.163 1.155 1.161	1.087 1.083 1.108	
1.104 1.088 1.116	1.167 1.150 1.151	1.081 1.083 1.105	1.101 1.099 1.093	.907 .919 .914
1.145 1.131 1.119	1.058 1.055 1.069	1.065 1.074 1.068	1.005 1.018 1.003	.677 .712 .677
.961 .960 .959	1.004 1.009 .975	.859 .885 .858	.620 .649 .629	
.731 .750 .721	.598 .618 .591			

TABLE 4.215
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 13250 MWd/tU

1.173 1.132 1.181			REF SPA IND	
1.209 1.157 1.205	1.174 1.133 1.178			
1.172 1.134 1.179	1.213 1.176 1.207	1.162 1.137 1.174		
1.207 1.163 1.204	1.170 1.140 1.178	1.200 1.179 1.203	1.151 1.139 1.159	
1.165 1.137 1.168	1.208 1.177 1.193	1.150 1.138 1.157	1.176 1.156 1.134	1.059 1.054 .956
1.198 1.170 1.159	1.139 1.122 1.119	1.156 1.147 1.109	1.180 1.173 1.044	1.027 1.042 .712
1.071 1.057 1.003	1.189 1.178 1.015	1.097 1.111 .903	.958 .980 .661	
.992 1.002 .758	.913 .927 .622			

TABLE 4.216
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 13250 MWd/tU

15724. 15509. 16307.			REF SPA IND	
15810. 15591. 15457.	15812. 15655. 16393.			
15781. 15637. 16348.	16174. 15982. 15884.	15603. 15460. 15971.		
15567. 15475. 15212.	15533. 15503. 16098.	15605. 15576. 15324.	14742. 14739. 15164.	
15258. 15287. 15772.	15464. 15420. 15116.	14639. 14682. 15083.	13853. 13800. 13433.	11616. 11643. 11744.
15205. 15143. 14782.	14239. 14289. 14577.	13419. 13489. 13136.	12485. 12486. 12267.	8511. 8756. 8580.
12752. 12597. 12653.	12752. 12741. 12158.	11152. 11343. 11299.	7777. 7931. 7953.	
9577. 9618. 9549.	7605. 7673. 7570.			

TABLE 4.217
NPP ALMARAZ Cycle 1, Assembly power distribution
Cycle 1 burnup = 15100 MWd/tU

1.100 1.061 1.109			REF SPA IND	
1.148 1.121 1.144	1.091 1.059 1.105			
1.091 1.063 1.107	1.155 1.127 1.145	1.089 1.039 1.085		
1.140 1.132 1.149	1.087 1.072 1.110	1.152 1.140 1.149	1.081 1.076 1.102	
1.089 1.077 1.107	1.156 1.145 1.148	1.080 1.080 1.103	1.109 1.111 1.105	.919 .935 .926
1.142 1.127 1.116	1.058 1.055 1.069	1.073 1.091 1.082	1.017 1.041 1.023	.691 .731 .691
.976 .945 .946	1.027 1.023 .989	.876 .908 .869	.636 .669 .643	
.750 .759 .727	.614 .631 .601			

TABLE 4.218
NPP ALMARAZ Cycle 1, Peak assembly power distribution
Cycle 1 burnup = 15100 MWd/tU

1.157 1.108 1.162			**REF** **SPA** **IND**	
1.184 1.138 1.187	1.155 1.106 1.158			
1.149 1.111 1.160	1.186 1.153 1.185	1.144 1.087 1.137		
1.175 1.152 1.192	1.149 1.122 1.163	1.184 1.168 1.190	1.146 1.127 1.155	
1.147 1.125 1.160	1.191 1.171 1.188	1.140 1.130 1.156	1.173 1.163 1.145	1.067 1.065 .969
1.189 1.165 1.157	1.133 1.118 1.120	1.153 1.157 1.122	1.177 1.185 1.064	1.033 1.061 .727
1.080 1.036 .991	1.189 1.178 1.028	1.108 1.138 .916	.966 1.001 .676	
1.011 1.007 .765	.930 .934 .633			

TABLE 4.219
NPP ALMARAZ Cycle 1, Assembly burnup distribution
Cycle 1 burnup = 15100 MWd/tU

17773. 17515. 18394.			**REF** **SPA** **IND**	
17956. 17702. 17602.	17852. 17664. 18475.			
17821. 17648. 18431.	18332. 18114. 18038.	17631. 17474. 18047.		
17702. 17593. 17354.	17563. 17521. 18179.	17746. 17713. 17471.	16748. 16742. 17213.	
17286. 17299. 17836.	17612. 17548. 17246.	16638. 16685. 17128.	15898. 15833. 15455.	13304. 13344. 13435.
17320. 17236. 16852.	16196. 16240. 16555.	15397. 15476. 15113.	14356. 14369. 14122.	9776. 10073. 9832.
14544. 14373. 14427.	14631. 14608. 13961.	12757. 12981. 12887.	8939. 9131. 9117.	
10947. 11005. 10883.	8726. 8817. 8664.			

TABLE 4.220
NPP ALMARAZ Cycle 2, Critical boron concentration comparison
Absolute error for boron concentration (ppm)

BURNUP (MWd/tU)	REF	SPA	IND
0.	1212.	-11.	24.
212.	771.	-1.	0.
1863.	616.	-20.	-23.
4461.	363.	-23.	-24.
6589.	155.	-19.	-21.
8436.	14.	-20.	-21.

TABLE 4.221
NPP ALMARAZ Cycle 2, Axial offset comparison

BURNUP (MWd/tU)	REF	SPA	IND
0.	58.1	50.9	-
212.	3.7	2.2	-
1863.	-1.9	-1.4	-
4461.	-3.3	-2.2	-
6589.	-4.3	-2.2	-
8436.	-1.8	-1.3	-

TABLE 4.222
NPP ALMARAZ Cycle 2, Maximum assembly
power comparison

BURNUP (MWD/tU)	REF	SPA	IND
0.	1.331	1.277	1.540
212.	1.255	1.258	1.330
1863.	1.272	1.251	1.292
4461.	1.249	1.236	1.238
6589.	1.212	1.218	1.194
8436.	1.192	1.202	1.191

TABLE 4.223
NPP ALMARAZ Cycle 1, Power peaking
factor comparison

BURNUP (MWd/tU)	REF	SPA	IND
0.	1.463	1.399	-
212.	1.367	1.371	-
1863.	1.380	1.359	-
4461.	1.350	1.337	-
6589.	1.311	1.312	-
8436.	1.287	1.294	-

TABLE 4.224
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 0 MWd/tU

.728 .760 .662			REF SPA IND	
.907 .934 .818	1.067 1.092 .972			
1.172 1.180 1.103	1.056 1.074 .977	1.160 1.190 1.101		
.987 .995 .947	1.163 1.172 1.146	1.063 1.090 1.056	1.200 1.222 1.242	
.898 .922 .905	1.081 1.094 1.096	1.195 1.203 1.260	.967 .977 .987	1.002 1.003 1.034
.877 .873 .910	.827 .813 .890	.951 .936 .978	1.015 1.004 1.079	.729 .743 .780
1.007 .970 1.086	1.331 1.277 1.536	1.056 1.038 1.198	.695 .690 .777	
.958 .928 1.141	.788 .764 .927			

TABLE 4.225
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 0 MWd/tU

.765 .785 .694			REF SPA IND	
1.016 1.037 .860	1.191 1.206 1.024			
1.250 1.252 1.161	1.150 1.167 1.027	1.240 1.273 1.160		
1.058 1.072 .996	1.288 1.283 1.207	1.135 1.160 1.110	1.285 1.291 1.307	
.961 .997 .951	1.195 1.206 1.155	1.302 1.288 1.326	1.060 1.078 1.038	1.078 1.085 1.088
.936 .918 .958	.918 .879 .932	1.019 1.003 1.029	1.109 1.085 1.135	1.080 1.100 .817
1.085 1.033 1.143	1.463 1.399 1.608	1.349 1.321 1.255	1.086 1.077 .814	
1.272 1.216 1.195	1.242 1.198 .971			

TABLE 4.226
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 0 MWd/tU

16749. 16749. 16749.			REF SPA IND	
17879. 17879. 17696.	14664. 14664. 14545.			
11092. 11092. 11110.	15671. 15671. 15466.	14534. 14534. 14776.		
17867. 17867. 17823.	12952. 12952. 12925.	16220. 16220. 16212.	10001. 10001. 10029.	
17988. 17988. 17731.	14878. 14878. 15103.	9094. 9094. 9199.	18015. 18015. 18039.	9999. 9999. 10067.
17591. 17591. 17770.	17775. 17775. 17638.	18615. 18615. 18510.	8867. 8867. 8596.	0. 0. 0.
18186. 18186. 18066.	0. 0. 0.	0. 0. 0.	0. 0. 0.	
0. 0. 0.	0. 0. 0.			

TABLE 4.227
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 212 MWd/tU

.789 .791 .782			REF SPA IND	
.958 .943 .915	1.109 1.084 1.051			
1.185 1.163 1.154	1.080 1.058 1.034	1.161 1.152 1.118		
1.010 .991 .991	1.170 1.151 1.157	1.069 1.073 1.070	1.193 1.204 1.218	
.928 .930 .931	1.090 1.085 1.088	1.176 1.192 1.220	.973 .982 .984	1.000 1.018 1.014
.904 .895 .898	.850 .839 .877	.954 .949 .949	1.007 1.020 1.035	.741 .767 .771
.985 .963 .977	1.255 1.258 1.328	1.020 1.036 1.080	.695 .713 .741	
.925 .923 .988	.766 .770 .816			

TABLE 4.228
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 212 MWd/tU

.831 .820 .819			REF SPA IND	
1.061 1.039 .963	1.215 1.187 1.108			
1.267 1.235 1.215	1.163 1.146 1.087	1.242 1.232 1.178		
1.086 1.066 1.043	1.277 1.254 1.219	1.139 1.146 1.125	1.268 1.276 1.282	
1.005 1.000 .980	1.185 1.180 1.147	1.270 1.271 1.283	1.064 1.076 1.035	1.080 1.091 1.067
.952 .937 .944	.919 .898 .919	1.015 1.015 .998	1.087 1.094 1.089	1.075 1.108 .809
1.044 1.023 1.028	1.367 1.371 1.392	1.283 1.297 1.133	1.060 1.084 .777	
1.195 1.194 1.036	1.169 1.176 .855			

TABLE 4.229
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 212 MWd/tU

16910. 16913. 16907.			REF SPA IND	
18077. 18077. 17884.	14895. 14893. 14763.			
11342. 11338. 11352.	15897. 15895. 15682.	14780. 14778. 15011.		
18079. 18076. 18030.	13199. 13196. 13170.	16446. 16448. 16438.	10255. 10257. 10289.	
18182. 18184. 17926.	15108. 15108. 15334.	9345. 9347. 9460.	18221. 18223. 18248.	10211. 10215. 10284.
17780. 17779. 17960.	17953. 17951. 17824.	18817. 18816. 18713.	9081. 9084. 8818.	156. 162. 164.
18397. 18390. 18278.	274. 269. 293.	220. 221. 236.	147. 151. 159.	
200. 197. 217.	165. 164. 179.			

TABLE 4.230
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 1863 MWd/tU

.798 .804 .813			REF SPA IND	
.949 .947 .937	1.086 1.083 1.067			
1.156 1.157 1.158	1.048 1.055 1.043	1.145 1.150 1.125		
.990 .991 .997	1.132 1.144 1.153	1.056 1.066 1.067	1.174 1.194 1.203	
.935 .938 .937	1.085 1.085 1.084	1.170 1.185 1.203	.974 .980 .979	1.003 1.018 1.008
.922 .907 .900	.863 .849 .877	.960 .951 .943	1.016 1.021 1.024	.754 .775 .771
1.011 .968 .967	1.271 1.251 1.290	1.033 1.034 1.057	.703 .719 .737	
.953 .923 .966	.794 .770 .799			

TABLE 4.231
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 1863 MWd/tU

.841 .834 .852			REF SPA IND	
1.041 1.038 .985	1.185 1.183 1.125			
1.232 1.228 1.220	1.129 1.141 1.097	1.222 1.228 1.186		
1.063 1.062 1.048	1.237 1.244 1.215	1.125 1.139 1.123	1.253 1.266 1.267	
1.006 1.006 .986	1.166 1.172 1.143	1.256 1.264 1.267	1.063 1.070 1.030	1.081 1.089 1.061
.979 .949 .947	.927 .904 .919	1.016 1.015 .992	1.102 1.094 1.078	1.087 1.111 .809
1.071 1.025 1.017	1.379 1.359 1.354	1.296 1.289 1.109	1.070 1.085 .773	
1.237 1.190 1.014	1.188 1.165 .839			

TABLE 4.232
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 1863 MWd/tU

18220. 18224. 18213.			REF SPA IND	
19651. 19635. 19406.	16707. 16682. 16509.			
13275. 13258. 13262.	17654. 17642. 17396.	16684. 16681. 16863.		
19730. 19713. 19671.	15100. 15095. 15081.	18201. 18217. 18206.	12208. 12242. 12298.	
19720. 19723. 19467.	16903. 16901. 17129.	11282. 11313. 11469.	19828. 19843. 19872.	11865. 11896. 11957.
19287. 19261. 19442.	19367. 19340. 19271.	20397. 20383. 20276.	10751. 10768. 10523.	1390. 1431. 1437.
20045. 19981. 19884.	2360. 2343. 2465.	1915. 1930. 2006.	1302. 1329. 1379.	
1750. 1720. 1835.	1453. 1434. 1514.			

TABLE 4.233
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 4461 MWd/tU

.823 .824 .856			REF SPA IND	
.960 .954 .967	1.097 1.082 1.088			
1.155 1.147 1.165	1.053 1.047 1.056	1.135 1.138 1.128		
1.001 .989 1.009	1.141 1.132 1.152	1.049 1.055 1.067	1.162 1.179 1.190	
.950 .946 .951	1.093 1.084 1.084	1.160 1.174 1.189	.974 .980 .982	1.009 1.022 1.008
.936 .922 .907	.876 .861 .882	.957 .955 .941	1.016 1.026 1.018	.770 .791 .777
.994 .969 .949	1.249 1.236 1.236	1.019 1.033 1.028	.718 .735 .735	
.935 .926 .935	.781 .776 .776			

TABLE 4.234
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 4461 MWd/tU

.864 .854 .897			REF SPA IND	
1.049 1.039 1.018	1.187 1.174 1.148			
1.229 1.217 1.228	1.132 1.129 1.111	1.205 1.211 1.191		
1.069 1.056 1.063	1.234 1.226 1.216	1.116 1.126 1.123	1.235 1.251 1.255	
1.017 1.010 1.002	1.168 1.161 1.144	1.245 1.252 1.253	1.057 1.064 1.034	1.083 1.088 1.062
.983 .962 .955	.940 .914 .925	1.020 1.018 .991	1.097 1.098 1.072	1.097 1.116 .816
1.053 1.025 1.000	1.350 1.337 1.299	1.267 1.273 1.080	1.069 1.090 .772	
1.204 1.183 .982	1.166 1.154 .815			

TABLE 4.235
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 4461 MWd/tU

20326. 20323. 20349.			REF SPA IND	
22131. 22097. 21855.	19542. 19492. 19289.			
16277. 16254. 16271.	20383. 20373. 20110.	19646. 19655. 19780.		
22316. 22284. 22265.	18053. 18057. 18073.	20935. 20978. 20975.	15243. 15333. 15412.	
22168. 22164. 21908.	19732. 19720. 19942.	14308. 14384. 14584.	22360. 22391. 22416.	14479. 14547. 14575.
21701. 21628. 21784.	21626. 21554. 21553.	22888. 22859. 22725.	13392. 13427. 13180.	3370. 3456. 3446.
22649. 22496. 22386.	5634. 5586. 5789.	4582. 4618. 4739.	3147. 3209. 3295.	
4204. 4122. 4331.	3498. 3440. 3580.			

TABLE 4.236
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 6589 MWd/tU

.848 .844 .893			REF SPA IND	
.976 .963 .994	1.108 1.085 1.108			
1.160 1.144 1.177	1.058 1.045 1.071	1.134 1.132 1.136		
1.008 .992 1.024	1.142 1.126 1.158	1.050 1.050 1.073	1.160 1.170 1.186	
.960 .955 .966	1.095 1.085 1.090	1.160 1.167 1.183	.981 .981 .986	1.016 1.025 1.008
.945 .932 .915	.885 .870 .888	.962 .957 .941	1.021 1.028 1.013	.781 .803 .779
.978 .965 .934	1.212 1.218 1.192	1.007 1.026 1.002	.724 .744 .731	
.913 .922 .905	.764 .776 .755			

TABLE 4.237
NPP ALMARAZ Cycle 2, Peak assembly power distribution
Cycle 2 burnup = 6589 MWd/tU

.889 .874 .936			REF SPA IND	
1.063 1.044 1.048	1.192 1.171 1.170			
1.233 1.213 1.242	1.135 1.123 1.128	1.200 1.201 1.200		
1.077 1.056 1.079	1.232 1.216 1.223	1.116 1.119 1.131	1.233 1.241 1.252	
1.030 1.016 1.018	1.168 1.155 1.151	1.244 1.244 1.248	1.060 1.061 1.040	1.091 1.087 1.063
.987 .970 .964	.942 .919 .932	1.025 1.019 .993	1.100 1.098 1.068	1.101 1.117 .820
1.033 1.021 .985	1.311 1.312 1.255	1.244 1.253 1.053	1.068 1.088 .769	
1.169 1.168 .952	1.131 1.137 .794			

TABLE 4.238
NPP ALMARAZ Cycle 2, Assembly burnup distribution
Cycle 2 burnup = 6589 MWd/tU

22103. 22085. 22192.			REF SPA IND	
24191. 24130. 23929.	21887. 21792. 21616.			
18740. 18692. 18758.	22629. 22597. 22365.	22060. 22069. 22184.		
24454. 24389. 24420.	20482. 20460. 20528.	23168. 23219. 23249.	17713. 17835. 17943.	
24200. 24182. 23940.	22060. 22026. 22252.	16777. 16879. 17110.	24440. 24477. 24507.	16633. 16724. 16719.
23702. 23596. 23718.	23499. 23392. 23433.	24930. 24891. 24728.	15559. 15611. 15343.	5021. 5148. 5102.
24747. 24556. 24395.	8253. 8209. 8394.	6738. 6817. 6912.	4682. 4780. 4857.	
6171. 6095. 6302.	5141. 5094. 5220.			

TABLE 4.239
NPP ALMARAZ Cycle 2, Assembly power distribution
Cycle 2 burnup = 8436 MWd/tU

.861 .858 .909			REF SPA IND	
.994 .971 1.005	1.107 1.088 1.113			
1.162 1.143 1.178	1.053 1.043 1.072	1.128 1.113 1.126		
1.013 .995 1.030	1.138 1.124 1.159	1.046 1.047 1.073	1.159 1.167 1.184	
.969 .962 .976	1.097 1.087 1.094	1.160 1.166 1.182	.986 .986 .992	1.024 1.030 1.013
.946 .937 .921	.886 .876 .895	.967 .960 .946	1.029 1.032 1.016	.792 .812 .783
.968 .948 .922	1.192 1.202 1.172	1.003 1.023 .990	.731 .752 .731	
.901 .914 .890	.756 .773 .744			

TABLE 4.240

NPP ALMARAZ Cycle 2, Peak assembly power distribution

Cycle 2 burnup = 8436 MWd/tU

.908 .888 .953			REF SPA IND	
1.067 1.047 1.060	1.191 1.168 1.177			
1.234 1.211 1.245	1.129 1.117 1.131	1.192 1.178 1.190		
1.079 1.057 1.087	1.227 1.208 1.224	1.113 1.116 1.132	1.232 1.239 1.251	
1.034 1.021 1.029	1.170 1.153 1.157	1.246 1.242 1.249	1.064 1.062 1.046	1.098 1.091 1.069
.989 .973 .972	.941 .922 .939	1.033 1.023 .998	1.109 1.101 1.071	1.110 1.120 .823
1.025 1.003 .972	1.287 1.294 1.235	1.233 1.246 1.043	1.070 1.088 .769	
1.151 1.152 .937	1.111 1.120 .783			

TABLE 4.241

NPP ALMARAZ Cycle 2, Assembly burnup distribution

Cycle 2 burnup = 8436 MWd/tU

23682. 23651. 23852.			REF SPA IND	
26000. 25912. 25772.	23932. 23796. 23666.			
20883. 20803. 20932.	24579. 24526. 24346.	24149. 24155. 24284.		
26321. 26222. 26315.	22588. 22537. 22667.	25104. 25157. 25231.	19855. 19992. 20132.	
25982. 25948. 25730.	24084. 24029. 24266.	18920. 19033. 19293.	26256. 26289. 26331.	18518. 18617. 18582.
25448. 25321. 25412.	25134. 25004. 25078.	26711. 26659. 26468.	17452. 17510. 17213.	6474. 6635. 6542.
26543. 26339. 26120.	10473. 10452. 10584.	8593. 8713. 8754.	6026. 6159. 6207.	
7846. 7798. 7967.	6544. 6529. 6610.			

TABLE 4.242
NPP ALMARAZ Cycle 1, Control Bank Worth Comparison

Control Bank In	Control Bank Worth(pcm)		
	REF	SPA	IND
D(Ref)	1394.	1424.	1387.
C(D-IN)	1192.	1229.	1146.
B(D+C-IN)	1964.	1977.	1860.
A(D+C+B-IN)	1253.	1154.	1449.
SB(D+C+B+A-IN)	1022.	1048.	997.
All but H-14	7697.	-	7285.

TABLE 4.243
NPP ALMARAZ Cycle 2, Control Bank Worth Comparison

Control Bank In	Control Bank Worth(pcm)		
	REF	SPA	IND
B(Ref)	1203.	1277.	1199.
D	1184.	1193.	1146.
SB	995.	1061.	772.
C	939.	992.	744.
SA	747.	746.	858.
A	613.	591.	882.

TABLE 4.244
NPP ALMARAZ Cycle 1, Axial power distribution comparison

AXIAL HEIGHT (%)	REF MAP-01	SPA	REF MAP-12	SPA	REF MAP-31	SPA
0.0000	0.181	0.120	0.305	0.276	0.488	0.521
1.7544	0.203	0.206	0.356	0.397	0.578	0.704
3.5088	0.295	0.291	0.490	0.509	0.759	0.850
5.2631	0.386	0.374	0.614	0.613	0.871	0.956
7.0175	0.472	0.454	0.725	0.709	0.975	1.030
8.7719	0.550	0.533	0.822	0.797	1.054	1.075
10.5263	0.631	0.608	0.906	0.878	1.097	1.102
12.2806	0.705	0.681	0.978	0.950	1.125	1.113
14.0350	0.772	0.751	1.036	1.016	1.134	1.113
15.7894	0.823	0.818	1.070	1.074	1.106	1.107
17.5438	0.836	0.881	1.052	1.126	1.029	1.097
19.2982	0.962	0.942	1.178	1.172	1.116	1.084
21.0525	1.048	0.998	1.242	1.212	1.125	1.070
22.8069	1.113	1.052	1.283	1.246	1.117	1.056
24.5613	1.171	1.101	1.313	1.276	1.116	1.043
26.3157	1.222	1.148	1.334	1.301	1.105	1.030
28.0700	1.260	1.191	1.343	1.322	1.090	1.019
29.8244	1.279	1.230	1.333	1.338	1.057	1.009
31.5788	1.227	1.266	1.245	1.352	0.967	1.000
33.3332	1.353	1.299	1.350	1.361	1.037	0.993
35.0876	1.419	1.328	1.386	1.368	1.055	0.987
36.8420	1.460	1.354	1.396	1.372	1.048	0.982
38.5964	1.491	1.377	1.400	1.374	1.052	0.978
40.3507	1.508	1.396	1.395	1.372	1.048	0.975
42.1051	1.514	1.412	1.383	1.369	1.040	0.974
43.8595	1.496	1.425	1.355	1.364	1.019	0.973
45.6139	1.403	1.435	1.247	1.356	0.938	0.973
47.3682	1.500	1.441	1.321	1.347	1.006	0.974
49.1226	1.543	1.444	1.347	1.336	1.035	0.975
50.8770	1.550	1.444	1.343	1.323	1.036	0.978
52.6314	1.547	1.441	1.331	1.308	1.049	0.981
54.3857	1.531	1.434	1.312	1.292	1.051	0.985
56.1401	1.504	1.425	1.286	1.274	1.050	0.990
57.8945	1.454	1.412	1.248	1.254	1.039	0.996
59.6489	1.330	1.395	1.144	1.233	0.966	1.003
61.4033	1.383	1.376	1.180	1.210	1.018	1.010
63.1577	1.391	1.353	1.193	1.185	1.066	1.019
64.9120	1.363	1.327	1.175	1.159	1.072	1.029
66.6664	1.325	1.298	1.150	1.130	1.091	1.040
68.4208	1.279	1.265	1.119	1.100	1.098	1.051
70.1752	1.223	1.229	1.083	1.067	1.102	1.063
71.9296	1.150	1.189	1.034	1.032	1.095	1.076
73.6839	1.015	1.146	0.938	0.995	1.028	1.090
75.4383	1.015	1.100	0.927	0.955	1.061	1.103
77.1927	0.984	1.050	0.924	0.912	1.117	1.115
78.9471	0.927	0.997	0.885	0.866	1.121	1.125
80.7015	0.863	0.940	0.839	0.817	1.126	1.132
82.4558	0.792	0.880	0.787	0.765	1.117	1.136
84.2102	0.713	0.816	0.727	0.709	1.098	1.133
85.9646	0.626	0.750	0.656	0.649	1.061	1.121
87.7190	0.512	0.680	0.558	0.582	0.966	1.099
89.4734	0.459	0.607	0.498	0.512	0.913	1.060
91.2277	0.395	0.531	0.449	0.443	0.898	1.004
92.9821	0.319	0.453	0.380	0.375	0.812	0.924
94.7365	0.248	0.373	0.307	0.308	0.709	0.817
96.4909	0.182	0.291	0.235	0.241	0.588	0.670
98.2453	0.135	0.206	0.176	0.171	0.489	0.502
100.0000	0.100	0.120	0.127	0.101	0.442	0.300

TABLE 4.245
NPP ALMARAZ Cycle 2, Axial power distribution comparison

AXIAL HEIGHT (%)	REF MAP-01	SPA	REF MAP-07	SPA	REF MAP-17	SPA
0.0000	0.070	0.083	0.425	0.457	0.593	0.582
1.7544	0.099	0.135	0.468	0.614	0.574	0.740
3.5088	0.113	0.180	0.631	0.740	0.771	0.861
5.2631	0.154	0.217	0.756	0.834	0.907	0.938
7.0175	0.188	0.249	0.849	0.902	0.996	0.985
8.7719	0.216	0.276	0.917	0.948	1.054	1.009
10.5263	0.238	0.300	0.963	0.979	1.087	1.022
12.2806	0.259	0.321	0.992	0.999	1.104	1.024
14.0350	0.278	0.341	1.008	1.011	1.105	1.023
15.7894	0.292	0.359	0.995	1.019	1.084	1.019
17.5438	0.303	0.378	0.927	1.022	0.972	1.014
19.2982	0.300	0.397	1.015	1.024	1.058	1.010
21.0525	0.335	0.417	1.040	1.024	1.092	1.006
22.8069	0.361	0.437	1.048	1.023	1.093	1.003
24.5613	0.384	0.459	1.050	1.023	1.090	1.001
26.3157	0.406	0.482	1.050	1.023	1.085	1.000
28.0700	0.428	0.506	1.046	1.023	1.077	0.999
29.8244	0.451	0.531	1.029	1.023	1.055	1.000
31.5788	0.467	0.559	0.939	1.024	0.945	1.001
33.3332	0.471	0.587	1.030	1.026	1.045	1.003
35.0876	0.531	0.618	1.055	1.027	1.076	1.005
36.8420	0.578	0.649	1.062	1.029	1.081	1.007
38.5964	0.617	0.683	1.065	1.031	1.081	1.010
40.3507	0.657	0.717	1.066	1.033	1.078	1.012
42.1051	0.699	0.753	1.063	1.035	1.071	1.015
43.8595	0.738	0.791	1.046	1.038	1.050	1.017
45.6139	0.762	0.830	0.959	1.040	0.948	1.020
47.3682	0.773	0.870	1.057	1.042	1.044	1.022
49.1226	0.868	0.912	1.084	1.045	1.075	1.024
50.8770	0.945	0.956	1.093	1.047	1.082	1.026
52.6314	1.004	1.000	1.098	1.050	1.084	1.028
54.3857	1.065	1.046	1.102	1.053	1.082	1.030
56.1401	1.124	1.094	1.101	1.056	1.077	1.032
57.8945	1.178	1.143	1.086	1.059	1.051	1.034
59.6489	1.218	1.194	1.001	1.063	0.946	1.035
61.4033	1.204	1.246	1.099	1.067	1.052	1.037
63.1577	1.358	1.300	1.131	1.071	1.079	1.039
64.9120	1.462	1.355	1.144	1.076	1.085	1.041
66.6664	1.544	1.413	1.153	1.081	1.087	1.044
68.4208	1.617	1.471	1.158	1.087	1.087	1.047
70.1752	1.690	1.531	1.161	1.094	1.083	1.051
71.9296	1.753	1.592	1.150	1.100	1.060	1.056
73.6839	1.792	1.653	1.059	1.107	0.959	1.061
75.4383	1.731	1.714	1.161	1.114	1.065	1.067
77.1927	1.920	1.774	1.193	1.120	1.097	1.073
78.9471	2.029	1.832	1.201	1.125	1.101	1.080
80.7015	2.088	1.884	1.201	1.128	1.101	1.087
82.4558	2.127	1.930	1.189	1.128	1.091	1.093
84.2102	2.142	1.964	1.166	1.122	1.074	1.096
85.9646	2.134	1.983	1.121	1.110	1.035	1.096
87.7190	2.066	1.982	0.992	1.088	0.907	1.091
89.4734	1.869	1.948	1.014	1.051	0.947	1.073
91.2277	1.878	1.882	0.961	0.999	0.913	1.044
92.9821	1.776	1.763	0.863	0.924	0.824	0.990
94.7365	1.575	1.588	0.729	0.823	0.701	0.906
96.4909	1.298	1.324	0.571	0.677	0.570	0.767
98.2453	0.997	1.016	0.479	0.509	0.524	0.601
100.0000	0.839	0.634	0.395	0.303	0.479	0.388

5. SUMMARY AND RECOMMENDATIONS

The benchmark parameters, consisting of core description and fuel assembly data for cycle 1 and cycle 2 of NPP Almaraz have been prepared to validate the code packages for in-core fuel management calculations of PWR reactors.

Six different code packages for PWR in-core fuel management calculations are benchmarked within CRP on In-Core Fuel Management Code Package Validation, i.e., SUPERB-AKHILESH code package from Bhabha Atomic Research Centre (India), JEN-UPM code package from Universidad Politecnica de Madrid (Spain), GELS-GEREBUS code system from Cekmece Nuclear Research and Training Centre (Turkey), PFMP/RBI code package from Rugjer Boskovic Institute (Croatia), WIMS-D/4.1-OSCAR2 code package from Atomic Energy Corporation of South Africa Limited (South Africa), and WIMS-D/4-VAMPIR code package from Boris Kidric Institute of Nuclear Sciences (Serbia).

The GELS-GEREBUS code system from Cekmece Nuclear Research and Training Centre (Turkey), the PFMP/RBI code package from Rugjer Boskovic Institute (Croatia), the WIMS-D/4.1-OSCAR2 code package from Atomic Energy Corporation of South Africa Limited (South Africa), and the WIMS-D/4-VAMPIR code package from Boris Kidric Institute of Nuclear Sciences (Serbia) are level II code packages(scoping and survey-type calculations). The SUPERB-AKHILESH code package from Bhabha Atomic Research Centre (India) and the JEN-UPM code package from Universidad Politecnica de Madrid (Spain) are level III code packages (sufficently accurate for actual reactor design and operation).

The benchmark calculations of all participants are presented and global calculation results are compared against the reference data(measurements). Discrepancies between calculational results and reference data are discussed.

The benchmark parameters presented in this document could be used to validate other incore fuel management package. The potential user could also compare his results with results of CRP participants in order to find out how well his code package calculates incore fuel management parameters.

REFERENCES

[1] IN-CORE FUEL MANAGEMENT PROGRAMS FOR NUCLEAR POWER REACTORS, Final Report of CRP on Codes Adaptable to Small or Medium Size Computers, IAEA-TECDOC-314, Vienna, 1984.

[2] CONSULTANTS REPORT ON IN-CORE FUEL MANAGEMENT ASPECTS OF NUCLEAR POWER REACTORS AND RELATED CORE PHYSICAL MATTERS, Doc. IFM-6, Vienna, December 1987.

[3] CONSULTANTS REPORT ON BENCHMARK FOR IN-CORE FUEL MANAGEMENT PROGRAMS RELATED TO CORE PHYSICS, Ljubljana, May 1988.

[4] C. AHNERT, J.M. ARAGONES, F. MERINO, PWR BENCHMARK PARAMETERS - ALMARAZ POWER PLANT, Circular letter to participants of the CRP on In-core Fuel Management Validation for LWR, April 1989.

[5] REPORT OF TECHNICAL COMMITTEE MEETING ON LWR CORE DESIGN PARAMETERS, 622-I3-TC-676.5, Rez, October 1991.

[6] Reference Safety Analysis Report. RESAR-3. DOCKET-RESARA. Amendment 3 (1973).

[7] FSAR. Central Nuclear Almaraz.

[8] Reactor Core Physics Design and operating Data for Cycles 1 and 2 of the Zion Unit 2. PWR Power Plant. EPRI-NP-1232 and -4148.

[9] Turkey Point Power Plant. EPRI-NP-827 (1978).

[10] Almaraz Startup Report - Cycle 2.

[11] Almaraz Reload Safety Evaluation Report- Cycle 2.

[12] D.D. Lanning et al., "Calculated Data, GAPCON-THERMAL Code", Pacific Northwest Laboratory, PNL-2434, (1978).

[13] A.J. Harrys and K.A. Jones, "The INCORE-3 Program", Westinghouse Electric Corporation, WCAP-8492 (1975).

[14] J.M. Aragones, C. Ahnert, "The generalized synthetic diffusion method. Implementation in the SEANAP code system and validation for PWR core analysis" Nuclear Espana. International ISSUE. 1987.

[15] V. Jagannathan et al., Annals of Nuclear Energy, I, p. 641 (1980).

[16] S.R. Dwivedi et al., Report B.A.R.C.-864. (1976)

[17] H.C. Huria, Atomkernenergie 31, 87 (1978)

[18] P. Mohanakrishnan and H.C. Huria, Nucl. Sci. Engg., 68, P.220. (1978)

[19] F.J. Fayers et al., Report, AEEW-R-785 (1972)

[20] R.P. Jain and V. Jagannathan, Report B.A.R.C./I-718 (1982).

[21] J.M. Aragones, C. Ahnert y otros, "Validation of the pressurized water reactor core analysis system SEANAP-86 with measurements in tests and operation". Nuc. Sci & Eng. 100, 1988.

[22] A. Crespo, J.M. Aragones y otros, "Pin power and burnup calculation by the SEANAP PWR core analysis system". ANS Topical Meeting, Jackson Hole 1988.

[23] C. AHNERT and J.M. ARAGONES, "Fuel Management and Core Design Code Systems for PWR Neutronic Calculations", Nucl. Technol., 69, 350 (1985).

[24] J.M. ARAGONES and C. AHNERT, "A Linear Discontinuous Finite Difference Fomulation for Synthetic Coarse-Mesh Few-Group Diffusion Calculations", Nucl. Sci. Eng., 94, 309 (1986).

[25] J.M. ARAGONES, J.M. MARTINEZ-VAL and M.R. CORELLA, "Core-State Models for Fuel Management of Equilibrium and Transition Cycles in Pressurized Water Reactors", Nucl. Technol., 34, 398 (1977).

[26] M.J. HALSALL, "A Summary of WIMS-D4 Input", AEEW-M-1327, U.K. Atomic Energy Establishment, Winfrith (1980).

[27] K. Penndorf, F. Schult, G. Schulz, " The PWR Spectral Code GELS", GKSS-76/E/21 (1976).

[28] M. Console, A. Daneri and E. Salina, "EREBUS: A Multigroup Difusion Depletion Programme in Two Dimensions", FN-E-88, (FIAT, 67).

[29] J. Adir and K.D. Lathrop, "Theory of Methods Used in the GGC-4 Multigroup Cross Section Code", GA-9021 (1968).

[30] Levine, S.H. and S.S. Kim, "PSU-LEOPARD, User's Manual", The Pennsylvania State University, Breazeale Nuclear Reactor, University Park, PA 16802, 1984.

[31] Huang, H.Y., Colletti, J.P., Kodah, Z.H. and S.S. Kim, "User's Guide, MCRAC-Multiple Cycle Reactor Analysis Code", 315-497991, The

Pennsylvania State University, Breazeale Nuclear Reactor, University Park, PA 16802, 1981.

[32] B. G. Petrović, D. Pevec and T. Šmuc, "PSU-LEOPARD/RBI, Version 91.1: User's Guide", Rudjer Bošković Institute, 1991.

[33] B. G. Petrović, D. Pevec and T. Šmuc, "MCRAC/RBI, Version 91.1: User's Guide", Rudjer Bošković Institute, 1991.

[34] D. Pevec, "In-Core Fuel Management: PWR Constants Generation Using PSU-LEOPARD Code", Workshop on Reactor Physics Calculations for Applications in Nuclear Technology, p. 328-359, World Scientific Publishing Company, Singapore, 1991.

[35] B. G. Petrović, "In-Core Fuel Management: PWR Core Calculations Using MCRAC Code", Workshop on Reactor Physics Calculations for Applications in Nuclear Technology, p. 360-398, World Scientific Publishing Company, Singapore, 1991.

[36] W.R. JOUBERT: "An Update of the Cell Code WIMSD4 (WIMSD4.1)", Report PEL 294 (1990).

[37] A.L. GRAHAM: "TABASCO: A Correlative Thermal-Hydraulics Code for PWR Fuel Rod Calculation", Internal Report RTE01-2/2-003 of the Reactor Theory Division of the AEC of S. Africa (1987).

[38] E.Z. MUELLER, H. RAS and G. BALL: "An Update of the WIMS-E Data Processing Routines (WEDRO-1.1)", Report PEL 296 (1990).

[39] E.Z. MUELLER: Nucl.Sci.Eng., 103, 359 (1989); see also: E.Z. MUELLER: "Reflector Modeling in Advanced Nodal Analysis of Pressurized Water Reactors", IAEA Specialist Mtg. on Advanced Calculation Methods for Power Reactors, Cadarache, France, 10-14 September 1990.

[40] E.Z. MUELLER: "A Note on the Approximate Diagonalization of the Diffusion Coefficient Matrix of the NGET-RM Nodal Reflector Model", Report PEL-297 (1990).

[41] D.R. VONDY, T.B. FOWLER and G.W. CUNNINGHAM: "The BOLD VENTURE Computation System for Nuclear Reactor Core Analysis, Version III", Report ORNL-5711 (1981).

[42] D.L. VOGEL: "*Technical Report for the PANIC 1.0 Nodal* Analysis Program", Internal Report RTE01-2/2-073 of the Reactor Theory Division of the AEC of S. Africa (1990).

[43] I. Zmijarevic, I. Petrovic, VAMPIR - TWOGROUP TWODIMENSIONAL DIFFUSION PROGRAM FOR FUEL BURNUP PREDICTION IN REACTOR CORE, XXIX Yugoslav Conf. of ETAN, Vol. IX, pp. 67, 1985.

ABBREVIATIONS AND DEFINITIONS

abbreviation/ definition	description	comments
ARI	all control rods fully inserted	
ARO	all control rods completely withdrawn from the active core	
HFP	hot full power conditions	steady state, 100% of rated power
HZP	hot zero power conditions	
No Xe	xenon free conditions	
Eq Xe	stationary Xe conditions at normal operation	
C_B	concentration of natural boron in coolant (ppm) ppm = 10^{-4} w/o	chemical solution of boric acid in water
$C_{B,crit}$	C_B at which reactor is critical	
BOC	beginning of cycle	
BU	burnup, i.e. total thermal energy released in MWd per 1000 kg of U initially loaded, (MWd/tU)	
EOC	end of cycle	
cycle length	core average BU at EOC minus core average BU at BOC	
k_{inf}	infinite medium multiplication factor	
k_{eff}	effective multiplication factor of the reactor	
excess k_{eff}	$\Delta k_{eff} = k_{eff}-1$	
ρ	reactivity = (k-1)/k	
$\Delta\rho$	reactivity change, $\Delta\rho = \rho_1 - \rho_2 = (k_1-1)/k_1 - (k_2-1)/k_2$	avoid definition $\Delta\rho = \ln(k_1/k_2)$
pcm	unit for measuring reactivity changes 1 pcm = 10^{-5} $\Delta k/k$ = 10^{-3} %$\Delta k/k$	avoid dollars and cents

peak Sm	samarium after long shut-down
fuel assembly normalized power	power produced by fuel assembly divided by the average fuel assembly power
axial core normalized power	power produced in a unit length of the fuel along the axial direction of the fuel assembly divided by the average power produced per unit length in this fuel assembly
x-y power peaking factor	maximum power released per one fuel pin divided by the core average fuel pin power
axial offset	power produced in upper half of core minus power produced in lower half of core divided by sum of both
boron worth $\Delta\rho/\Delta C_B$	reactivity change of reactor per unit change of boron concentration at all other operating parameters (temperature, power) fixed (pcm/ppm)
moderator temperature coefficient $\Delta\rho_m/\Delta T_m$	reactivity change of reactor per unit change of moderator temperature T_m at all other operating parameters (fuel temperature, power) fixed (pcm/°C)
Doppler reactivity coefficient $\Delta\rho/\Delta T_f$	reactivity change of reactor per unit change of fuel temperature T_f at all other operating conditions (moderator temperature, power) fixed (pcm/°C)

CONTRIBUTORS TO DRAFTING AND REVIEW

C. AHNERT J.M. ARAGONES F. MERINO	Instituto de Fusion Nuclear (DENIM) ETS Ings. Industriales Universidad Politecnica de Madrid E.T.S. Ingenieros Industriales c/Jose Gutierrez Abascal. 2 28006 Madrid Spain
V.K. JAIN V. JAGANNATHAN R.P. JAIN R.D.S. YADAV	Bhabha Atomic Research Centre Theoretical Physics Division Trombay, Bombay 400085 India
M. MATAUSEK N. MARINKOVIC	Boris Kidric Institute of Nuclear Sciences - VINCA P,O. Box 522 Yu-11001 Belgrade Yugoslavia
E.Z. MUELLER G. BALL D.L. VOGEL H. RAS	Atomic Energy Corporation of South Africa Ltd. P.O. Box 582 Pretoria 001 South Africa
B. PETROVIC T. SMUC N. URLI	Ruder Boskovic Institute (OOUR IME) P.O. Box 1016 Bijenicka c. 54 41000 Zagreb Croatia
M. TURGUT T. TURKER S. TAYLAN A. AYTEKIN U. ADALIOGLU	Cekmece Nuclear Research and Training Centre P.K. 1, Havaalani Instanbul Turkey
D. PEVEC	Faculty of Electrical Engineering University of Zagreb Unska 3 41000 Zagreb Croatia

QUESTIONNAIRE ON IAEA-TECDOCs

It would greatly assist the International Atomic Energy Agency in its analysis of the effectiveness of its Technical Document programme if you could kindly answer the following questions and return the form to the address shown below. Your co-operation is greatly appreciated.

Title: **In-core fuel management code package validation for PWRs**
Number: **IAEA-TECDOC-815**

1. How did you obtain this TECDOC?

[ ] From the IAEA:
  [ ] At own request
  [ ] Without request
  [ ] As participant at an IAEA meeting
[ ] From a professional colleague
[ ] From library

2. How do you rate the content of the TECDOC?

[ ] Useful, includes information not found elsewhere
[ ] Useful as a survey of the subject area
[ ] Useful for reference
[ ] Useful because of its international character
[ ] Useful for training or study purposes
[ ] Not very useful. If not, why not?

3. How do you become aware of the TECDOCs available from the IAEA?

[ ] From references in:
  [ ] IAEA publications
  [ ] Other publications
[ ] From IAEA meetings
[ ] From IAEA newsletters
[ ] By other means (please specify)

[ ] If you find it difficult to obtain information on TECDOCs please tick this box

4. Do you make use of IAEA-TECDOCs?

[ ] Frequently
[ ] Occasionally
[ ] Rarely

5. Please state the institute (or country) in which you are working:

Please return to:

R.F. Kelleher
Head, Publishing Section
International Atomic Energy Agency
P.O. Box 100
Wagramerstrasse 5
A-1400 Vienna, Austria