ENGINEERING CALCULATIONS AND ANALYSIS REPORT

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 1 Project File No.: 23843 Date: 08/18/2011

1. Index Codes

   Building/Type: **NA** SSC ID: **NA** Site Area: **NA**

2. Quality Level and Determination #:

   QL-2-REC-000169

3. Objective/Purpose:

   Revision 1. The objective of this task was to perform a high-resolution or daily as-run physics depletion analysis for the AGR-1 TRISO-particle fuel experiment in the Advanced Test Reactor (ATR) B-10 test facility. The AGR-1 experiment was irradiated for thirteen (13) ATR power cycles and the as-run physics analysis here comprises 13 separate ATR cycle depletions. Calculated estimates for the following key physics parameters are included in the analysis here:

   1) Compact fission heat rates (MW/m^3) on a daily basis for each ATR power cycle,
   2) Compact fast fluence ($neutrons/m^2$) at neutron energies >0.18 MeV on a daily basis for each ATR power cycle,
   3) Compact burnup in fissions of initial metal atoms (%FIMA) on a daily basis for each ATR power cycle,
   4) Compact I-135 concentrations at the end of each ATR power cycle with no decay, and
   5) Selected compact actinide and fission product concentrations at the end of the 13-cycle AGR-1 irradiation.

   The AGR-1 JMOCUP depletion analysis was performed using the computer codes MCNP5 and ORIGEN2.2 coupled through the JMOCUP processing modules. A description of the depletion analysis and calculated results are presented herein.

   The 1st AGR-1 JMOCUP depletion calculation was documented in the original ECAR-958 (Rev. 0). The 2nd JMOCUP depletion calculation here, or rerun calculation is documented in this document as Revision 1 or ECAR-958 (Rev. 1). The rerun calculation is referred throughout this document as "the 2nd calculation". The main purpose for rerunning the physics analysis was to increase the number of tracked fission product isotopes in the TRISO particle compacts in order to assist the post-irradiation examination measurements and to better characterize the irradiated compacts analytically. Rerunning the JMOCUP depletion calculation also allowed us the opportunity to make several corrections (errors identified in the technical check of the 1st calculation) and modifications relative to the 1st calculation. The corrections/modifications are described below in Section 1.1.

4. Conclusions/Recommendations:

   The JMOCUP Monte Carlo depletion methodology has again been successfully applied in the detailed physics 2nd calculation or rerun of the AGR-1 TRISO-coated fuel particle irradiation test in the B-10 position in the ATR. The JMOCUP depletion calculations include all 13 ATR power cycles of the AGR-1 test. Selected calculated results are presented in this ECAR; the full inventory of calculated results will be downloaded into the NDMAS database.

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 1 Project File No.: 23843 Date: 08/18/2011

As part of the QA process, the original calculation (1st calculation) of AGR-1 JMOCUP depletion calculation/methodology underwent a rigorous verification by technical checkers. The errors identified by the technical checkers were corrected and updated for the 2nd calculation. The 2nd calculation also underwent a technical verification with the focus on those changes made relative to the 1st calculation.

5. Review (R) and Approval (A) and Acceptance (Ac)[1]:

		Typed Name/Organization	Signature or eCR No. [2]
Performer/Author	R	J. W. Sterbentz/C110	James W. Sterbentz
Technical Checker	R	G. L. Hawkes/C120	Grant Hawkes
Technical Checker	R	R. L. Sant/C210	[signature]
Technical Checker	R	D. P. Zeek/C210	Doug Zeek
Independent Peer Reviewer[3]		None	
Performer's Manager	A	G. Youinou/C110	[signature]
Requester	Ac	J. T. Maki/C640	John T. Maki
NGNP Manager	Ac	D. A. Petti/C700	David Petti
Quality Assurance	Ac	K. Armour/N000	Kimberly Armour

1 Review and Approval are required. See LWP-10200 for definitions and responsibilities.

2 Electronic Change Request (ECR) numbers in lieu of signatures on this page indicate electronic final review, approval and acceptance by the listed individuals.

3 If Required, per LWP-10200.

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 1 Project File No.: 23843 Date: 08/18/2011

CONTENTS

1. INTRODUCTION

This report documents the JMOCUP Monte Carlo depletion methodology as applied to the AGR-1 TRISO-coated fuel particle irradiation test in the B-10 test facility in the Advanced Test Reactor. Although the JMOCUP depletion methodology and processing modules have previously been used on a variety of other nuclear reactor cores, the application of JMOCUP to an ATR experiment is new. The high-resolution or daily depletions, desired for the AGR-1 test also added to the complexity of the physics calculation. Hence, the AGR-1 depletion calculation here is considered to be a shakedown calculation for the JMOCUP modules, ATR MCNP models, and the script linkages. The technical check or verification process of the 1st JMOCUP depletion calculation revealed a couple of minor errors along with several improvements that could potentially increase the calculating efficiency and accuracy of the ATR JMOCUP process. These improvements have been implemented in the 2nd calculation here.

The JMOCUP physics calculation applied to the AGR-1 test takes an important step forward in the advancement of Monte Carlo depletion in that it attempts to fully simulate the entire physical ATR critical core under as-run or actual operating conditions during a power cycle. The ATR driver core is simultaneously depleted with the AGR-1 experiment (fuel compacts, borated graphite holder, and hafnium shroud) with relatively small time steps in order to achieve the high resolution needed for specific AGR-1 calculated parameters. The relatively small nominally daily time steps (24-hours or less) drive the calculation to require significant computing power, speed, and disk space storage in order to complete the calculations in a reasonable amount of time. In addition, at each time step, the JMOCUP simulation adjusts the ATR outer shim control cylinders (OSCC) and the neck shim rods appropriately using the as-run measured ATR surveillance data in order to achieve and maintain a near-critical core configuration in time.

In general, reactor core depletion calculations do not require daily time steps to achieve desired computational accuracy for burnup estimates. Currently, routine ATR physics depletion calculations typically use 3-4 equally-spaced time steps over an ATR cycle. This number of time steps is usually sufficient to estimate important physics parameters, such as burnup, fast fluence, and heat rates. The main reason is that the ATR total core power is typically very steady under normal operating conditions and, consequently, the irradiation neutron flux remains relatively constant as well. So, longer time steps are usually justified for normal ATR physics calculations needed to simulate burnup over an ATR power cycle.

For the AGR-1 test, however, it was desired to reduce the depletion time step down to a daily or a 24-hour period. Although the finer time steps resulted in significantly more computational effort, any daily changes or perturbations in the fuel compact fission powers (heat rates) could be accounted for. Such perturbations would include total core power or lobe power fluctuations, OSCC movements, neck shim withdrawals, and ATR core burnup. The calculated daily compact fission powers were needed as input for an ABAQUS thermal model of the AGR-1 test, a thermal model that could predict thermocouple and fuel temperatures in the AGR-1 test capsule. By comparing the calculated temperatures with the actual thermocouple temperature measurements, the thermocouple drift could be assessed; temperature is an important variable for understanding the time-dependent irradiation behavior of the TRISO-coated fuel particles.

In addition to the daily (24-hour) time step subdivision of the each ATR power cycle, some time steps were less than 24-hours. Shorter time steps were required for transient operating conditions that included beginning-of-cycle (BOC) power ramp-up, scrams, power ramp-up from a scram, and end-of-cycle (EOC) shutdown. Some additional short times were also used to line up with the data acquisition times of the gas gap control system.

The daily depletion time steps, as mentioned, were required in part to account for the continuous adjustment of the outer shim control cylinders during reactor operation. The AGR-1 test capsule was in the B-10 test location, which is sandwiched between two OSCCs (E2 and E3). Rotational movement of these two cylinders can significantly impact the magnitude of the thermal neutron flux in the B-10 test facility [1] and, hence, the fuel compact fission powers. The greatest impact or increase to the thermal flux in a large-B position, such as the B-10, is near the end of some ATR power cycles when the OSCCs are turned way out. For example, a 62% increase in the thermal neutron flux is possible for OSCC rotations starting at 85º and ending at 110º.

Many of the 13 AGR-1 ATR power cycles experienced large-angle OSCC rotations near end-of-cycle. For example, in Cycle 139B, over the last 8 time steps, the 4 OSCCs in the NE lobe rotated from 98º to 124º. The impact of these large-angle EOC rotations is evident relative to the calculated capsule-power and thermocouple-temperature measurements. Inclusion of the OSCC rotations in the JMOCUP depletion calculation was therefore needed in order to capture this important effect on the compact fission powers.

Sub-dividing each ATR power cycle into 24-hour increments leads to a relatively large number of time steps per power cycle. This drives the JMOCUP depletion calculation to be a computationally intensive calculation. Table 1 lists the 13 ATR power cycles along with the number of time steps per cycle, number of MCNP KCODE calculations, and the number of ORIGEN calculations.

Table 1. AGR-1 JMOCUP depletion calculation metrics.

No. of ATR Cycles	ATR Cycle	No. Time steps per cycle	MCNP Runs	ORIGEN Runs	ShutdownTime* (days)
1	138B	49	49	50,519	15
2	139A	56	56	57,736	95
3	139B	55	55	56,705	15
4	140A	48	48	49,488	14
5	140B	37	37	38,147	9
6	141A	34	34	35,054	56
7	142A	51	51	52,581	14
8	142B	57	57	58,767	24
9	143A	53	53	54,643	16
10	143B	60	60	61,860	20
11	144A	45	45	46,395	15
12	144B	54	54	55,674	62
13	145A	63	63	64,953	1
Total	—	662	662	682,522	—

* Shutdown or decay time between cycles

Although the sheer number of ORIGEN runs in Table 1 is substantially larger (682,522) than the MCNP runs (662), the MCNP runs are the bottleneck in terms of computer runtime, even after optimization on the faster INL ICESTORM supercomputer system. Each MCNP run takes approximately 4 hours; whereas, a single ORIGEN run takes only approximately 15 msec. In fact, during the testing phase of the JMOCUP calculation, the first depletion calculation of ATR Cycle 138B on the INL HELIOS super-computer system was projected to take over 1 month to complete. The JMOCUP calculation was nearly abandoned at this point, until the codes, models, modules, and scripts were ported to the ICESTORM system and re-optimized for speed. The ICESTORM calculation resulted in more acceptable runtimes of 8-12 days per ATR power cycle. Optimization of the 2nd calculation has resulted in a further 50% reduction in runtime.

One important feature of the JMOCUP depletion calculation is that it is fully automated. Once the cycle depletion calculation is set up, and the START button pushed, the JMOCUP modules and scripts control the depletion calculation from the beginning to the end of the cycle without user assistance. The modules read and write data, and the scripts control execution of the codes and direct file inputs and outputs to appropriate directories for later data reduction and evaluation. Large debug output files are also written in order to allow the user to monitor the calculation processes and check calculated data. The JMOCUP calculation produces massive amounts of output data and, for this reason, many post processing modules have been built to read the thousands of output files and extract data. Plotting these data provides desired calculated results as well as a variety of output data that can be used to help verify the JMOCUP calculation.

The JMOCUP depletion calculation does, however, require substantial input data preparation at the beginning of each cycle. ATR surveillance data, such as the total core power, lobe powers, OSCC positions, and neck shim withdrawals, along with the beginning-of-cycle ATR driver fuel-element loadings, all need to be preprocessed, formatted, and loaded into the appropriate JMOCUP modules by the user. Pre-assessment of the as-run data also requires the user to determine the break points for the time steps and, ultimately, the total number of time step subdivisions for each cycle.

Although the JMOCUP calculation appears to have been successful, this first application of the JMOCUP method and linkage to the AGR-1 test in the ATR should be viewed as a shakedown test. Many errors have been corrected over the course of the calculation and many potential modifications and improvements have been identified, all of which need to be incorporated into the JMOCUP methodology.

This report documents the JMOCUP depletion calculation assumptions, limitations, methodology, models, calculated results, and conclusions as applied to the AGR-1 experiment in the ATR B-10 test facility.

1.1 Revision 1

The entire AGR-1 JMOCUP depletion calculation was rerun. This rerun calculation is referred to as the 2nd calculation and documented here in this ECAR-958 as Revision No. 1.

1.1.1 Additional tracked fission products and actinides

The main reason for rerunning the depletion calculation was to increase the number of fission products tracked in the MCNP input model material cards for TRISO particle compacts. The increased number of fission products was desired to support the post irradiation examination (PIE) tests on the TRISO particle compacts. Table 2 lists the 24 fission products in the first (1st) and the 71 fission products in the second (2nd) JMOCUP depletion calculations. The 2nd calculation added 47 more fission products. Table 2 lists the 18 actinide isotopes in the 1st calculation and the 19 actinide isotopes in the 2nd calculation. Only one additional actinide was added to the list, namely, Am-242m. Tracked fission products and actinide isotopes are nuclides that the JMOCUP depletion calculation updates cross sections at each time step for maximum concentration accuracy. Untracked nuclides do not have JMOCUP-updated cross sections and simply use the standard ORIGEN library cross section data.

Table 2. Tracked fission product isotopes in the MCNP TRISO fuel compact cells.

2nd Calculation				1st Calculation
Kr-83	Ag-109	Cs-135	Sm-151	Kr-83
Kr-84	Ag-110m	Cs-136	Eu-151	Kr-85
Kr-85	Cd-113	Cs-137	Sm-152	Tc-99
Sr-88	Sb-123	La-139	Eu-152	I-127
Sr-89	Sn-124	Ce-140	Gd-152	I-129
Sr-90	Sb-124	Ce-142	Eu-153	Xe-131
Y-91	Te-124	Ce-143	Eu-154	Xe-135
Zr-95	Sb-125	Pr-143	Eu-155	Cs-135
Mo-95	Te-125	Nd-143	Gd-155	Cs-136
Tc-99	Te-126	Ce-144	Gd-157	Pr-143
Ru-102	Te-127m	Nd-145	Dy-164	Nd-147
Ru-103	I-127	Nd-147		Sm-147
Rh-103	Te-128	Pm-147		Nd-148
Pd-104	I-129	Sm-147		Pm-148
Rh-105	Xe-131	Nd-148		Pm-149
Pd-105	Xe-133	Pm-148		Sm-149
Ru-106	Cs-133	Pm-149		Pm-151
Pd-106	Cs-134	Sm-149		Sm-151
Pd-107	I-135	Sm-150		Eu-151
Pd-108	Xe-135	Pm-151		Eu-152
				Gd-152
				Gd-155
				Gd-157
				Dy-164

Isotopes in red are added in the 2nd calculation.

Table 3. Tracked actinides isotopes in the MCNP TRISO fuel compact cells.

2nd Calculation	1st Calculation
Th-232	Th-232
U-233	U-233
U-234	U-234
U-235	U-235
U-236	U-236
U-237	U-237
U-238	U-238
Np-237	Np-237
Np-238	Np-238
Pu-238	Pu-238
Pu-239	Pu-239
Pu-240	Pu-240
Pu-241	Pu-241
Pu-242	Pu-242
Am-241	Am-241
Am-242m	Am-243
Am-243	Cm-242
Cm-242	Cm-244
Cm-244	

Isotopes in red are added in the 2nd calculation.

In order to accommodate the additional 47 fission product isotopes and the one actinide isotope (Am-242m), several straightforward changes had to be made to the MCNP input file and the JMOCUP modules (array size increase) that control the compact depletion. In addition, new MCNP ACER neutron cross section libraries were generated using the NJOY code and the latest ENDF7 cross section data for these added isotopes. Cross sections were generated at 300, 873, and 1472.7 K, or 27, 600, and 1200°C.

1.1.2 Boron-10 (B^{10}) number density correction

There was also one number density correction made to the very first MCNP input model (Cycle 138B). In Capsule 6, the borated graphite holder was designed to have a B_4C content of 5.5 wt%. In the MCNP model, 3 of the 4 axial segments had the correct 5.5 wt% B_4C, but the bottom axial segment (2-inches in length) of the graphite holder had 7.0 wt% B_4C instead. The 4th segment at 2-inches in length represented the entire bottom one-half of the borated-graphite holder. The reduction in the B_4C and consequently the B^{10} burnable poison concentration in this segment could have a significant impact on the thermal neutron absorption rate in the six compacts at the bottom of the capsule 6 stacks.

1.1.3 MCNP model northeast lobe reactivity improvement

In order to further improve the JMOCUP MCNP model, the northeast lobe experiment was updated to better reflect the actual experimental setup, the experiment reactivity, and ultimately and most importantly, the overall ATR calculated lobe power splits. The northeast lobe MCNP cards were generated by B. Schnitzler (summer 2010) and simply spliced into the JMOCUP MCNP input file.

Table 4 gives the measured lobe fractional power splits as measured by the ATR surveillance data system (ASUDAS) report for beginning-of-cycle (BOC) of Cycle 145A. The last two columns are MCNP-calculated lobe fractional power splits for the 1st calculation (original) and the updated 2nd calculation.

Table 4. Comparison of measured versus calculated lobe fractional power splits.

ATR Lobe	Measured ASUDAS	Calculated (1st calculation)	Calculated (2nd calculation)
NW	0.1625	0.1606	0.1646
NE	0.1625	0.1934	0.1722
C	0.2418	0.2276	0.2290
SE	0.2251	0.2198	0.2248
SW	0.2081	0.1987	0.2094

The goal was to reduce the lobe power split of 0.1934 in the NE lobe in the 1st calculation to something closer to the ASUDAS split of 0.1625. Apparently the MCNP model in the 1st calculation did not have enough negative reactivity worth in the northeast lobe flux trap and was tending to draw too much power. This problem was improved in the 2nd calculation with the incorporation of Schnitzler's improved NE lobe MCNP model description. The SW, SE, and NW lobe power splits are now in excellent agreement with ASUDAS, the C lobe in slightly better agreement, and the NE lobe split has been greatly improved.

The lobe-improved MCNP model was then used throughout the 2nd calculation which improved the overall ATR core reactivity, as evidenced by a downward shift in core k-effective toward unity. Also, the calculated east lobe power was improved along with an expected improvement in neutron flux intensity and spectrum in the vicinity of the B-10 test facility.

1.1.4 Decay Time Between Power Cycles

Between every ATR power cycle there is a shutdown period in which the reactor is de-fueled, refueled, experiments unloaded, and new experiments are loaded into the ATR core. The 1st JMOCUP depletion calculation did not account for the shutdown or decay time between cycles, although the capability was available in the JMOCUP modules. In the 2nd JMOCUP depletion calculation, the decay time between ATR power cycles was included (see Table 2).

1.1.5 Otherwise Identical Calculations

With the exception of the changes noted above, the 1st and 2nd JMOCUP calculations were identical. They both used the same identical ATR input data (core element loadings and positions, ATR core power, ATR lobe powers, ATR OSCC positions, shim rods ejection patterns), same no. of timesteps per cycle, and the same identical initial AGR-1 materials and geometry. Consequently, despite the modifications described above, much of the calculated data was very close in magnitude between the 1st and 2nd calculations.

2. ASSUMPTIONS

The assumptions used in the JMOCUP depletion calculations and analyses include the following:

1) ATR measured data used as input data for the JMOCUP depletion calculation included the hourly ATR total core power, five lobe powers, 16 outer shim control cylinder positions, and

24 neck shim positions for all 13 AGR-1 ATR power cycles. These ATR power and control history data were obtained specifically from the following ATR surveillance data system (ASUDAS) reports:

(i) Cycle 138B-1 ATR Surveillance Data report, Feb. 12, 2007.
(ii) Cycle 139A-1 ATR Surveillance Data report, April 23, 2007.
(iii) Cycle 139B-1 ATR Surveillance Data report, Oct. 01, 2007.
(iv) Cycle 140A-1 ATR Surveillance Data report, Dec. 03, 2007.
(v) Cycle 140B-1 ATR Surveillance Data report, Jan. 28, 2008.
(vi) Cycle 141A-1 ATR Surveillance Data report, March 10, 2008.
(vii) Cycle 142A-1 ATR Surveillance Data report, June 23, 2008.
(viii) Cycle 142B-1 ATR Surveillance Data report, Sep. 03, 2008.
(ix) Cycle 143A-1 ATR Surveillance Data report, Dec. 08, 2008.
(x) Cycle 143B-1 ATR Surveillance Data report, Feb. 23, 2009.
(xi) Cycle 144A-1 ATR Surveillance Data report, April 27, 2009.
(xii) Cycle 144B-1 ATR Surveillance Data report, July 06, 2009.
(xiii) Cycle 145A-1 ATR Surveillance Data report, Nov. 09, 2009.

2) Input data for the JMOCUP depletion calculation also included the initial ATR driver core fuel loadings (U-235 uranium and B-10 loadings by element and position in the core). These data were extracted from the following references:

(i) P. A. Roth, EDF-7537, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 138B.
(ii) A. W. LaPorta, EDF-7705, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 139A.
(iii) P. A. Roth, EDF-8078, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 139B, May 16, 2007.
(iv) A. W. LaPorta, ECAR-8299, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 140A, August 7, 2007.
(v) P. A. Roth, EDF-84, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 140B, November 19, 2007.
(vi) A. W. LaPorta, ECAR-125, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 141A, December 27, 2007.
(vii) P. A. Roth, ECAR-195, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 142A, March 25, 2008.
(viii) A. W. LaPorta, ECAR-282, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 142B, June 03, 2008.
(ix) P. A. Roth, ECAR-348, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 143A, August 20, 2008.
(x) P. A. Roth, ECAR-447, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 143B, November 17, 2008.
(xi) A. W. LaPorta, ECAR-509, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 144A, February 10, 2009.
(xii) B. M. Chase, ECAR-603, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 144B, April 20, 2009.
(xiii) E. T. Swain, ECAR-731, Rev. 0, “Results of Reactor Physics Safety Analysis for Advanced Test Reactor (ATR) Cycle 145A, August 13, 2009.

3) The original MCNP base model used in the JMOCUP calculations is identical to the MCNP model developed in EDF-7120 [1] along with the AGR-1 experiment constituent data from the same reference. The base model (***nspec***) was obtained from M. Lillo (August 2008) with an updated model (aar8b1) containing corrected material card number densities for the fuel compacts containing TRISO-coated particles (October 2008).

4) Compact materials are homogenized in the MCNP model which means the TRISO particles and graphite binder matrix materials are assumed to be uniformly mixed.

5) Fuel compacts were assumed to be at 600ºC for the first ATR cycle (138B) and 1200°C for the following 12 cycles.

6) Neutron cross-section data were primarily ENDF-6 (endf60), plus some ENDF-5 cross-section data for certain fission products and natural elements. In the 2nd calculation all the fission products in the compacts and Am-242m were from the ENDF-7 cross section library data.

7) High-temperature neutron cross-section data for actinides and fission products in the compacts were generated using both ENDF-6 (endf60) data at room temperature. High-temperature cross sections for all the fission products and Am-242m were generated using ENDF-7 data.

8) The east-lobe source power is defined as the average of the NE, C and SE lobe powers, E = (NE + C + SE)/3 and is used to normalize powers and fluxes in the B-10 test facility.

9) Beginning of cycle (BOC) refers to the start of an ATR power cycle; end of cycle (EOC) refers to the end of an ATR power cycle.

10) Beginning of life (BOL) refers to the beginning of the first AGR-1 ATR power cycle (138B); End of life (EOL) refers to the end of reactor operation following 13 ATR power cycles and the end of Cycle 145A (the final ATR power cycle for the AGR-1 irradiation test).

3. AGR-1 EXPERIMENT ASSEMBLY

The AGR-1 experiment test train assembly was irradiated in the ATR B-10 test facility (see Figure 1). The test train assembly consisted of 6 capsules stacked vertically end-to-end in the B-10 facility (see Figure 2). Capsule 1 was at the bottom of the test train assembly, and capsule 6, at the top. Each capsule contained a borated graphite holder. Each borated graphite holder had three equally-spaced bore holes to hold three stacks of compacts. Figure 3 shows the three stack locations labeled 1, 2, and 3. Note: stacks 1 and 3 face toward the ATR core center. Each stack contained 4 compacts; each compact had a measured average length of 0.99-inch (2.52 cm) length and a diameter of 0.4858 inch (1.234 cm) per reference [2]. In the MCNP ATR full core model, the compact cells had a slightly longer 1.00-inch length, but the same 0.4858-inch diameter. Compact uranium mass was, however, conserved in the MCNP compact cells.

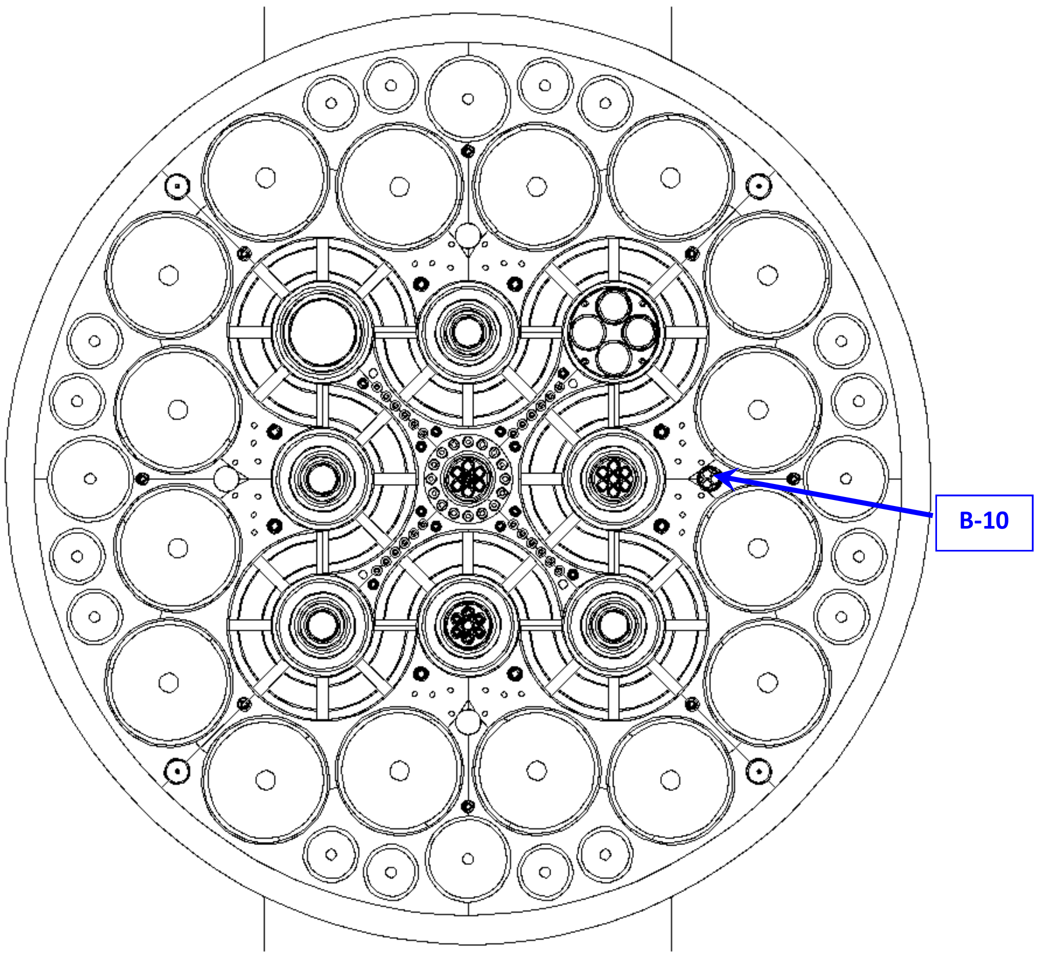

Figure 1. Cross-section view of the ATR core and the B-10 irradiation test facility.

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 1 Project File No.: 23843 Date: 08/18/2011

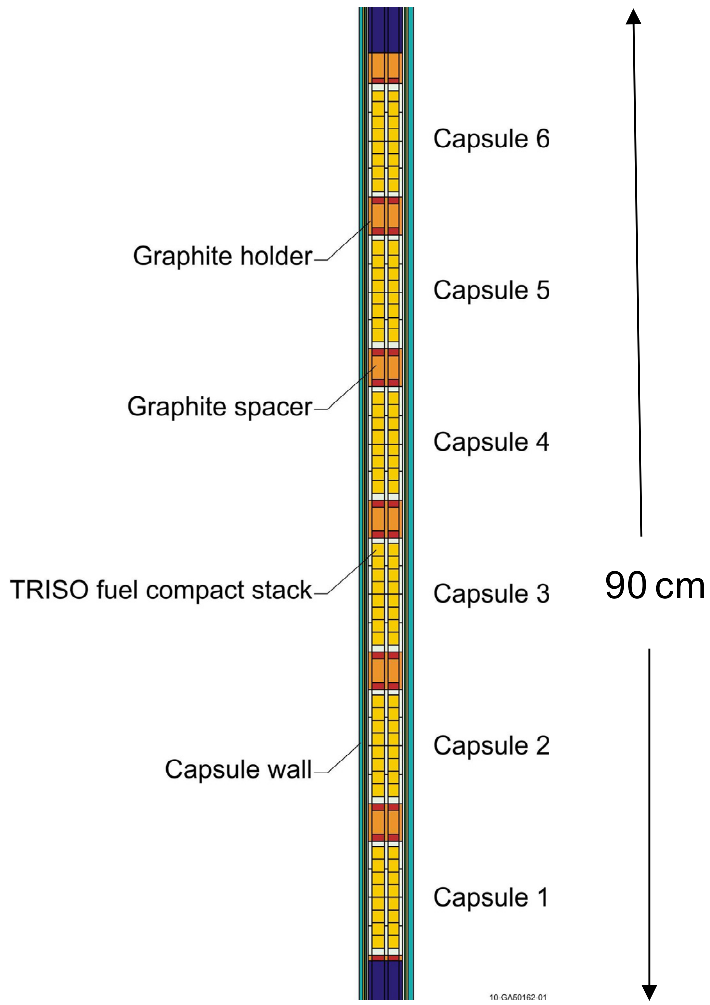

Figure 2. Axial view of the AGR-1 test train assembly, showing the six capsules and details of two of the fuel compact stacks.

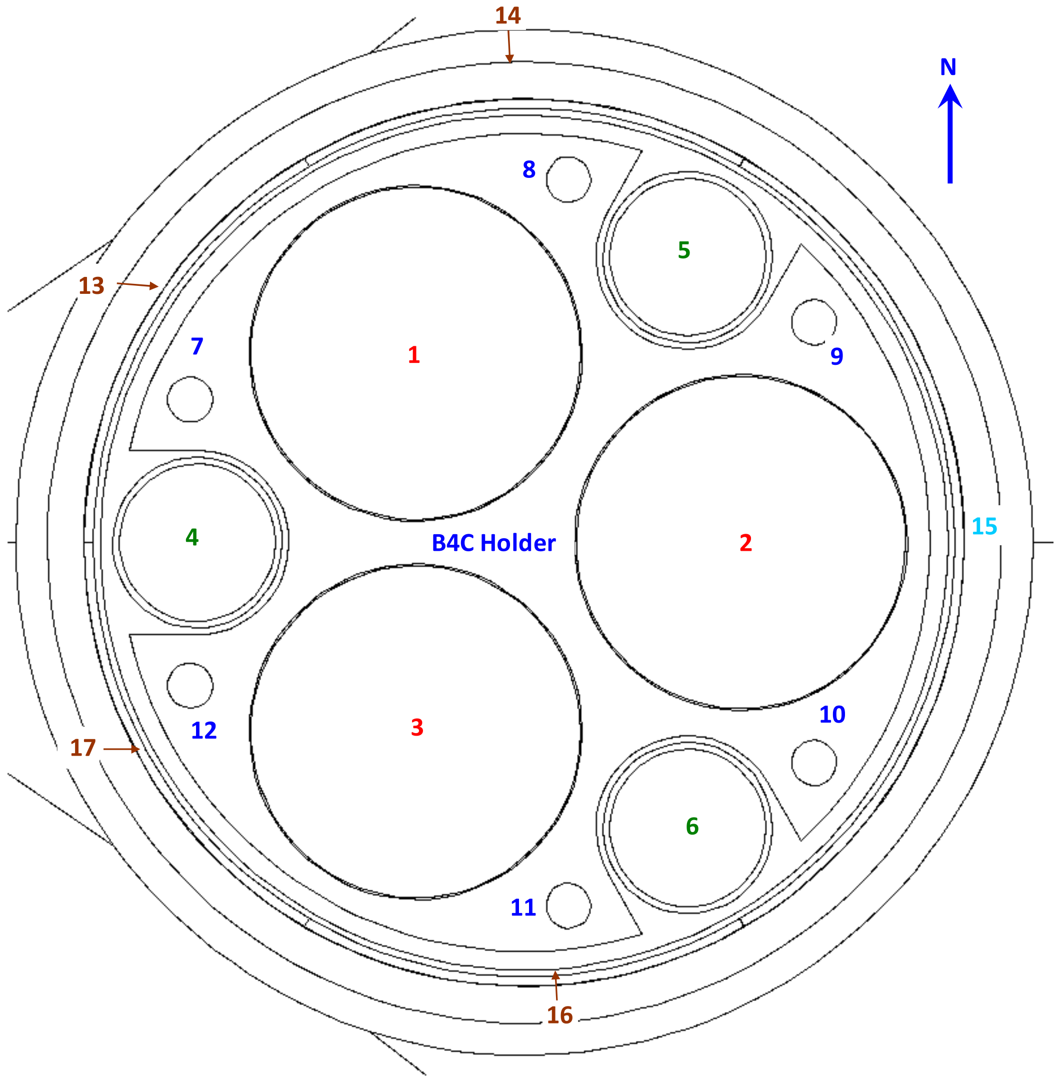

Figure 3. Cross-section view of an AGR-1 mini-capsule.

(Components shown include: Graphite Holder, Thru Tubes, Fuel Compacts, SS Sleeve, Hf/SS Shroud, TC and Gas Line Openings, Capsule Body, Gas Gaps, and Water Gap)

Key:
- Red Numbers – Fuel Compact (1, 2, 3)
- Green Numbers – Thru Tube (4, 5, 6)
- Blue Numbers – TC and Gas Line (7, 8, 9, 10, 11, 12)
- Brown Numbers – Hf Shroud (13, 14, 16, 17)
- Turquoise Number – SS Shroud (15)

In summary, each capsule then had 3 compact stacks with 4 compacts per stack, for a total of 12 compacts per capsule. AGR-1 thus had a total of 72 fuel compacts. Baseline fuel compacts were placed in capsule 6 (top capsule) and capsule 3, and variant fuel compacts were placed in capsules 1 (bottom capsule), 2, 4, and 5 [2]. In the MCNP model, each compact was subdivided into 2 equal-volume cylindrical cells for increased resolution of the compact fission powers or heat rates.

4. COMPUTER CODES

The following computer codes were used in the AGR-1 JMOCUP depletion calculation:

(1) The MCNP (Monte Carlo N-Particle) code [3], version 5, or MCNP5, is a general purpose, continuous energy, generalized geometry, coupled neutron-photon-electron Monte Carlo transport computer code. The powerful geometry capability allows for fully-explicit three-dimensional cell representations of nuclear-reactor core components and geometrical features. The code can be used to calculate a variety of different reactor-physics parameters that include neutron flux, neutron spectra, nuclear reaction rates, fission powers, gamma and neutron heating rates, and core eigenvalues (k-effectives). The MCNP code uses continuous-energy neutron cross sections spanning the energy range from 1.0E-10 to 20.0 MeV for a wide range of natural elements and isotopes; the photon cross-section energy range is from 1 keV to 100 MeV. Cross-section data libraries used in the ATR MCNP full core model for the JMOCUP AGR-1 depletion calculation are mostly from the ENDF-6 or Evaluated Nuclear Data Files version 6 (endf60), but some cross section data also comes from ENDF-5.

(2) The ORIGEN2.2 (Oak Ridge Isotope Generation) code [4], version 2.2, is used to calculate the time-dependent, coupled behavior of radioactive- and stable-isotope buildup, depletion, and decay under constant power or flux conditions. For the AGR-1 JMOCUP depletion calculation, the constant power option is used for both the ATR driver fuel and the compact depletions. For the borated graphite holder and hafnium shroud depletions, the constant flux approximation is used at each time step. Isotope production and destruction mechanisms include transmutation or neutron radiative capture, fission, threshold particle reactions, and radioactive decay processes. The code mathematical basis uses the matrix exponential method to solve the coupled ordinary differential equations relating the isotope interactions. The ORIGEN2.2 exponential matrix method calculates isotopic concentration with a very high degree of numerical accuracy.

(3) The JMOCUP code system is a Monte Carlo depletion methodology, which is functionally similar to the MOCUP (MCNP-ORIGEN2 Coupled Utility Program) code system [5]. JMOCUP (or Jim Sterbentz's MOCUP) and MOCUP are both systems of external processors or modules that link the input and output files of MCNP5 and ORIGEN2.2. No modifications to either MCNP5 or ORIGEN2.2 are required to run either JMOCUP or MOCUP. MOCUP is written in C+ and JMOCUP is written in FORTRAN. FORTRAN was the language of choice for JMOCUP since execution speed is not a limiting factor and a GUI interface was not needed nor desired for the computer-intensive and repetitive AGR-1 JMOCUP depletion calculations. Both JMOCUP and MOCUP perform time-dependent depletion calculations in discrete time steps.

(4) The DOPPLER code [6] allows a user to prepare customized temperature dependent nuclear data files for use with the MCNP5 computer code. The user does not have to then go through the laborious task of processing ENDF data files through the NJOY code to generate new temperature dependent cross sections. Instead, existing point-wise MCNP cross-section files in ACE format can be broadened to the desired temperature quickly and easily using methods identical to those used for the original preparation of the base data files with the NJOY Nuclear Data Processing System. Thermal-scattering tables and unresolved resonance-range probability tables are interpolated between tables for temperatures surrounding the desired value. This gives the MCNP user a simple but accurate way to prepare nuclear data libraries that exactly match the conditions of the problem being analyzed.

(5) The NJOY code [6] allows a user to prepare MCNP ACER cross section libraries from the Evaluated Nuclear Data Files (ENDF).

5. ATR MCNP MODEL

The MCNP model used in the AGR-1 JMOCUP depletion calculations is based on the same MCNP model from reference [7]. The base model (***nspec***) is a full-core ATR model that includes the AGR-1 test assembly in the B-10 test facility. This model was obtained directly from M. Lillo in August 2008. An update to the model's fuel compact material card number densities was also received from M. Lillo in October 2008, prior to the start of the JMOCUP depletion calculation of the AGR-1 test.

Some modifications to the base model (***nspec***) were necessary in order to accommodate the JMOCUP-module requirements and temperature dependent cross sections for the AGR-1 experiment; otherwise, the model geometry cell and surface cards remained the same, as did the material cards for everything, except the compact cells.

Modifications made to the base MCNP model (***nspec***) for the AGR-1 JMOCUP depletion calculations include the following:

(1) Renumbering and modifying the tallies for the JMOCUP module tally data readers.

(2) Global replacement of the 'nspec' model neutron cross sections with standard ENDF-6 cross sections for the ATR driver core and fuel compact actinides, and the use of ENDF-5/6 cross sections for the fission products.

(3) High-temperature neutron cross sections (600 and 1200ºC) specifically developed for the compact actinides and fission products.

(4) Changing ATR driver core cell card number densities to account for the actinides and fission products included in the material card descriptions.

(5) Format changes to the ATR driver core and compact fuel material cards.

(6) Addition of comment cards.

Inclusion of the above modifications produced the base MCNP full core model for the AGR-1 JMOCUP depletion calculations (***inp.1***). This model was used throughout the 13 ATR power cycles and each of the 662 neutron transport calculations.

At the beginning of each new time step, the MCNP base model (***inp.1***) receives several updates to produce the next MCNP model (***inp.2***) at the next time step. These updates include:

(1) ATR driver fuel cell cards total number density

(2) Material card number density updates for the ATR driver fuel cells, compact cells, hafnium shroud cells, and the borated graphite holder cells

(3) OSCC surface card changes to reflect the new positions

(4) Neck shim cell card changes to reflect withdrawals

The typical JMOCUP MCNP model is approximately 65,000 lines long and requires approximately 4 hours of execution time on the ICESTORM system with 48 CPUs. The KCODE option used 500,000 starting neutrons/cycle, 1,006 cycles, and 6 skipped or inactive cycles.

The primary neutron cross-section library data used in the MCNP model and transport calculations was from ENDF-VI-2 (endf60). Special temperature dependent cross sections were also developed using the DOPPLER code [6] for the compacts (600 and 1200°C). Fission-product cross sections used both ENDF-V and VI.2 depending on availability.

6. JMOCUP METHODOLOGY

The JMOCUP depletion methodology was used to perform the AGR-1 fuel compact depletions. Use of the JMOCUP code/module system for an experiment in the ATR is a new application of the JMOCUP system. Despite the complexity and massive number-crunching operations associated with the AGR-1 JMOCUP depletion, the JMOCUP calculation appears to have been successful, and it performed admirably for all 13 AGR-1 power cycles. Verification of the JMOCUP calculation has been performed by three independent technical checkers. Validation of the JMOCUP calculation will be limited to comparisons between calculated results and post-irradiation examination (PIE) measurement data. Comparisons may include compact/particle U-235 burnup and selected actinide and fission-product concentrations (both absolute and relative).

The AGR-1 JMOCUP depletion calculation coordinated four depletions: (1) ATR driver core, (2) AGR-1 compacts, (3) AGR-1 hafnium capsule shroud, and (4) AGR-1 borated graphite holder. The ATR driver core consists of 840 depletion cells in the MCNP model; 3 radial and 7 axial zones (cells) per element (or 3x7x40=840 depletion cells total). The 72 compacts were split in half for a total 144 depletion cells; the hafnium shroud a total of 24 depletion cells, and the borated graphite holder a total of 23 depletion cells. There are, therefore, a total of 1,031 depletion cells that JMOCUP operated on and kept track of during each time step for every cycle.

The ATR driver depletion cells each contain 9 actinides and 24 fission-product isotopes that are tracked and, along with their fission cross section and radiative capture cross section, were updated every time step. Similarly, the compacts have 18 tracked actinides and 24 fission products. In the hafnium shroud cells, the six naturally occurring hafnium isotopes are tracked, as is the Boron-10 in the 23 borated graphite cells that compose the AGR-1 graphite compact holder. The MCNP code calculates, for each of the depletion cells, the cell neutron flux and nuclear reaction rate(s) for each specified isotope and nuclear reaction at each time step. Using these data, updated one-group cross sections are fed to the ORIGEN input files for the next ORIGEN depletion calculation.

Three JMOCUP modules were specifically tailored for (1) the ATR driver fuel, (2) the compacts, and (3) the hafnium shroud and borated graphite holder. These three JMOCUP modules were set up to read the MCNP output-tally data, arithmetically manipulate the data, normalize it to the east lobe power, and finally write out the ORIGEN input files with updated cell power, cross sections, and isotopic masses. The JMOCUP script then executes the ORIGEN input files for the depletion calculation. When the ORIGEN depletion calculations are complete, the script executes three other JMOCUP modules that read the appropriate ORIGEN output files, manipulate the data, and write an MCNP scratch file updated with the new total number densities for the depletion-cell cards and new isotopic concentrations or number densities for the depletion-cell material cards. A seventh module reads the MCNP scratch file, calculates the new OSCC positions, determines if a neck shim rod has been withdrawn during this time step, and finally writes out the new MCNP input file. The bash script then executes the new MCNP model (input file) and the cycle starts over with the next time step. The process is repeated until the script execution completes the last time step.

Although the basic functionality of the JMOCUP system is similar to the MOCUP system, the JMOCUP system provides greater flexibility for the user in that modules can be easily copied and modified for reactor-specific applications. New functional modules can readily be interfaced with existing modules and incorporated into the JMOCUP execution script. This gives the JMOCUP system a certain degree of added flexibility and the ability to be applied to a variety of steady-state and transient reactor problems for any reactor system.

Some of the more notable features of the JMOCUP depletion calculation and code system include:

(1) Full core simulation

(2) Fully automated execution

(3) Control-element movement (OSCC and neck shim)

(4) Criticality search

(5) Easy restart capability

(6) Input data use as-run ATR measured data

(7) MCNP KCODE transport calculation option

(8) Unlimited number of time steps, plus variable length time steps

(9) Multiple region depletions with different type and number of isotopes/nuclear reactions

(10) Any number of MCNP depletion cells in each region

(11) Decay of radionuclides between ATR power cycles with variable shutdown times between cycles

(11) High resolution depletion calculation

(12) Computer-intensive calculation

The JMOCUP methodology and base modules have previously been applied to several different nuclear reactors for spent-fuel isotopic predictions and reactor core designs [8]—[13], and to an actual measured reactor power maneuver or transient analysis with variable-length time steps. In this transient case, a power up-down-up maneuver was used to measure the reactor's power coefficient of reactivity. The core k-effective was calculated at each time step, where the time step lengths varied over a range of just a few seconds to up to several minutes. Very short time steps were necessary in order to simulate the rapid control-rod movements and the resulting measured core power changes and xenon concentration changes during the power-down and the power-up segments of the transient. Longer time steps (few minutes) were used before and after the power maneuver and during the steady-state power conditions. The transient calculation produced estimates of the core k-effective and reactivity changes while accounting for the time-dependent behavior of important isotopes such as Xe-135 during the transient.

In the JMOCUP methodology, the neutron-transport problem is solved using the KCODE option in the MCNP code. In order for the KCODE option to be effective, the reactor core, in this case the ATR driver fuel, must be simultaneously depleted along with the AGR-1 experiment depletions. Depleting the ATR driver core provides, in theory, an excellent irradiation neutron source or neutron starting distribution for the AGR-1 experiment exposure. Depleting the full ATR core, however, comes with a price, namely, (1) significant computer runtime to execute the massive MCNP model at each time step using the KCODE option, and to calculate the large amount of tally data required for the JMOCUP depletion calculation, (2) the need to load the ATR driver core at the beginning of each power cycle with the appropriate 40-element loading placed in the correct serpentine-core positions, (3) depletion of 840 extra ATR driver core cells in the MCNP model at each time step, (4) the need to move the 16 OSCC drums and the 24 neck shim rods at each time step in order to maintain a near critical condition (k-effective ≈ 1.00), and finally, the need to model experiments in the flux traps in order to balance core reactivity and reproduce the actual ATR lobe power splits. Each of these issues costs either computer runtime or problem set-up time prior to the start of the depletion calculation. However, none of these issues, either individually or in combination, defeats the use of the KCODE option and, hence, the possibility of a full core high-resolution depletion calculation. The end result is, however, an impressive full core simulation with the best possible neutron source distribution for ATR experiment irradiations.

The JMOCUP calculation, as applied to the AGR-1 test in the ATR, still has room for improvement in terms of both numerical accuracy and computational efficiency. For example, more actinides and fission products could be included and tracked in the compacts to improve final isotopic characterizations. Also, additional isotope nuclear reactions could be easily added, for example, (n,2n), (n,3n), (n,p), and (n,alpha) cross sections could be added and tracked as well, in order to further refine the overall actinide concentration distribution. Following the success of the AGR-1 JMOCUP depletion calculation, the ICESTORM computer system should easily allow for additional enhancements such as those mentioned above.

The JMOCUP modules are linked by a bash shell script which is relatively easy to modify in order to accommodate additional modules. Additional modules can be added to increase the sophistication of the depletion calculation, (for example, changing MCNP cell material properties (density, temperature) at each time step, changing temperature dependent cross sections at given time steps for cases involving variable experimental conditions, searching for the control rod position or a burnable poison concentration for criticality, or the use of super-fine time steps to simulate a reactor power maneuver or transient in which the control rods move on the order of seconds or less). Many of these additional features have previously been implemented with the specific JMOCUP modules for different reactor problems and applications.

One powerful feature of the Monte Carlo depletion technique is the use of continuous energy cross sections (MCNP) to solve the neutron-transport problem. Continuous energy cross sections eliminate the need for energy and spatial weighting of group cross sections needed in deterministic code transport calculations. Another powerful feature is the MCNP three-dimensional geometry capability that can essentially model any reactor system in explicit detail. The main drawback of Monte Carlo depletion calculations is, of course, the relatively longer runtimes to solve the neutron transport problem. This is particularly true in the case of the KCODE option in MCNP5 and the very large ATR MCNP models.

6.1 ATR Measured Data

For each ATR power cycle, ATR measured data, or hourly as-run data, is taken directly from the ATR ASUDAS reports listed in Section 2.0 of this ECAR. The hourly data is first loaded into special EXCEL spreadsheets in long columns of data, and then partitioned into time steps of 24-hour intervals; the hourly data in each time step is then averaged over the 24 hour time step and, finally, the averaged values are formatted for use in the JMOCUP modules. At the start of each JMOCUP depletion calculation, the as-run data must be loaded into the appropriate JMOCUP modules prior to execution.

Required as-run hourly ATR includes: (1) total core power (MW), (2) lobe powers (MW) for the northwest (NW), northeast (NE), center (C), southwest (SW), and southeast (SE) lobes, (3) outer shim control cylinder (OSCC) position measurements in degrees, and (4) neck shim withdrawals. Table 5 shows an example of some of the hourly as-run data for the total core power data at the start of Cycle 145A.

Table 5. Typical hourly total core power as-run ATR data for the beginning of Cycle 145A used in the JMOCUP depletion calculation.

		N-16 Unconstrained (MW)					**N-16 Constrained (MW)**				
Time	Date	NW	NE	C	SW	SE	NW	NE	C	SW	SE
200	9/5/2009	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
300	9/5/2009	0.06	0.06	0.09	0.07	0.08	0.06	0.06	0.09	0.07	0.08
400	9/5/2009	0.55	0.55	0.87	0.71	0.71	0.55	0.55	0.87	0.71	0.71
500	9/5/2009	6.18	6.17	9.67	8.02	8.10	6.41	6.42	9.83	8.29	8.35
600	9/5/2009	6.14	6.15	9.58	7.85	8.45	6.36	6.39	9.73	8.10	8.69
700	9/5/2009	6.08	6.11	9.46	7.80	8.48	6.26	6.31	9.58	8.01	8.68
800	9/5/2009	6.09	6.07	9.27	7.81	8.54	6.17	6.16	9.33	7.91	8.63
900	9/5/2009	6.08	6.05	9.15	7.80	8.58	6.22	6.20	9.25	7.96	8.73
1000	9/5/2009	13.50	13.49	20.20	17.42	18.98	13.29	13.27	20.06	17.18	18.76
1100	9/5/2009	13.46	13.43	19.72	17.11	18.65	13.26	13.21	19.58	16.87	18.44
1200	9/5/2009	16.14	16.17	23.35	20.57	22.29	15.77	15.77	23.10	20.15	21.89
1300	9/5/2009	16.20	16.23	23.08	20.69	22.40	15.73	15.71	22.74	20.13	21.89
1400	9/5/2009	16.80	16.81	23.50	21.42	23.04	16.22	16.18	23.09	20.74	22.42
1500	9/5/2009	16.97	17.01	23.33	21.61	23.00	16.41	16.41	22.94	20.96	22.40
1600	9/5/2009	17.00	16.96	23.02	21.54	23.13	16.39	16.30	22.59	20.84	22.48
1700	9/5/2009	17.09	17.06	22.92	21.57	23.06	16.49	16.41	22.50	20.87	22.41
1800	9/5/2009	17.10	17.10	22.79	21.73	23.20	16.51	16.45	22.37	21.04	22.55

A fifth piece of as-run data is needed in the set up of the ATR JMOCUP depletion calculation. This is the ATR core driver fuel-element loadings at beginning of cycle. These data include the U-235 and B-10 mass loadings for each element, and are obtained from the ATR technical operations staff in the form of ECARs and EDFs. In addition, these reports identify the fuel element type and designated location in the core, and whether the elements are fresh or previously burned. For the AGR-1 JMOCUP calculation, all 13 ECARs and EDFs are listed in Section 2.0. These element loadings are put into a FORTRAN computer program that appropriately distributes the uranium and Boron-10 to the 21 cells composing each ATR element and writes out a material card for each cell. These data are then loaded into the MCNP model by the user.

It should be noted that the logic and functionality of the JMOCUP modules do not change from cycle to cycle; only the as-run cycle data (input data) loaded into each module prior to execution change.

6.2 Data Libraries

Standard MCNP cross-section data libraries (ENDF-6 and ENDF-5) were used in the AGR-1 JMOCUP depletion calculation. The DOPPLER code was also used to generate temperature dependent cross sections for the AGR-1 compact actinides using the standard room-temperature libraries. The ORIGEN2 base library was the PWRU.LIB that comes with the RSICC standard issue of the ORIGEN code.

7. ANALYSIS AND CALCULATIONS

MCNP output tally results are reported in the MCNP output on a per source-neutron basis. All fission power, heat-rate, flux, and reaction-rate tallies must be normalized to the ATR total core power or the ATR lobe powers. In the JMOCUP calculation, the ATR depletion calculation is normalized to the total core power, and the AGR-1 depletions are normalized to an "east" flux trap power which is approximated as the average of the NE, C, and SE lobe powers (Section 2.0, Assumption 8).

8. SOFTWARE

The five computer codes (MCNP5, JMOCUP, ORIGEN2.2, DOPPLER, NJOY) used to perform this physics analysis are listed in Table 6.

Table 6. INL qualified analysis software version and record number

Code Name	Version	V&V Record Number	Computer System	Operating System Software
MCNP	5 (Release 1.40)	3268955	Icestorm	SUSE Linux Enterprise Server Version 10.2
ORIGEN	2.2	2326731	Icestorm	SUSE Linux Enterprise Server Version 10.2
DOPPLER	0	Ref. [8]	PC (Prop. ID 372767)	Microsoft Windows XP Version 2002
NJOY	99.0	Appendix C	Helios	Open SUSE 11.1
JMOCUP	0	Appendix D	Icestorm	SUSE Linux Enterprise Server Version 10.2

MCNP5 and ORIGEN2.2 are listed under the INL Enterprise Architecture Repository and are accepted as qualified scientific and engineering analysis software. MCNP has been verified for use on the INL ICESTORM and HELIOS supercomputers by running the 42 sample problems transmitted on the installation MCNP CD issued by the Radiation Safety Information Computational Center (RSICC) and comparing the calculated results against the standard results provided on the CD. This verification process was performed for MCNP Version 5 (Release 1.40).

The DOPPLER code was obtained directly from R. E. MacFarlane (code author) and P. Talou at the Los Alamos National Laboratory. An extensive verification of this code on the WINDOWS PC (372767) has previously been performed [8]. Development of the high-temperature cross sections for the AGR-1 JMOCUP depletion calculation used this same verified code, input files, and computer platform. DOPPLER input files from [8] were only slightly modified for the development of the limited number of AGR-1 high-temperature cross-section libraries. The slight modifications involved only the change of the desired cross-section temperature and/or the starting room-temperature cross-section library.

The NJOY computer code software and nuclear data was obtained directly from the Radiation safety Information Computational Center (RSICC) under the code name NJOY99.0, software package P00480MNYCP00, and RSICC #: PSR-480 and installed on the INL Helios computer system.

The JMOCUP depletion calculation underwent a rigorous verification process because of its first time application to the ATR reactor and the AGR-1 experiment and because of the sheer complexity and multi-faceted processes associated with the JMOCUP depletion calculation. The JMOCUP verification is described next.

9. JMOCUP VERIFICATION

The JMOCUP modules have recently undergone an extensive technical and functional verification [8] on a different reactor-analysis project. Although the basic JMOCUP module functions have not changed, the modules have undergone some modifications to accommodate the ATR as-run input data and AGR-1 test data and parameters. JMOCUP verification for the AGR-1 test has focused on three areas: (1) verification of the as-run ATR data into JMOCUP formatted data (G. Hawkes), (2) JMOCUP module functionality and execution performance (D. Zeek and R. Sant) and, because of the large amount of output data, data selection, and data extraction, (3) data plotting of key physics parameters in order to assess the performance and accuracy of the JMOCUP depletion calculation (J. Sterbentz).

9.1 ATR Measured Data

The as-run ATR data (Section 6.1) were loaded directly into EXCEL spreadsheets designed to handle the hourly as-run ATR data format, partition and average the data by time step, and then reformat the data for JMOCUP modules. The as-run ATR data included the total core power, lobe powers, OSCC positions, and neck shim positions. These four data sets were loaded in EXCEL spreadsheets for each of the 13 AGR-1 ATR power cycles; the entire set of 13 EXCEL spreadsheets were checked by the technical checker.

9.2 JMOCUP Module Functionality

The JMOCUP module functionality was performed by checking the input and output of the JMOCUP modules. Because of the sheer number of MCNP and ORIGEN input and output files created during the JMOCUP depletion calculation, technical checking was limited to two ATR cycles, namely, 138B and 145A. Within these two cycles, the first, second, and last time steps were thoroughly evaluated. Calculated MCNP flux and reaction rates, conversion to cross sections, placement of the cross sections into the appropriate ORIGEN inputs, extraction of the ORIGEN output data, conversion to number densities and placement back into the new MCNP input file were checked for the ATR core depletion, the AGR-1 compact depletion, the hafnium shroud depletion, and the borated graphite holder depletion.

9.3 Key Calculated Physics Parameters

The JMOCUP depletion calculation for the AGR-1 test generated a significant number of output files with calculated results making it difficult, if not impossible to check each and every number. However, it is possible to plot key physics data to ensure that the JMOCUP depletion performed as expected and the calculated results are reasonable and well-behaved. This section will present calculated results of key parameters that provide additional verification for the JMOCUP calculation. Selected parameters include: (1) ATR uranium-235 depletion versus total ATR core power as a function of burnup (time step), (2) compact U-235 depletion as a function of burnup, (3) Boron-10 depletion in the borated graphite holders as a function of burnup, (4) hafnium-isotope depletion and buildup as a function of burnup, and (5) calculated ATR core k-effective during a power cycle. Additional parameters are also evaluated in this section.

9.3.1 ATR Driver Fuel Depletion

Of the four JMOCUP depletions performed as part of the AGR-1 JMOCUP depletion calculation, the first depletion, or the depletion of the ATR driver fuel, was largest in terms of the number of cells (840) to be depleted at each time step. One would expect the depletion of the uranium in the 840 driver cells to be directly proportional to the ATR total core power. And in particular, since the ATR driver fuel is high enriched (93 wt%), the depletion of the total U-235 driver fuel mass should track the total ATR core power.

Figure 4 is a plot of the ATR U-235 total core mass depleted by time step, or the incremental depleted U-235 mass, and the total ATR core power as a function of the time step for Cycle 145A, or last AGR-1 cycle. It is evident that the amount of U-235 depleted in each time step tracks the ATR total core power very closely. Figure 5 is an expanded view of the two curves showing finer detail in the variation of the ATR total core and the U-235 mass burned up by time step. Again, the two curves track very well, indicating the JMOCUP calculation depleted the ATR driver fuel elements as expected and in an accurate manner. Figures 4 and 5 are from the 2nd JMOCUP depletion calculation and are nearly identical to the 1st calculation (some small numerical differences). The close agreement between the 1st and 2nd calculation indicates the JMOCUP modules performed perfectly for the 2nd calculation as expected since the ATR input data (total core power, lobe powers, OSCC and shim positions were identical in each calculation.

It should be noted that plots similar to Figures 4 and 5 were made for each of the 13 ATR power cycles for the AGR-1 test, and each one exhibited the same excellent behavior. Although not shown here, additional plots of the total accumulated U-235 mass depleted as a function of time step for each power cycle also showed expected behavior with uniform, monotonically increasing curves; and plots of U-235 mass for individual depletion cells in each ATR element also showed well-behaved depletion behavior as well. It was concluded that the JMOCUP calculation performed the depletion of the ATR driver core accurately.

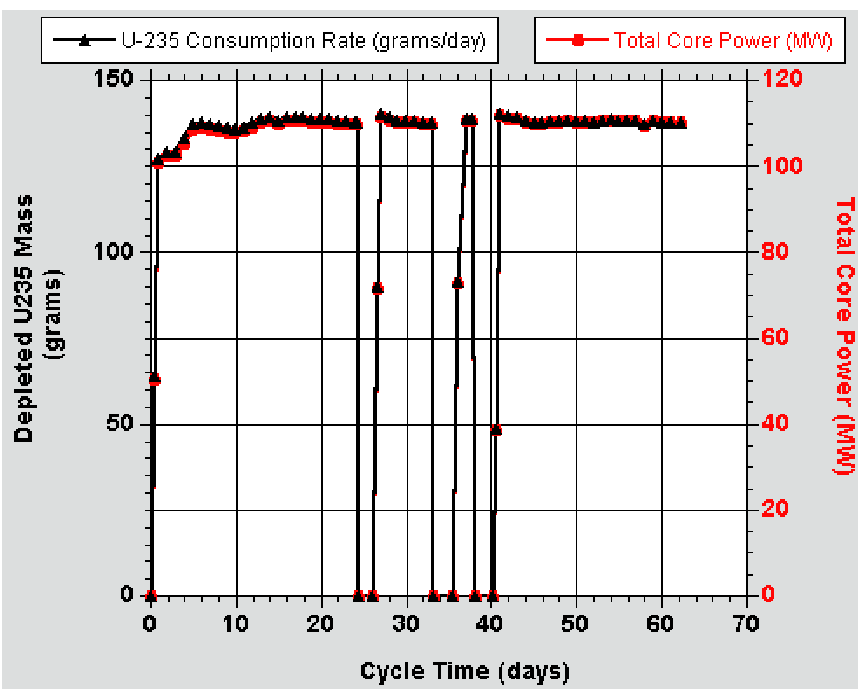

Figure 4. ATR driver fuel U-235 mass depletion and total ATR core power as a function of time step or cycle time (2nd calculation, Cycle 145A).

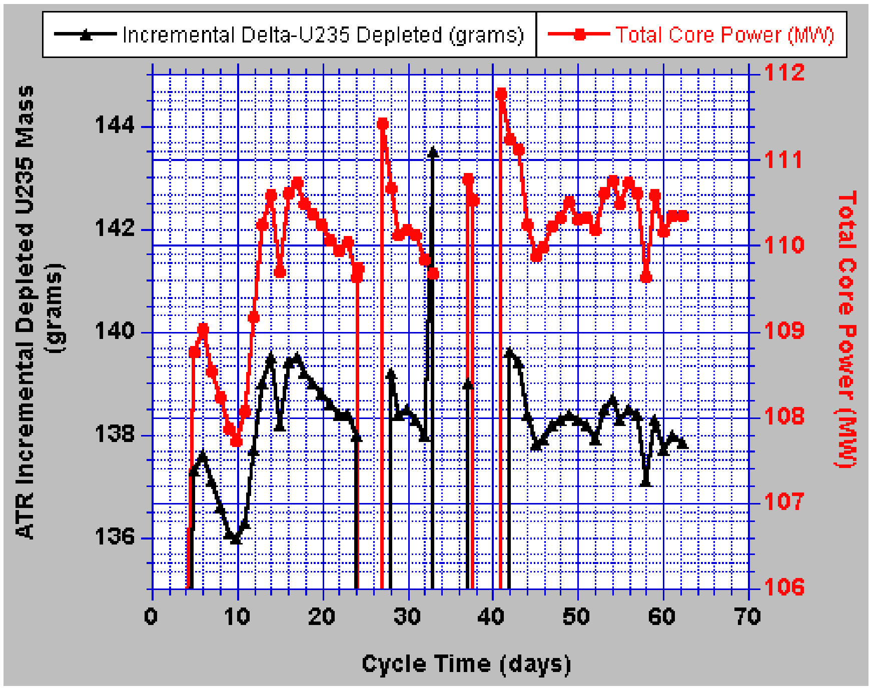

Figure 5. Expanded view of the same two curves in Figure 4 (2nd calculation, Cycle 145A).

9.3.2 Compact Depletion

The second depletion performed by the JMOCUP calculation was the depletion of the 144 compact cells that composed the 72 total compacts in the AGR-1 test capsule. Several important parameters were calculated for the compacts, including fission power, U-235 mass burnup, higher-order actinide isotopic mass, burnup in %FIMA, and fast-neutron fluence. These data will be presented in the results section.

Depletion of the compact U-235 mass was a good measure or indication that the JMOCUP depletion of the compacts performed the calculation as expected. Figure 6 shows the depletion of the total U-235 mass in the 72 compacts as a function of time for the first ATR power cycle (Cycle 138B) and relative to the total ATR core power (red). The U-235 mass decreases smoothly and monotonically for relatively steady ATR total core power.

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 1 Project File No.: 23843 Date: 08/18/2011

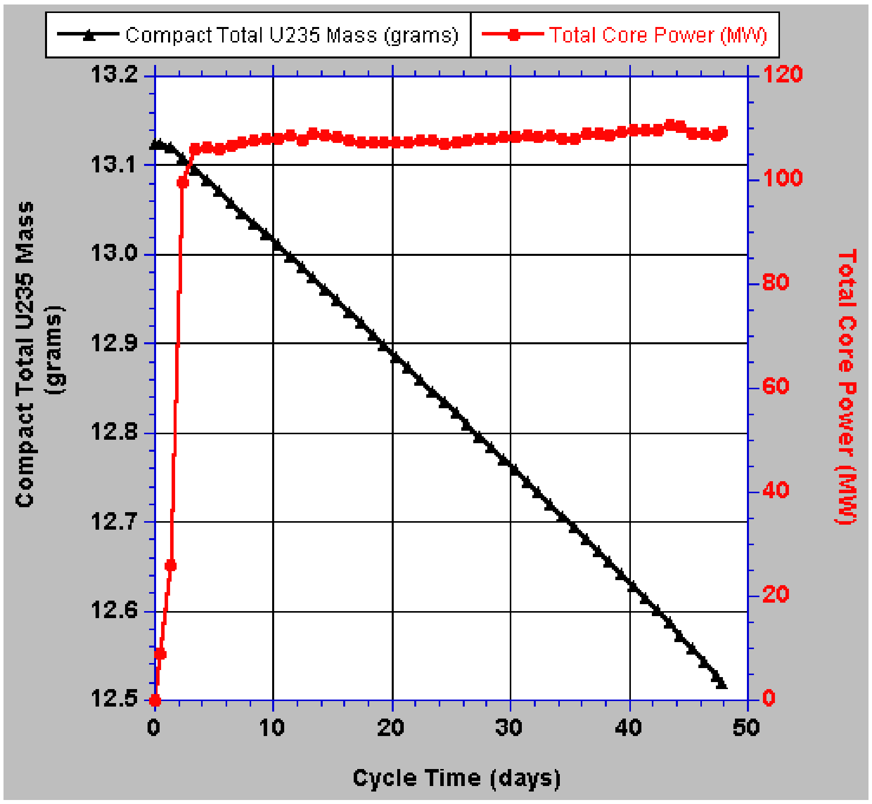

Figure 6. Depletion of the total U-235 mass in all 72 compacts during the first ATR power cycle or Cycle 138B (2nd calculation).

Figure 7 shows the amount of U-235 in the 72 compacts depleted as a function of cycle time, or the U-235 depletion rate (grams/day). The depletion rate follows the ATR total core power for approximately 80% of the cycle, and then, at the end of the cycle, the depletion rate makes a noticeable increase. This increase over the last 20% of the cycle is attributed to the OSCC large-angle positions in the northeast quadrant. Figure 8 is the same as Figure 7, but with an expanded ordinate axis scale in order to show addition detail between the depletion rate and the ATR core power. Again the U-235 depletion behavior for the compacts appears to be reasonable.

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 1 Project File No.: 23843 Date: 08/18/2011

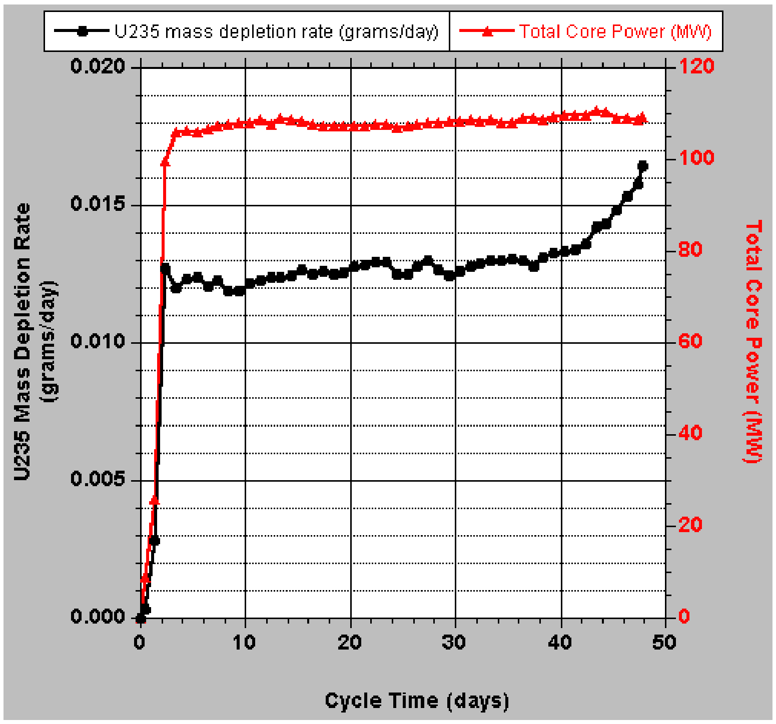

Figure 7. U-235 depletion rate for all 72 compacts during the first ATR power cycle or Cycle 138B (2nd calculation).

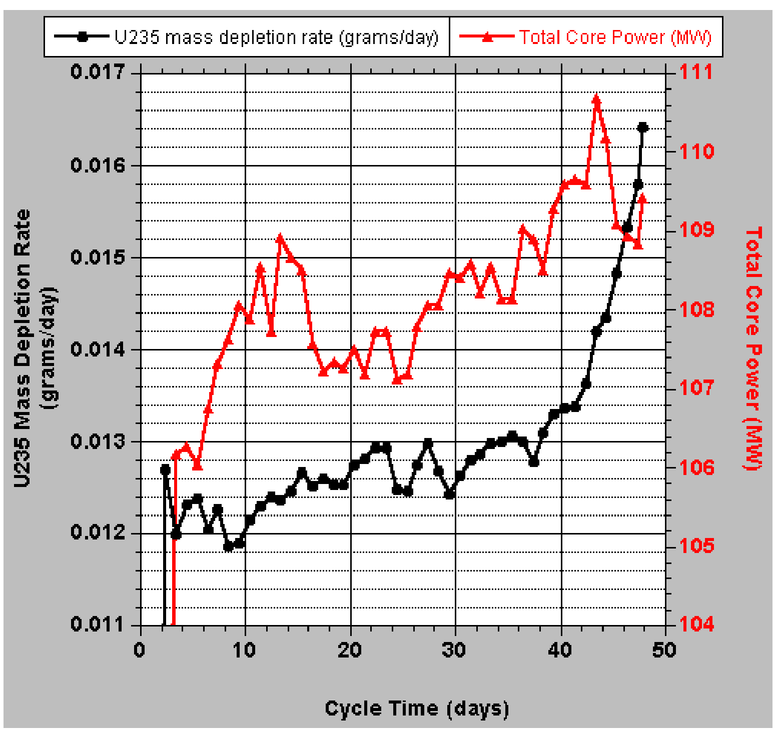

Figure 8. U-235 depletion rate for all 72 compacts during the first ATR power cycle or Cycle 138B (2nd calculation). This figure is identical to Figure 7, but with an expanded scale.

Figure 9 shows the combined fission-power output of the 72 fuel compacts in the AGR-1 test as a function of calendar days in which the AGR-1 was in the ATR reactor. This figure also partitions the calendar days by ATR power cycle. The AGR-1 assembly power starts off initially around 10 kW and steadily increases in power over the first six power cycles as the Boron-10 in the borated graphite holders depletes. By Cycle 7, the Boron-10 is depleted, and the capsule power levels out over the next three power cycles. The assembly power then begins to decrease as the compact U-235 significantly depletes, the decrease in assembly power is apparent in the last five cycles, as is evident by the overall downward drift. The data in Figure 9 were not replotted for the 2nd calculation since the differences would not be detectable on this scale.

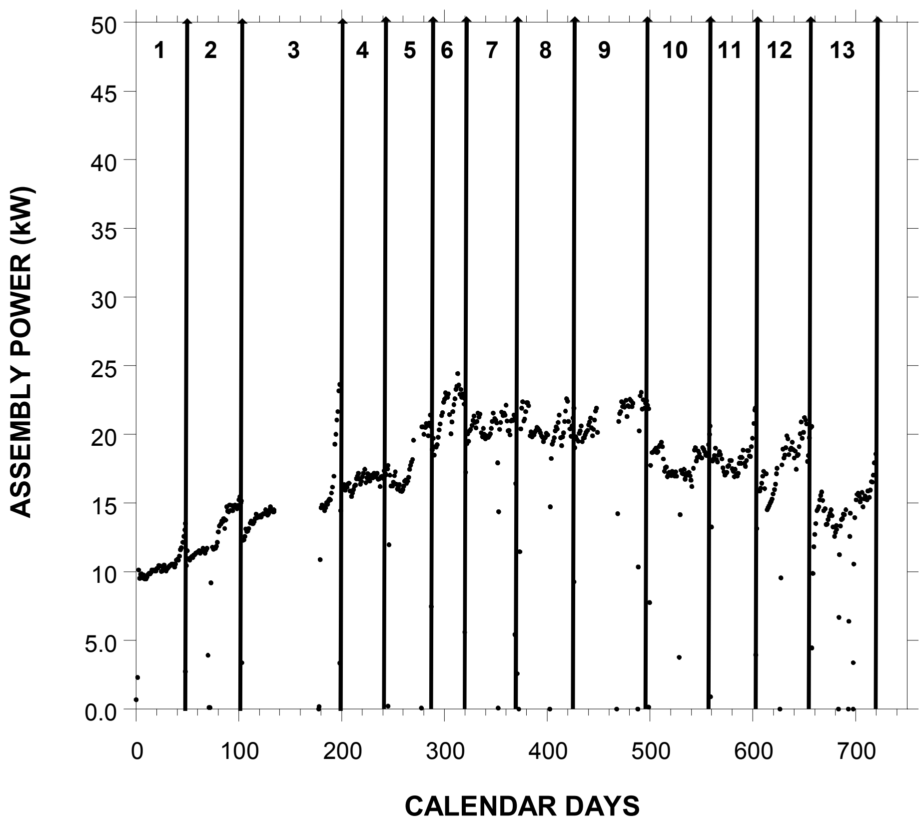

Figure 9. AGR-1 assembly power (kW) as a function of calendar days divided into the AGR-1 ATR power cycles, where 1=Cycle 138B and 13=Cycle 145A (1st calculation).

It is interesting to note that near the end of nearly every cycle, the assembly power or the total compact fission power tends to spike up. This is believed to be due to the high-angle OSCC rotation positions at the end of these cycles. The end of cycle 3 (Cycle 139B) is particularly notable. These power spikes are apparently real and not just a calculation artifact. Thermocouple temperature readings increased at the end of Cycle 139B despite gas gap mixture control to maintain a constant thermocouple temperature. Even more notable was the gas gap mixture during this power spike; the gas controllers significantly increased the helium gas concentration to reduce the capsule/compact temperatures. Hence, it is concluded that the calculated compact U-235 depletion and fission powers are reasonable.

9.3.3 Borated Graphite Holder Depletion

The third depletion performed by the JMOCUP calculation was the depletion of the 23 cells comprising the six borated graphite holders (4 depletion cells for each graphite holder, except one which arbitrarily had only 3). Each of the six capsules had a borated graphite holder (see Figures 2 and 3) to provide structural support and configuration control of the compacts. The purpose of the Boron-10 in the borated graphite holders was to reduce the thermal neutron flux intensity in the vicinity of the compacts, particularly during the first several ATR power cycles when the compacts were fresh and predicted fission rates were excessive. The Boron-10 prevented excessive heating of the compacts and balanced the U-235 depletion rate in order to maintain a relatively constant temperature in the AGR-1 capsules and achieve a very high burnup of the compact U-235 at EOL.

Figure 10 shows the total Boron-10 concentration in all six borated graphite holders as a function of ATR power cycle. At each number on the x-axis, the concentration is at the beginning-of-cycle. Hence, at no. 14 cycle, this would be the end-of-cycle Boron-10 concentration for the last or 13th ATR power cycle (145A).

Depletion of the Boron-10 in the holders was an important part of the JMOCUP depletion calculation. At beginning-of-life (ATR Cycle 138B), the total Boron-10 mass in the six graphite holders was 2.444 grams. Figure 10 shows the depletion of the total Boron-10 mass in the graphite holders as a function of ATR cycle. By the seventh cycle, most of the Boron-10 is gone, and after the ninth cycle, the BORON-10 is almost completely depleted. The BORON-10 depletes uniformly and monotonically, as anticipated and, hence, adds confidence that the JMOCUP calculation performed as expected.

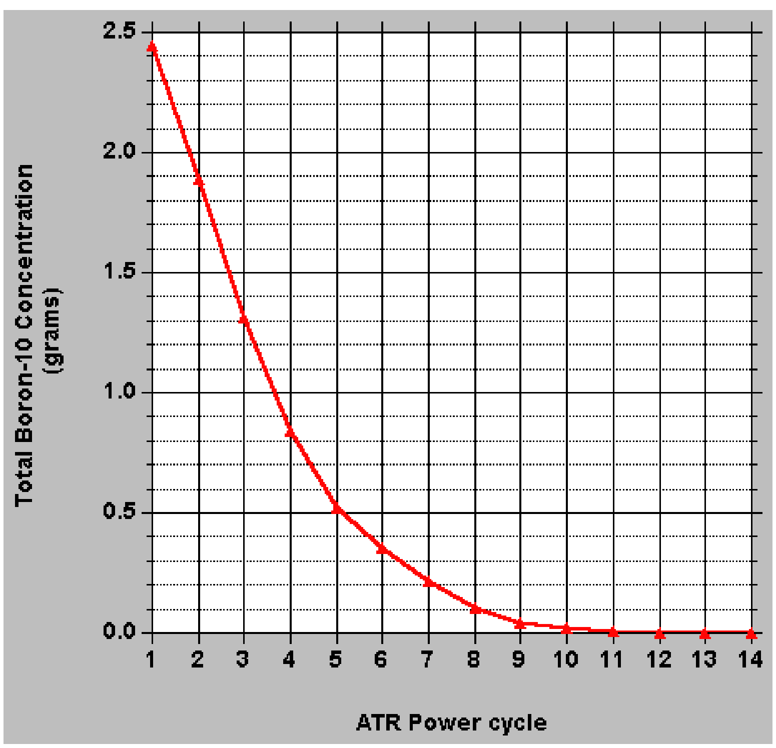

Figure 10. Total BORON-10 mass in the six borated graphite holders (2nd calculation).

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table 7. Boron-10 concentration (grams) in each the borated graphite MCNP cell as a function of ATR power cycle (2nd calculation).

Capsule No.	MCNP Cell No.	138B BOC	139A BOC	139B BOC	140A BOC	140B BOC	141A BOC	142A BOC	142B BOC	143A BOC	143B BOC	144A BOC	144B BOC	145A BOC	145A EOC
6	9669	4.042E-02	3.263E-02	2.455E-02	1.765E-02	1.276E-02	9.898E-03	7.271E-03	4.528E-03	2.554E-03	1.323E-03	6.090E-04	3.029E-04	1.131E-04	4.177E-05
6	9670	4.309E-02	3.604E-02	2.840E-02	2.146E-02	1.619E-02	1.294E-02	9.794E-03	6.307E-03	3.634E-03	1.904E-03	8.734E-04	4.288E-04	1.562E-04	5.608E-05
6	9671	8.687E-02	7.257E-02	5.698E-02	4.290E-02	3.217E-02	2.554E-02	1.911E-02	1.206E-02	6.730E-03	3.384E-03	1.472E-03	6.897E-04	2.362E-04	7.935E-05
6	9672	1.735E-01	1.394E-01	1.034E-01	7.241E-02	5.028E-02	3.752E-02	2.605E-02	1.468E-02	7.219E-03	3.195E-03	1.220E-03	5.140E-04	1.543E-04	4.541E-05
5	9673	1.084E-01	8.499E-02	6.049E-02	3.988E-02	2.561E-02	1.780E-02	1.123E-02	5.388E-03	2.152E-03	7.599E-04	2.266E-04	7.708E-05	1.759E-05	3.914E-06
5	9674	1.091E-01	8.778E-02	6.481E-02	4.462E-02	2.977E-02	2.120E-02	1.367E-02	6.645E-03	2.628E-03	9.007E-04	2.567E-04	8.343E-05	1.788E-05	3.709E-06
5	9675	1.651E-01	1.309E-01	9.422E-02	6.262E-02	3.999E-02	2.741E-02	1.683E-02	7.607E-03	2.778E-03	8.864E-04	2.340E-04	7.146E-05	1.413E-05	2.690E-06
5	9676	5.533E-02	4.066E-02	2.613E-02	1.510E-02	8.379E-03	5.188E-03	2.866E-03	1.150E-03	3.806E-04	1.127E-04	2.786E-05	8.079E-06	1.505E-06	2.709E-07
4	9677	1.086E-01	8.082E-02	5.256E-02	3.047E-02	1.669E-02	1.011E-02	5.383E-03	2.028E-03	6.212E-04	1.700E-04	3.850E-05	1.029E-05	1.737E-06	2.816E-07
4	9678	1.093E-01	8.468E-02	5.851E-02	3.654E-02	2.148E-02	1.360E-02	7.528E-03	2.923E-03	9.002E-04	2.439E-04	5.423E-05	1.415E-05	2.319E-06	3.627E-07
4	9679	1.101E-01	8.497E-02	5.836E-02	3.611E-02	2.093E-02	1.309E-02	7.136E-03	2.704E-03	8.104E-04	2.133E-04	4.595E-05	1.168E-05	1.845E-06	2.781E-07
4	9680	1.112E-01	8.178E-02	5.210E-02	2.929E-02	1.541E-02	9.006E-03	4.597E-03	1.633E-03	4.671E-04	1.196E-04	2.511E-05	6.255E-06	9.670E-07	1.432E-07
3	9681	1.081E-01	7.867E-02	4.921E-02	2.696E-02	1.377E-02	7.850E-03	3.895E-03	1.340E-03	3.712E-04	9.211E-05	1.863E-05	4.507E-06	6.741E-07	9.640E-08
3	9682	1.094E-01	8.379E-02	5.671E-02	3.432E-02	1.931E-02	1.174E-02	6.179E-03	2.240E-03	6.396E-04	1.617E-04	3.305E-05	8.022E-06	1.203E-06	1.721E-07
3	9683	1.103E-01	8.458E-02	5.739E-02	3.477E-02	1.958E-02	1.189E-02	6.253E-03	2.258E-03	6.396E-04	1.608E-04	3.263E-05	7.860E-06	1.167E-06	1.652E-07
3	9684	1.111E-01	8.149E-02	5.163E-02	2.870E-02	1.486E-02	8.532E-03	4.265E-03	1.474E-03	4.087E-04	1.017E-04	2.060E-05	4.972E-06	7.417E-07	1.064E-07
2	9685	1.081E-01	7.961E-02	5.101E-02	2.895E-02	1.546E-02	9.135E-03	4.738E-03	1.729E-03	5.082E-04	1.342E-04	2.896E-05	7.384E-06	1.178E-06	1.816E-07
2	9686	1.093E-01	8.506E-02	5.937E-02	3.761E-02	2.251E-02	1.443E-02	8.115E-03	3.236E-03	1.016E-03	2.817E-04	6.341E-05	1.670E-05	2.776E-06	4.449E-07
2	9687	1.102E-01	8.635E-02	6.106E-02	3.940E-02	2.412E-02	1.576E-02	9.076E-03	3.721E-03	1.201E-03	3.424E-04	7.909E-05	2.132E-05	3.649E-06	6.024E-07
2	9688	1.108E-01	8.406E-02	5.666E-02	3.445E-02	1.995E-02	1.257E-02	7.008E-03	2.808E-03	9.085E-04	2.642E-04	6.279E-05	1.746E-05	3.112E-06	5.384E-07
1	9689	8.528E-02	6.370E-02	4.217E-02	2.539E-02	1.484E-02	9.586E-03	5.599E-03	2.468E-03	9.192E-04	3.119E-04	8.878E-05	2.897E-05	6.385E-06	1.373E-06
1	9690	8.680E-02	6.871E-02	4.962E-02	3.320E-02	2.160E-02	1.510E-02	9.613E-03	4.714E-03	1.930E-03	7.107E-04	2.185E-04	7.624E-05	1.814E-05	4.226E-06
1	9691	1.738E-01	1.380E-01	1.005E-01	6.861E-02	4.595E-02	3.302E-02	2.187E-02	1.143E-02	5.066E-03	2.036E-03	6.900E-04	2.625E-04	7.048E-05	1.854E-05
	Sum	2.44405	1.89124	1.31586	0.84142	0.52162	0.35291	0.21808	0.10508	0.04448	0.01781	0.00642	0.00267	0.00083	0.00026

9.3.4 Hafnium Shroud Depletion

The fourth depletion performed by the JMOCUP calculation was the depletion of the hafnium shroud. The hafnium shroud was actually part of the stainless steel (SS316) test capsule wall; sandwiched between the thicker outer pressure vessel-containment steel wall and the thinner inner steel wall. The shroud itself was composed of six metal sheets, each a 60º arc section approximately 90 cm in length and 0.254 mm (0.01-inches) thick, formed together into an annular tube. Four (4) of these 60º arc sections were hafnium metal, and two (2) were SS316 steel. Figure 3 shows the six arc sections and corresponding hafnium/steel material assignments. The four hafnium sections faced toward the ATR core center.

The purpose of the hafnium shroud was to balance the thermal flux and hence the compact stack powers. The two fuel compact stacks facing the core (stacks 1 and 3) were shrouded by the hafnium in order to reduce their respective fission powers relative to the un-shrouded stack 2 furthest away from the core center. Whereas the Boron-10 acted like a front-end burnable poison and depleted relatively rapidly during the initial ATR cycles, the hafnium shroud depleted at a relatively slower rate and maintained reduced levels of both the thermal and epithermal fluxes over the full 13 ATR power cycles.

Natural hafnium is composed of six stable isotopes: Hf-174,176, 177, 178, 179, and 180. Of the six naturally-occurring isotopes, Hf-177 has the largest thermal and epithermal radiative capture cross section, followed by Hf-174 and Hf-178. The other isotopes, Hf-176, Hf-179, and Hf-180 have relatively small capture cross sections. The natural abundances of the six hafnium isotopes are 0.162% (Hf-174), 5.206% (Hf-176), 18.606% (Hf-177), 27.297% (Hf-178), 13.629% (Hf-179), and 35.1% (Hf-180). Hence, the thermal neutron absorption is dominated by Hf-177 and, to a lesser extent, by Hf-178. The small abundance of Hf-174 provides only a minor absorption effect.

Figure 11 shows the total hafnium isotopic mass in the four shroud sections as a function of burnup or ATR power cycle, as predicted by the JMOCUP depletion calculation. One can clearly see how the Hf-177 strongly depletes over time, due mainly to its relatively large absorption cross section and little buildup contribution from Hf-176. Similarly, Hf-174 mass noticeably depletes since it, too, has a substantial capture cross section and no transmutation buildup from lower hafnium isotopes.

Hafnium-178 remains relatively stable over the first 1-7 power cycles due to buildup from Hf-177 capture, but tends to decrease over the last 6 ATR cycles as Hf-177 burns down and Hf-178 continues to deplete due to its substantial capture cross section, which transmutes it into Hf-179. Hf-179, as expected, simply continues to buildup in time from Hf-178 transmutation and minor depletion from its own relatively small capture cross section. Hf-180 mass remains relatively stable over the 13 ATR cycles, balanced by Hf-179 transmutation and its own small capture cross section.

Therefore, depletion of the hafnium shroud isotopes behaves as one might expect, further building confidence that the JMOCUP calculation performed as expected.

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ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

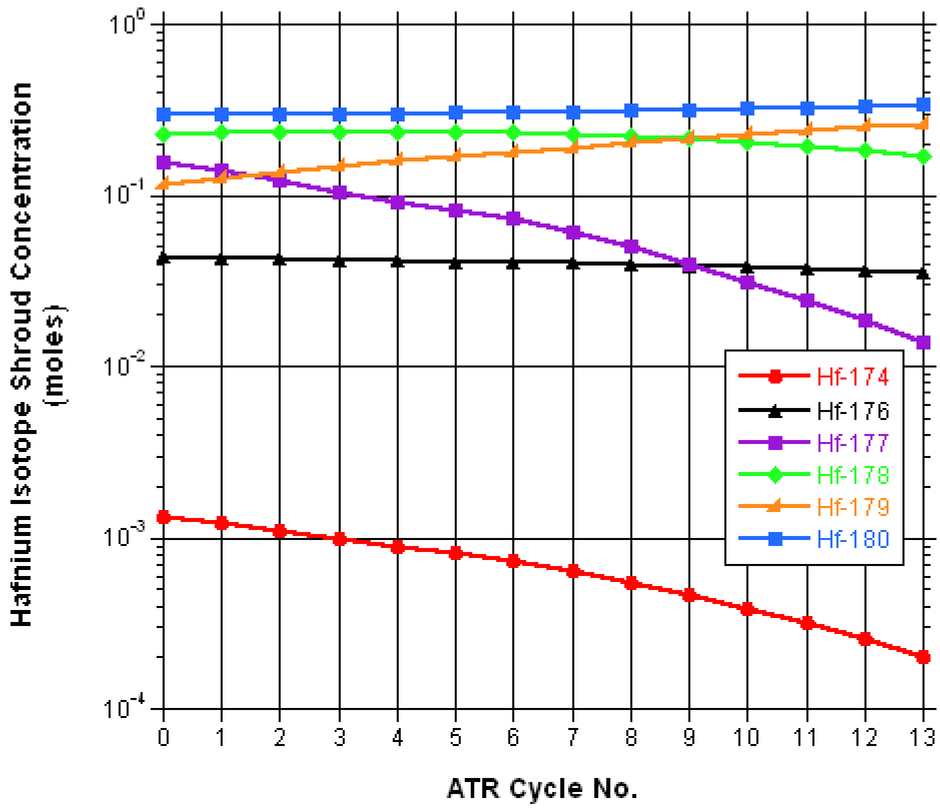

Figure 11. Total hafnium shroud isotopic mass as a function of the number of ATR power cycles.

9.3.5 ATR Core K-effective

An example of the JMOCUP-calculated core k-effective over an ATR power cycle (145A) is shown in Figures 12a and 12b for the 1st and 2nd calculations, respectively. Also plotted on these figures is the ATR total core power which is identical on both figures (red). The k-effective curves are different for the two calculations. The difference is due to the change in the northeast flux trap experiment in the MCNP input model. The northeast flux trap was remodeled as explained above in section 1.1.3 to improve the ATR MCNP model lobe power splits. The remodeled northeast flux trap added negative reactivity to the ATR core and this is now reflected in Figure 12b (2nd calculation) relative to Figure 12a (1st calculation). The two k-effective curves are virtually identical, except now the Figure 12b curve is shifted down relative to the curve in Figure 12a. This same downward shift was observed in every k-effective cycle curve, and is typical of the other 12 cycles as well. In Figure 12a, the k-effective curve (black) exhibits very reasonable behavior by hovering around 1.00, or critical, as would be expected of a simulation of a critical reactor. Spikes in the k-effective curve are the result of neck shim withdrawals; positive reactivity insertions into the core that would tend to increase the core k-effective for that time step. The curve for k-effective remains relatively flat near 1.00 over the first two-thirds of the cycle, but then increases over the latter third of the cycle. In Figure 12b (2nd calculation), the k-effective curve hovers around 0.994 and towards the end of cycle increases to 1.000 and then ends up exceeding 1.000.

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ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

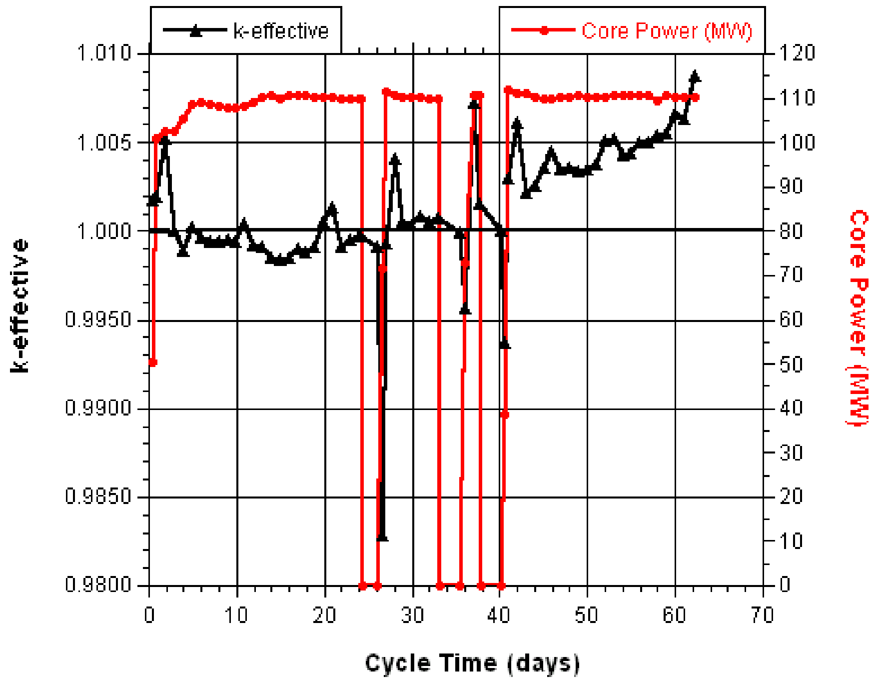

Figure 12a. JMOCUP calculated k-effective for Cycle 145A (1st calculation).

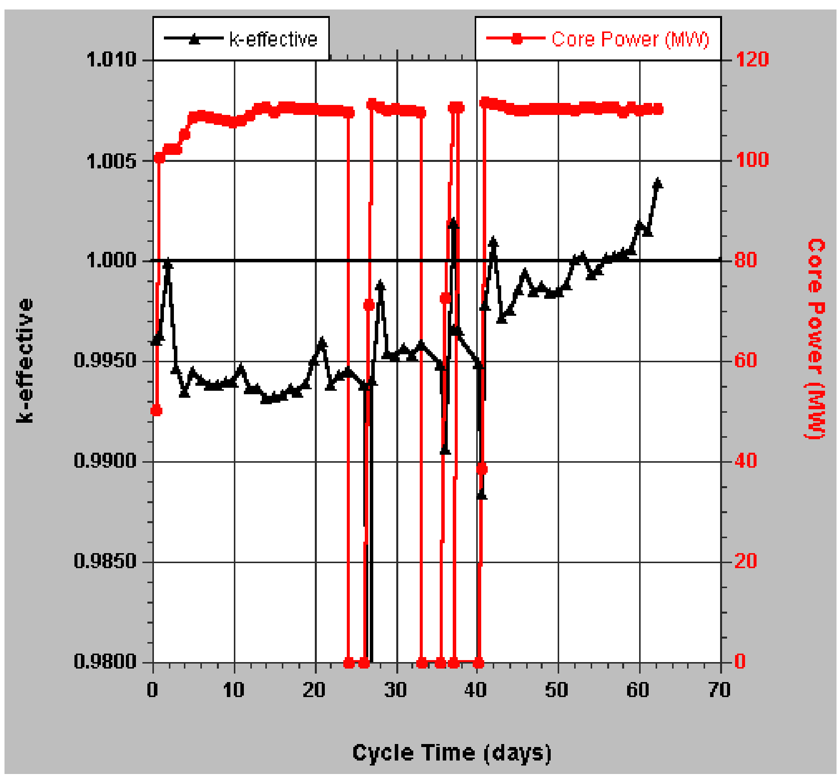

Figure 12b. JMOCUP calculated k-effective for Cycle 145A (2nd calculation).

This increase at the end of the cycle is not yet well understood. It would be highly desirable to have a flat k-effective = 1.00 curve over the entire power cycle during the JMOCUP calculation. The following several factors may contribute to fluctuation in the k-effective curve: (1) MCNP model of the OSCCs, (2) depletion of the OSCC hafnium plates and hafnium shim rods, (3) lobe reactivity imbalances, and (4) possibly other depletion factors associated with other ATR experiments near the B-10 test facility. These factors would need to be explored further to further improve the k-effective curves; otherwise, the general k-effective behavior is reasonable.

9.3.6 OSCC Rotation

One important feature of the JMOCUP calculation was the automatic rotation of the OSCCs at each time step to coincide with the actual ATR reactor operation. In order to verify the OSCCs were rotated properly in the JMOCUP depletion calculations, the northeast lobe OSCCs in the MCNP models were plotted at different time steps and compared to the ATR ASUDAS measured data.

As an example, Figures 13 and 14 show the two northeast OSCCs (N4 and E1) at beginning and end of cycle, respectively, for the ATR Cycle 145A. In these two figures, the N4 (top) and E1 (lower) OSCCs are the full, big, dark-blue circular regions with a smaller light-blue or gray circle in the middle and a bright-pink arc (bent plate) on the periphery of the dark-blue regions. These bright-pink arcs are the hafnium plates, and they rotate counterclockwise from BOC to EOC.

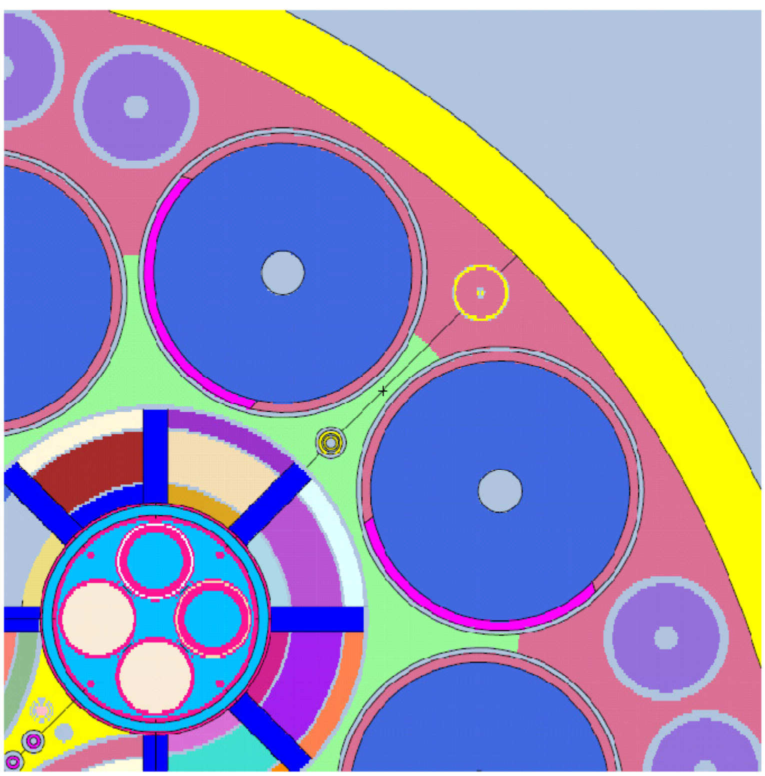

Figure 13. MCNP plot of the northeast (NE) OSCC at beginning-of-cycle for Cycle 145A showing the hafnium plate position on the N4 and E1 OSCCs (53.12º).

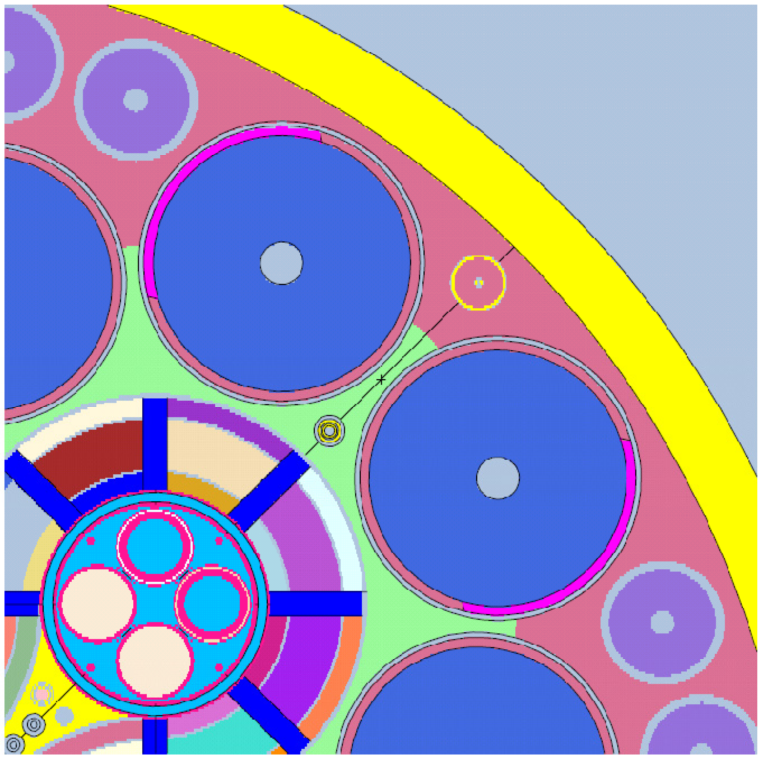

Figure 14. MCNP plot of the northeast (NE) OSCC at end-of-cycle for Cycle 145A showing the hafnium plate position on the N4 and E1 OSCCs (115.78º).

From the ATR ASUDAS data, the beginning-of-cycle position was 53.12º (time step = 1) and the end-of-cycle position was 115.78º (time step = 63). This is an angle change of 62.66º. Using a protractor to measure the angular difference in the two MCNP plotted figures (Figures 13 and 14); the difference is estimated to be 63º. These two values are in excellent agreement with one another, and one would conclude that the JMOCUP module performing the OSCC rotations is working properly. Note: the end-of-cycle 115.78º position is a high-angle rotation position of an OSCC.

9.3.7 Lobe Powers

The MCNP model requires the following four items to be modeled accurately in order to accurately predict the ATR core reactivity as a function of burnup. These four items include: (1) 40-element driver core loading, (2) OSCC positions, (3) neck shim positions, and (4) lobe or flux-trap reactivity of each experiment. In the JMOCUP MCNP model, the 40-element driver core was loaded as prescribed by the as-run cycle loading data, the OSCC positions were modeled using as-run or measured ATR OSCC position data, and the neck shim positions were modeled using as-run or measured ATR data. So, little or no additional improvement in the first three items can be achieved by the reactor-physics analyst, who simply receives and uses the as-run ASUDAS data. The fourth item, however, may provide some leeway to improve the JMOCUP calculation. The JMOCUP base MCNP model (*inp.1*) currently has an experiment modeled in each of the flux traps, some with incredible geometric and material detail. However, not all the modeled experiments in the flux traps may be what is actually in the ATR core.

Maintaining an ATR MCNP model up to date with the latest experimental tests in each flux trap would require substantial modeling effort, or at least a rigorous coordination effort between many ATR reactor physics analysts. One of the JMOCUP calculation assumptions was that the experiments modeled in the MCNP model were reasonable approximations of the actual experiments in the ATR core – reasonable in the sense that the MCNP model represented the parasitic structural mass and uranium loadings in the flux traps well enough to reasonably approximate the flux-trap reactivity worth. The calculated ATR lobe powers revealed, however, that there were some differences between the calculated lobe powers from the MCNP model and the actual ATR measured lobe powers.

Table 8 compares the MCNP calculated lobe powers (MW) versus the ATR measured, or as-run, lobe powers for the 1st calculation. The northwest (NW)-, southwest (SW)-, and southeast (SE)-lobe powers are in very good agreement, and the center (C) is in reasonable agreement, although the calculated center-lobe power is 1.5-2.0 MW lower than the measured value over the entire cycle. The northeast (NE) produces the largest difference with the calculated lobe power being approximately 3-4 MW high relative to the measured value over the power cycle.

Table 8. Comparison of calculated versus measured lobe powers for Cycle 145A (1st calculation).

Time-step (#)		NW Lobe Power (MW)	NE Lobe Power (MW)	C Lobe Power (MW)	SW Lobe Power (MW)	SE Lobe Power (MW)	TOTAL (MW)	NE+C+SE Lobe Power (MW)	Diff (%)
8	Calc	17.70	22.23	21.11	21.86	25.64	108.55	68.98	+3.23
8	Meas.	18.32	18.26	23.19	23.40	25.37	108.55	66.83	
15	Calc	17.58	21.95	21.45	22.96	26.66	110.60	70.06	+2.96
15	Meas.	18.29	18.25	23.61	24.26	26.19	110.60	68.05	
25	Calc	17.38	21.53	21.04	22.86	26.84	109.65	69.41	+2.82
25	Meas.	18.11	18.13	23.20	24.04	26.17	109.65	67.50	
35	Calc	17.47	21.35	20.67	23.35	26.83	109.68	68.85	+2.26
35	Meas.	18.17	18.18	23.01	24.19	26.14	109.68	67.33	
45	Calc	17.61	21.34	20.56	23.84	26.91	110.26	68.81	+1.86
45	Meas.	18.31	18.34	22.89	24.40	26.31	110.26	67.55	
55	Calc	17.32	20.49	21.57	24.50	26.87	110.75	68.93	+0.98
55	Meas.	18.22	18.24	23.71	24.28	26.30	110.75	68.26	
63	Calc	17.11	20.15	21.85	24.36	26.88	110.35	68.88	+1.25
63	Meas.	18.20	18.22	23.61	24.12	26.21	110.35	68.03	

It is interesting to note that the calculated lobe powers in Table 8 tend to approach the measured lobe powers with increasing burnup. This is expected since over-powered ATR elements will burn down faster than the under-powered elements and approach lobe power split balance driven by the initial element loadings, OSCC positions, and neck shim positions.

It is also of interest to note that the combined NE+C+SE lobe powers are only 1-3% higher than the combined measured value. This means that the starting source neutrons in the MCNP calculation are favored slightly for these three lobes and would probably result in a slight increase in the fast-neutron flux track tally in the B-10 AGR-1 test facility and, correspondingly, a slightly higher thermal neutron flux track tally as well, but probably to a smaller degree. Although the Table 8 data are for Cycle 145A only, it is expected that the other 12 AGR-1 ATR power cycles would exhibit similar calculated behavior since the same MCNP base model was used in the JMOCUP calculations and the ATR core had very similar cycle-to-cycle lobe power splits.

Table 9 compares the MCNP calculated lobe powers (MW) versus the ATR measured, or as-run, lobe powers for the 2nd calculation. The northwest (NW)-, southwest (SW)-, and southeast (SE)-lobe powers are in very good agreement, and the center (C) is in reasonable agreement, although the calculated center-lobe power is still 1.5-2.0 MW lower than the measured value over the entire cycle. The northeast (NE) lobe power (MCNP northeast flux trap was remodeled) is now in good agreement with the measured values as well. It is also interesting to note that the combined NE+C+SE lobe powers are now all less than 1% different from the combined measured value.

Table 9. Comparison of calculated versus measured lobe powers for Cycle 145A (2nd calculation).

Time-step (#)		NW Lobe Power (MW)	NE Lobe Power (MW)	C Lobe Power (MW)	SW Lobe Power (MW)	SE Lobe Power (MW)	TOTAL (MW)	NE+C+SE Lobe Power (MW)	Diff (%)
8	Calc	18.34	19.91	21.19	23.11	26.00	108.55	67.10	+0.40
8	Meas.	18.32	18.26	23.19	23.40	25.37	108.55	66.83	
15	Calc	18.18	19.73	21.52	24.16	27.01	110.60	68.26	+0.30
15	Meas.	18.29	18.25	23.61	24.26	26.19	110.60	68.05	
25	Calc	17.94	19.48	21.09	23.97	27.17	109.65	67.74	+0.40
25	Meas.	18.11	18.13	23.20	24.04	26.17	109.65	67.50	
35	Calc	18.01	19.40	20.75	24.41	27.12	109.68	67.27	-0.09
35	Meas.	18.17	18.18	23.01	24.19	26.14	109.68	67.33	
45	Calc	18.16	19.49	20.59	24.81	27.22	110.26	67.30	-0.40
45	Meas.	18.31	18.34	22.89	24.40	26.31	110.26	67.55	
55	Calc	17.78	18.97	21.63	25.23	27.14	110.75	67.74	-0.76
55	Meas.	18.22	18.24	23.71	24.28	26.30	110.75	68.26	
63	Calc	17.59	18.81	21.92	24.92	27.10	110.35	67.83	-0.30
63	Meas.	18.20	18.22	23.61	24.12	26.21	110.35	68.03	

It will be worthwhile to further explore updating the JMOCUP MCNP base model to reflect more accurately the actual reactivity worth in the nine flux traps. Of course, very detailed modeling of each ATR flux trap experiment could be somewhat prohibitive in terms of acquiring and evaluating data for each experiment and then modeling each experiment in MCNP model format for every ATR power cycle. Simplified flux-trap models within the ATR model however may be appropriate where volume fractions and total material masses are preserved in simple cylindrical geometries. This approach will not only achieve the desired flux-trap reactivity worth, but could also greatly simplify the MCNP model and speed up the depletion calculation since the MCNP model transport calculation is the slowest part of the JMOCUP depletion calculation.

9.4 JMOCUP Validation

Partial validation of AGR-1 JMOCUP depletion calculation will be done through comparison with PIE data. TRISO-compact end-of-life actinide and fission-product isotopic assay measurements and fast- and thermal-neutron flux wire measurements are expected to be the two primary data used to validate parts of the JMOCUP depletion calculation results.

The JMOCUP depletion methodology has also been previously validated for several different nuclear reactors and their assayed spent nuclear fuels [8]-[12].

10. DATA RETENTION

The number of input files and output files generated during the course of the AGR-1 JMOCUP depletion calculation is considerable. Storage of all of these files is prohibitive in terms of disk space, and some have been deleted. Selected MCNP5 and ORIGEN2.2 files are stored on the HELIOS and ICESTORM hard-disk storage systems; in particular, those files associated with the AGR-1 fuel compacts have all been retained. Most of the deleted files are associated with the numerous (and less interesting) ATR driver core elements.

Post-processors that read, process, and output selected data from these input and output files are located on the HELIOS computer system. All post-processed data has been downloaded to the INL NDMAS (NGNP Data Management and Analysis System).

11. CALCULATED RESULTS

This section presents selected summary results calculated by the 2nd JMOCUP depletion calculation. The summary results are specifically for the TRISO-particle compacts and include: (1) compact fission powers, (2) EOL %FIMA burnup, (3) EOL actinide isotopic concentrations, (4) EOL fission product concentrations, (5) EOL iodine-135 concentration, and (6) EOL neutron fast fluence. A complete inventory of these data and more can be found in NDMAS for each ATR power cycle on a day-by-day basis.

11.1 Compact Fission Power

Compact fission power was a key physics parameter to be calculated in the JMOCUP depletion calculation. Calculated compact fission powers were part of the input for the thermal analysis [14]; these detailed data will be stored in the NDMAS system by cycle, time step, and compact cell (144 compact cells or 2 cells per compact).

Figure 15 shows the average specific fission-power or heat-generation rate (MW/m^3) in each capsule as a function of cycle and EFPD. The general trend shared by each capsule is an increase in fission power for the early power cycles as the boron in the graphite holders is depleted, followed by a leveling-off in the mid-cycles, and an average decrease over the last cycles. In many of the individual irradiation cycles, an increase in power density can be observed toward the end of each cycle. This is attributed to the high-angle rotation of the northeast (NE) outer shim cylinders. High-angle rotation of the OSCC at EOC is often required to maintain core criticality and balance lobe powers in the ATR; the main effect of these high-angle rotations is to substantially increase the thermal flux in the vicinity of the B-10 facility and, hence, the compact fission powers. The data in Figure 15 were not replotted for the 2nd calculation since the differences would not be detectable on this scale.

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

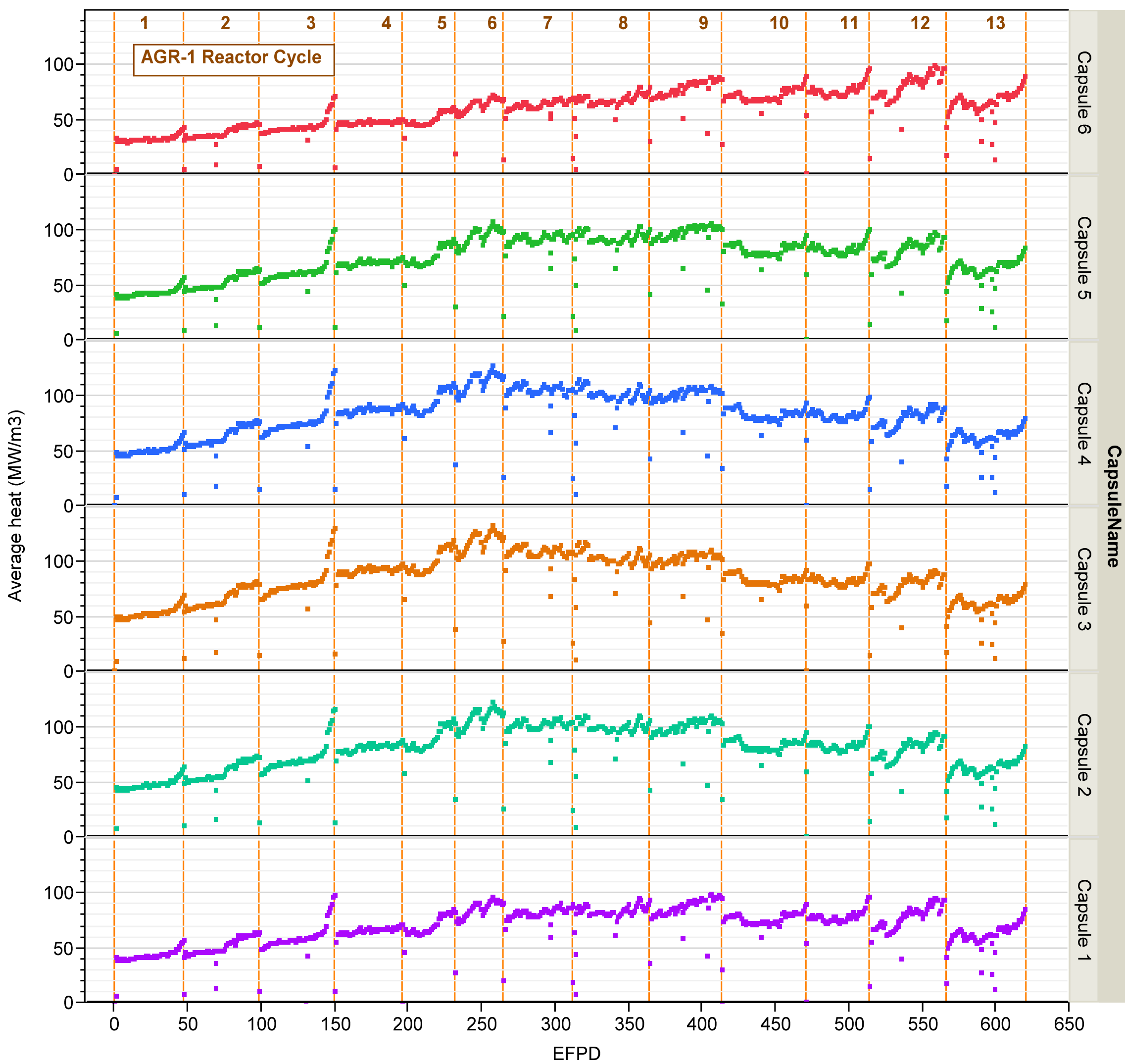

Figure 15. Capsule average power density (MW/m3) versus irradiation time in EFPD (1st calculation).

Figure 9 in Section 9.3 gives the total assembly power, or sum of all six capsules, as a function of cycle. The total assembly power trend behaves similar to the individual capsules as above in Figure 15.

11.2 EOL %FIMA Burnup

Compact burnup (% FIMA) was calculated by the JMOCUP depletion 2nd calculation. Burnups were calculated for each MCNP cell (two cells per compact), where the two cells per compact provided a little more detail on the axial burnup profiles of the compact. Averaging the two cell burnup values provided a compact average burnup (% FIMA). Compact average burnups for all 72 compacts are in NDMAS. Figure 16 shows the more detailed compact-cell average burnups for Stack 1 in each of the six capsules. Since there are four compacts per capsule stack and two MCNP cells per compact, there are a total of eight burnup values per capsule shown in the figure.

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

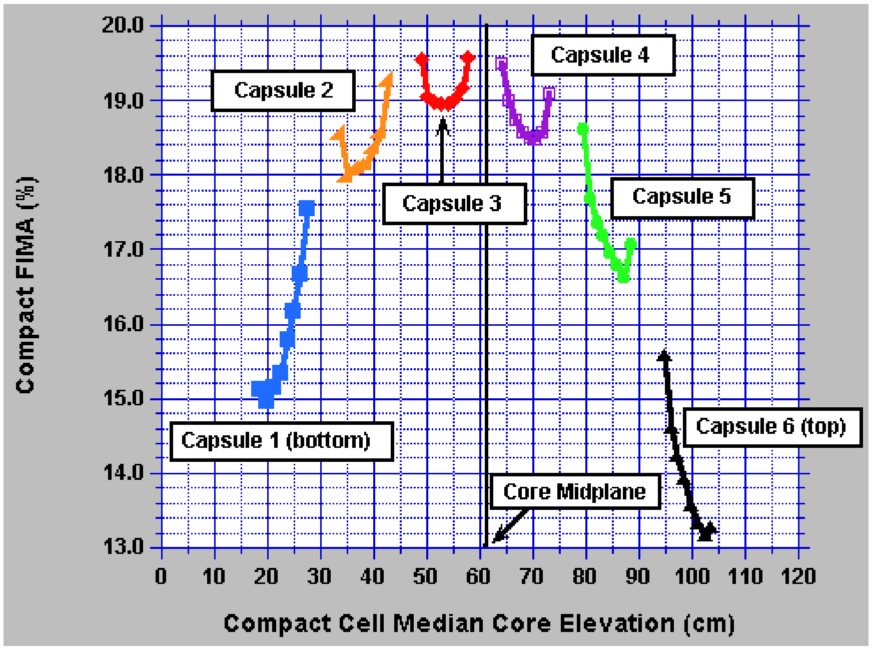

Figure 16. Calculated burnups (%FIMA) for the compacts in Stack 1 at the end-of-life or end of Cycle 145A (2nd calculation).

The overall axial burnup profile in Figure 16 follows the cosine-shape ATR axial thermal-flux profile. There is some noticeable asymmetry about the core midplane, however, which is generally attributed to the hafnium safety rods parked at the top of the core. These rods tend to suppress the thermal-neutron flux and, hence, potentially the compact fission power at the top of the core. It is also interesting to note the U-shaped burnup profiles of the compacts in each capsule. This is attributed to a slight increase in the thermal-neutron flux and, therefore, the thermal fission compact power near the stack ends because of the open end design of the borated-graphite holder. The overall calculated burnup results show a well distributed compact burnup profile for Stack 1 compacts with burnups ranging from 13-20 % FIMA. In a typical high temperature gas-cooled reactor (HTGR), one would also expect a wide range of compact and particle burnups as well. Table 10 gives the EOL %FIMA for all 72 compacts.

Table 10. End-of-Life Compact burnup in %FIMA (2nd calculation).

Capsule No.	Compact No.	Stack 1 (%FIMA)	Stack 3 (%FIMA)	Stack 2 (%FIMA)
6	1	13.22	13.25	11.23
6	2	13.45	13.47	11.31
6	3	14.09	14.13	11.93
6	4	15.11	15.18	12.68
5	5	16.86	16.96	14.11
5	6	16.88	16.93	14.07
5	7	17.29	17.31	14.50
5	8	18.15	18.17	15.70
4	9	18.84	18.83	16.59
4	10	18.50	18.52	16.24
4	11	18.66	18.62	16.47
4	12	19.26	19.30	17.25
3	13	19.38	19.47	17.46
3	14	19.00	19.05	16.87
3	15	18.98	19.03	16.87
3	16	19.31	19.41	17.47
2	17	18.95	19.06	17.05
2	18	18.28	18.31	16.16
2	19	18.11	18.12	15.89
2	20	18.29	18.35	16.18
1	21	17.12	17.29	14.83
1	22	15.98	16.14	13.76
1	23	15.26	15.46	13.27
1	24	15.05	15.21	13.11

11.3 EOL Actinide Isotopic Concentrations

This section presents the total end-of-life actinide isotopic inventory for the 72 compacts. Initially, at beginning of life, or the start of Cycle 138B and the start of the JMOCUP depletion calculation, the 72 compacts contained a total of 13.1237 grams of U-235 and approximately 53.373 grams of U-238, with a corresponding enrichment of approximately 19.736 wt% U-235. At the end-of-life, or after the 13 ATR irradiation cycles (end of Cycle 145A), the 72 compacts contained a total of only 2.4227 grams of U-235 and approximately 50.236 grams of U-238, with a final enrichment of approximately 4.46 wt% U-235. This represents an average U-235 compact burnup of approximately 81.5%. Table 6 gives the total compact (all 72 compacts) actinide isotopic concentrations for beginning-of-life (Cycle 138B) and end-of-life (Cycle 145A) concentrations. Appendix A gives the actinide isotopic EOL concentration as a function of compact for the 2nd calculation; concentrations are in units of moles/compact.

Table 6. Total end-of-Life actinide isotopic mass for all 72 compacts (2nd calculation).

Actinide Isotope	BOL Mass (grams)	EOL Mass (grams)
U-234	0.0	0.0027400
U-235	13.1237	2.4227000
U-236	0.0	1.6657000
U-237	0.0	0.0032900
U-238	53.373	50.2360000
Np-237	0.0	0.0825000
Np-238	0.0	0.0003980
Pu-238	0.0	0.0201000
Pu-239	0.0	0.5919000
Pu-240	0.0	0.3086000
Pu-241	0.0	0.1554000
Pu-242	0.0	0.0844000
Am-241	0.0	0.0035700
Am-242m	0.0	0.0000182
Am-243	0.0	0.0092600
Cm-242	0.0	0.0017100
Cm-244	0.0	0.0030400

11.4 EOL Fission Product Isotopic Concentrations

In addition to the compact actinide concentrations, concentrations for the 71 tracked fission product isotopes are also given in Appendix B as a function of compact for the 2nd calculation; concentrations are in units of moles/compact.

11.5 EOL Iodine-135 Concentration

The concentration of I-135 was calculated for each of the compacts at the end of each ATR power cycle. Table 7 gives an example of the calculated I-135 concentrations (moles) with no decay at the end of the last AGR-1 irradiation cycle (Cycle 145A) for the 2nd calculation. These iodine values are for the end of reactor operation at the end of Cycle 145A, so there is no decay. Calculated iodine-135 values for the other 12 cycles can be found in NDMAS, also with no decay.

Table 7. Iodine-135 concentration (moles) in the compacts at the end of Cycle 145A (2nd calculation).

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.709E-08	2.759E-08	2.899E-08
6	2	2.868E-08	2.883E-08	3.133E-08
6	3	2.815E-08	2.788E-08	3.161E-08
6	4	2.709E-08	2.738E-08	3.057E-08
5	5	2.689E-08	2.725E-08	3.120E-08
5	6	2.778E-08	2.780E-08	3.237E-08
5	7	2.731E-08	2.772E-08	3.219E-08
5	8	2.612E-08	2.639E-08	3.087E-08
4	9	2.544E-08	2.587E-08	3.011E-08
4	10	2.592E-08	2.643E-08	3.101E-08
4	11	2.564E-08	2.628E-08	3.061E-08
4	12	2.517E-08	2.566E-08	2.959E-08
3	13	2.494E-08	2.554E-08	2.969E-08
3	14	2.578E-08	2.621E-08	3.090E-08
3	15	2.579E-08	2.652E-08	3.110E-08
3	16	2.551E-08	2.588E-08	3.000E-08
2	17	2.534E-08	2.599E-08	2.982E-08
2	18	2.667E-08	2.684E-08	3.133E-08
2	19	2.668E-08	2.720E-08	3.160E-08
2	20	2.603E-08	2.642E-08	3.041E-08
1	21	2.594E-08	2.659E-08	3.021E-08
1	22	2.726E-08	2.772E-08	3.133E-08
1	23	2.778E-08	2.815E-08	3.182E-08
1	24	2.696E-08	2.730E-08	3.055E-08

11.6 EOL Neutron Fast Fluence

The fast fluence or cumulative fast flux (E_n > 0.18 MeV) was calculated for each compact cell at every time step for each of the 13 ATR power cycles. From these time-integrated fast fluxes, the corresponding compact cell fast fluence can be estimated. The entire cumulative and incremental fast fluence inventory by compact, cycle, and time step are in the NDMAS. Table 8 is a summary of the cumulative end-of-life (EOL) compact fast fluence, as calculated by the 2nd JMOCUP depletion calculation.

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table 8. Compact fast fluence (E_n > 0.18 MeV) summary (2nd calculation).

Capsule No. (#)	Compact No. (#)	Stack No. 1 (n/cm^2)	Stack No. 3 (n/cm^2)	Stack No. 2 (n/cm^2)
6	1	2.43E+21	2.46E+21	2.17E+21
6	2	2.67E+21	2.70E+21	2.38E+21
6	3	2.87E+21	2.90E+21	2.55E+21
6	4	3.00E+21	3.04E+21	2.68E+21
5	5	3.43E+21	3.48E+21	3.08E+21
5	6	3.60E+21	3.65E+21	3.23E+21
5	7	3.71E+21	3.77E+21	3.33E+21
5	8	3.76E+21	3.82E+21	3.38E+21
4	9	3.99E+21	4.06E+21	3.59E+21
4	10	4.10E+21	4.16E+21	3.68E+21
4	11	4.15E+21	4.21E+21	3.73E+21
4	12	4.13E+21	4.20E+21	3.72E+21
3	13	4.18E+21	4.24E+21	3.76E+21
3	14	4.23E+21	4.30E+21	3.80E+21
3	15	4.21E+21	4.28E+21	3.79E+21
3	16	4.13E+21	4.20E+21	3.72E+21
2	17	3.98E+21	4.05E+21	3.59E+21
2	18	3.96E+21	4.02E+21	3.56E+21
2	19	3.87E+21	3.93E+21	3.48E+21
2	20	3.71E+21	3.77E+21	3.35E+21
1	21	3.33E+21	3.39E+21	3.01E+21
1	22	3.22E+21	3.27E+21	2.90E+21
1	23	3.05E+21	3.10E+21	2.74E+21
1	24	2.81E+21	2.86E+21	2.52E+21

Capsule no. 6 is at the vertical top of the AGR-1 test assembly (and top of the ATR core); capsule no. 1 is at the bottom of the AGR-1 test assembly.

11.1 Calculational Variable Uncertainties

There are uncertainties associated with the calculated JMOCUP depletion results. These uncertainties enter into the calculation from the ATR as-run data, ENDF cross-section data, MCNP statistical errors, etc. There are also unquantifiable propagation errors associated with Monte Carlo depletion calculations, although it has been shown that these errors tend to be well-behaved and average out over the depletion calculation. The high-resolution JMOCUP calculation is expected to behave very well and average out these propagation errors better than any other longer time step Monte Carlo calculation.

Table 9 lists potential variables in the JMOCUP calculation that might have an associated uncertainty. The uncertainties given in the table are estimates, and it is emphasized that they are only estimates, even though some uncertainties are more easily quantifiable than others.

Table 9. Variables and associated uncertainty estimates.

Entity/Item	Variable	Units	Uncertainty Estimate
ATR	Total core power	MW	±4.1%[15] ±8.0%[16]
ATR	Lobe power	MW	±4.1%[15] ±8.0%[16]
ATR	OSCC position	degrees (º)	<1.0%
ATR	OSCC hafnium isotope number densities	a/b/cm	<1.0%
ATR	Beryllium reflector poison		<1.0%
ATR	Flux trap reactivity		unknown
Fuel Compacts	BOL number densities	a/b/cm	±0.5%
JMOCUP-MCNP	k-effective		±0.5%
JMOCUP-MCNP	Flux (statistical error)	1/cm2/sn	±0.8%
JMOCUP-MCNP	Reaction rates (statistical error)	1/cm2/sn	±2.0%
JMOCUP-MCNP	Fission powers (statistical error)	MeV/gm/sn	±1.5%
JMOCUP-MCNP	ENDF nuclear data		0-10%
JMOCUP calc	Lobe power normalization	MW	+1-3%
JMOCUP calc	nu	n/fiss	±0.1%
JMOCUP calc	Q	MeV/fiss	±1.0%
JMOCUP-ORIGEN	Cross section	barns	±2.0%
JMOCUP-ORIGEN	Numerical error		±0.5%

The largest uncertainties listed in Table 9 are associated with the ATR total core power and lobe powers based on the cited references. The lobe powers and their summation, the total core power, are used in the JMOCUP calculation to normalize the neutron fluxes, reaction rates, and fission power densities. From the preliminary comparison of calculated compact FIMA and the measured FIMA, the excellent agreement between the calculated and measured burnups would indicate that the referenced uncertainty estimates for the ATR lobe powers and total core power are over-estimated in magnitude. In fact, the measured ATR lobe powers and total core power estimates are instead probably quite good estimates and probably much more accurate than the quoted ±4%.

12. CONCLUSIONS

The 2nd JMOCUP depletion calculation for the AGR-1 TRISO-coated fuel particle irradiation test has been executed and appears to have completed successfully and accurately. The calculated results for the 2nd JMOCUP calculation here match very closely the calculated results of the 1st JMOCUP calculation. This was expected as both calculations were nearly identical with the exception of relatively small differences. The primary reason for rerunning the JMOCUP calculation was to substantially increase the number of tracked fission products in the TRISO-particle compacts for PIE purposes and better characterization. Small errors identified in the 1st JMOCUP depletion calculation technical check were corrected for the 2nd JMOCUP calculation here.

One important calculated physics parameter was the daily compact fission powers or heat rates (MW/cm^3) for each of the 13 ATR power cycles. These data were calculated taking into account the daily ATR total and lobe power fluctuations, the OSCC rotational movement, and the periodic withdrawal of the hafnium neck shims. These compact heat rates were transmitted as input to the thermal calculation [14] for the prediction of the AGR-1 fuel and thermocouple temperatures.

In addition to the calculated compact fission powers, the JMOCUP depletion calculation provided additional calculated data as well. These additional data included compact (1) burnup (% FIMA), (2) thermal, epithermal, and fast fluxes, (3) fast fluence, (4) iodine-135 EOC concentrations, and (5) compact actinide and fission product concentrations. Large amounts of other calculated data, not directly associated with the desired AGR-1 calculated results/depletions, but definitely part of the JMOCUP calculation, included the ATR driver core, hafnium shroud, and borated graphite holder depletions and associated burnup and isotopic data, and calculated ATR core k-effective.

The JMOCUP depletion calculations have undergone a technical check or verification by independent technical checkers. Errors identified in the 1st calculation technical check were made prior to the initiation of the 2nd calculation. Modifications were made to the MCNP model, specifically the northeast flux trap experiment; in order to improve core reactivity and more importantly lobe power splits that now match very closely to the actual ATR core during the 13 ATR power cycles comprising the AGR-1 test.

It should also be noted that JMOCUP calculated FIMA values are in very good agreement (within 2-5%) with a second verified AGR-1 physics analysis [17]. However, although the FIMA values are in good agreement, the fast-fluence values calculated by JMOCUP are approximately 10% higher.

The JMOCUP depletion calculation was the first application of the JMOCUP methodology to an ATR experiment and can be considered to be a shakedown calculation. The detailed JMOCUP calculation appears to be the first of its kind in terms of a full-core simulation using beginning-of-cycle driver core loadings and as-run ATR measured OSCC and neck shim data to adjust for control-element movement. The JMOCUP depletion calculation is fully automated and is well positioned to continue to perform high resolution or fine time step (daily) depletions necessary for thermocouple temperature prediction comparisons.

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APPENDIX A—EOL TRISO-PARTICLE COMPACT ACTINIDE CONCENTRATIONS

Table A.1. U-234 Concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.213E-08	1.222E-08	1.119E-08
6	2	1.295E-08	1.302E-08	1.201E-08
6	3	1.369E-08	1.375E-08	1.267E-08
6	4	1.449E-08	1.455E-08	1.333E-08
5	5	1.598E-08	1.611E-08	1.474E-08
5	6	1.629E-08	1.641E-08	1.508E-08
5	7	1.674E-08	1.682E-08	1.547E-08
5	8	1.744E-08	1.751E-08	1.596E-08
4	9	1.830E-08	1.841E-08	1.675E-08
4	10	1.819E-08	1.831E-08	1.677E-08
4	11	1.844E-08	1.858E-08	1.692E-08
4	12	1.897E-08	1.915E-08	1.738E-08
3	13	1.931E-08	1.937E-08	1.761E-08
3	14	1.884E-08	1.904E-08	1.738E-08
3	15	1.880E-08	1.900E-08	1.732E-08
3	16	1.917E-08	1.933E-08	1.754E-08
2	17	1.843E-08	1.853E-08	1.691E-08
2	18	1.777E-08	1.793E-08	1.643E-08
2	19	1.745E-08	1.764E-08	1.611E-08
2	20	1.735E-08	1.749E-08	1.593E-08
1	21	1.598E-08	1.608E-08	1.465E-08
1	22	1.511E-08	1.526E-08	1.400E-08
1	23	1.440E-08	1.455E-08	1.336E-08
1	24	1.379E-08	1.393E-08	1.269E-08

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. U-235 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.369E-04	2.357E-04	3.272E-04
6	2	2.265E-04	2.257E-04	3.225E-04
6	3	1.989E-04	1.978E-04	2.921E-04
6	4	1.686E-04	1.679E-04	2.553E-04
5	5	1.290E-04	1.276E-04	2.082E-04
5	6	1.288E-04	1.272E-04	2.105E-04
5	7	1.173E-04	1.164E-04	1.969E-04
5	8	9.963E-05	9.902E-05	1.709E-04
4	9	8.328E-05	8.217E-05	1.482E-04
4	10	8.766E-05	8.639E-05	1.554E-04
4	11	8.402E-05	8.280E-05	1.496E-04
4	12	7.410E-05	7.301E-05	1.333E-04
3	13	7.120E-05	6.947E-05	1.281E-04
3	14	7.777E-05	7.607E-05	1.395E-04
3	15	7.761E-05	7.614E-05	1.394E-04
3	16	7.146E-05	7.026E-05	1.286E-04
2	17	7.945E-05	7.763E-05	1.371E-04
2	18	9.185E-05	8.979E-05	1.557E-04
2	19	9.697E-05	9.538E-05	1.628E-04
2	20	9.474E-05	9.332E-05	1.573E-04
1	21	1.179E-04	1.161E-04	1.839E-04
1	22	1.418E-04	1.394E-04	2.142E-04
1	23	1.581E-04	1.556E-04	2.334E-04
1	24	1.636E-04	1.612E-04	2.385E-04

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. U-236 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	8.528E-05	8.548E-05	7.324E-05
6	2	8.729E-05	8.749E-05	7.478E-05
6	3	9.109E-05	9.130E-05	7.923E-05
6	4	9.471E-05	9.485E-05	8.407E-05
5	5	9.962E-05	9.983E-05	9.053E-05
5	6	1.003E-04	1.006E-04	9.097E-05
5	7	1.016E-04	1.018E-04	9.275E-05
5	8	1.029E-04	1.031E-04	9.547E-05
4	9	1.046E-04	1.049E-04	9.828E-05
4	10	1.050E-04	1.051E-04	9.817E-05
4	11	1.053E-04	1.054E-04	9.893E-05
4	12	1.054E-04	1.056E-04	1.001E-04
3	13	1.061E-04	1.064E-04	1.012E-04
3	14	1.064E-04	1.065E-04	1.007E-04
3	15	1.064E-04	1.066E-04	1.006E-04
3	16	1.061E-04	1.063E-04	1.011E-04
2	17	1.048E-04	1.051E-04	9.943E-05
2	18	1.043E-04	1.046E-04	9.792E-05
2	19	1.038E-04	1.041E-04	9.706E-05
2	20	1.033E-04	1.036E-04	9.697E-05
1	21	1.002E-04	1.005E-04	9.285E-05
1	22	9.790E-05	9.824E-05	8.940E-05
1	23	9.580E-05	9.616E-05	8.667E-05
1	24	9.443E-05	9.485E-05	8.523E-05

Table A.1. U-237 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.170E-07	1.175E-07	9.016E-08
6	2	1.255E-07	1.307E-07	9.485E-08
6	3	1.419E-07	1.387E-07	1.104E-07
6	4	1.612E-07	1.656E-07	1.286E-07
5	5	1.863E-07	1.962E-07	1.527E-07
5	6	1.950E-07	1.919E-07	1.568E-07
5	7	2.040E-07	2.029E-07	1.628E-07
5	8	2.214E-07	2.164E-07	1.798E-07
4	9	2.361E-07	2.453E-07	1.970E-07
4	10	2.252E-07	2.346E-07	1.927E-07
4	11	2.360E-07	2.337E-07	2.021E-07
4	12	2.424E-07	2.511E-07	2.121E-07
3	13	2.425E-07	2.543E-07	2.147E-07
3	14	2.368E-07	2.467E-07	2.078E-07
3	15	2.367E-07	2.482E-07	2.111E-07
3	16	2.482E-07	2.574E-07	2.164E-07
2	17	2.369E-07	2.477E-07	2.113E-07
2	18	2.257E-07	2.291E-07	1.935E-07
2	19	2.231E-07	2.213E-07	1.919E-07
2	20	2.178E-07	2.244E-07	1.888E-07
1	21	1.840E-07	1.935E-07	1.645E-07
1	22	1.743E-07	1.836E-07	1.467E-07
1	23	1.614E-07	1.644E-07	1.306E-07
1	24	1.534E-07	1.639E-07	1.273E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. U-238 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.000E-03	3.000E-03	3.001E-03
6	2	2.999E-03	2.998E-03	3.000E-03
6	3	2.996E-03	2.995E-03	2.999E-03
6	4	2.977E-03	2.975E-03	2.996E-03
5	5	2.925E-03	2.922E-03	2.962E-03
5	6	2.926E-03	2.925E-03	2.963E-03
5	7	2.919E-03	2.919E-03	2.958E-03
5	8	2.898E-03	2.898E-03	2.929E-03
4	9	2.885E-03	2.885E-03	2.914E-03
4	10	2.896E-03	2.896E-03	2.924E-03
4	11	2.893E-03	2.895E-03	2.920E-03
4	12	2.875E-03	2.874E-03	2.899E-03
3	13	2.887E-03	2.885E-03	2.910E-03
3	14	2.899E-03	2.898E-03	2.927E-03
3	15	2.900E-03	2.898E-03	2.927E-03
3	16	2.890E-03	2.886E-03	2.910E-03
2	17	2.884E-03	2.881E-03	2.906E-03
2	18	2.902E-03	2.902E-03	2.928E-03
2	19	2.905E-03	2.905E-03	2.933E-03
2	20	2.898E-03	2.896E-03	2.924E-03
1	21	2.926E-03	2.920E-03	2.957E-03
1	22	2.954E-03	2.949E-03	2.977E-03
1	23	2.969E-03	2.963E-03	2.981E-03
1	24	2.972E-03	2.968E-03	2.983E-03

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. Np-237 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.976E-06	3.002E-06	2.195E-06
6	2	3.137E-06	3.151E-06	2.292E-06
6	3	3.544E-06	3.543E-06	2.633E-06
6	4	4.162E-06	4.185E-06	3.196E-06
5	5	4.829E-06	4.936E-06	3.803E-06
5	6	4.788E-06	4.816E-06	3.707E-06
5	7	5.032E-06	5.067E-06	3.938E-06
5	8	5.606E-06	5.628E-06	4.512E-06
4	9	5.986E-06	6.040E-06	4.935E-06
4	10	5.742E-06	5.799E-06	4.674E-06
4	11	5.892E-06	5.910E-06	4.781E-06
4	12	6.322E-06	6.373E-06	5.281E-06
3	13	6.463E-06	6.497E-06	5.440E-06
3	14	6.075E-06	6.175E-06	5.051E-06
3	15	6.056E-06	6.120E-06	5.032E-06
3	16	6.441E-06	6.483E-06	5.412E-06
2	17	6.121E-06	6.178E-06	5.149E-06
2	18	5.629E-06	5.716E-06	4.627E-06
2	19	5.489E-06	5.545E-06	4.460E-06
2	20	5.672E-06	5.702E-06	4.678E-06
1	21	5.075E-06	5.121E-06	4.131E-06
1	22	4.428E-06	4.504E-06	3.527E-06
1	23	4.080E-06	4.156E-06	3.229E-06
1	24	4.028E-06	4.075E-06	3.175E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. Np-238 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	9.449E-09	9.673E-09	5.851E-09
6	2	1.075E-08	1.096E-08	6.583E-09
6	3	1.302E-08	1.315E-08	8.155E-09
6	4	1.625E-08	1.669E-08	1.047E-08
5	5	2.179E-08	2.272E-08	1.460E-08
5	6	2.247E-08	2.290E-08	1.462E-08
5	7	2.440E-08	2.496E-08	1.612E-08
5	8	2.801E-08	2.865E-08	1.926E-08
4	9	3.168E-08	3.254E-08	2.239E-08
4	10	3.100E-08	3.177E-08	2.140E-08
4	11	3.223E-08	3.283E-08	2.247E-08
4	12	3.488E-08	3.577E-08	2.485E-08
3	13	3.599E-08	3.716E-08	2.626E-08
3	14	3.417E-08	3.559E-08	2.454E-08
3	15	3.419E-08	3.523E-08	2.434E-08
3	16	3.641E-08	3.700E-08	2.605E-08
2	17	3.317E-08	3.424E-08	2.418E-08
2	18	3.020E-08	3.101E-08	2.149E-08
2	19	2.898E-08	2.973E-08	2.037E-08
2	20	2.923E-08	2.994E-08	2.077E-08
1	21	2.340E-08	2.391E-08	1.656E-08
1	22	1.946E-08	2.006E-08	1.353E-08
1	23	1.690E-08	1.768E-08	1.171E-08
1	24	1.594E-08	1.644E-08	1.082E-08

Table A.1. Pu-238 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	5.103E-07	5.181E-07	3.060E-07
6	2	5.652E-07	5.693E-07	3.317E-07
6	3	6.865E-07	6.896E-07	4.110E-07
6	4	8.776E-07	8.836E-07	5.520E-07
5	5	1.140E-06	1.167E-06	7.452E-07
5	6	1.138E-06	1.152E-06	7.236E-07
5	7	1.238E-06	1.247E-06	7.978E-07
5	8	1.449E-06	1.459E-06	9.790E-07
4	9	1.630E-06	1.651E-06	1.133E-06
4	10	1.550E-06	1.570E-06	1.057E-06
4	11	1.608E-06	1.631E-06	1.096E-06
4	12	1.782E-06	1.810E-06	1.272E-06
3	13	1.842E-06	1.863E-06	1.324E-06
3	14	1.698E-06	1.735E-06	1.198E-06
3	15	1.693E-06	1.725E-06	1.190E-06
3	16	1.834E-06	1.858E-06	1.319E-06
2	17	1.686E-06	1.707E-06	1.217E-06
2	18	1.491E-06	1.525E-06	1.041E-06
2	19	1.430E-06	1.456E-06	9.817E-07
2	20	1.478E-06	1.498E-06	1.037E-06
1	21	1.227E-06	1.243E-06	8.459E-07
1	22	9.964E-07	1.022E-06	6.692E-07
1	23	8.730E-07	8.978E-07	5.769E-07
1	24	8.399E-07	8.578E-07	5.523E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. Pu-239 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.519E-05	3.528E-05	3.890E-05
6	2	3.408E-05	3.431E-05	3.788E-05
6	3	3.408E-05	3.396E-05	3.803E-05
6	4	3.547E-05	3.542E-05	3.979E-05
5	5	3.455E-05	3.448E-05	3.857E-05
5	6	3.279E-05	3.263E-05	3.656E-05
5	7	3.259E-05	3.252E-05	3.594E-05
5	8	3.415E-05	3.393E-05	3.792E-05
4	9	3.361E-05	3.386E-05	3.708E-05
4	10	3.194E-05	3.197E-05	3.479E-05
4	11	3.186E-05	3.202E-05	3.476E-05
4	12	3.360E-05	3.369E-05	3.705E-05
3	13	3.362E-05	3.364E-05	3.673E-05
3	14	3.185E-05	3.199E-05	3.451E-05
3	15	3.173E-05	3.195E-05	3.458E-05
3	16	3.364E-05	3.367E-05	3.677E-05
2	17	3.355E-05	3.364E-05	3.651E-05
2	18	3.176E-05	3.171E-05	3.469E-05
2	19	3.177E-05	3.221E-05	3.456E-05
2	20	3.347E-05	3.379E-05	3.682E-05
1	21	3.419E-05	3.409E-05	3.750E-05
1	22	3.232E-05	3.251E-05	3.560E-05
1	23	3.244E-05	3.255E-05	3.555E-05
1	24	3.402E-05	3.404E-05	3.703E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. Pu-240 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.592E-05	1.596E-05	1.400E-05
6	2	1.654E-05	1.660E-05	1.455E-05
6	3	1.729E-05	1.745E-05	1.568E-05
6	4	1.829E-05	1.844E-05	1.698E-05
5	5	1.855E-05	1.857E-05	1.806E-05
5	6	1.841E-05	1.839E-05	1.794E-05
5	7	1.835E-05	1.846E-05	1.813E-05
5	8	1.885E-05	1.886E-05	1.889E-05
4	9	1.848E-05	1.860E-05	1.902E-05
4	10	1.817E-05	1.834E-05	1.865E-05
4	11	1.803E-05	1.809E-05	1.848E-05
4	12	1.830E-05	1.840E-05	1.901E-05
3	13	1.850E-05	1.848E-05	1.904E-05
3	14	1.813E-05	1.795E-05	1.855E-05
3	15	1.781E-05	1.794E-05	1.855E-05
3	16	1.826E-05	1.829E-05	1.893E-05
2	17	1.843E-05	1.850E-05	1.872E-05
2	18	1.801E-05	1.811E-05	1.816E-05
2	19	1.776E-05	1.795E-05	1.787E-05
2	20	1.802E-05	1.816E-05	1.809E-05
1	21	1.816E-05	1.843E-05	1.780E-05
1	22	1.751E-05	1.758E-05	1.678E-05
1	23	1.707E-05	1.728E-05	1.615E-05
1	24	1.690E-05	1.707E-05	1.575E-05

Table A.1. Pu-241 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	5.997E-06	6.075E-06	5.063E-06
6	2	6.401E-06	6.441E-06	5.484E-06
6	3	7.048E-06	7.064E-06	6.182E-06
6	4	7.976E-06	8.039E-06	7.241E-06
5	5	9.147E-06	9.248E-06	8.526E-06
5	6	9.023E-06	9.050E-06	8.412E-06
5	7	9.231E-06	9.195E-06	8.595E-06
5	8	9.805E-06	9.839E-06	9.522E-06
4	9	1.008E-05	1.014E-05	9.844E-06
4	10	9.733E-06	9.803E-06	9.449E-06
4	11	9.839E-06	9.918E-06	9.669E-06
4	12	1.029E-05	1.045E-05	1.029E-05
3	13	1.036E-05	1.047E-05	1.041E-05
3	14	9.970E-06	1.012E-05	9.908E-06
3	15	9.957E-06	1.011E-05	9.928E-06
3	16	1.039E-05	1.055E-05	1.041E-05
2	17	1.007E-05	1.011E-05	1.002E-05
2	18	9.614E-06	9.684E-06	9.388E-06
2	19	9.620E-06	9.633E-06	9.277E-06
2	20	9.850E-06	9.967E-06	9.643E-06
1	21	9.034E-06	9.125E-06	8.579E-06
1	22	8.292E-06	8.415E-06	7.728E-06
1	23	7.882E-06	8.015E-06	7.233E-06
1	24	7.843E-06	7.975E-06	7.081E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. Pu-242 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.731E-06	1.753E-06	1.068E-06
6	2	2.003E-06	2.020E-06	1.228E-06
6	3	2.489E-06	2.514E-06	1.576E-06
6	4	3.218E-06	3.253E-06	2.114E-06
5	5	4.593E-06	4.657E-06	3.081E-06
5	6	4.659E-06	4.730E-06	3.109E-06
5	7	5.079E-06	5.119E-06	3.422E-06
5	8	5.910E-06	5.964E-06	4.150E-06
4	9	6.779E-06	6.877E-06	4.774E-06
4	10	6.523E-06	6.637E-06	4.587E-06
4	11	6.768E-06	6.858E-06	4.837E-06
4	12	7.418E-06	7.563E-06	5.464E-06
3	13	7.682E-06	7.890E-06	5.690E-06
3	14	7.253E-06	7.421E-06	5.286E-06
3	15	7.285E-06	7.463E-06	5.299E-06
3	16	7.764E-06	7.889E-06	5.720E-06
2	17	6.960E-06	7.119E-06	5.185E-06
2	18	6.266E-06	6.428E-06	4.550E-06
2	19	6.096E-06	6.178E-06	4.332E-06
2	20	6.173E-06	6.304E-06	4.477E-06
1	21	4.725E-06	4.855E-06	3.406E-06
1	22	3.892E-06	4.015E-06	2.759E-06
1	23	3.401E-06	3.513E-06	2.357E-06
1	24	3.206E-06	3.290E-06	2.187E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. Am-241 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.465E-07	1.462E-07	1.266E-07
6	2	1.518E-07	1.510E-07	1.321E-07
6	3	1.669E-07	1.660E-07	1.507E-07
6	4	1.928E-07	1.917E-07	1.824E-07
5	5	2.131E-07	2.113E-07	2.078E-07
5	6	2.028E-07	2.016E-07	1.972E-07
5	7	2.055E-07	2.037E-07	2.038E-07
5	8	2.237E-07	2.217E-07	2.316E-07
4	9	2.267E-07	2.246E-07	2.372E-07
4	10	2.130E-07	2.123E-07	2.215E-07
4	11	2.141E-07	2.124E-07	2.260E-07
4	12	2.275E-07	2.270E-07	2.473E-07
3	13	2.290E-07	2.286E-07	2.488E-07
3	14	2.161E-07	2.151E-07	2.311E-07
3	15	2.161E-07	2.159E-07	2.307E-07
3	16	2.308E-07	2.291E-07	2.494E-07
2	17	2.255E-07	2.237E-07	2.410E-07
2	18	2.114E-07	2.105E-07	2.192E-07
2	19	2.128E-07	2.105E-07	2.161E-07
2	20	2.240E-07	2.243E-07	2.316E-07
1	21	2.127E-07	2.135E-07	2.138E-07
1	22	1.927E-07	1.939E-07	1.876E-07
1	23	1.847E-07	1.864E-07	1.752E-07
1	24	1.897E-07	1.901E-07	1.770E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. Am-242m concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	7.315E-10	7.306E-10	6.625E-10
6	2	7.698E-10	7.671E-10	7.036E-10
6	3	8.508E-10	8.482E-10	8.141E-10
6	4	9.854E-10	9.794E-10	9.898E-10
5	5	1.080E-09	1.070E-09	1.122E-09
5	6	1.023E-09	1.017E-09	1.062E-09
5	7	1.030E-09	1.023E-09	1.097E-09
5	8	1.120E-09	1.113E-09	1.246E-09
4	9	1.131E-09	1.120E-09	1.268E-09
4	10	1.062E-09	1.058E-09	1.182E-09
4	11	1.065E-09	1.056E-09	1.202E-09
4	12	1.130E-09	1.125E-09	1.316E-09
3	13	1.135E-09	1.131E-09	1.317E-09
3	14	1.067E-09	1.061E-09	1.216E-09
3	15	1.066E-09	1.063E-09	1.212E-09
3	16	1.138E-09	1.129E-09	1.312E-09
2	17	1.113E-09	1.100E-09	1.262E-09
2	18	1.042E-09	1.035E-09	1.144E-09
2	19	1.046E-09	1.037E-09	1.125E-09
2	20	1.099E-09	1.103E-09	1.205E-09
1	21	1.052E-09	1.057E-09	1.114E-09
1	22	9.513E-10	9.584E-10	9.702E-10
1	23	9.095E-10	9.172E-10	9.006E-10
1	24	9.226E-10	9.259E-10	8.958E-10

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table A.1. Am-243 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.141E-07	1.170E-07	5.666E-08
6	2	1.403E-07	1.432E-07	6.882E-08
6	3	1.927E-07	1.940E-07	9.795E-08
6	4	2.760E-07	2.847E-07	1.493E-07
5	5	4.636E-07	4.690E-07	2.504E-07
5	6	4.678E-07	4.779E-07	2.528E-07
5	7	5.370E-07	5.406E-07	2.939E-07
5	8	6.758E-07	6.812E-07	3.867E-07
4	9	8.316E-07	8.504E-07	4.795E-07
4	10	7.901E-07	8.032E-07	4.512E-07
4	11	8.338E-07	8.469E-07	4.896E-07
4	12	9.510E-07	9.818E-07	5.875E-07
3	13	1.008E-06	1.046E-06	6.201E-07
3	14	9.138E-07	9.486E-07	5.542E-07
3	15	9.356E-07	9.529E-07	5.585E-07
3	16	1.010E-06	1.033E-06	6.275E-07
2	17	8.748E-07	8.902E-07	5.457E-07
2	18	7.389E-07	7.584E-07	4.420E-07
2	19	6.967E-07	7.091E-07	4.091E-07
2	20	7.093E-07	7.379E-07	4.277E-07
1	21	4.869E-07	5.044E-07	2.915E-07
1	22	3.607E-07	3.787E-07	2.150E-07
1	23	2.981E-07	3.125E-07	1.731E-07
1	24	2.731E-07	2.790E-07	1.525E-07

Table A.1. Cm-242 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.950E-08	3.977E-08	2.584E-08
6	2	4.497E-08	4.513E-08	2.914E-08
6	3	5.485E-08	5.520E-08	3.703E-08
6	4	7.004E-08	7.078E-08	4.964E-08
5	5	9.517E-08	9.588E-08	6.910E-08
5	6	9.477E-08	9.560E-08	6.839E-08
5	7	1.019E-07	1.024E-07	7.492E-08
5	8	1.178E-07	1.185E-07	9.082E-08
4	9	1.314E-07	1.329E-07	1.021E-07
4	10	1.253E-07	1.269E-07	9.682E-08
4	11	1.293E-07	1.305E-07	1.018E-07
4	12	1.415E-07	1.438E-07	1.155E-07
3	13	1.456E-07	1.488E-07	1.192E-07
3	14	1.367E-07	1.392E-07	1.099E-07
3	15	1.377E-07	1.401E-07	1.103E-07
3	16	1.469E-07	1.486E-07	1.201E-07
2	17	1.340E-07	1.362E-07	1.097E-07
2	18	1.210E-07	1.233E-07	9.583E-08
2	19	1.185E-07	1.195E-07	9.163E-08
2	20	1.216E-07	1.239E-07	9.603E-08
1	21	9.718E-08	9.955E-08	7.572E-08
1	22	8.092E-08	8.312E-08	6.156E-08
1	23	7.184E-08	7.393E-08	5.311E-08
1	24	6.892E-08	7.029E-08	5.005E-08

Table A.1. Cm-244 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.999E-08	2.058E-08	7.951E-09
6	2	2.657E-08	2.685E-08	1.006E-08
6	3	4.038E-08	4.073E-08	1.596E-08
6	4	6.594E-08	6.737E-08	2.783E-08
5	5	1.303E-07	1.336E-07	5.523E-08
5	6	1.343E-07	1.375E-07	5.591E-08
5	7	1.626E-07	1.648E-07	6.870E-08
5	8	2.244E-07	2.271E-07	1.001E-07
4	9	3.011E-07	3.105E-07	1.354E-07
4	10	2.820E-07	2.893E-07	1.244E-07
4	11	3.043E-07	3.139E-07	1.387E-07
4	12	3.695E-07	3.855E-07	1.789E-07
3	13	3.998E-07	4.192E-07	1.928E-07
3	14	3.493E-07	3.668E-07	1.651E-07
3	15	3.570E-07	3.675E-07	1.660E-07
3	16	3.995E-07	4.112E-07	1.941E-07
2	17	3.227E-07	3.347E-07	1.600E-07
2	18	2.548E-07	2.659E-07	1.203E-07
2	19	2.338E-07	2.414E-07	1.084E-07
2	20	2.392E-07	2.503E-07	1.139E-07
1	21	1.426E-07	1.494E-07	6.891E-08
1	22	9.470E-08	9.996E-08	4.527E-08
1	23	7.210E-08	7.615E-08	3.360E-08
1	24	6.315E-08	6.535E-08	2.866E-08

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

APPENDIX B—EOL TRISO-PARTICLE COMPACT FISSION PRODUCT CONCENTRATIONS

Table B.1. Kr-83 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.128E-06	2.131E-06	1.869E-06
6	2	2.155E-06	2.157E-06	1.888E-06
6	3	2.217E-06	2.220E-06	1.988E-06
6	4	2.276E-06	2.278E-06	2.101E-06
5	5	2.313E-06	2.315E-06	2.214E-06
5	6	2.310E-06	2.310E-06	2.206E-06
5	7	2.312E-06	2.311E-06	2.235E-06
5	8	2.314E-06	2.314E-06	2.290E-06
4	9	2.297E-06	2.296E-06	2.319E-06
4	10	2.296E-06	2.296E-06	2.305E-06
4	11	2.290E-06	2.288E-06	2.314E-06
4	12	2.279E-06	2.278E-06	2.338E-06
3	13	2.283E-06	2.280E-06	2.351E-06
3	14	2.289E-06	2.288E-06	2.336E-06
3	15	2.289E-06	2.290E-06	2.335E-06
3	16	2.286E-06	2.283E-06	2.351E-06
2	17	2.289E-06	2.285E-06	2.330E-06
2	18	2.299E-06	2.299E-06	2.303E-06
2	19	2.306E-06	2.306E-06	2.294E-06
2	20	2.311E-06	2.311E-06	2.307E-06
1	21	2.309E-06	2.311E-06	2.256E-06
1	22	2.291E-06	2.295E-06	2.190E-06
1	23	2.272E-06	2.277E-06	2.140E-06
1	24	2.268E-06	2.273E-06	2.128E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Kr-84 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	5.504E-06	5.520E-06	4.432E-06
6	2	5.641E-06	5.653E-06	4.493E-06
6	3	6.016E-06	6.029E-06	4.856E-06
6	4	6.465E-06	6.478E-06	5.320E-06
5	5	7.057E-06	7.081E-06	5.909E-06
5	6	7.055E-06	7.080E-06	5.872E-06
5	7	7.248E-06	7.264E-06	6.057E-06
5	8	7.594E-06	7.610E-06	6.460E-06
4	9	7.922E-06	7.949E-06	6.798E-06
4	10	7.812E-06	7.843E-06	6.671E-06
4	11	7.889E-06	7.919E-06	6.766E-06
4	12	8.125E-06	8.159E-06	7.057E-06
3	13	8.238E-06	8.285E-06	7.181E-06
3	14	8.072E-06	8.113E-06	6.978E-06
3	15	8.075E-06	8.113E-06	6.976E-06
3	16	8.238E-06	8.269E-06	7.176E-06
2	17	8.002E-06	8.044E-06	6.984E-06
2	18	7.721E-06	7.768E-06	6.663E-06
2	19	7.627E-06	7.659E-06	6.556E-06
2	20	7.681E-06	7.715E-06	6.650E-06
1	21	7.230E-06	7.270E-06	6.235E-06
1	22	6.815E-06	6.856E-06	5.803E-06
1	23	6.560E-06	6.603E-06	5.542E-06
1	24	6.478E-06	6.517E-06	5.477E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Kr-85 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.201E-06	1.204E-06	1.000E-06
6	2	1.229E-06	1.232E-06	1.016E-06
6	3	1.295E-06	1.297E-06	1.087E-06
6	4	1.367E-06	1.370E-06	1.173E-06
5	5	1.462E-06	1.467E-06	1.282E-06
5	6	1.466E-06	1.470E-06	1.280E-06
5	7	1.495E-06	1.498E-06	1.312E-06
5	8	1.540E-06	1.543E-06	1.376E-06
4	9	1.583E-06	1.588E-06	1.429E-06
4	10	1.573E-06	1.577E-06	1.414E-06
4	11	1.583E-06	1.587E-06	1.429E-06
4	12	1.609E-06	1.615E-06	1.470E-06
3	13	1.626E-06	1.633E-06	1.490E-06
3	14	1.608E-06	1.615E-06	1.464E-06
3	15	1.609E-06	1.616E-06	1.464E-06
3	16	1.627E-06	1.632E-06	1.490E-06
2	17	1.593E-06	1.599E-06	1.458E-06
2	18	1.561E-06	1.568E-06	1.413E-06
2	19	1.548E-06	1.554E-06	1.396E-06
2	20	1.552E-06	1.558E-06	1.407E-06
1	21	1.483E-06	1.490E-06	1.333E-06
1	22	1.425E-06	1.432E-06	1.263E-06
1	23	1.384E-06	1.392E-06	1.217E-06
1	24	1.368E-06	1.375E-06	1.201E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Sr-88 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.749E-05	1.753E-05	1.445E-05
6	2	1.785E-05	1.788E-05	1.462E-05
6	3	1.883E-05	1.886E-05	1.566E-05
6	4	1.994E-05	1.998E-05	1.696E-05
5	5	2.132E-05	2.138E-05	1.851E-05
5	6	2.131E-05	2.137E-05	1.841E-05
5	7	2.174E-05	2.176E-05	1.889E-05
5	8	2.248E-05	2.253E-05	1.990E-05
4	9	2.315E-05	2.320E-05	2.072E-05
4	10	2.293E-05	2.297E-05	2.041E-05
4	11	2.307E-05	2.313E-05	2.063E-05
4	12	2.355E-05	2.362E-05	2.131E-05
3	13	2.380E-05	2.389E-05	2.162E-05
3	14	2.346E-05	2.355E-05	2.115E-05
3	15	2.347E-05	2.355E-05	2.115E-05
3	16	2.380E-05	2.387E-05	2.161E-05
2	17	2.331E-05	2.339E-05	2.114E-05
2	18	2.274E-05	2.283E-05	2.039E-05
2	19	2.254E-05	2.261E-05	2.013E-05
2	20	2.267E-05	2.274E-05	2.037E-05
1	21	2.172E-05	2.180E-05	1.935E-05
1	22	2.077E-05	2.086E-05	1.825E-05
1	23	2.016E-05	2.026E-05	1.756E-05
1	24	1.998E-05	2.007E-05	1.739E-05

Table B.1. Sr-89 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.754E-06	1.775E-06	1.798E-06
6	2	1.837E-06	1.857E-06	1.919E-06
6	3	1.789E-06	1.807E-06	1.918E-06
6	4	1.689E-06	1.711E-06	1.853E-06
5	5	1.641E-06	1.661E-06	1.890E-06
5	6	1.713E-06	1.728E-06	1.993E-06
5	7	1.668E-06	1.685E-06	1.968E-06
5	8	1.528E-06	1.546E-06	1.828E-06
4	9	1.435E-06	1.455E-06	1.756E-06
4	10	1.515E-06	1.528E-06	1.857E-06
4	11	1.495E-06	1.510E-06	1.845E-06
4	12	1.388E-06	1.405E-06	1.717E-06
3	13	1.368E-06	1.381E-06	1.698E-06
3	14	1.458E-06	1.472E-06	1.818E-06
3	15	1.463E-06	1.477E-06	1.821E-06
3	16	1.379E-06	1.392E-06	1.707E-06
2	17	1.413E-06	1.426E-06	1.726E-06
2	18	1.536E-06	1.551E-06	1.870E-06
2	19	1.572E-06	1.586E-06	1.899E-06
2	20	1.506E-06	1.519E-06	1.799E-06
1	21	1.531E-06	1.543E-06	1.768E-06
1	22	1.668E-06	1.683E-06	1.902E-06
1	23	1.711E-06	1.729E-06	1.918E-06
1	24	1.659E-06	1.676E-06	1.833E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Sr-90 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.643E-05	2.650E-05	2.191E-05
6	2	2.699E-05	2.704E-05	2.220E-05
6	3	2.845E-05	2.851E-05	2.376E-05
6	4	3.009E-05	3.015E-05	2.567E-05
5	5	3.215E-05	3.224E-05	2.803E-05
5	6	3.218E-05	3.226E-05	2.792E-05
5	7	3.280E-05	3.286E-05	2.863E-05
5	8	3.385E-05	3.391E-05	3.009E-05
4	9	3.483E-05	3.491E-05	3.129E-05
4	10	3.454E-05	3.462E-05	3.088E-05
4	11	3.476E-05	3.484E-05	3.121E-05
4	12	3.541E-05	3.552E-05	3.218E-05
3	13	3.579E-05	3.592E-05	3.263E-05
3	14	3.533E-05	3.546E-05	3.196E-05
3	15	3.533E-05	3.546E-05	3.197E-05
3	16	3.578E-05	3.587E-05	3.262E-05
2	17	3.507E-05	3.518E-05	3.193E-05
2	18	3.426E-05	3.441E-05	3.086E-05
2	19	3.400E-05	3.410E-05	3.047E-05
2	20	3.413E-05	3.423E-05	3.080E-05
1	21	3.269E-05	3.283E-05	2.924E-05
1	22	3.133E-05	3.147E-05	2.763E-05
1	23	3.044E-05	3.058E-05	2.661E-05
1	24	3.015E-05	3.029E-05	2.633E-05

Table B.1. Y-91 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.510E-06	2.541E-06	2.551E-06
6	2	2.632E-06	2.662E-06	2.724E-06
6	3	2.576E-06	2.603E-06	2.733E-06
6	4	2.448E-06	2.480E-06	2.653E-06
5	5	2.403E-06	2.434E-06	2.727E-06
5	6	2.508E-06	2.532E-06	2.874E-06
5	7	2.451E-06	2.476E-06	2.844E-06
5	8	2.261E-06	2.287E-06	2.655E-06
4	9	2.139E-06	2.169E-06	2.563E-06
4	10	2.251E-06	2.274E-06	2.707E-06
4	11	2.225E-06	2.251E-06	2.692E-06
4	12	2.077E-06	2.105E-06	2.518E-06
3	13	2.052E-06	2.074E-06	2.493E-06
3	14	2.179E-06	2.202E-06	2.661E-06
3	15	2.186E-06	2.209E-06	2.665E-06
3	16	2.068E-06	2.090E-06	2.507E-06
2	17	2.109E-06	2.131E-06	2.528E-06
2	18	2.280E-06	2.304E-06	2.726E-06
2	19	2.327E-06	2.351E-06	2.763E-06
2	20	2.232E-06	2.253E-06	2.621E-06
1	21	2.247E-06	2.267E-06	2.558E-06
1	22	2.431E-06	2.454E-06	2.738E-06
1	23	2.484E-06	2.511E-06	2.752E-06
1	24	2.405E-06	2.431E-06	2.628E-06

Table B.1. Zr-95 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.231E-06	3.272E-06	3.229E-06
6	2	3.399E-06	3.439E-06	3.451E-06
6	3	3.364E-06	3.401E-06	3.491E-06
6	4	3.253E-06	3.297E-06	3.436E-06
5	5	3.275E-06	3.320E-06	3.587E-06
5	6	3.406E-06	3.441E-06	3.768E-06
5	7	3.358E-06	3.394E-06	3.745E-06
5	8	3.168E-06	3.204E-06	3.559E-06
4	9	3.054E-06	3.104E-06	3.478E-06
4	10	3.182E-06	3.219E-06	3.639E-06
4	11	3.161E-06	3.202E-06	3.635E-06
4	12	3.010E-06	3.055E-06	3.457E-06
3	13	2.990E-06	3.031E-06	3.436E-06
3	14	3.125E-06	3.165E-06	3.618E-06
3	15	3.133E-06	3.175E-06	3.624E-06
3	16	3.013E-06	3.050E-06	3.453E-06
2	17	3.027E-06	3.067E-06	3.452E-06
2	18	3.204E-06	3.244E-06	3.660E-06
2	19	3.252E-06	3.291E-06	3.694E-06
2	20	3.138E-06	3.177E-06	3.531E-06
1	21	3.086E-06	3.119E-06	3.395E-06
1	22	3.263E-06	3.301E-06	3.571E-06
1	23	3.299E-06	3.341E-06	3.562E-06
1	24	3.192E-06	3.232E-06	3.401E-06

Table B.1. Mo-95 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.459E-05	1.461E-05	1.173E-05
6	2	1.482E-05	1.483E-05	1.175E-05
6	3	1.576E-05	1.578E-05	1.271E-05
6	4	1.698E-05	1.700E-05	1.405E-05
5	5	1.829E-05	1.833E-05	1.544E-05
5	6	1.814E-05	1.818E-05	1.519E-05
5	7	1.858E-05	1.860E-05	1.566E-05
5	8	1.952E-05	1.954E-05	1.682E-05
4	9	2.022E-05	2.026E-05	1.762E-05
4	10	1.983E-05	1.988E-05	1.715E-05
4	11	1.999E-05	2.003E-05	1.737E-05
4	12	2.066E-05	2.072E-05	1.823E-05
3	13	2.093E-05	2.101E-05	1.853E-05
3	14	2.039E-05	2.046E-05	1.787E-05
3	15	2.039E-05	2.046E-05	1.787E-05
3	16	2.091E-05	2.096E-05	1.851E-05
2	17	2.040E-05	2.046E-05	1.805E-05
2	18	1.963E-05	1.971E-05	1.712E-05
2	19	1.942E-05	1.947E-05	1.685E-05
2	20	1.969E-05	1.975E-05	1.724E-05
1	21	1.876E-05	1.884E-05	1.633E-05
1	22	1.766E-05	1.774E-05	1.510E-05
1	23	1.706E-05	1.714E-05	1.444E-05
1	24	1.699E-05	1.707E-05	1.441E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Tc-99 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.919E-05	2.927E-05	2.422E-05
6	2	2.986E-05	2.992E-05	2.459E-05
6	3	3.151E-05	3.158E-05	2.638E-05
6	4	3.341E-05	3.348E-05	2.857E-05
5	5	3.585E-05	3.594E-05	3.132E-05
5	6	3.584E-05	3.595E-05	3.118E-05
5	7	3.656E-05	3.660E-05	3.198E-05
5	8	3.779E-05	3.786E-05	3.370E-05
4	9	3.889E-05	3.904E-05	3.503E-05
4	10	3.853E-05	3.866E-05	3.455E-05
4	11	3.878E-05	3.889E-05	3.494E-05
4	12	3.954E-05	3.968E-05	3.608E-05
3	13	3.999E-05	4.018E-05	3.657E-05
3	14	3.946E-05	3.960E-05	3.580E-05
3	15	3.945E-05	3.964E-05	3.581E-05
3	16	4.000E-05	4.014E-05	3.655E-05
2	17	3.911E-05	3.928E-05	3.573E-05
2	18	3.819E-05	3.838E-05	3.448E-05
2	19	3.790E-05	3.802E-05	3.404E-05
2	20	3.807E-05	3.822E-05	3.440E-05
1	21	3.630E-05	3.647E-05	3.255E-05
1	22	3.473E-05	3.491E-05	3.069E-05
1	23	3.371E-05	3.390E-05	2.953E-05
1	24	3.338E-05	3.357E-05	2.918E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Ru-102 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.319E-05	2.327E-05	1.903E-05
6	2	2.385E-05	2.390E-05	1.938E-05
6	3	2.539E-05	2.546E-05	2.095E-05
6	4	2.731E-05	2.739E-05	2.299E-05
5	5	2.987E-05	2.999E-05	2.556E-05
5	6	2.985E-05	2.997E-05	2.542E-05
5	7	3.063E-05	3.071E-05	2.621E-05
5	8	3.214E-05	3.223E-05	2.799E-05
4	9	3.349E-05	3.362E-05	2.936E-05
4	10	3.296E-05	3.312E-05	2.879E-05
4	11	3.329E-05	3.343E-05	2.922E-05
4	12	3.439E-05	3.458E-05	3.053E-05
3	13	3.488E-05	3.511E-05	3.102E-05
3	14	3.408E-05	3.428E-05	3.011E-05
3	15	3.410E-05	3.431E-05	3.012E-05
3	16	3.489E-05	3.507E-05	3.104E-05
2	17	3.380E-05	3.400E-05	3.012E-05
2	18	3.256E-05	3.279E-05	2.870E-05
2	19	3.219E-05	3.234E-05	2.823E-05
2	20	3.246E-05	3.265E-05	2.867E-05
1	21	3.037E-05	3.059E-05	2.673E-05
1	22	2.862E-05	2.882E-05	2.487E-05
1	23	2.755E-05	2.776E-05	2.374E-05
1	24	2.722E-05	2.739E-05	2.342E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Ru-103 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.388E-06	1.405E-06	1.342E-06
6	2	1.468E-06	1.485E-06	1.436E-06
6	3	1.488E-06	1.503E-06	1.478E-06
6	4	1.502E-06	1.521E-06	1.503E-06
5	5	1.590E-06	1.614E-06	1.618E-06
5	6	1.634E-06	1.651E-06	1.678E-06
5	7	1.642E-06	1.660E-06	1.684E-06
5	8	1.631E-06	1.648E-06	1.671E-06
4	9	1.633E-06	1.666E-06	1.675E-06
4	10	1.659E-06	1.680E-06	1.708E-06
4	11	1.662E-06	1.690E-06	1.721E-06
4	12	1.657E-06	1.686E-06	1.705E-06
3	13	1.663E-06	1.694E-06	1.709E-06
3	14	1.676E-06	1.703E-06	1.738E-06
3	15	1.679E-06	1.710E-06	1.741E-06
3	16	1.675E-06	1.699E-06	1.715E-06
2	17	1.636E-06	1.665E-06	1.683E-06
2	18	1.647E-06	1.673E-06	1.713E-06
2	19	1.652E-06	1.679E-06	1.710E-06
2	20	1.625E-06	1.652E-06	1.671E-06
1	21	1.528E-06	1.547E-06	1.563E-06
1	22	1.527E-06	1.551E-06	1.575E-06
1	23	1.510E-06	1.534E-06	1.543E-06
1	24	1.463E-06	1.486E-06	1.477E-06

Table B.1. Rh-103 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.365E-05	1.367E-05	1.168E-05
6	2	1.389E-05	1.391E-05	1.183E-05
6	3	1.453E-05	1.456E-05	1.265E-05
6	4	1.528E-05	1.533E-05	1.368E-05
5	5	1.603E-05	1.605E-05	1.479E-05
5	6	1.596E-05	1.598E-05	1.468E-05
5	7	1.612E-05	1.613E-05	1.498E-05
5	8	1.653E-05	1.653E-05	1.572E-05
4	9	1.669E-05	1.671E-05	1.614E-05
4	10	1.651E-05	1.654E-05	1.588E-05
4	11	1.654E-05	1.656E-05	1.601E-05
4	12	1.676E-05	1.682E-05	1.646E-05
3	13	1.689E-05	1.693E-05	1.662E-05
3	14	1.671E-05	1.672E-05	1.628E-05
3	15	1.667E-05	1.674E-05	1.630E-05
3	16	1.692E-05	1.694E-05	1.662E-05
2	17	1.671E-05	1.673E-05	1.632E-05
2	18	1.644E-05	1.648E-05	1.581E-05
2	19	1.639E-05	1.641E-05	1.564E-05
2	20	1.651E-05	1.657E-05	1.586E-05
1	21	1.605E-05	1.613E-05	1.516E-05
1	22	1.553E-05	1.560E-05	1.437E-05
1	23	1.521E-05	1.529E-05	1.388E-05
1	24	1.514E-05	1.522E-05	1.377E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Pd-104 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.747E-06	3.775E-06	2.322E-06
6	2	4.014E-06	4.026E-06	2.420E-06
6	3	4.713E-06	4.732E-06	2.902E-06
6	4	5.684E-06	5.700E-06	3.639E-06
5	5	7.220E-06	7.286E-06	4.716E-06
5	6	7.220E-06	7.289E-06	4.632E-06
5	7	7.773E-06	7.809E-06	5.013E-06
5	8	8.834E-06	8.883E-06	5.932E-06
4	9	9.924E-06	1.002E-05	6.731E-06
4	10	9.562E-06	9.677E-06	6.415E-06
4	11	9.849E-06	9.940E-06	6.666E-06
4	12	1.070E-05	1.082E-05	7.472E-06
3	13	1.103E-05	1.121E-05	7.759E-06
3	14	1.041E-05	1.058E-05	7.181E-06
3	15	1.045E-05	1.057E-05	7.180E-06
3	16	1.102E-05	1.115E-05	7.756E-06
2	17	1.020E-05	1.034E-05	7.227E-06
2	18	9.246E-06	9.406E-06	6.386E-06
2	19	8.960E-06	9.056E-06	6.118E-06
2	20	9.131E-06	9.234E-06	6.365E-06
1	21	7.679E-06	7.783E-06	5.363E-06
1	22	6.547E-06	6.650E-06	4.468E-06
1	23	5.910E-06	6.011E-06	3.980E-06
1	24	5.728E-06	5.803E-06	3.857E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Rh-105 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.934E-08	2.964E-08	2.938E-08
6	2	3.075E-08	3.105E-08	3.105E-08
6	3	3.158E-08	3.161E-08	3.251E-08
6	4	3.266E-08	3.314E-08	3.347E-08
5	5	3.535E-08	3.571E-08	3.621E-08
5	6	3.558E-08	3.583E-08	3.665E-08
5	7	3.605E-08	3.629E-08	3.685E-08
5	8	3.686E-08	3.725E-08	3.804E-08
4	9	3.722E-08	3.802E-08	3.850E-08
4	10	3.712E-08	3.755E-08	3.815E-08
4	11	3.714E-08	3.785E-08	3.856E-08
4	12	3.811E-08	3.886E-08	3.918E-08
3	13	3.851E-08	3.916E-08	3.979E-08
3	14	3.799E-08	3.871E-08	3.938E-08
3	15	3.803E-08	3.879E-08	3.914E-08
3	16	3.893E-08	3.946E-08	3.971E-08
2	17	3.775E-08	3.858E-08	3.893E-08
2	18	3.717E-08	3.748E-08	3.859E-08
2	19	3.699E-08	3.764E-08	3.835E-08
2	20	3.719E-08	3.787E-08	3.846E-08
1	21	3.497E-08	3.531E-08	3.603E-08
1	22	3.384E-08	3.434E-08	3.507E-08
1	23	3.288E-08	3.355E-08	3.419E-08
1	24	3.228E-08	3.273E-08	3.322E-08

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Pd-105 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	7.163E-06	7.190E-06	5.947E-06
6	2	7.411E-06	7.430E-06	6.105E-06
6	3	7.944E-06	7.970E-06	6.653E-06
6	4	8.679E-06	8.718E-06	7.422E-06
5	5	9.637E-06	9.677E-06	8.359E-06
5	6	9.580E-06	9.615E-06	8.266E-06
5	7	9.847E-06	9.866E-06	8.536E-06
5	8	1.049E-05	1.051E-05	9.269E-06
4	9	1.096E-05	1.102E-05	9.726E-06
4	10	1.069E-05	1.076E-05	9.450E-06
4	11	1.082E-05	1.086E-05	9.612E-06
4	12	1.130E-05	1.139E-05	1.019E-05
3	13	1.148E-05	1.159E-05	1.036E-05
3	14	1.111E-05	1.119E-05	9.932E-06
3	15	1.111E-05	1.121E-05	9.941E-06
3	16	1.151E-05	1.158E-05	1.037E-05
2	17	1.106E-05	1.114E-05	9.992E-06
2	18	1.053E-05	1.062E-05	9.389E-06
2	19	1.041E-05	1.046E-05	9.210E-06
2	20	1.057E-05	1.066E-05	9.442E-06
1	21	9.734E-06	9.834E-06	8.678E-06
1	22	9.039E-06	9.125E-06	7.959E-06
1	23	8.650E-06	8.744E-06	7.544E-06
1	24	8.561E-06	8.636E-06	7.431E-06

Table B.1. Ru-106 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.613E-06	2.641E-06	2.169E-06
6	2	2.796E-06	2.821E-06	2.313E-06
6	3	3.051E-06	3.079E-06	2.555E-06
6	4	3.397E-06	3.431E-06	2.873E-06
5	5	4.003E-06	4.053E-06	3.401E-06
5	6	4.051E-06	4.093E-06	3.441E-06
5	7	4.214E-06	4.248E-06	3.573E-06
5	8	4.529E-06	4.563E-06	3.886E-06
4	9	4.827E-06	4.897E-06	4.129E-06
4	10	4.747E-06	4.815E-06	4.064E-06
4	11	4.833E-06	4.896E-06	4.162E-06
4	12	5.062E-06	5.153E-06	4.408E-06
3	13	5.167E-06	5.273E-06	4.492E-06
3	14	5.014E-06	5.097E-06	4.342E-06
3	15	5.019E-06	5.115E-06	4.351E-06
3	16	5.198E-06	5.271E-06	4.505E-06
2	17	4.895E-06	4.976E-06	4.281E-06
2	18	4.644E-06	4.728E-06	4.040E-06
2	19	4.574E-06	4.633E-06	3.947E-06
2	20	4.588E-06	4.667E-06	3.988E-06
1	21	3.988E-06	4.063E-06	3.483E-06
1	22	3.648E-06	3.718E-06	3.183E-06
1	23	3.431E-06	3.501E-06	2.971E-06
1	24	3.323E-06	3.384E-06	2.851E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Pd-106 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.309E-06	3.324E-06	2.378E-06
6	2	3.503E-06	3.514E-06	2.469E-06
6	3	3.976E-06	3.997E-06	2.846E-06
6	4	4.659E-06	4.687E-06	3.411E-06
5	5	5.705E-06	5.743E-06	4.207E-06
5	6	5.685E-06	5.728E-06	4.153E-06
5	7	6.031E-06	6.057E-06	4.416E-06
5	8	6.779E-06	6.811E-06	5.082E-06
4	9	7.479E-06	7.544E-06	5.616E-06
4	10	7.196E-06	7.274E-06	5.380E-06
4	11	7.381E-06	7.440E-06	5.551E-06
4	12	7.987E-06	8.088E-06	6.123E-06
3	13	8.223E-06	8.356E-06	6.314E-06
3	14	7.764E-06	7.871E-06	5.893E-06
3	15	7.771E-06	7.885E-06	5.900E-06
3	16	8.227E-06	8.318E-06	6.313E-06
2	17	7.648E-06	7.745E-06	5.924E-06
2	18	6.977E-06	7.084E-06	5.321E-06
2	19	6.782E-06	6.846E-06	5.128E-06
2	20	6.921E-06	7.011E-06	5.307E-06
1	21	5.910E-06	6.003E-06	4.565E-06
1	22	5.140E-06	5.220E-06	3.922E-06
1	23	4.717E-06	4.799E-06	3.568E-06
1	24	4.596E-06	4.660E-06	3.466E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Pd-107 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.085E-06	3.107E-06	2.434E-06
6	2	3.276E-06	3.292E-06	2.558E-06
6	3	3.639E-06	3.663E-06	2.882E-06
6	4	4.173E-06	4.204E-06	3.356E-06
5	5	4.992E-06	5.034E-06	4.028E-06
5	6	4.984E-06	5.023E-06	4.002E-06
5	7	5.225E-06	5.250E-06	4.198E-06
5	8	5.770E-06	5.799E-06	4.722E-06
4	9	6.242E-06	6.305E-06	5.092E-06
4	10	6.036E-06	6.108E-06	4.916E-06
4	11	6.167E-06	6.223E-06	5.053E-06
4	12	6.596E-06	6.693E-06	5.493E-06
3	13	6.763E-06	6.879E-06	5.625E-06
3	14	6.442E-06	6.533E-06	5.312E-06
3	15	6.448E-06	6.551E-06	5.322E-06
3	16	6.788E-06	6.867E-06	5.633E-06
2	17	6.351E-06	6.437E-06	5.320E-06
2	18	5.879E-06	5.972E-06	4.869E-06
2	19	5.762E-06	5.818E-06	4.725E-06
2	20	5.862E-06	5.950E-06	4.867E-06
1	21	5.062E-06	5.151E-06	4.228E-06
1	22	4.498E-06	4.575E-06	3.734E-06
1	23	4.183E-06	4.262E-06	3.444E-06
1	24	4.087E-06	4.149E-06	3.338E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Pd-108 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.953E-06	1.966E-06	1.529E-06
6	2	2.084E-06	2.096E-06	1.616E-06
6	3	2.329E-06	2.346E-06	1.832E-06
6	4	2.692E-06	2.716E-06	2.151E-06
5	5	3.259E-06	3.288E-06	2.610E-06
5	6	3.253E-06	3.281E-06	2.592E-06
5	7	3.422E-06	3.440E-06	2.726E-06
5	8	3.798E-06	3.817E-06	3.084E-06
4	9	4.124E-06	4.170E-06	3.339E-06
4	10	3.984E-06	4.033E-06	3.217E-06
4	11	4.073E-06	4.112E-06	3.313E-06
4	12	4.371E-06	4.441E-06	3.616E-06
3	13	4.490E-06	4.572E-06	3.706E-06
3	14	4.264E-06	4.328E-06	3.491E-06
3	15	4.270E-06	4.342E-06	3.498E-06
3	16	4.506E-06	4.560E-06	3.711E-06
2	17	4.200E-06	4.260E-06	3.495E-06
2	18	3.875E-06	3.940E-06	3.183E-06
2	19	3.794E-06	3.832E-06	3.086E-06
2	20	3.862E-06	3.922E-06	3.181E-06
1	21	3.302E-06	3.365E-06	2.741E-06
1	22	2.917E-06	2.969E-06	2.404E-06
1	23	2.698E-06	2.754E-06	2.207E-06
1	24	2.631E-06	2.674E-06	2.133E-06

Table B.1. Ag-109 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.047E-06	1.054E-06	8.406E-07
6	2	1.113E-06	1.118E-06	8.870E-07
6	3	1.233E-06	1.241E-06	9.979E-07
6	4	1.406E-06	1.415E-06	1.157E-06
5	5	1.667E-06	1.676E-06	1.381E-06
5	6	1.664E-06	1.675E-06	1.374E-06
5	7	1.737E-06	1.740E-06	1.435E-06
5	8	1.898E-06	1.907E-06	1.603E-06
4	9	2.037E-06	2.057E-06	1.715E-06
4	10	1.973E-06	1.999E-06	1.661E-06
4	11	2.015E-06	2.032E-06	1.702E-06
4	12	2.135E-06	2.167E-06	1.841E-06
3	13	2.184E-06	2.220E-06	1.876E-06
3	14	2.094E-06	2.119E-06	1.782E-06
3	15	2.094E-06	2.127E-06	1.785E-06
3	16	2.195E-06	2.216E-06	1.882E-06
2	17	2.063E-06	2.089E-06	1.781E-06
2	18	1.924E-06	1.953E-06	1.643E-06
2	19	1.895E-06	1.914E-06	1.598E-06
2	20	1.920E-06	1.949E-06	1.640E-06
1	21	1.675E-06	1.705E-06	1.435E-06
1	22	1.503E-06	1.527E-06	1.275E-06
1	23	1.402E-06	1.428E-06	1.179E-06
1	24	1.370E-06	1.392E-06	1.142E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Ag-110m concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	4.161E-09	4.226E-09	2.774E-09
6	2	4.777E-09	4.836E-09	3.140E-09
6	3	5.737E-09	5.826E-09	3.848E-09
6	4	7.034E-09	7.157E-09	4.834E-09
5	5	9.651E-09	9.811E-09	6.702E-09
5	6	9.939E-09	1.012E-08	6.857E-09
5	7	1.077E-08	1.092E-08	7.460E-09
5	8	1.227E-08	1.246E-08	8.732E-09
4	9	1.407E-08	1.437E-08	1.001E-08
4	10	1.375E-08	1.410E-08	9.776E-09
4	11	1.424E-08	1.452E-08	1.019E-08
4	12	1.538E-08	1.579E-08	1.126E-08
3	13	1.596E-08	1.647E-08	1.169E-08
3	14	1.520E-08	1.560E-08	1.098E-08
3	15	1.519E-08	1.564E-08	1.100E-08
3	16	1.592E-08	1.630E-08	1.164E-08
2	17	1.434E-08	1.474E-08	1.061E-08
2	18	1.302E-08	1.340E-08	9.458E-09
2	19	1.251E-08	1.280E-08	8.969E-09
2	20	1.244E-08	1.278E-08	9.047E-09
1	21	9.667E-09	9.982E-09	7.075E-09
1	22	8.162E-09	8.416E-09	5.894E-09
1	23	7.175E-09	7.416E-09	5.122E-09
1	24	6.612E-09	6.803E-09	4.663E-09

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Cd-113 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.998E-09	2.001E-09	2.268E-09
6	2	1.963E-09	1.971E-09	2.248E-09
6	3	1.932E-09	1.929E-09	2.223E-09
6	4	1.953E-09	1.953E-09	2.248E-09
5	5	1.912E-09	1.916E-09	2.178E-09
5	6	1.856E-09	1.846E-09	2.114E-09
5	7	1.834E-09	1.823E-09	2.082E-09
5	8	1.871E-09	1.869E-09	2.130E-09
4	9	1.833E-09	1.846E-09	2.074E-09
4	10	1.781E-09	1.785E-09	2.004E-09
4	11	1.776E-09	1.788E-09	2.007E-09
4	12	1.826E-09	1.841E-09	2.065E-09
3	13	1.822E-09	1.833E-09	2.054E-09
3	14	1.768E-09	1.779E-09	1.990E-09
3	15	1.765E-09	1.786E-09	1.991E-09
3	16	1.835E-09	1.842E-09	2.057E-09
2	17	1.829E-09	1.831E-09	2.042E-09
2	18	1.781E-09	1.779E-09	2.003E-09
2	19	1.794E-09	1.805E-09	2.016E-09
2	20	1.843E-09	1.863E-09	2.083E-09
1	21	1.859E-09	1.859E-09	2.093E-09
1	22	1.821E-09	1.833E-09	2.064E-09
1	23	1.840E-09	1.849E-09	2.080E-09
1	24	1.895E-09	1.900E-09	2.124E-09

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Sb-123 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.142E-07	1.146E-07	9.399E-08
6	2	1.178E-07	1.181E-07	9.619E-08
6	3	1.256E-07	1.261E-07	1.041E-07
6	4	1.354E-07	1.359E-07	1.144E-07
5	5	1.488E-07	1.494E-07	1.277E-07
5	6	1.489E-07	1.495E-07	1.272E-07
5	7	1.529E-07	1.532E-07	1.312E-07
5	8	1.607E-07	1.610E-07	1.402E-07
4	9	1.675E-07	1.683E-07	1.471E-07
4	10	1.649E-07	1.658E-07	1.443E-07
4	11	1.667E-07	1.674E-07	1.465E-07
4	12	1.721E-07	1.733E-07	1.532E-07
3	13	1.747E-07	1.761E-07	1.557E-07
3	14	1.707E-07	1.718E-07	1.510E-07
3	15	1.707E-07	1.720E-07	1.511E-07
3	16	1.748E-07	1.758E-07	1.556E-07
2	17	1.690E-07	1.701E-07	1.508E-07
2	18	1.627E-07	1.639E-07	1.437E-07
2	19	1.609E-07	1.617E-07	1.413E-07
2	20	1.621E-07	1.631E-07	1.434E-07
1	21	1.509E-07	1.521E-07	1.331E-07
1	22	1.420E-07	1.431E-07	1.237E-07
1	23	1.364E-07	1.376E-07	1.179E-07
1	24	1.345E-07	1.355E-07	1.160E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Sn-124 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.816E-07	1.822E-07	1.491E-07
6	2	1.874E-07	1.879E-07	1.525E-07
6	3	2.000E-07	2.007E-07	1.652E-07
6	4	2.158E-07	2.166E-07	1.817E-07
5	5	2.375E-07	2.386E-07	2.031E-07
5	6	2.376E-07	2.386E-07	2.023E-07
5	7	2.440E-07	2.447E-07	2.086E-07
5	8	2.568E-07	2.574E-07	2.232E-07
4	9	2.680E-07	2.695E-07	2.345E-07
4	10	2.639E-07	2.654E-07	2.300E-07
4	11	2.667E-07	2.680E-07	2.335E-07
4	12	2.757E-07	2.775E-07	2.443E-07
3	13	2.799E-07	2.822E-07	2.484E-07
3	14	2.732E-07	2.752E-07	2.408E-07
3	15	2.734E-07	2.754E-07	2.409E-07
3	16	2.801E-07	2.817E-07	2.483E-07
2	17	2.707E-07	2.724E-07	2.406E-07
2	18	2.602E-07	2.622E-07	2.289E-07
2	19	2.571E-07	2.584E-07	2.249E-07
2	20	2.591E-07	2.608E-07	2.284E-07
1	21	2.412E-07	2.429E-07	2.119E-07
1	22	2.265E-07	2.282E-07	1.968E-07
1	23	2.174E-07	2.193E-07	1.874E-07
1	24	2.143E-07	2.159E-07	1.843E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Sb-124 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	4.700E-10	4.739E-10	3.239E-10
6	2	5.164E-10	5.256E-10	3.599E-10
6	3	5.894E-10	5.954E-10	4.175E-10
6	4	6.955E-10	7.009E-10	5.021E-10
5	5	8.799E-10	8.941E-10	6.424E-10
5	6	8.968E-10	9.112E-10	6.607E-10
5	7	9.704E-10	9.719E-10	6.885E-10
5	8	1.054E-09	1.075E-09	7.790E-10
4	9	1.173E-09	1.199E-09	8.870E-10
4	10	1.147E-09	1.176E-09	8.605E-10
4	11	1.174E-09	1.201E-09	8.804E-10
4	12	1.241E-09	1.287E-09	9.522E-10
3	13	1.293E-09	1.322E-09	9.819E-10
3	14	1.245E-09	1.274E-09	9.370E-10
3	15	1.236E-09	1.269E-09	9.446E-10
3	16	1.282E-09	1.316E-09	9.732E-10
2	17	1.185E-09	1.219E-09	9.143E-10
2	18	1.107E-09	1.131E-09	8.296E-10
2	19	1.065E-09	1.090E-09	8.021E-10
2	20	1.055E-09	1.093E-09	8.111E-10
1	21	8.825E-10	9.148E-10	6.786E-10
1	22	7.745E-10	7.872E-10	5.892E-10
1	23	6.967E-10	7.173E-10	5.272E-10
1	24	6.544E-10	6.693E-10	4.898E-10

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Te-124 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.947E-09	1.960E-09	1.250E-09
6	2	2.093E-09	2.110E-09	1.303E-09
6	3	2.463E-09	2.475E-09	1.548E-09
6	4	2.984E-09	3.016E-09	1.972E-09
5	5	3.798E-09	3.832E-09	2.527E-09
5	6	3.763E-09	3.817E-09	2.465E-09
5	7	4.047E-09	4.090E-09	2.670E-09
5	8	4.668E-09	4.727E-09	3.182E-09
4	9	5.304E-09	5.373E-09	3.662E-09
4	10	5.050E-09	5.129E-09	3.416E-09
4	11	5.191E-09	5.277E-09	3.511E-09
4	12	5.738E-09	5.821E-09	3.995E-09
3	13	5.957E-09	6.033E-09	4.139E-09
3	14	5.504E-09	5.566E-09	3.755E-09
3	15	5.510E-09	5.561E-09	3.769E-09
3	16	5.874E-09	5.972E-09	4.137E-09
2	17	5.448E-09	5.524E-09	3.836E-09
2	18	4.822E-09	4.907E-09	3.300E-09
2	19	4.610E-09	4.686E-09	3.155E-09
2	20	4.730E-09	4.836E-09	3.302E-09
1	21	3.981E-09	4.043E-09	2.789E-09
1	22	3.315E-09	3.367E-09	2.259E-09
1	23	2.966E-09	3.024E-09	2.012E-09
1	24	2.845E-09	2.899E-09	1.917E-09

Table B.1. Sb-125 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.933E-07	1.944E-07	1.621E-07
6	2	2.016E-07	2.026E-07	1.684E-07
6	3	2.151E-07	2.161E-07	1.823E-07
6	4	2.313E-07	2.326E-07	1.993E-07
5	5	2.570E-07	2.587E-07	2.249E-07
5	6	2.588E-07	2.604E-07	2.262E-07
5	7	2.656E-07	2.668E-07	2.329E-07
5	8	2.781E-07	2.794E-07	2.472E-07
4	9	2.899E-07	2.921E-07	2.587E-07
4	10	2.870E-07	2.892E-07	2.558E-07
4	11	2.901E-07	2.921E-07	2.597E-07
4	12	2.983E-07	3.012E-07	2.701E-07
3	13	3.028E-07	3.062E-07	2.741E-07
3	14	2.972E-07	2.999E-07	2.677E-07
3	15	2.973E-07	3.004E-07	2.680E-07
3	16	3.036E-07	3.061E-07	2.745E-07
2	17	2.924E-07	2.951E-07	2.652E-07
2	18	2.829E-07	2.858E-07	2.547E-07
2	19	2.799E-07	2.819E-07	2.504E-07
2	20	2.805E-07	2.831E-07	2.523E-07
1	21	2.576E-07	2.606E-07	2.312E-07
1	22	2.432E-07	2.458E-07	2.165E-07
1	23	2.334E-07	2.362E-07	2.060E-07
1	24	2.287E-07	2.310E-07	2.006E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Te-125 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	5.416E-08	5.410E-08	4.090E-08
6	2	5.484E-08	5.471E-08	4.033E-08
6	3	5.994E-08	5.991E-08	4.484E-08
6	4	6.762E-08	6.758E-08	5.221E-08
5	5	7.537E-08	7.534E-08	5.891E-08
5	6	7.350E-08	7.353E-08	5.642E-08
5	7	7.637E-08	7.630E-08	5.903E-08
5	8	8.409E-08	8.406E-08	6.707E-08
4	9	8.960E-08	8.965E-08	7.203E-08
4	10	8.558E-08	8.582E-08	6.790E-08
4	11	8.689E-08	8.696E-08	6.925E-08
4	12	9.319E-08	9.347E-08	7.608E-08
3	13	9.517E-08	9.563E-08	7.793E-08
3	14	8.991E-08	9.023E-08	7.225E-08
3	15	8.981E-08	9.021E-08	7.221E-08
3	16	9.489E-08	9.517E-08	7.771E-08
2	17	9.090E-08	9.119E-08	7.462E-08
2	18	8.387E-08	8.426E-08	6.725E-08
2	19	8.217E-08	8.230E-08	6.543E-08
2	20	8.502E-08	8.532E-08	6.895E-08
1	21	7.889E-08	7.937E-08	6.425E-08
1	22	7.073E-08	7.110E-08	5.619E-08
1	23	6.687E-08	6.730E-08	5.261E-08
1	24	6.712E-08	6.739E-08	5.316E-08

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Te-126 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.199E-08	1.205E-08	9.323E-09
6	2	1.256E-08	1.261E-08	9.638E-09
6	3	1.381E-08	1.388E-08	1.072E-08
6	4	1.550E-08	1.559E-08	1.225E-08
5	5	1.803E-08	1.816E-08	1.434E-08
5	6	1.804E-08	1.816E-08	1.425E-08
5	7	1.886E-08	1.894E-08	1.490E-08
5	8	2.054E-08	2.063E-08	1.653E-08
4	9	2.210E-08	2.230E-08	1.784E-08
4	10	2.151E-08	2.173E-08	1.728E-08
4	11	2.193E-08	2.210E-08	1.767E-08
4	12	2.324E-08	2.347E-08	1.899E-08
3	13	2.378E-08	2.409E-08	1.944E-08
3	14	2.278E-08	2.302E-08	1.848E-08
3	15	2.277E-08	2.305E-08	1.848E-08
3	16	2.372E-08	2.396E-08	1.939E-08
2	17	2.245E-08	2.270E-08	1.849E-08
2	18	2.097E-08	2.124E-08	1.708E-08
2	19	2.047E-08	2.067E-08	1.659E-08
2	20	2.073E-08	2.097E-08	1.698E-08
1	21	1.842E-08	1.864E-08	1.515E-08
1	22	1.661E-08	1.681E-08	1.355E-08
1	23	1.558E-08	1.580E-08	1.263E-08
1	24	1.520E-08	1.538E-08	1.231E-08

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Te-127m concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.116E-08	1.120E-08	1.225E-08
6	2	1.126E-08	1.131E-08	1.260E-08
6	3	1.094E-08	1.096E-08	1.248E-08
6	4	1.065E-08	1.067E-08	1.229E-08
5	5	1.010E-08	1.012E-08	1.193E-08
5	6	1.004E-08	1.001E-08	1.200E-08
5	7	9.794E-09	9.798E-09	1.174E-08
5	8	9.596E-09	9.586E-09	1.147E-08
4	9	9.197E-09	9.259E-09	1.100E-08
4	10	9.168E-09	9.172E-09	1.100E-08
4	11	9.081E-09	9.116E-09	1.092E-08
4	12	9.053E-09	9.076E-09	1.081E-08
3	13	9.017E-09	9.021E-09	1.069E-08
3	14	8.983E-09	8.975E-09	1.074E-08
3	15	8.961E-09	8.992E-09	1.076E-08
3	16	9.041E-09	9.044E-09	1.071E-08
2	17	9.092E-09	9.096E-09	1.072E-08
2	18	9.192E-09	9.174E-09	1.095E-08
2	19	9.309E-09	9.349E-09	1.105E-08
2	20	9.374E-09	9.420E-09	1.107E-08
1	21	9.662E-09	9.667E-09	1.124E-08
1	22	9.908E-09	9.936E-09	1.156E-08
1	23	1.016E-08	1.018E-08	1.171E-08
1	24	1.023E-08	1.027E-08	1.164E-08

Table B.1. I-127 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	9.234E-07	9.268E-07	7.609E-07
6	2	9.524E-07	9.546E-07	7.776E-07
6	3	1.017E-06	1.021E-06	8.438E-07
6	4	1.103E-06	1.106E-06	9.332E-07
5	5	1.215E-06	1.220E-06	1.044E-06
5	6	1.212E-06	1.217E-06	1.037E-06
5	7	1.245E-06	1.248E-06	1.069E-06
5	8	1.316E-06	1.319E-06	1.150E-06
4	9	1.373E-06	1.380E-06	1.207E-06
4	10	1.347E-06	1.354E-06	1.179E-06
4	11	1.362E-06	1.368E-06	1.197E-06
4	12	1.413E-06	1.424E-06	1.260E-06
3	13	1.435E-06	1.447E-06	1.280E-06
3	14	1.396E-06	1.406E-06	1.236E-06
3	15	1.396E-06	1.407E-06	1.237E-06
3	16	1.437E-06	1.445E-06	1.281E-06
2	17	1.387E-06	1.396E-06	1.239E-06
2	18	1.328E-06	1.339E-06	1.174E-06
2	19	1.313E-06	1.320E-06	1.153E-06
2	20	1.328E-06	1.337E-06	1.175E-06
1	21	1.232E-06	1.242E-06	1.088E-06
1	22	1.153E-06	1.162E-06	1.006E-06
1	23	1.106E-06	1.116E-06	9.569E-07
1	24	1.093E-06	1.102E-06	9.429E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Te-128 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.528E-06	2.537E-06	2.064E-06
6	2	2.607E-06	2.614E-06	2.109E-06
6	3	2.787E-06	2.796E-06	2.289E-06
6	4	3.016E-06	3.026E-06	2.525E-06
5	5	3.325E-06	3.340E-06	2.831E-06
5	6	3.321E-06	3.336E-06	2.815E-06
5	7	3.415E-06	3.425E-06	2.906E-06
5	8	3.602E-06	3.612E-06	3.118E-06
4	9	3.765E-06	3.783E-06	3.279E-06
4	10	3.700E-06	3.719E-06	3.210E-06
4	11	3.740E-06	3.757E-06	3.260E-06
4	12	3.875E-06	3.901E-06	3.420E-06
3	13	3.936E-06	3.968E-06	3.478E-06
3	14	3.835E-06	3.860E-06	3.365E-06
3	15	3.836E-06	3.864E-06	3.367E-06
3	16	3.938E-06	3.960E-06	3.477E-06
2	17	3.802E-06	3.826E-06	3.368E-06
2	18	3.648E-06	3.677E-06	3.198E-06
2	19	3.604E-06	3.623E-06	3.141E-06
2	20	3.637E-06	3.660E-06	3.194E-06
1	21	3.381E-06	3.407E-06	2.959E-06
1	22	3.167E-06	3.191E-06	2.741E-06
1	23	3.038E-06	3.065E-06	2.607E-06
1	24	2.998E-06	3.021E-06	2.567E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. I-129 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.800E-06	3.811E-06	3.145E-06
6	2	3.907E-06	3.916E-06	3.208E-06
6	3	4.152E-06	4.163E-06	3.465E-06
6	4	4.461E-06	4.475E-06	3.802E-06
5	5	4.859E-06	4.878E-06	4.219E-06
5	6	4.851E-06	4.866E-06	4.194E-06
5	7	4.966E-06	4.978E-06	4.315E-06
5	8	5.205E-06	5.217E-06	4.605E-06
4	9	5.398E-06	5.422E-06	4.814E-06
4	10	5.310E-06	5.337E-06	4.716E-06
4	11	5.358E-06	5.379E-06	4.783E-06
4	12	5.529E-06	5.562E-06	4.997E-06
3	13	5.602E-06	5.642E-06	5.073E-06
3	14	5.476E-06	5.506E-06	4.921E-06
3	15	5.477E-06	5.512E-06	4.925E-06
3	16	5.610E-06	5.636E-06	5.075E-06
2	17	5.442E-06	5.470E-06	4.927E-06
2	18	5.250E-06	5.285E-06	4.700E-06
2	19	5.198E-06	5.220E-06	4.625E-06
2	20	5.247E-06	5.277E-06	4.702E-06
1	21	4.923E-06	4.960E-06	4.392E-06
1	22	4.646E-06	4.679E-06	4.089E-06
1	23	4.482E-06	4.516E-06	3.906E-06
1	24	4.432E-06	4.463E-06	3.854E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Xe-131 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.184E-05	1.187E-05	1.018E-05
6	2	1.204E-05	1.206E-05	1.030E-05
6	3	1.254E-05	1.255E-05	1.094E-05
6	4	1.308E-05	1.310E-05	1.171E-05
5	5	1.366E-05	1.368E-05	1.258E-05
5	6	1.363E-05	1.365E-05	1.255E-05
5	7	1.376E-05	1.378E-05	1.278E-05
5	8	1.402E-05	1.401E-05	1.328E-05
4	9	1.412E-05	1.414E-05	1.357E-05
4	10	1.406E-05	1.408E-05	1.346E-05
4	11	1.408E-05	1.409E-05	1.355E-05
4	12	1.420E-05	1.423E-05	1.386E-05
3	13	1.428E-05	1.431E-05	1.398E-05
3	14	1.421E-05	1.422E-05	1.380E-05
3	15	1.424E-05	1.425E-05	1.382E-05
3	16	1.433E-05	1.435E-05	1.400E-05
2	17	1.418E-05	1.419E-05	1.376E-05
2	18	1.403E-05	1.406E-05	1.346E-05
2	19	1.403E-05	1.404E-05	1.336E-05
2	20	1.409E-05	1.412E-05	1.349E-05
1	21	1.375E-05	1.380E-05	1.295E-05
1	22	1.339E-05	1.344E-05	1.240E-05
1	23	1.315E-05	1.321E-05	1.203E-05
1	24	1.310E-05	1.316E-05	1.194E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Xe-133 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	4.757E-07	4.807E-07	4.933E-07
6	2	4.960E-07	5.040E-07	5.246E-07
6	3	4.885E-07	4.935E-07	5.279E-07
6	4	4.727E-07	4.799E-07	5.170E-07
5	5	4.724E-07	4.797E-07	5.319E-07
5	6	4.861E-07	4.919E-07	5.528E-07
5	7	4.793E-07	4.855E-07	5.479E-07
5	8	4.578E-07	4.645E-07	5.248E-07
4	9	4.432E-07	4.521E-07	5.123E-07
4	10	4.553E-07	4.615E-07	5.281E-07
4	11	4.523E-07	4.597E-07	5.273E-07
4	12	4.393E-07	4.464E-07	5.050E-07
3	13	4.373E-07	4.453E-07	5.054E-07
3	14	4.498E-07	4.580E-07	5.264E-07
3	15	4.514E-07	4.599E-07	5.265E-07
3	16	4.416E-07	4.484E-07	5.079E-07
2	17	4.436E-07	4.503E-07	5.083E-07
2	18	4.609E-07	4.671E-07	5.343E-07
2	19	4.672E-07	4.743E-07	5.400E-07
2	20	4.574E-07	4.646E-07	5.215E-07
1	21	4.527E-07	4.583E-07	5.098E-07
1	22	4.733E-07	4.803E-07	5.338E-07
1	23	4.788E-07	4.872E-07	5.339E-07
1	24	4.668E-07	4.742E-07	5.141E-07

Table B.1. Cs-133 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.239E-05	3.247E-05	2.691E-05
6	2	3.309E-05	3.315E-05	2.727E-05
6	3	3.486E-05	3.494E-05	2.923E-05
6	4	3.689E-05	3.697E-05	3.163E-05
5	5	3.941E-05	3.951E-05	3.455E-05
5	6	3.939E-05	3.949E-05	3.439E-05
5	7	4.010E-05	4.016E-05	3.525E-05
5	8	4.137E-05	4.146E-05	3.709E-05
4	9	4.246E-05	4.259E-05	3.849E-05
4	10	4.207E-05	4.220E-05	3.796E-05
4	11	4.232E-05	4.241E-05	3.834E-05
4	12	4.306E-05	4.324E-05	3.954E-05
3	13	4.353E-05	4.372E-05	4.006E-05
3	14	4.299E-05	4.312E-05	3.925E-05
3	15	4.296E-05	4.316E-05	3.926E-05
3	16	4.352E-05	4.365E-05	4.005E-05
2	17	4.267E-05	4.281E-05	3.919E-05
2	18	4.176E-05	4.191E-05	3.788E-05
2	19	4.144E-05	4.157E-05	3.740E-05
2	20	4.162E-05	4.179E-05	3.781E-05
1	21	3.987E-05	4.006E-05	3.590E-05
1	22	3.825E-05	3.843E-05	3.389E-05
1	23	3.718E-05	3.738E-05	3.264E-05
1	24	3.683E-05	3.702E-05	3.228E-05

Table B.1. Cs-134 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.683E-06	1.700E-06	1.170E-06
6	2	1.799E-06	1.804E-06	1.222E-06
6	3	2.079E-06	2.092E-06	1.440E-06
6	4	2.492E-06	2.499E-06	1.791E-06
5	5	3.078E-06	3.117E-06	2.257E-06
5	6	3.070E-06	3.097E-06	2.209E-06
5	7	3.281E-06	3.305E-06	2.376E-06
5	8	3.700E-06	3.714E-06	2.776E-06
4	9	4.086E-06	4.120E-06	3.093E-06
4	10	3.937E-06	3.975E-06	2.938E-06
4	11	4.041E-06	4.075E-06	3.054E-06
4	12	4.377E-06	4.411E-06	3.390E-06
3	13	4.479E-06	4.542E-06	3.503E-06
3	14	4.236E-06	4.303E-06	3.249E-06
3	15	4.255E-06	4.296E-06	3.252E-06
3	16	4.492E-06	4.543E-06	3.509E-06
2	17	4.184E-06	4.237E-06	3.284E-06
2	18	3.827E-06	3.879E-06	2.923E-06
2	19	3.719E-06	3.756E-06	2.813E-06
2	20	3.805E-06	3.852E-06	2.938E-06
1	21	3.252E-06	3.295E-06	2.505E-06
1	22	2.803E-06	2.852E-06	2.114E-06
1	23	2.557E-06	2.602E-06	1.897E-06
1	24	2.487E-06	2.524E-06	1.848E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. I-135 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.295E-09	2.302E-09	2.509E-09
6	2	2.385E-09	2.393E-09	2.624E-09
6	3	2.332E-09	2.342E-09	2.674E-09
6	4	2.242E-09	2.294E-09	2.579E-09
5	5	2.261E-09	2.278E-09	2.649E-09
5	6	2.316E-09	2.343E-09	2.753E-09
5	7	2.294E-09	2.302E-09	2.710E-09
5	8	2.185E-09	2.216E-09	2.612E-09
4	9	2.092E-09	2.138E-09	2.547E-09
4	10	2.183E-09	2.189E-09	2.629E-09
4	11	2.154E-09	2.184E-09	2.627E-09
4	12	2.088E-09	2.129E-09	2.497E-09
3	13	2.097E-09	2.120E-09	2.529E-09
3	14	2.156E-09	2.186E-09	2.627E-09
3	15	2.169E-09	2.199E-09	2.588E-09
3	16	2.117E-09	2.148E-09	2.505E-09
2	17	2.115E-09	2.158E-09	2.543E-09
2	18	2.219E-09	2.223E-09	2.683E-09
2	19	2.247E-09	2.267E-09	2.716E-09
2	20	2.209E-09	2.234E-09	2.628E-09
1	21	2.196E-09	2.186E-09	2.567E-09
1	22	2.313E-09	2.311E-09	2.683E-09
1	23	2.301E-09	2.350E-09	2.692E-09
1	24	2.250E-09	2.276E-09	2.598E-09

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Xe-135 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	8.892E-09	8.916E-09	9.824E-09
6	2	9.202E-09	9.231E-09	1.024E-08
6	3	8.968E-09	9.000E-09	1.038E-08
6	4	8.597E-09	8.782E-09	9.978E-09
5	5	8.602E-09	8.660E-09	1.016E-08
5	6	8.794E-09	8.888E-09	1.053E-08
5	7	8.694E-09	8.721E-09	1.035E-08
5	8	8.274E-09	8.387E-09	9.961E-09
4	9	7.908E-09	8.075E-09	9.686E-09
4	10	8.241E-09	8.262E-09	9.985E-09
4	11	8.128E-09	8.238E-09	9.971E-09
4	12	7.879E-09	8.029E-09	9.478E-09
3	13	7.906E-09	7.990E-09	9.586E-09
3	14	8.127E-09	8.233E-09	9.954E-09
3	15	8.174E-09	8.284E-09	9.813E-09
3	16	7.983E-09	8.093E-09	9.499E-09
2	17	7.984E-09	8.140E-09	9.648E-09
2	18	8.381E-09	8.388E-09	1.018E-08
2	19	8.487E-09	8.560E-09	1.032E-08
2	20	8.353E-09	8.441E-09	9.992E-09
1	21	8.341E-09	8.305E-09	9.811E-09
1	22	8.801E-09	8.791E-09	1.028E-08
1	23	8.783E-09	8.956E-09	1.034E-08
1	24	8.610E-09	8.700E-09	1.001E-08

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Cs-135 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	7.180E-06	7.193E-06	7.258E-06
6	2	7.261E-06	7.275E-06	7.321E-06
6	3	7.268E-06	7.280E-06	7.410E-06
6	4	7.246E-06	7.266E-06	7.494E-06
5	5	7.309E-06	7.336E-06	7.565E-06
5	6	7.387E-06	7.407E-06	7.600E-06
5	7	7.396E-06	7.414E-06	7.618E-06
5	8	7.364E-06	7.387E-06	7.626E-06
4	9	7.397E-06	7.426E-06	7.619E-06
4	10	7.462E-06	7.492E-06	7.669E-06
4	11	7.482E-06	7.512E-06	7.692E-06
4	12	7.452E-06	7.493E-06	7.674E-06
3	13	7.498E-06	7.548E-06	7.702E-06
3	14	7.547E-06	7.588E-06	7.749E-06
3	15	7.560E-06	7.599E-06	7.750E-06
3	16	7.523E-06	7.560E-06	7.718E-06
2	17	7.400E-06	7.436E-06	7.630E-06
2	18	7.434E-06	7.477E-06	7.651E-06
2	19	7.443E-06	7.468E-06	7.641E-06
2	20	7.374E-06	7.408E-06	7.602E-06
1	21	7.188E-06	7.219E-06	7.454E-06
1	22	7.234E-06	7.260E-06	7.461E-06
1	23	7.214E-06	7.248E-06	7.419E-06
1	24	7.151E-06	7.175E-06	7.363E-06

Table B.1. Cs-136 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.187E-08	1.201E-08	1.029E-08
6	2	1.292E-08	1.315E-08	1.112E-08
6	3	1.378E-08	1.388E-08	1.206E-08
6	4	1.457E-08	1.488E-08	1.295E-08
5	5	1.695E-08	1.738E-08	1.510E-08
5	6	1.761E-08	1.790E-08	1.571E-08
5	7	1.825E-08	1.850E-08	1.613E-08
5	8	1.891E-08	1.926E-08	1.673E-08
4	9	1.998E-08	2.048E-08	1.774E-08
4	10	2.020E-08	2.049E-08	1.784E-08
4	11	2.053E-08	2.101E-08	1.825E-08
4	12	2.091E-08	2.131E-08	1.851E-08
3	13	2.114E-08	2.184E-08	1.897E-08
3	14	2.116E-08	2.178E-08	1.884E-08
3	15	2.129E-08	2.180E-08	1.878E-08
3	16	2.130E-08	2.190E-08	1.903E-08
2	17	2.035E-08	2.083E-08	1.825E-08
2	18	1.982E-08	2.030E-08	1.772E-08
2	19	1.951E-08	1.995E-08	1.742E-08
2	20	1.916E-08	1.962E-08	1.709E-08
1	21	1.684E-08	1.705E-08	1.524E-08
1	22	1.587E-08	1.630E-08	1.455E-08
1	23	1.501E-08	1.538E-08	1.367E-08
1	24	1.428E-08	1.458E-08	1.283E-08

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Cs-137 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.103E-05	3.113E-05	2.559E-05
6	2	3.187E-05	3.193E-05	2.603E-05
6	3	3.381E-05	3.388E-05	2.805E-05
6	4	3.613E-05	3.624E-05	3.060E-05
5	5	3.924E-05	3.940E-05	3.385E-05
5	6	3.925E-05	3.940E-05	3.370E-05
5	7	4.019E-05	4.028E-05	3.468E-05
5	8	4.196E-05	4.204E-05	3.682E-05
4	9	4.351E-05	4.368E-05	3.850E-05
4	10	4.297E-05	4.316E-05	3.785E-05
4	11	4.334E-05	4.350E-05	3.836E-05
4	12	4.454E-05	4.476E-05	3.990E-05
3	13	4.511E-05	4.540E-05	4.051E-05
3	14	4.426E-05	4.450E-05	3.946E-05
3	15	4.427E-05	4.453E-05	3.947E-05
3	16	4.516E-05	4.536E-05	4.051E-05
2	17	4.389E-05	4.411E-05	3.942E-05
2	18	4.249E-05	4.277E-05	3.777E-05
2	19	4.207E-05	4.224E-05	3.718E-05
2	20	4.234E-05	4.255E-05	3.770E-05
1	21	3.990E-05	4.012E-05	3.534E-05
1	22	3.779E-05	3.804E-05	3.308E-05
1	23	3.649E-05	3.675E-05	3.167E-05
1	24	3.606E-05	3.628E-05	3.125E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. La-139 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.298E-05	3.307E-05	2.723E-05
6	2	3.378E-05	3.384E-05	2.764E-05
6	3	3.577E-05	3.584E-05	2.971E-05
6	4	3.815E-05	3.821E-05	3.236E-05
5	5	4.117E-05	4.131E-05	3.562E-05
5	6	4.114E-05	4.127E-05	3.541E-05
5	7	4.208E-05	4.216E-05	3.640E-05
5	8	4.379E-05	4.389E-05	3.860E-05
4	9	4.531E-05	4.547E-05	4.029E-05
4	10	4.475E-05	4.490E-05	3.961E-05
4	11	4.509E-05	4.524E-05	4.012E-05
4	12	4.628E-05	4.648E-05	4.167E-05
3	13	4.685E-05	4.710E-05	4.229E-05
3	14	4.601E-05	4.621E-05	4.121E-05
3	15	4.601E-05	4.623E-05	4.122E-05
3	16	4.687E-05	4.704E-05	4.228E-05
2	17	4.566E-05	4.586E-05	4.121E-05
2	18	4.430E-05	4.455E-05	3.954E-05
2	19	4.389E-05	4.404E-05	3.896E-05
2	20	4.418E-05	4.438E-05	3.950E-05
1	21	4.188E-05	4.210E-05	3.722E-05
1	22	3.977E-05	4.001E-05	3.489E-05
1	23	3.850E-05	3.873E-05	3.346E-05
1	24	3.809E-05	3.831E-05	3.306E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Ce-140 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.736E-05	2.743E-05	2.231E-05
6	2	2.804E-05	2.808E-05	2.265E-05
6	3	2.980E-05	2.987E-05	2.443E-05
6	4	3.196E-05	3.202E-05	2.676E-05
5	5	3.474E-05	3.485E-05	2.960E-05
5	6	3.470E-05	3.480E-05	2.940E-05
5	7	3.556E-05	3.562E-05	3.028E-05
5	8	3.723E-05	3.728E-05	3.227E-05
4	9	3.869E-05	3.880E-05	3.382E-05
4	10	3.812E-05	3.825E-05	3.317E-05
4	11	3.848E-05	3.858E-05	3.362E-05
4	12	3.964E-05	3.979E-05	3.507E-05
3	13	4.016E-05	4.039E-05	3.563E-05
3	14	3.931E-05	3.949E-05	3.461E-05
3	15	3.933E-05	3.949E-05	3.462E-05
3	16	4.016E-05	4.031E-05	3.562E-05
2	17	3.900E-05	3.918E-05	3.464E-05
2	18	3.767E-05	3.787E-05	3.307E-05
2	19	3.725E-05	3.738E-05	3.255E-05
2	20	3.755E-05	3.770E-05	3.306E-05
1	21	3.539E-05	3.557E-05	3.100E-05
1	22	3.343E-05	3.363E-05	2.891E-05
1	23	3.224E-05	3.244E-05	2.765E-05
1	24	3.189E-05	3.207E-05	2.733E-05

Table B.1. Ce-142 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.023E-05	3.031E-05	2.489E-05
6	2	3.095E-05	3.102E-05	2.527E-05
6	3	3.280E-05	3.287E-05	2.719E-05
6	4	3.501E-05	3.508E-05	2.962E-05
5	5	3.784E-05	3.796E-05	3.265E-05
5	6	3.783E-05	3.795E-05	3.246E-05
5	7	3.868E-05	3.876E-05	3.337E-05
5	8	4.031E-05	4.039E-05	3.539E-05
4	9	4.174E-05	4.189E-05	3.698E-05
4	10	4.121E-05	4.136E-05	3.633E-05
4	11	4.156E-05	4.169E-05	3.681E-05
4	12	4.266E-05	4.282E-05	3.825E-05
3	13	4.320E-05	4.343E-05	3.884E-05
3	14	4.238E-05	4.260E-05	3.782E-05
3	15	4.239E-05	4.262E-05	3.783E-05
3	16	4.321E-05	4.336E-05	3.882E-05
2	17	4.209E-05	4.227E-05	3.782E-05
2	18	4.079E-05	4.100E-05	3.627E-05
2	19	4.040E-05	4.054E-05	3.575E-05
2	20	4.066E-05	4.084E-05	3.624E-05
1	21	3.851E-05	3.872E-05	3.412E-05
1	22	3.656E-05	3.677E-05	3.197E-05
1	23	3.533E-05	3.555E-05	3.064E-05
1	24	3.497E-05	3.518E-05	3.028E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Ce-143 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	7.309E-08	7.361E-08	7.925E-08
6	2	7.607E-08	7.672E-08	8.381E-08
6	3	7.401E-08	7.428E-08	8.432E-08
6	4	7.052E-08	7.172E-08	8.108E-08
5	5	6.948E-08	7.015E-08	8.233E-08
5	6	7.150E-08	7.216E-08	8.554E-08
5	7	7.023E-08	7.079E-08	8.452E-08
5	8	6.606E-08	6.699E-08	8.020E-08
4	9	6.296E-08	6.411E-08	7.750E-08
4	10	6.541E-08	6.592E-08	8.037E-08
4	11	6.460E-08	6.543E-08	7.999E-08
4	12	6.204E-08	6.306E-08	7.554E-08
3	13	6.175E-08	6.263E-08	7.594E-08
3	14	6.416E-08	6.510E-08	7.973E-08
3	15	6.445E-08	6.544E-08	7.920E-08
3	16	6.257E-08	6.335E-08	7.588E-08
2	17	6.314E-08	6.417E-08	7.686E-08
2	18	6.688E-08	6.720E-08	8.181E-08
2	19	6.782E-08	6.860E-08	8.290E-08
2	20	6.625E-08	6.706E-08	7.975E-08
1	21	6.689E-08	6.724E-08	7.912E-08
1	22	7.125E-08	7.176E-08	8.363E-08
1	23	7.203E-08	7.336E-08	8.435E-08
1	24	7.036E-08	7.126E-08	8.132E-08

Table B.1. Pr-143 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	8.635E-07	8.721E-07	8.850E-07
6	2	9.016E-07	9.131E-07	9.424E-07
6	3	8.846E-07	8.928E-07	9.445E-07
6	4	8.492E-07	8.593E-07	9.217E-07
5	5	8.390E-07	8.497E-07	9.450E-07
5	6	8.671E-07	8.753E-07	9.874E-07
5	7	8.513E-07	8.604E-07	9.764E-07
5	8	8.034E-07	8.125E-07	9.257E-07
4	9	7.712E-07	7.835E-07	8.987E-07
4	10	7.978E-07	8.060E-07	9.338E-07
4	11	7.912E-07	8.012E-07	9.310E-07
4	12	7.589E-07	7.684E-07	8.850E-07
3	13	7.531E-07	7.629E-07	8.803E-07
3	14	7.816E-07	7.914E-07	9.245E-07
3	15	7.841E-07	7.944E-07	9.257E-07
3	16	7.588E-07	7.679E-07	8.850E-07
2	17	7.658E-07	7.746E-07	8.875E-07
2	18	8.052E-07	8.144E-07	9.415E-07
2	19	8.189E-07	8.280E-07	9.526E-07
2	20	7.968E-07	8.055E-07	9.145E-07
1	21	7.945E-07	8.017E-07	8.946E-07
1	22	8.411E-07	8.499E-07	9.455E-07
1	23	8.560E-07	8.666E-07	9.483E-07
1	24	8.336E-07	8.433E-07	9.113E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Nd-143 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.113E-05	2.114E-05	1.894E-05
6	2	2.131E-05	2.133E-05	1.909E-05
6	3	2.179E-05	2.179E-05	2.003E-05
6	4	2.218E-05	2.220E-05	2.108E-05
5	5	2.217E-05	2.218E-05	2.197E-05
5	6	2.211E-05	2.209E-05	2.186E-05
5	7	2.199E-05	2.198E-05	2.206E-05
5	8	2.184E-05	2.182E-05	2.249E-05
4	9	2.142E-05	2.140E-05	2.259E-05
4	10	2.144E-05	2.141E-05	2.246E-05
4	11	2.134E-05	2.130E-05	2.250E-05
4	12	2.111E-05	2.109E-05	2.263E-05
3	13	2.109E-05	2.103E-05	2.268E-05
3	14	2.122E-05	2.117E-05	2.262E-05
3	15	2.121E-05	2.118E-05	2.260E-05
3	16	2.112E-05	2.107E-05	2.270E-05
2	17	2.126E-05	2.120E-05	2.257E-05
2	18	2.152E-05	2.147E-05	2.242E-05
2	19	2.167E-05	2.163E-05	2.237E-05
2	20	2.170E-05	2.169E-05	2.250E-05
1	21	2.199E-05	2.198E-05	2.219E-05
1	22	2.203E-05	2.204E-05	2.166E-05
1	23	2.199E-05	2.202E-05	2.126E-05
1	24	2.202E-05	2.203E-05	2.119E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Ce-144 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.063E-05	1.072E-05	9.617E-06
6	2	1.113E-05	1.121E-05	1.012E-05
6	3	1.146E-05	1.154E-05	1.061E-05
6	4	1.162E-05	1.171E-05	1.094E-05
5	5	1.233E-05	1.244E-05	1.191E-05
5	6	1.269E-05	1.279E-05	1.232E-05
5	7	1.279E-05	1.287E-05	1.248E-05
5	8	1.259E-05	1.267E-05	1.243E-05
4	9	1.265E-05	1.276E-05	1.262E-05
4	10	1.297E-05	1.307E-05	1.296E-05
4	11	1.300E-05	1.309E-05	1.305E-05
4	12	1.271E-05	1.284E-05	1.284E-05
3	13	1.276E-05	1.289E-05	1.291E-05
3	14	1.307E-05	1.319E-05	1.323E-05
3	15	1.310E-05	1.322E-05	1.324E-05
3	16	1.283E-05	1.293E-05	1.295E-05
2	17	1.265E-05	1.276E-05	1.275E-05
2	18	1.294E-05	1.307E-05	1.299E-05
2	19	1.297E-05	1.307E-05	1.294E-05
2	20	1.264E-05	1.275E-05	1.261E-05
1	21	1.202E-05	1.213E-05	1.181E-05
1	22	1.211E-05	1.222E-05	1.181E-05
1	23	1.194E-05	1.205E-05	1.152E-05
1	24	1.158E-05	1.169E-05	1.108E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Nd-145 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.823E-05	1.827E-05	1.533E-05
6	2	1.860E-05	1.863E-05	1.553E-05
6	3	1.951E-05	1.955E-05	1.659E-05
6	4	2.056E-05	2.060E-05	1.789E-05
5	5	2.180E-05	2.185E-05	1.943E-05
5	6	2.178E-05	2.184E-05	1.934E-05
5	7	2.213E-05	2.216E-05	1.979E-05
5	8	2.275E-05	2.277E-05	2.075E-05
4	9	2.324E-05	2.330E-05	2.145E-05
4	10	2.305E-05	2.311E-05	2.117E-05
4	11	2.318E-05	2.321E-05	2.137E-05
4	12	2.353E-05	2.360E-05	2.200E-05
3	13	2.374E-05	2.382E-05	2.226E-05
3	14	2.349E-05	2.355E-05	2.186E-05
3	15	2.349E-05	2.357E-05	2.186E-05
3	16	2.378E-05	2.382E-05	2.227E-05
2	17	2.336E-05	2.341E-05	2.183E-05
2	18	2.291E-05	2.300E-05	2.116E-05
2	19	2.280E-05	2.286E-05	2.093E-05
2	20	2.291E-05	2.297E-05	2.115E-05
1	21	2.205E-05	2.214E-05	2.014E-05
1	22	2.124E-05	2.134E-05	1.911E-05
1	23	2.072E-05	2.082E-05	1.844E-05
1	24	2.056E-05	2.066E-05	1.826E-05

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Nd-147 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.801E-07	2.829E-07	2.894E-07
6	2	2.921E-07	2.959E-07	3.075E-07
6	3	2.870E-07	2.895E-07	3.088E-07
6	4	2.767E-07	2.802E-07	3.019E-07
5	5	2.745E-07	2.780E-07	3.096E-07
5	6	2.827E-07	2.854E-07	3.223E-07
5	7	2.781E-07	2.810E-07	3.189E-07
5	8	2.643E-07	2.674E-07	3.042E-07
4	9	2.547E-07	2.590E-07	2.959E-07
4	10	2.623E-07	2.651E-07	3.060E-07
4	11	2.603E-07	2.638E-07	3.053E-07
4	12	2.515E-07	2.549E-07	2.917E-07
3	13	2.500E-07	2.536E-07	2.909E-07
3	14	2.579E-07	2.615E-07	3.038E-07
3	15	2.588E-07	2.626E-07	3.039E-07
3	16	2.521E-07	2.553E-07	2.922E-07
2	17	2.537E-07	2.569E-07	2.928E-07
2	18	2.649E-07	2.679E-07	3.088E-07
2	19	2.690E-07	2.722E-07	3.123E-07
2	20	2.628E-07	2.660E-07	3.011E-07
1	21	2.614E-07	2.639E-07	2.946E-07
1	22	2.749E-07	2.779E-07	3.097E-07
1	23	2.789E-07	2.827E-07	3.103E-07
1	24	2.721E-07	2.755E-07	2.988E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Pm-147 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	5.314E-06	5.326E-06	4.942E-06
6	2	5.381E-06	5.388E-06	5.034E-06
6	3	5.408E-06	5.417E-06	5.193E-06
6	4	5.341E-06	5.345E-06	5.276E-06
5	5	5.266E-06	5.254E-06	5.434E-06
5	6	5.313E-06	5.317E-06	5.502E-06
5	7	5.246E-06	5.233E-06	5.498E-06
5	8	5.043E-06	5.043E-06	5.413E-06
4	9	4.880E-06	4.870E-06	5.336E-06
4	10	4.977E-06	4.970E-06	5.437E-06
4	11	4.929E-06	4.924E-06	5.419E-06
4	12	4.746E-06	4.753E-06	5.289E-06
3	13	4.723E-06	4.719E-06	5.268E-06
3	14	4.871E-06	4.855E-06	5.402E-06
3	15	4.876E-06	4.874E-06	5.413E-06
3	16	4.754E-06	4.737E-06	5.289E-06
2	17	4.831E-06	4.814E-06	5.307E-06
2	18	5.029E-06	5.015E-06	5.460E-06
2	19	5.104E-06	5.092E-06	5.496E-06
2	20	5.023E-06	5.020E-06	5.404E-06
1	21	5.141E-06	5.144E-06	5.378E-06
1	22	5.326E-06	5.325E-06	5.455E-06
1	23	5.389E-06	5.388E-06	5.422E-06
1	24	5.362E-06	5.371E-06	5.353E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Sm-147 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.098E-06	2.088E-06	1.703E-06
6	2	2.058E-06	2.048E-06	1.636E-06
6	3	2.149E-06	2.140E-06	1.750E-06
6	4	2.277E-06	2.265E-06	1.931E-06
5	5	2.302E-06	2.288E-06	2.013E-06
5	6	2.236E-06	2.224E-06	1.924E-06
5	7	2.254E-06	2.243E-06	1.965E-06
5	8	2.341E-06	2.329E-06	2.120E-06
4	9	2.358E-06	2.344E-06	2.178E-06
4	10	2.291E-06	2.281E-06	2.082E-06
4	11	2.290E-06	2.278E-06	2.096E-06
4	12	2.352E-06	2.340E-06	2.208E-06
3	13	2.367E-06	2.359E-06	2.236E-06
3	14	2.311E-06	2.296E-06	2.132E-06
3	15	2.309E-06	2.298E-06	2.133E-06
3	16	2.369E-06	2.354E-06	2.232E-06
2	17	2.367E-06	2.352E-06	2.209E-06
2	18	2.295E-06	2.282E-06	2.083E-06
2	19	2.290E-06	2.277E-06	2.064E-06
2	20	2.355E-06	2.344E-06	2.154E-06
1	21	2.384E-06	2.377E-06	2.156E-06
1	22	2.282E-06	2.274E-06	1.992E-06
1	23	2.249E-06	2.241E-06	1.933E-06
1	24	2.300E-06	2.295E-06	1.993E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Nd-148 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	8.930E-06	8.956E-06	7.319E-06
6	2	9.164E-06	9.188E-06	7.443E-06
6	3	9.742E-06	9.768E-06	8.028E-06
6	4	1.044E-05	1.047E-05	8.778E-06
5	5	1.137E-05	1.141E-05	9.734E-06
5	6	1.137E-05	1.141E-05	9.689E-06
5	7	1.166E-05	1.169E-05	9.979E-06
5	8	1.219E-05	1.221E-05	1.061E-05
4	9	1.267E-05	1.272E-05	1.112E-05
4	10	1.250E-05	1.256E-05	1.093E-05
4	11	1.262E-05	1.267E-05	1.108E-05
4	12	1.298E-05	1.305E-05	1.154E-05
3	13	1.316E-05	1.325E-05	1.173E-05
3	14	1.290E-05	1.297E-05	1.141E-05
3	15	1.290E-05	1.298E-05	1.141E-05
3	16	1.317E-05	1.323E-05	1.172E-05
2	17	1.278E-05	1.285E-05	1.140E-05
2	18	1.236E-05	1.244E-05	1.091E-05
2	19	1.223E-05	1.228E-05	1.074E-05
2	20	1.231E-05	1.237E-05	1.088E-05
1	21	1.157E-05	1.164E-05	1.019E-05
1	22	1.095E-05	1.101E-05	9.513E-06
1	23	1.055E-05	1.063E-05	9.095E-06
1	24	1.043E-05	1.049E-05	8.975E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Pm-148 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	5.800E-08	5.894E-08	4.656E-08
6	2	6.301E-08	6.483E-08	5.057E-08
6	3	6.791E-08	6.781E-08	5.570E-08
6	4	7.176E-08	7.313E-08	6.176E-08
5	5	7.981E-08	8.251E-08	7.173E-08
5	6	8.293E-08	8.396E-08	7.504E-08
5	7	8.501E-08	8.613E-08	7.756E-08
5	8	8.587E-08	8.586E-08	8.001E-08
4	9	8.747E-08	8.933E-08	8.277E-08
4	10	8.814E-08	8.967E-08	8.469E-08
4	11	8.911E-08	9.025E-08	8.642E-08
4	12	8.770E-08	8.924E-08	8.699E-08
3	13	8.766E-08	9.091E-08	8.688E-08
3	14	8.894E-08	9.172E-08	8.830E-08
3	15	8.966E-08	9.238E-08	8.789E-08
3	16	8.884E-08	9.128E-08	8.796E-08
2	17	8.807E-08	9.058E-08	8.648E-08
2	18	8.917E-08	8.996E-08	8.575E-08
2	19	8.846E-08	9.037E-08	8.530E-08
2	20	8.609E-08	8.842E-08	8.252E-08
1	21	7.820E-08	8.126E-08	7.436E-08
1	22	7.802E-08	8.062E-08	7.122E-08
1	23	7.453E-08	7.662E-08	6.623E-08
1	24	7.195E-08	7.413E-08	6.338E-08

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Pm-149 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.629E-08	3.669E-08	3.580E-08
6	2	3.859E-08	3.917E-08	3.844E-08
6	3	3.917E-08	3.945E-08	3.981E-08
6	4	3.915E-08	3.986E-08	3.994E-08
5	5	4.173E-08	4.246E-08	4.326E-08
5	6	4.330E-08	4.391E-08	4.507E-08
5	7	4.356E-08	4.414E-08	4.546E-08
5	8	4.255E-08	4.328E-08	4.471E-08
4	9	4.252E-08	4.346E-08	4.494E-08
4	10	4.379E-08	4.446E-08	4.629E-08
4	11	4.372E-08	4.458E-08	4.662E-08
4	12	4.291E-08	4.381E-08	4.532E-08
3	13	4.303E-08	4.413E-08	4.583E-08
3	14	4.418E-08	4.524E-08	4.736E-08
3	15	4.441E-08	4.544E-08	4.718E-08
3	16	4.357E-08	4.443E-08	4.588E-08
2	17	4.290E-08	4.388E-08	4.541E-08
2	18	4.414E-08	4.479E-08	4.688E-08
2	19	4.420E-08	4.503E-08	4.691E-08
2	20	4.299E-08	4.384E-08	4.519E-08
1	21	4.056E-08	4.125E-08	4.248E-08
1	22	4.124E-08	4.200E-08	4.314E-08
1	23	4.047E-08	4.141E-08	4.221E-08
1	24	3.878E-08	3.959E-08	4.011E-08

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Sm-149 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	4.382E-08	4.392E-08	4.901E-08
6	2	4.400E-08	4.454E-08	5.002E-08
6	3	4.283E-08	4.304E-08	4.876E-08
6	4	4.112E-08	4.130E-08	4.732E-08
5	5	3.955E-08	3.984E-08	4.571E-08
5	6	3.992E-08	3.991E-08	4.618E-08
5	7	3.896E-08	3.922E-08	4.531E-08
5	8	3.763E-08	3.792E-08	4.374E-08
4	9	3.643E-08	3.676E-08	4.225E-08
4	10	3.686E-08	3.717E-08	4.289E-08
4	11	3.661E-08	3.700E-08	4.280E-08
4	12	3.579E-08	3.608E-08	4.155E-08
3	13	3.554E-08	3.598E-08	4.119E-08
3	14	3.620E-08	3.664E-08	4.223E-08
3	15	3.624E-08	3.675E-08	4.240E-08
3	16	3.585E-08	3.609E-08	4.145E-08
2	17	3.611E-08	3.636E-08	4.142E-08
2	18	3.726E-08	3.737E-08	4.303E-08
2	19	3.763E-08	3.800E-08	4.350E-08
2	20	3.714E-08	3.749E-08	4.269E-08
1	21	3.767E-08	3.815E-08	4.306E-08
1	22	3.922E-08	3.969E-08	4.496E-08
1	23	4.021E-08	4.039E-08	4.553E-08
1	24	4.005E-08	4.029E-08	4.519E-08

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Sm-150 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	5.596E-06	5.617E-06	4.614E-06
6	2	5.774E-06	5.790E-06	4.720E-06
6	3	6.137E-06	6.155E-06	5.100E-06
6	4	6.553E-06	6.577E-06	5.574E-06
5	5	7.141E-06	7.169E-06	6.200E-06
5	6	7.179E-06	7.205E-06	6.197E-06
5	7	7.344E-06	7.366E-06	6.385E-06
5	8	7.620E-06	7.645E-06	6.760E-06
4	9	7.890E-06	7.928E-06	7.080E-06
4	10	7.835E-06	7.872E-06	6.989E-06
4	11	7.901E-06	7.932E-06	7.088E-06
4	12	8.060E-06	8.106E-06	7.337E-06
3	13	8.160E-06	8.215E-06	7.450E-06
3	14	8.056E-06	8.100E-06	7.285E-06
3	15	8.055E-06	8.106E-06	7.286E-06
3	16	8.160E-06	8.200E-06	7.442E-06
2	17	7.939E-06	7.983E-06	7.235E-06
2	18	7.741E-06	7.793E-06	6.956E-06
2	19	7.663E-06	7.701E-06	6.845E-06
2	20	7.677E-06	7.720E-06	6.909E-06
1	21	7.212E-06	7.261E-06	6.442E-06
1	22	6.868E-06	6.913E-06	6.033E-06
1	23	6.621E-06	6.673E-06	5.765E-06
1	24	6.511E-06	6.555E-06	5.661E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Pm-151 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	5.353E-09	5.401E-09	5.572E-09
6	2	5.616E-09	5.669E-09	5.908E-09
6	3	5.622E-09	5.637E-09	6.074E-09
6	4	5.587E-09	5.686E-09	6.029E-09
5	5	5.850E-09	5.918E-09	6.372E-09
5	6	5.979E-09	6.041E-09	6.565E-09
5	7	5.994E-09	6.045E-09	6.556E-09
5	8	5.902E-09	5.986E-09	6.491E-09
4	9	5.840E-09	5.975E-09	6.455E-09
4	10	5.957E-09	6.021E-09	6.561E-09
4	11	5.932E-09	6.040E-09	6.590E-09
4	12	5.916E-09	6.039E-09	6.457E-09
3	13	5.949E-09	6.063E-09	6.546E-09
3	14	6.012E-09	6.133E-09	6.675E-09
3	15	6.034E-09	6.161E-09	6.629E-09
3	16	6.026E-09	6.124E-09	6.531E-09
2	17	5.916E-09	6.054E-09	6.496E-09
2	18	6.020E-09	6.072E-09	6.668E-09
2	19	6.030E-09	6.130E-09	6.684E-09
2	20	5.965E-09	6.070E-09	6.542E-09
1	21	5.725E-09	5.776E-09	6.253E-09
1	22	5.792E-09	5.863E-09	6.342E-09
1	23	5.711E-09	5.837E-09	6.276E-09
1	24	5.564E-09	5.648E-09	6.046E-09

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Sm-151 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.405E-07	1.407E-07	1.540E-07
6	2	1.407E-07	1.408E-07	1.552E-07
6	3	1.394E-07	1.393E-07	1.534E-07
6	4	1.381E-07	1.384E-07	1.512E-07
5	5	1.351E-07	1.357E-07	1.477E-07
5	6	1.345E-07	1.344E-07	1.470E-07
5	7	1.340E-07	1.342E-07	1.456E-07
5	8	1.340E-07	1.336E-07	1.453E-07
4	9	1.326E-07	1.328E-07	1.438E-07
4	10	1.319E-07	1.324E-07	1.426E-07
4	11	1.322E-07	1.326E-07	1.424E-07
4	12	1.328E-07	1.331E-07	1.429E-07
3	13	1.332E-07	1.332E-07	1.425E-07
3	14	1.328E-07	1.329E-07	1.421E-07
3	15	1.322E-07	1.325E-07	1.422E-07
3	16	1.331E-07	1.335E-07	1.422E-07
2	17	1.315E-07	1.315E-07	1.409E-07
2	18	1.312E-07	1.314E-07	1.407E-07
2	19	1.317E-07	1.319E-07	1.411E-07
2	20	1.317E-07	1.322E-07	1.414E-07
1	21	1.321E-07	1.328E-07	1.418E-07
1	22	1.320E-07	1.325E-07	1.430E-07
1	23	1.329E-07	1.332E-07	1.438E-07
1	24	1.333E-07	1.332E-07	1.434E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Eu-151 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	9.746E-11	9.577E-11	1.460E-10
6	2	8.803E-11	8.676E-11	1.344E-10
6	3	7.833E-11	7.694E-11	1.198E-10
6	4	7.034E-11	6.895E-11	1.070E-10
5	5	5.480E-11	5.348E-11	8.264E-11
5	6	5.178E-11	5.058E-11	7.834E-11
5	7	4.841E-11	4.763E-11	7.340E-11
5	8	4.613E-11	4.509E-11	6.909E-11
4	9	4.183E-11	4.085E-11	6.192E-11
4	10	4.078E-11	4.001E-11	6.045E-11
4	11	3.990E-11	3.911E-11	5.852E-11
4	12	3.925E-11	3.855E-11	5.735E-11
3	13	3.876E-11	3.765E-11	5.567E-11
3	14	3.857E-11	3.748E-11	5.540E-11
3	15	3.822E-11	3.736E-11	5.545E-11
3	16	3.843E-11	3.767E-11	5.546E-11
2	17	4.032E-11	3.925E-11	5.742E-11
2	18	4.148E-11	4.027E-11	5.925E-11
2	19	4.262E-11	4.176E-11	6.094E-11
2	20	4.394E-11	4.315E-11	6.329E-11
1	21	5.267E-11	5.165E-11	7.537E-11
1	22	5.704E-11	5.578E-11	8.142E-11
1	23	6.217E-11	6.068E-11	8.891E-11
1	24	6.707E-11	6.544E-11	9.598E-11

Table B.1. Sm-152 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	3.213E-06	3.244E-06	2.618E-06
6	2	3.297E-06	3.317E-06	2.662E-06
6	3	3.465E-06	3.477E-06	2.841E-06
6	4	3.638E-06	3.655E-06	3.042E-06
5	5	3.899E-06	3.927E-06	3.328E-06
5	6	3.913E-06	3.940E-06	3.331E-06
5	7	3.976E-06	3.997E-06	3.404E-06
5	8	4.078E-06	4.089E-06	3.538E-06
4	9	4.183E-06	4.205E-06	3.659E-06
4	10	4.155E-06	4.181E-06	3.622E-06
4	11	4.163E-06	4.193E-06	3.655E-06
4	12	4.202E-06	4.237E-06	3.721E-06
3	13	4.256E-06	4.289E-06	3.786E-06
3	14	4.227E-06	4.253E-06	3.730E-06
3	15	4.222E-06	4.245E-06	3.728E-06
3	16	4.250E-06	4.271E-06	3.766E-06
2	17	4.176E-06	4.210E-06	3.712E-06
2	18	4.110E-06	4.144E-06	3.621E-06
2	19	4.087E-06	4.108E-06	3.590E-06
2	20	4.072E-06	4.110E-06	3.593E-06
1	21	3.907E-06	3.934E-06	3.421E-06
1	22	3.778E-06	3.801E-06	3.278E-06
1	23	3.675E-06	3.705E-06	3.158E-06
1	24	3.630E-06	3.650E-06	3.110E-06

Table B.1. Eu-152 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.115E-10	1.095E-10	1.633E-10
6	2	1.022E-10	1.008E-10	1.538E-10
6	3	9.116E-11	8.946E-11	1.385E-10
6	4	8.141E-11	7.991E-11	1.240E-10
5	5	6.262E-11	6.108E-11	9.687E-11
5	6	5.917E-11	5.763E-11	9.231E-11
5	7	5.480E-11	5.382E-11	8.649E-11
5	8	5.166E-11	5.062E-11	8.110E-11
4	9	4.620E-11	4.499E-11	7.223E-11
4	10	4.523E-11	4.423E-11	7.089E-11
4	11	4.398E-11	4.299E-11	6.848E-11
4	12	4.296E-11	4.201E-11	6.635E-11
3	13	4.239E-11	4.112E-11	6.465E-11
3	14	4.236E-11	4.105E-11	6.472E-11
3	15	4.192E-11	4.093E-11	6.469E-11
3	16	4.215E-11	4.112E-11	6.443E-11
2	17	4.460E-11	4.321E-11	6.678E-11
2	18	4.635E-11	4.463E-11	6.954E-11
2	19	4.775E-11	4.666E-11	7.148E-11
2	20	4.916E-11	4.834E-11	7.395E-11
1	21	6.032E-11	5.899E-11	8.844E-11
1	22	6.598E-11	6.449E-11	9.583E-11
1	23	7.214E-11	7.037E-11	1.040E-10
1	24	7.746E-11	7.554E-11	1.108E-10

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Gd-152 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.877E-10	1.879E-10	2.500E-10
6	2	1.882E-10	1.885E-10	2.550E-10
6	3	1.714E-10	1.717E-10	2.387E-10
6	4	1.538E-10	1.541E-10	2.208E-10
5	5	1.287E-10	1.281E-10	1.910E-10
5	6	1.291E-10	1.286E-10	1.925E-10
5	7	1.208E-10	1.210E-10	1.836E-10
5	8	1.093E-10	1.094E-10	1.676E-10
4	9	9.796E-11	9.747E-11	1.519E-10
4	10	1.006E-10	1.002E-10	1.557E-10
4	11	9.798E-11	9.745E-11	1.511E-10
4	12	9.152E-11	9.106E-11	1.413E-10
3	13	8.989E-11	8.877E-11	1.376E-10
3	14	9.368E-11	9.257E-11	1.437E-10
3	15	9.298E-11	9.241E-11	1.431E-10
3	16	8.926E-11	8.874E-11	1.368E-10
2	17	9.402E-11	9.281E-11	1.406E-10
2	18	1.018E-10	1.006E-10	1.513E-10
2	19	1.047E-10	1.041E-10	1.550E-10
2	20	1.029E-10	1.027E-10	1.516E-10
1	21	1.170E-10	1.165E-10	1.665E-10
1	22	1.313E-10	1.305E-10	1.829E-10
1	23	1.401E-10	1.396E-10	1.918E-10
1	24	1.404E-10	1.398E-10	1.911E-10

Table B.1. Eu-153 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.757E-06	1.749E-06	1.388E-06
6	2	1.826E-06	1.822E-06	1.428E-06
6	3	2.009E-06	2.016E-06	1.603E-06
6	4	2.263E-06	2.268E-06	1.853E-06
5	5	2.577E-06	2.582E-06	2.154E-06
5	6	2.563E-06	2.570E-06	2.125E-06
5	7	2.664E-06	2.667E-06	2.220E-06
5	8	2.877E-06	2.883E-06	2.466E-06
4	9	3.044E-06	3.060E-06	2.634E-06
4	10	2.971E-06	2.988E-06	2.558E-06
4	11	3.020E-06	3.030E-06	2.612E-06
4	12	3.179E-06	3.195E-06	2.804E-06
3	13	3.232E-06	3.253E-06	2.852E-06
3	14	3.116E-06	3.137E-06	2.722E-06
3	15	3.117E-06	3.148E-06	2.726E-06
3	16	3.233E-06	3.254E-06	2.861E-06
2	17	3.097E-06	3.109E-06	2.734E-06
2	18	2.923E-06	2.945E-06	2.539E-06
2	19	2.875E-06	2.890E-06	2.472E-06
2	20	2.926E-06	2.941E-06	2.549E-06
1	21	2.656E-06	2.678E-06	2.301E-06
1	22	2.410E-06	2.435E-06	2.046E-06
1	23	2.276E-06	2.296E-06	1.912E-06
1	24	2.243E-06	2.264E-06	1.880E-06

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Eu-154 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.510E-07	2.509E-07	1.809E-07
6	2	2.630E-07	2.633E-07	1.864E-07
6	3	2.991E-07	3.002E-07	2.183E-07
6	4	3.517E-07	3.530E-07	2.692E-07
5	5	4.188E-07	4.206E-07	3.294E-07
5	6	4.129E-07	4.142E-07	3.198E-07
5	7	4.350E-07	4.353E-07	3.402E-07
5	8	4.832E-07	4.848E-07	3.944E-07
4	9	5.213E-07	5.234E-07	4.308E-07
4	10	5.009E-07	5.038E-07	4.091E-07
4	11	5.111E-07	5.133E-07	4.208E-07
4	12	5.500E-07	5.532E-07	4.668E-07
3	13	5.601E-07	5.659E-07	4.765E-07
3	14	5.294E-07	5.350E-07	4.433E-07
3	15	5.314E-07	5.367E-07	4.436E-07
3	16	5.611E-07	5.653E-07	4.778E-07
2	17	5.315E-07	5.347E-07	4.521E-07
2	18	4.898E-07	4.940E-07	4.053E-07
2	19	4.789E-07	4.818E-07	3.913E-07
2	20	4.939E-07	4.972E-07	4.113E-07
1	21	4.356E-07	4.407E-07	3.600E-07
1	22	3.808E-07	3.856E-07	3.050E-07
1	23	3.530E-07	3.584E-07	2.780E-07
1	24	3.487E-07	3.531E-07	2.741E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Eu-155 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	1.045E-07	1.046E-07	8.147E-08
6	2	1.094E-07	1.093E-07	8.396E-08
6	3	1.223E-07	1.226E-07	9.453E-08
6	4	1.414E-07	1.413E-07	1.124E-07
5	5	1.661E-07	1.672E-07	1.340E-07
5	6	1.647E-07	1.660E-07	1.313E-07
5	7	1.731E-07	1.740E-07	1.384E-07
5	8	1.908E-07	1.917E-07	1.577E-07
4	9	2.055E-07	2.067E-07	1.715E-07
4	10	1.992E-07	2.002E-07	1.646E-07
4	11	2.024E-07	2.028E-07	1.682E-07
4	12	2.164E-07	2.176E-07	1.849E-07
3	13	2.210E-07	2.228E-07	1.890E-07
3	14	2.102E-07	2.123E-07	1.769E-07
3	15	2.102E-07	2.130E-07	1.778E-07
3	16	2.210E-07	2.228E-07	1.897E-07
2	17	2.095E-07	2.116E-07	1.795E-07
2	18	1.944E-07	1.963E-07	1.624E-07
2	19	1.896E-07	1.915E-07	1.572E-07
2	20	1.951E-07	1.964E-07	1.643E-07
1	21	1.721E-07	1.745E-07	1.449E-07
1	22	1.522E-07	1.546E-07	1.254E-07
1	23	1.421E-07	1.445E-07	1.153E-07
1	24	1.398E-07	1.413E-07	1.135E-07

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Gd-155 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	2.034E-10	2.016E-10	1.963E-10
6	2	2.004E-10	1.977E-10	1.898E-10
6	3	2.111E-10	2.091E-10	1.982E-10
6	4	2.302E-10	2.260E-10	2.203E-10
5	5	2.365E-10	2.347E-10	2.255E-10
5	6	2.280E-10	2.262E-10	2.147E-10
5	7	2.316E-10	2.303E-10	2.190E-10
5	8	2.496E-10	2.472E-10	2.414E-10
4	9	2.576E-10	2.547E-10	2.488E-10
4	10	2.460E-10	2.448E-10	2.362E-10
4	11	2.477E-10	2.454E-10	2.376E-10
4	12	2.622E-10	2.594E-10	2.589E-10
3	13	2.655E-10	2.626E-10	2.588E-10
3	14	2.519E-10	2.501E-10	2.417E-10
3	15	2.502E-10	2.494E-10	2.435E-10
3	16	2.634E-10	2.613E-10	2.596E-10
2	17	2.564E-10	2.542E-10	2.501E-10
2	18	2.410E-10	2.395E-10	2.296E-10
2	19	2.380E-10	2.369E-10	2.249E-10
2	20	2.476E-10	2.459E-10	2.391E-10
1	21	2.391E-10	2.398E-10	2.314E-10
1	22	2.203E-10	2.206E-10	2.090E-10
1	23	2.163E-10	2.144E-10	2.018E-10
1	24	2.214E-10	2.189E-10	2.076E-10

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Gd-157 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	5.860E-10	5.945E-10	5.554E-10
6	2	6.246E-10	6.327E-10	5.874E-10
6	3	6.743E-10	6.741E-10	6.253E-10
6	4	7.408E-10	7.465E-10	6.725E-10
5	5	8.778E-10	8.913E-10	7.655E-10
5	6	8.939E-10	9.050E-10	7.741E-10
5	7	9.371E-10	9.507E-10	8.000E-10
5	8	1.012E-09	1.026E-09	8.709E-10
4	9	1.101E-09	1.126E-09	9.276E-10
4	10	1.089E-09	1.114E-09	9.106E-10
4	11	1.111E-09	1.140E-09	9.348E-10
4	12	1.176E-09	1.203E-09	9.935E-10
3	13	1.207E-09	1.243E-09	1.015E-09
3	14	1.171E-09	1.209E-09	9.852E-10
3	15	1.176E-09	1.207E-09	9.839E-10
3	16	1.212E-09	1.240E-09	1.014E-09
2	17	1.125E-09	1.156E-09	9.594E-10
2	18	1.066E-09	1.087E-09	9.087E-10
2	19	1.039E-09	1.061E-09	8.848E-10
2	20	1.028E-09	1.053E-09	8.858E-10
1	21	8.749E-10	8.983E-10	7.779E-10
1	22	7.939E-10	8.164E-10	7.173E-10
1	23	7.468E-10	7.619E-10	6.769E-10
1	24	7.147E-10	7.271E-10	6.512E-10

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Table B.1. Dy-164 concentration at the end of Cycle 145A (2nd calculation) with 1-day decay.

Capsule No. (#)	Compact No. (#)	Stack No. 1 (moles)	Stack No. 3 (moles)	Stack No. 2 (moles)
6	1	8.544E-11	8.561E-11	8.930E-11
6	2	8.604E-11	8.626E-11	9.065E-11
6	3	8.720E-11	8.726E-11	9.330E-11
6	4	9.107E-11	9.109E-11	9.834E-11
5	5	9.205E-11	9.225E-11	9.932E-11
5	6	8.966E-11	8.943E-11	9.685E-11
5	7	8.958E-11	8.950E-11	9.630E-11
5	8	9.328E-11	9.303E-11	1.009E-10
4	9	9.290E-11	9.367E-11	9.986E-11
4	10	9.017E-11	9.039E-11	9.617E-11
4	11	9.014E-11	9.074E-11	9.659E-11
4	12	9.377E-11	9.430E-11	1.011E-10
3	13	9.441E-11	9.484E-11	1.010E-10
3	14	9.106E-11	9.129E-11	9.697E-11
3	15	9.075E-11	9.148E-11	9.711E-11
3	16	9.471E-11	9.493E-11	1.011E-10
2	17	9.277E-11	9.309E-11	9.904E-11
2	18	8.939E-11	8.949E-11	9.540E-11
2	19	8.940E-11	8.998E-11	9.489E-11
2	20	9.195E-11	9.282E-11	9.848E-11
1	21	9.036E-11	9.068E-11	9.680E-11
1	22	8.629E-11	8.690E-11	9.252E-11
1	23	8.561E-11	8.619E-11	9.096E-11
1	24	8.714E-11	8.771E-11	9.187E-11

APPENDIX C—NJOY CROSS SECTION DATA VERIFICATION

Traceability

The NJOY computer code was obtained from the Radiation Safety Information Computational Center as: ID#: P00480MNYCP00, RSIC#: PSR-480, Code Name: NJOY99.0. Applying patch updates created a new version of NJOY or NJOY99.161 on the INL HELIOS computer system.

Verification

In order to verify that the HELIOS NJOY code was generating ACER neutron cross sections properly, cross sections generated with the HELIOS NJOY code were compared to standard cross sections that are distributed with the MCNP computer codes. The standard cross sections issued by RSICC with the MCNP code are referred to as "RSICC 300K" in the following figures.

A comparison example is given in Figure C.1. This figure is a plot of the total cross section for U-235 at 300 K over the neutron energy range of 1.0E-11 to 20.0 MeV. Figure C.2 is the same as C.1, but only over the 1.0E-5 to 1.0E-3 MeV energy range showing more detail in the individual resonance behavior. Note that the red curves (NJOY HELIOS (300K)) overlay the black curves (RSICC 300K) nearly identically which is indicative of excellent agreement between the two cross section data sets and the fact that the HELIOS NJOY code is generating ACER cross section data properly. The absorption, elastic scattering and fission cross sections are also in excellent agreement, although they are not shown here.

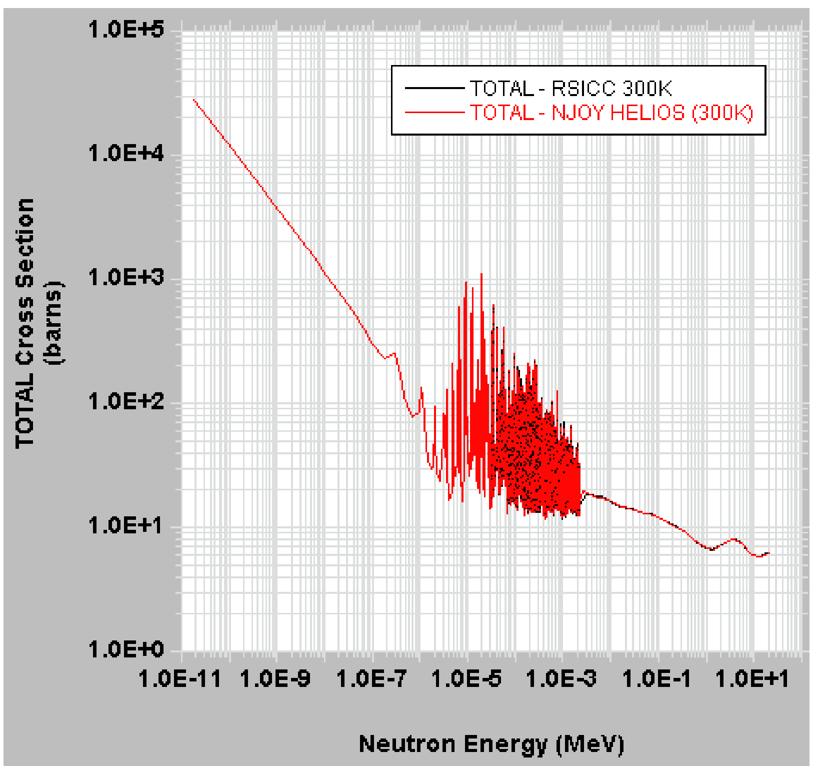

Figure C.1. Comparison of the U-235 TOTAL cross sections (300 K).

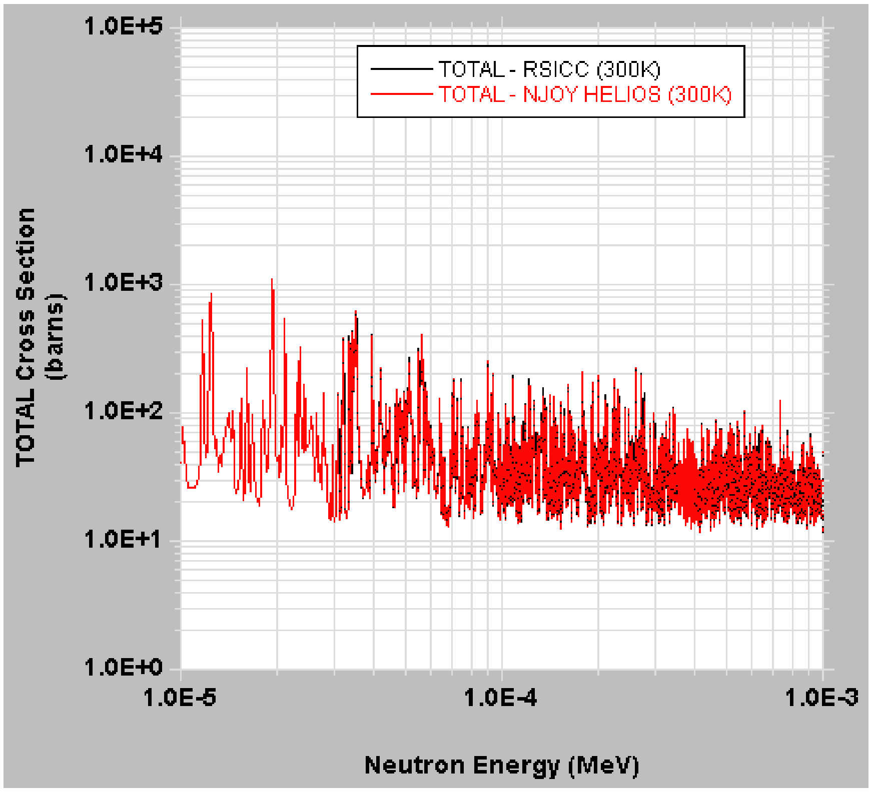

Figure C.2. Detailed comparison of the U-235 TOTAL cross sections (300 K).

As a second comparison example, Figure C.3 is a plot of the total cross section for the fission product Ag-110m at 300 K over the entire 1.0E-11 to 20.0 MeV energy range. Figure C.4 is the same as C.3, but only over the 2.0E-5 to 2.5E-5 MeV energy range showing a single resonance. Note that the red curves (NJOY HELIOS (300K)) again overlay the black curves (RSICC 300K) which is also indicative of excellent agreement between the two cross section data sets, and the fact that the HELIOS NJOY code is generating ACER cross section data properly.

The HELIOS NJOY code was also used to generate cross sections at temperature, namely 300 K, 600°C, and 1200°C. As an example to demonstrate that the HELIOS NJOY code properly Doppler-broadened the cross section data, Figures C.5 and C.6 are presented for the total cross section (barns) of U-235 and Am-242m at 300 K, 600°C, and 1200°C, respectively. Doppler-broadening of a single resonance, specifically for U-235, the resonance at 2.05E-6 MeV (2.05 eV) and for Am-242m, the resonance at 2.09E-6 MeV (2.09 eV) clearly show the desired broadening effect. Note that the 600°C and 1200°C cross section library data was used in the AGR-1 JMOCUP depletion calculations for compacts. Specifically, the 600°C data was used for the first Cycle (138B) which was held at a relatively lower temperature, and the 1200°C data was used for the all subsequent ATR power cycles.

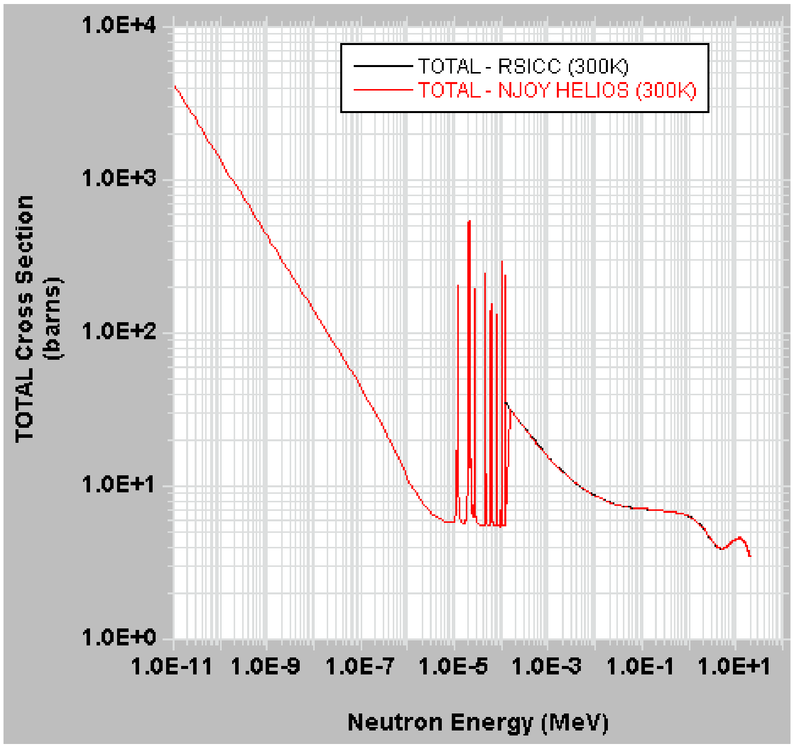

Figure C.3. Comparison of the Ag-110m Total cross sections (300 K).

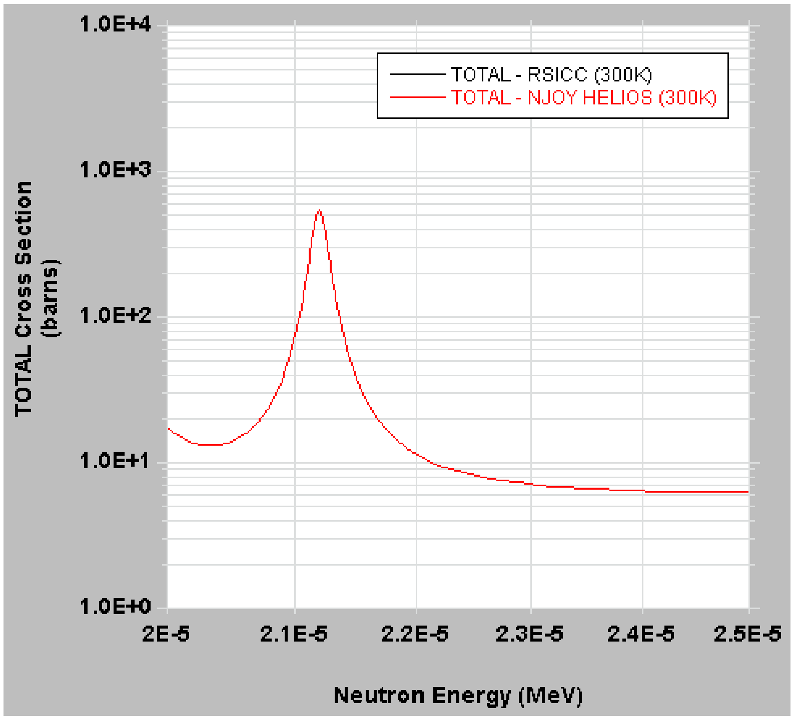

Figure C.4. Comparison of the Ag-110m TOTAL cross sections (300 K) for a single resonance.

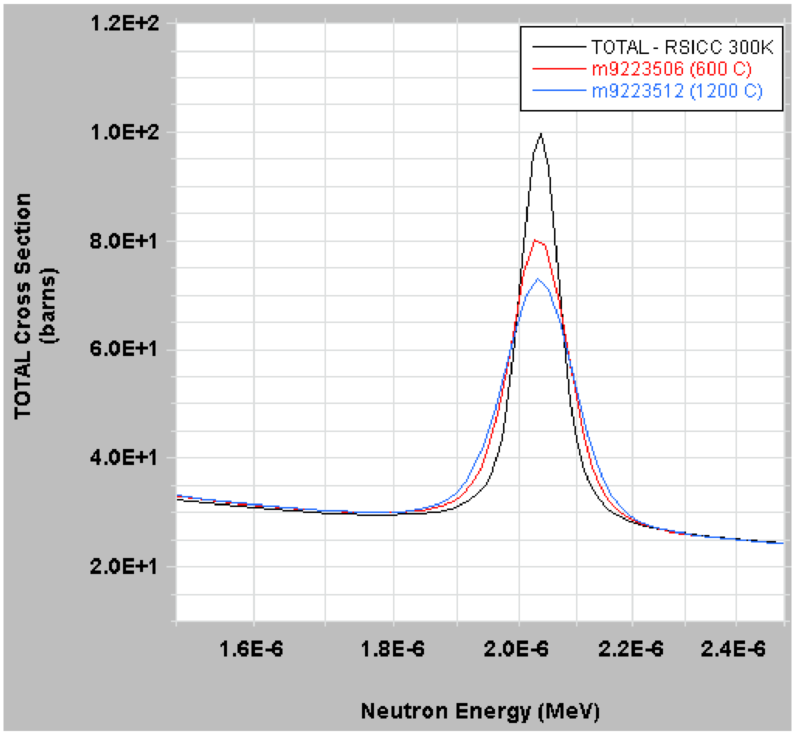

Figure C.5. Comparison of the U-235 TOTAL cross section at 300 K, 600°C and 1200°C for a single resonance.

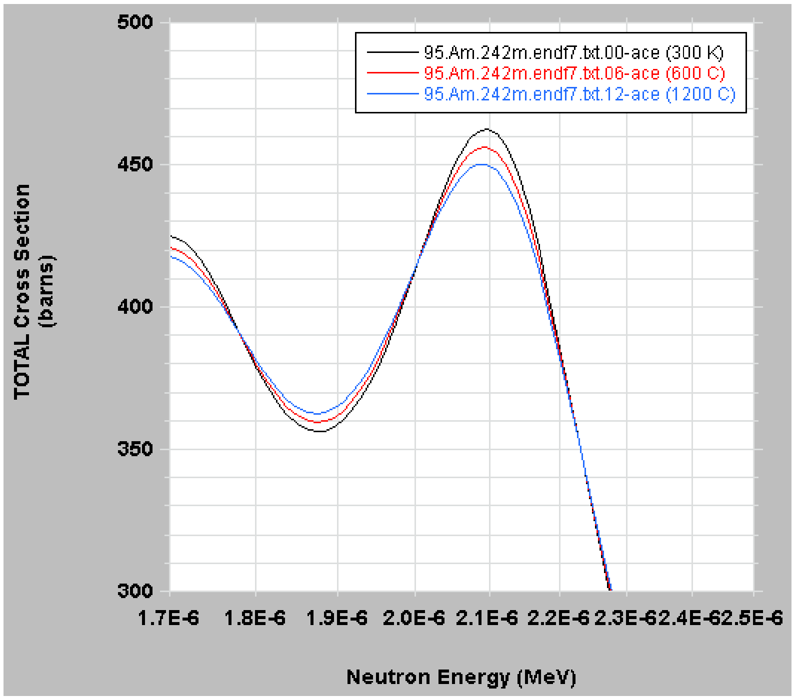

Figure C.6. Comparison of the Am-242m TOTAL cross section at 300 K, 600°C and 1200°C for a single resonance.

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

APPENDIX D—JMOCUP Verification and Validation

PC: Zeek

INTEROFFICE MEMORANDUM

Idaho National Laboratory INL

Date:	April 12, 2010		
To:	James Sterbentz	MS 3870	6-9810
From:	Doug Zeek	MS 3850	6-7728
Subject:	Review of Calculated Result from MCNP output versus ORIGEN input for the AGR-1 experiment. (JMOCUP V & V)		

AGR-1 MCNP Data Validation and Verification

This memo describes the work performed to check calculated results from MCNP output data versus ORIGEN input file data for the AGR-1 experiment. There were no errors found in any of the data I checked. This involved MCNP output of reaction rates and fluxes, calculating the reaction rate divided by the appropriate flux, and checking to see that these results were identical to the values used in ORIGEN input files. The scope of the data that was checked was for two ATR reactor cycles (Cycles 138B and 145A) and three time steps for each of:

- 43 isotopes at three ATR fuel locations,
- 60 isotopes at three TRISO compact locations,
- 12 isotopes at three hafnium shroud locations, and
- 12 isotopes at three Boron-10 graphite holders.

METHODOLOGY

The data extracted from the provided AGR-1 files was formatted and put into an Excel spreadsheet. Worksheets for each combination of 'cell' number and time step number were created corresponding to the names of the AGR-1 files provided. While the name 'cell' was only used in the provided files for the ATR fuel locations, in the spreadsheet 'cell' is used, as a convenience, for the named ranges for TRISO compacts, hafnium shrouds, boron-10 graphite holders, as well as ATR fuel locations. These named ranges (e.g. 'cell9502363' is the named range for part of the file 'shho.9502363') are the target of VLOOKUP functions to look up values based on unique combinations of the 'cell' number, the isotope code (ZM#) and the reaction code (e.g. 102 = n, gamma reaction).

Spot checks of the calculation were done by hand for select 'cells' – time steps. These are indicated by red check marks on the attached printouts. Most of the printouts also include one of these checks as a handwritten calculation.

The results of my review are contained in the following files, given to you separately.

Excel Workbooks: AGR-1 Cycle 138B.xls, AGR-1 Cycle 145A.xls

Included Excel Worksheets in these workbooks:

- Flux: neutron flux values for all 'cells' and three time steps.
- Reaction RatesX: reaction rates for time step X.
- Calculated-X: reaction rate divided by flux for time step X.
- ORIGEN input-X: Calculation results used for ORIGEN input at X
- Comparison-X: ORIGEN input divided by Calculated value

Where the time step X = 1, 2 and [49 (cycle 138B) or 63 (cycle 145A)]

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Cycle 138B cell.600011 Doug Zeck 4/12/10

Timestep 1

Flux = 5.55738E-5

$$\frac{2.55652E-2}{5.55738E-5} = 460.02$$

```
-1
-1
-1
TIT  ATR REACTOR JMOCUP CORE DEPLETION
BAS  ATR REACTOR JMOCUP CORE DEPLETION
LIP  0 0 0
LPU  50100   -1
LPU  922340 922350 922360 922370 922380
     932370 942390 942400 942410  -1
LPU  360830 420950 441010 451030 451050
     481130 541310 541330 551330 541350
     571400 581410 591430 601430 601450
     611470 611490 621490 611510 621510
     621520 631530 63155 641570   -1
LIB  0 1 2 3  -204 -205 -206   9 50 0 4 0
OPTL 8 8 8 8 5  8 8 8 8 8  8 8 8 8 8  8 8 8 8 8  8 8 8 8
OPTA 8 8 8 8 5  8 8 8 8 8  8 8 8 8 8  8 8 8 8 8  8 8 8 8
OPTF 8 8 8 8 5  8 8 8 8 8  8 8 8 8 8  8 8 8 8 8  8 8 8 8
CUT  5 1.0E-24  28 1.0E-75  -1
INP  1 2   -1 -1  1  1
BUP
 IRP  4.16667E-02  2.91680E-03    1    2  4  2
 IRP  8.33333E-02  2.91680E-03    2    3  4  0
 IRP  1.25000E-01  2.91680E-03    3    4  4  0
 IRP  1.66667E-01  2.91680E-03    4    5  4  0
 IRP  2.08333E-01  2.91680E-03    5    6  4  0
 IRP  2.50000E-01  2.91680E-03    6    7  4  0
 IRP  2.91667E-01  2.91680E-03    7    8  4  0
 IRP  3.33333E-01  2.91680E-03    8    9  4  0
 IRP  3.75000E-01  2.91680E-03    9   10  4  0
PCH  10 10 10
OUT  10 1  0  0
BUP
STP  4          102                 107        18
                                               19;20
204   50100 4.598E-02 0.000E+00 4.600E+02 2.480E-03 0.000E+00 0.000E+00  -1.0
205  922340 2.708E+01 4.266E-04 1.349E-05 5.465E-01 0.000E+00 0.000E+00  -1.0
205  922350 1.396E+01 2.696E-03 1.160E-06 6.744E+01 0.000E+00 0.000E+00  -1.0
205  922360 8.779E+00 2.644E-03 2.207E-05 3.194E-01 0.000E+00 0.000E+00  -1.0
205  922370 5.766E+01 0.000E+00 0.000E+00 6.804E-01 0.000E+00 0.000E+00  -1.0
205  922380 6.913E+00 5.525E-03 4.597E-05 1.037E-01 0.000E+00 0.000E+00  -1.0
205  932370 3.976E+01 2.746E-04 2.912E-06 5.324E-01 0.000E+00 7.877E-04  -1.0
205  942390 6.735E+01 1.120E-03 8.560E-07 1.318E+02 0.000E+00 0.000E+00  -1.0
205  942400 2.529E+02 4.478E-04 1.073E-05 6.000E-01 0.000E+00 0.000E+00  -1.0
205  942410 5.493E+01 7.518E-03 2.421E-05 1.514E+02 0.000E+00 0.000E+00  -1.0
206  360830 2.711E+01 2.054E-03 3.110E-06 7.961E-05 0.000E+00 0.000E+00   1.0
206    4.73E-07 5.12E-05 3.65E-06 1.40E-07 9.47E-05 1.01E-06 9.90E-07 9.90E-07
206  420950 4.720E+00 0.000E+00 1.134E-03 3.991E-05 0.000E+00 0.000E+00   1.0
206    1.90E-11 1.46E-07 2.87E-09 1.17E-11 1.09E-07 1.07E-09 1.07E-09 1.07E-09
206  441010 3.162E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00   1.0
206    9.65E-11 2.21E-06 4.91E-08 1.13E-09 2.55E-06 3.84E-08 3.83E-08 3.83E-08
206  451030 4.557E+01 2.237E-04 0.000E+00 0.000E+00 2.873E+00 0.000E+00   1.0
206    0.0      7.35E-10 3.70E-07 3.66E-11 6.90E-08 5.60E-05 5.54E-05 5.54E-05
206  451050 2.151E+03 0.000E+00 0.000E+00 0.000E+00 4.945E+02 0.000E+00   1.0
206    4.09E-10 3.45E-07 5.20E-03 4.41E-06 6.55E-05 1.75E-06 1.78E-06 1.78E-06
206  481130 3.999E+03 1.471E-03 0.000E+00 2.065E-06 0.000E+00 0.000E+00   1.0
206    2.89E-09 3.08E-07 1.67E-08 8.08E-10 1.51E-06 2.52E-07 3.16E-07 3.16E-07
```

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Cycle 138B cell.600011 (continued) Doug Zeek 4/12/10

102

```
206 541310 3.643E+01 6.436E-03 1.639E-06 2.946E-06 0.000E+00 0.000E+00  1.0
206   1.08E-08 4.29E-05 1.04E-06 3.12E-04 8.21E-06 6.65E-07 6.64E-07 6.64E-07
206 541330 3.006E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00  1.0
206   5.43E-05 1.53E-02 8.79E-04 3.32E-03 1.02E-02 1.06E-03 1.06E-03 1.06E-03
206 551330 1.306E+01 6.130E-03 1.103E-06 8.514E-05 1.082E+00 0.000E+00  1.0
206   7.46E-09 3.69E-05 4.46E-05 1.68E-05 1.52E-05 4.27E-07 4.26E-07 4.26E-07
206 541350 3.283E+05 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00  1.0
206   2.01E-02 5.38E-01 9.78E-02 7.85E-02 4.61E-01 9.46E-02 9.44E-02 9.44E-02
206 571400 2.183E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00  1.0
206   8.88E-05 2.27E-02 6.04E-03 2.56E-03 2.30E-02 5.86E-03 5.84E-03 5.84E-03
206 581410 3.807E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00  1.0
206   7.67E-07 1.00E-03 2.43E-05 3.05E-06 9.09E-05 2.41E-05 2.41E-05 2.41E-05
206 591430 1.477E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00  1.0
206   3.99E-07 1.51E-04 2.95E-06 2.80E-07 9.17E-06 2.69E-06 2.69E-06 2.69E-06
206 601430 3.819E+01 8.888E-03 5.293E-05 2.651E-06 0.000E+00 0.000E+00  1.0
206   0.0      2.46E-08 2.83E-10 6.91E-12 4.84E-10 1.20E-10 1.20E-10 1.20E-10
206 601450 1.086E+01 1.165E-02 1.897E-05 8.002E-07 0.000E+00 0.000E+00  1.0
206   6.81E-09 3.27E-05 4.04E-07 2.95E-08 1.20E-06 1.92E-07 1.91E-07 1.91E-07
206 611470 7.503E+01 3.065E-03 6.188E-06 1.661E-06 3.212E+01 0.000E+00  1.0
206   7.78E-10 3.33E-06 2.73E-07 9.06E-05 2.10E-07 2.35E-08 2.35E-08 2.35E-08
206 611490 1.732E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00  1.0
206   8.07E-07 4.79E-04 3.12E-05 4.51E-06 1.06E-04 2.49E-05 2.48E-05 2.48E-05
206 621490 8.509E+03 4.597E-03 4.505E-05 4.505E-05 0.000E+00 0.000E+00  1.0
206   3.62E-11 2.98E-07 6.53E-09 4.18E-10 1.91E-08 3.48E-09 3.48E-09 3.48E-09
206 611510 1.271E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00  1.0
206   6.69E-05 1.12E-02 1.77E-03 8.93E-04 7.00E-03 2.97E-03 2.97E-03 2.97E-03
206 621510 1.258E+03 1.563E-02 9.878E-06 8.855E-07 0.000E+00 0.000E+00  1.0
206   3.75E-08 8.39E-05 3.80E-06 3.22E-04 2.47E-05 6.19E-06 6.18E-06 6.18E-06
206 621520 9.901E+01 1.870E-03 5.569E-07 7.858E-08 0.000E+00 0.000E+00  1.0
206   5.69E-07 6.41E-04 4.65E-05 1.45E-05 3.29E-04 8.19E-05 8.17E-05 8.17E-05
206 631530 6.904E+01 1.808E-03 0.000E+00 0.000E+00 0.000E+00 0.000E+00  1.0
206   6.24E-10 6.26E-04 6.02E-05 3.85E-08 1.76E-06 3.01E-07 2.99E-07 2.99E-07
206 631550 4.858E+02 2.360E-03 4.021E-07 3.302E-07 0.000E+00 0.000E+00  1.0
206   5.90E-08 1.61E-04 1.25E-05 5.01E-06 2.38E-04 4.85E-05 4.92E-05 4.92E-05
206 641570 1.971E+04 0.000E+00 5.058E-05 0.000E+00 0.000E+00 0.000E+00  1.0
206   1.55E-09 1.76E-05 4.12E-06 2.55E-07 1.38E-05 4.17E-06 4.17E-06 4.17E-06
1   50100    4.10982E-04   0 0.0
2   922340   8.42073E-04   0 0.0
2   922350   5.91935E-02   0 0.0
2   922360   2.52702E-03   0 0.0
2   922370   2.40601E-05   0 0.0
2   922380   4.42650E-03   0 0.0
2   932370   3.98168E-05   0 0.0
2   942390   6.75538E-05   0 0.0
2   942400   6.39836E-06   0 0.0
2   942410   2.44411E-06   0 0.0
3   360830   4.75841E-05   0 0.0
3   420950   2.22008E-05   0 0.0
3   441010   4.71311E-04   0 0.0
3   451030   7.23861E-05   0 0.0
3   451050   1.07863E-28   0 0.0
3   481130   1.06792E-07   0 0.0
3   541310   1.72729E-04   0 0.0
3   541330   8.51393E-29   0 0.0
3   551330   4.53945E-04   0 0.0
3   541350   8.32584E-29   0 0.0
```

$$\frac{1.09537}{5.55738E\text{-}5} = 1.9710E+4$$

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Cycle 138B comp. 9360449 Doug Zerk 4/12/10
Timestep 49
Flux = 2.05302 E-5

$\frac{2.29158E-7}{2.05302E-5} = 1.1162E-2$

```
-1
-1
-1
TIT   TRISO COMPACTS JMOCUP CORE DEPLETION
BAS   TRISO COMPACTS JMOCUP CORE DEPLETION
LIP   0 0 0
LPU   902320  922330  922340  922350  922360
      922370  922380  932370  932380  942380
      942390  942400  942410  942420  952410
      952430  962420  962440              -1
LPU   360830  360850  430990  531270  531290
      541310  541350  551350  551360  591430
      601470  621470  601480  611480  611490
      621490  611510  621510  631510  631520
      641520  641550  641570  661640      -1
LIB   0 1 2 3    204 -205 -206    9 50 0 4 0
OPTL  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
OPTA  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
OPTF  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
CUT   5 1.0E-24  28 1.0E-75   -1
INP   1  2      -1  -1   1   1
BUP
 IRP   4.16667E-02  7.36393E-05     1     2   4   2
 IRP   8.33333E-02  7.36393E-05     2     3   4   0
 IRP   1.25000E-01  7.36393E-05     3     4   4   0
 IRP   1.66667E-01  7.36393E-05     4     5   4   0
 IRP   2.08333E-01  7.36393E-05     5     6   4   0
 IRP   2.50000E-01  7.36393E-05     6     7   4   0
 IRP   2.91667E-01  7.36393E-05     7     8   4   0
 IRP   3.33333E-01  7.36393E-05     8     9   4   0
 IRP   3.75000E-01  7.36393E-05     9    10   4   0
PCH   10 10 10
OUT   10  1  0  0
BUP
STP    4       102                       167       18 19:20
205   902320 4.162E+00 5.089E-03 2.660E-05 1.116E-02 0.000E+00 0.000E+00   -1.0
205   922330 9.385E+00 2.863E-03 1.931E-06 7.981E+01 0.000E+00 0.000E+00   -1.0
205   922340 3.061E+01 4.266E-04 1.349E-05 3.303E-01 0.000E+00 0.000E+00   -1.0
205   922350 1.470E+01 2.696E-03 1.160E-06 6.772E+01 0.000E+00 0.000E+00   -1.0
205   922360 9.313E+00 2.644E-03 2.207E-05 2.221E-01 0.000E+00 0.000E+00   -1.0
205   922370 7.618E+01 0.000E+00 0.000E+00 1.938E+00 0.000E+00 0.000E+00   -1.0
205   922380 5.101E+00 5.525E-03 4.597E-05 4.650E-02 0.000E+00 0.000E+00   -1.0
205   932370 4.594E+01 2.746E-04 2.912E-06 2.835E-01 0.000E+00 7.877E-04   -1.0
205   932380 5.340E+01 0.000E+00 0.000E+00 2.463E+02 0.000E+00 0.000E+00   -1.0
205   942380 5.579E+01 1.673E-04 9.195E-06 2.993E+00 0.000E+00 0.000E+00   -1.0
205   942390 6.669E+01 1.120E-03 8.560E-07 1.296E+02 0.000E+00 0.000E+00   -1.0
205   942400 1.860E+02 4.478E-04 1.073E-05 3.687E-01 0.000E+00 0.000E+00   -1.0
205   942410 5.110E+01 7.518E-03 2.421E-05 1.534E+02 0.000E+00 0.000E+00   -1.0
205   942420 4.811E+01 2.307E-03 2.268E-05 2.403E-01 0.000E+00 0.000E+00   -1.0
205   952410 1.326E+02 3.280E-04 1.532E-06 1.015E+00 1.307E+01 0.000E+00   -1.0
205   952430 6.301E+01 2.074E-04 0.000E+00 2.895E-01 4.726E+01 0.000E+00   -1.0
205   962420 6.831E+00 5.295E-05 0.000E+00 4.875E-01 0.000E+00 0.000E+00   -1.0
205   962440 2.073E+01 1.048E-03 0.000E+00 7.869E-01 0.000E+00 0.000E+00   -1.0
206   360830 2.966E+01 2.054E-03 3.110E-06 7.961E-05 0.000E+00 0.000E+00    1.0
206      4.73E-07 5.12E-05 3.65E-06 1.40E-07 9.47E-05 1.01E-06 9.90E-07 9.90E-07
206   360850 2.498E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00    1.0
206      6.02E-04 2.14E-02 2.28E-03 8.55E-03 7.01E-03 5.76E-04 5.84E-04 5.84E-04
```

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Cycle 138B comp. 9360449

102 107 18 19:20

Doug Peek 4/12/10

```
206   430990 1.065E+01 6.130E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      2.98E-09 8.61E-06 4.16E-05 3.24E-09 6.23E-06 2.04E-07 2.03E-07 2.03E-07
206   531270 6.470E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      3.14E-11 4.55E-06 8.04E-08 1.84E-04 3.75E-07 5.63E-10 5.62E-10 5.62E-10
206   531290 4.376E+00 0.000E+00 0.000E+00 0.000E+00 2.047E+00 0.000E+00     1.0
206      3.29E-08 2.22E-03 1.80E-04 5.46E-03 1.90E-04 1.60E-06 1.60E-06 1.60E-06
206   541310 4.693E+01 6.436E-03 1.639E-06 2.946E-06 0.000E+00 0.000E+00     1.0
206      1.08E-08 4.29E-05 1.04E-06 3.12E-04 8.21E-06 6.65E-07 6.64E-07 6.64E-07
206   541350 3.370E+05 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      2.01E-02 5.38E-01 9.78E-02 7.85E-02 4.61E-01 9.46E-02 9.44E-02 9.44E-02
206   551350 3.403E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      2.10E-05 1.05E-02 9.01E-04 1.89E-04 4.07E-03 4.49E-04 4.48E-04 4.48E-04
206   551360 1.616E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      1.39E-04 1.12E-01 7.26E-03 1.30E-02 1.11E-01 1.74E-02 1.74E-02 1.74E-02
206   591430 1.562E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      3.99E-07 1.51E-04 2.95E-06 2.80E-07 9.17E-06 2.69E-06 2.69E-06 2.69E-06
206   601470 2.827E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      2.07E-05 6.62E-03 2.96E-04 3.11E-05 6.51E-04 2.45E-04 2.45E-04 2.45E-04
206   621470 3.368E+01 7.049E-03 6.513E-05 4.509E-06 0.000E+00 0.000E+00     1.0
206      0.0         2.02E-10 1.01E-06 0.0         2.42E-12 0.0       0.0       0.0
206   601480 1.027E+00 3.678E-04 7.255E-07 1.472E-08 0.000E+00 0.000E+00     1.0
206      3.04E-04 2.74E-02 3.07E-03 5.53E-04 6.00E-03 2.64E-03 2.63E-03 2.63E-03
206   611480 1.335E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      2.17E-08 9.47E-07 5.10E-06 7.02E-08 2.07E-06 5.43E-07 5.42E-07 5.42E-07
206   611490 1.756E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      8.07E-07 4.79E-04 3.12E-05 4.51E-06 1.06E-04 2.49E-05 2.48E-05 2.48E-05
206   621490 9.189E+03 4.597E-03 4.505E-05 4.505E-05 0.000E+00 0.000E+00     1.0
206      3.62E-11 2.98E-07 6.53E-09 4.18E-10 1.91E-08 3.48E-09 3.48E-09 3.48E-09
206   611510 1.386E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      6.69E-05 1.12E-02 1.77E-03 8.93E-04 7.00E-03 2.97E-03 2.97E-03 2.97E-03
206   621510 1.103E+03 1.563E-02 9.878E-06 8.855E-07 0.000E+00 0.000E+00     1.0
206      3.75E-08 8.39E-05 3.80E-06 3.22E-04 2.47E-05 6.19E-06 6.18E-06 6.18E-06
206   631510 9.651E+02 1.165E-03 3.891E-05 1.983E-05 2.964E+02 0.000E+00     1.0
206      0.0         1.53E-08 4.99E-05 9.06E-08 1.50E-09 1.83E-10 1.83E-10 1.83E-10
206   631520 2.653E+02 4.291E-03 5.077E-05 6.653E-05 0.000E+00 0.000E+00     1.0
206      1.16E-11 2.04E-07 3.33E-09 5.78E-10 4.55E-08 5.44E-09 5.43E-09 5.43E-09
206   641520 1.565E+01 0.000E+00 6.475E-04 0.000E+00 0.000E+00 0.000E+00     1.0
206      0.0         2.49E-11 6.68E-13 0.0         2.15E-12 0.0       0.0       0.0
206   641550 4.348E+03 0.000E+00 8.185E-06 0.000E+00 0.000E+00 0.000E+00     1.0
206      8.08E-12 3.97E-07 6.31E-09 1.18E-09 2.50E-07 1.93E-08 1.96E-08 1.96E-08
206   641570 1.858E+04 0.000E+00 5.058E-05 0.000E+00 0.000E+00 0.000E+00     1.0
206      1.55E-09 1.76E-05 4.12E-06 2.55E-07 1.38E-05 4.17E-06 4.17E-06 4.17E-06
206   661640 2.604E+02 2.360E-03 6.038E-05 7.650E-06 1.434E+02 0.000E+00     1.0
206      8.36E-10 2.64E-07 8.99E-08 1.15E-06 8.17E-06 1.31E-06 1.30E-06 1.30E-06
  1  10010  0.0000E+00  10020  0.0000E+00  10030  0.0000E+00  10040  0.0000E+00
  1  20030  0.0000E+00  20040  0.0000E+00  20060  0.0000E+00  30060  0.0000E+00
  1  30070  0.0000E+00  30080  0.0000E+00  40080  0.0000E+00  40090  0.0000E+00
  1  40100  0.0000E+00  40110  0.0000E+00  50100  0.0000E+00  50110  0.0000E+00
  1  50120  0.0000E+00  60120  0.0000E+00  60130  0.0000E+00  60140  0.0000E+00
  1  60150  0.0000E+00  70130  0.0000E+00  70140  0.0000E+00  70150  0.0000E+00
  1  70160  0.0000E+00  80160  0.0000E+00  80170  0.0000E+00  80180  0.0000E+00
  1  80190  0.0000E+00  90190  0.0000E+00  90200  0.0000E+00 100200  0.0000E+00
  1 100210  0.0000E+00 100220  0.0000E+00 100230  0.0000E+00 110220  0.0000E+00
  1 110230  0.0000E+00 110240  0.0000E+00 110241  0.0000E+00 110250  0.0000E+00
  1 120240  0.0000E+00 120250  0.0000E+00 120260  0.0000E+00 120270  0.0000E+00
  1 120280  0.0000E+00 130270  0.0000E+00 130280  0.0000E+00 130290  0.0000E+00
  1 130300  0.0000E+00 140280  0.0000E+00 140290  0.0000E+00 140300  0.0000E+00
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Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Cycle 138B shho.90492 Doug Zeek 4/12/10

→ Time step 2

→ Flux = ~~2.62791E-5~~ 2.35901E-5

1.15609E-2 / 2.35901E-5 = 490.07

```
-1
-1
-1
TIT    HAFNIUM SHROUD and B-10 GRAPHITE HKDERS JMOCUP CORE DEPLETION
BAS    HAFNIUM SHROUD and B-10 GRAPHITE HKDERS JMOCUP CORE DEPLETION
LIP    0 0 0
LPU     30070    50100   721740   721760   721770
       721780   721790   721800   731810   741820
       741830   741840                      -1
LIB    0 1 2 3    -204   205   206     9 50 0 4 0
OPTL   8 8 8 8 5    8 8 8 8 8    8 8 8 8 8    8 8 8 8 8    8 8 8 8
OPTA   8 8 8 8 5    8 8 8 8 8    8 8 8 8 8    8 8 8 8 8    8 8 8 8
OPTF   8 8 8 8 5    8 8 8 8 8    8 8 8 8 8    8 8 8 8 8    8 8 8 8
CUT    5 1.0E-24  28 1.0E-75   -1
INP    1  2      -1  -1   1   1
BUP
 IRF    1.11111E-01  4.37777E+13       1      2   4   2
 IRF    2.22222E-01  4.37777E+13       2      3   4   0
 IRF    3.33333E-01  4.37777E+13       3      4   4   0
 IRF    4.44444E-01  4.37777E+13       4      5   4   0
 IRF    5.55556E-01  4.37777E+13       5      6   4   0
 IRF    6.66667E-01  4.37777E+13       6      7   4   0
 IRF    7.77778E-01  4.37777E+13       7      8   4   0
 IRF    8.88889E-01  4.37777E+13       8      9   4   0
 IRF    1.00000E+00  4.37777E+13       9     10   4   0
PCH    10 10 10
OUT    10  1  0  0
BUP                                                 18
STP     4       102                 107           19:20
204    30070 5.802E-03 0.000E+00 7.908E-03 0.000E+00 0.000E+00 0.000E+00   -1.0
204    50100 4.598E-02 0.000E+00 4.901E+02 2.480E-03 0.000E+00 0.000E+00   -1.0
204   721740 7.602E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00   -1.0
204   721760 1.037E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00   -1.0
204   721770 1.035E+02 0.000E+00 0.000E+00 0.000E+00 6.244E-01 0.000E+00   -1.0
204   721780 1.864E+01 0.000E+00 0.000E+00 0.000E+00 3.386E+01 0.000E+00   -1.0
204   721790 1.743E+01 0.000E+00 0.000E+00 0.000E+00 1.398E-01 0.000E+00   -1.0
204   721800 2.207E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00   -1.0
204   731810 2.444E+01 0.000E+00 0.000E+00 0.000E+00 9.392E-03 0.000E+00   -1.0
204   741820 2.307E+01 0.000E+00 0.000E+00 0.000E+00 4.569E-02 0.000E+00   -1.0
204   741830 1.045E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00   -1.0
204   741840 9.229E-01 0.000E+00 0.000E+00 0.000E+00 5.392E-04 0.000E+00   -1.0
  1  10010  6.9998E-27  10020  0.0000E+00  10030  0.0000E+00  10040  8.6078E-34
  1  20030  0.0000E+00  20040  1.1765E-21  20060  0.0000E+00  30060  0.0000E+00
  1  30070  5.0978E-18  30080  4.5120E-31  40080  1.0717E-36  40090  0.0000E+00
  1  40100  6.9998E-27  40110  0.0000E+00  50100  5.8854E-18  50110  1.2978E-25
  1  50120  0.0000E+00  60120  0.0000E+00  60130  0.0000E+00  60140  0.0000E+00
  1  60150  0.0000E+00  70130  0.0000E+00  70140  0.0000E+00  70150  0.0000E+00
  1  70160  0.0000E+00  80160  0.0000E+00  80170  0.0000E+00  80180  0.0000E+00
  1  80190  0.0000E+00  90190  0.0000E+00  90200  0.0000E+00 100200  0.0000E+00
  1 100210  0.0000E+00 100220  0.0000E+00 100230  0.0000E+00 110220  0.0000E+00
  1 110230  0.0000E+00 110240  0.0000E+00 110241  0.0000E+00 110250  0.0000E+00
  1 120240  0.0000E+00 120250  0.0000E+00 120260  0.0000E+00 120270  0.0000E+00
  1 120280  0.0000E+00 130270  0.0000E+00 130280  0.0000E+00 130290  0.0000E+00
  1 130300  0.0000E+00 140280  0.0000E+00 140290  0.0000E+00 140300  0.0000E+00
  1 140310  0.0000E+00 140320  0.0000E+00 150310  0.0000E+00 150320  0.0000E+00
  1 150330  0.0000E+00 150340  0.0000E+00 160320  0.0000E+00 160330  0.0000E+00
  1 160340  0.0000E+00 160350  0.0000E+00 160360  0.0000E+00 160370  0.0000E+00
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Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Cycle 145A comp. 9360463 (Doug Seale 4/12/10)

→ Time step 63

→ Flux = 3.46418 E-5

2.62264 E-7 / 3.46418 E-5 = 7.5707 E-3

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-1
-1
-1
TIT   TRISO COMPACTS JMOCUP CORE DEPLETION
BAS   TRISO COMPACTS JMOCUP CORE DEPLETION
LIP   0 0 0
LPU   902320  922330  922340  922350  922360
      922370  922380  932370  932380  942380
      942390  942400  942410  942420  952410
      952430  962420  962440              -1
LPU   360830  360850  430990  531270  531290
      541310  541350  551350  551360  591430
      601470  621470  601480  611480  611490
      621490  611510  621510  631510  631520
      641520  641550  641570  661640      -1
LIB   0 1 2 3    204 -205 -206    9 50 0 4 0
OPTL  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
OPTA  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
OPTF  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
CUT   5 1.0E-24  28 1.0E-75   -1
INP   1  2      -1  -1   1   1
BUP
 IRP   1.34259E-01  1.41191E-04      1      2   4   2
 IRP   2.68519E-01  1.41191E-04      2      3   4   0
 IRP   4.02778E-01  1.41191E-04      3      4   4   0
 IRP   5.37037E-01  1.41191E-04      4      5   4   0
 IRP   6.71296E-01  1.41191E-04      5      6   4   0
 IRP   8.05556E-01  1.41191E-04      6      7   4   0
 IRP   9.39815E-01  1.41191E-04      7      8   4   0
 IRP   1.07407E+00  1.41191E-04      8      9   4   0
 IRP   1.20833E+00  1.41191E-04      9     10   4   0
PCH   10 10 10
OUT   10  1  0  0
BUP
STP   4          102                         107        18
                                                        19:20
205   902320 4.587E+00 5.089E-03 2.660E-05 7.571E-03 0.000E+00 0.000E+00   -1.0
205   922330 1.884E+01 2.863E-03 1.931E-06 1.848E+02 0.000E+00 0.000E+00   -1.0
205   922340 4.581E+01 4.266E-04 1.349E-05 3.305E-01 0.000E+00 0.000E+00   -1.0
205   922350 3.329E+01 2.696E-03 1.160E-06 1.813E+02 0.000E+00 0.000E+00   -1.0
205   922360 9.377E+00 2.644E-03 2.207E-05 1.884E-01 0.000E+00 0.000E+00   -1.0
205   922370 1.606E+02 0.000E+00 0.000E+00 1.810E+00 0.000E+00 0.000E+00   -1.0
205   922380 4.972E+00 5.525E-03 4.597E-05 3.181E-02 0.000E+00 0.000E+00   -1.0
205   932370 8.028E+01 2.746E-04 2.912E-06 1.947E-01 0.000E+00 7.877E-04   -1.0
205   932380 1.455E+02 0.000E+00 0.000E+00 6.698E+02 0.000E+00 0.000E+00   -1.0
205   942380 1.585E+02 1.673E-04 9.195E-06 5.610E+00 0.000E+00 0.000E+00   -1.0
205   942390 1.568E+02 1.120E-03 8.560E-07 3.267E+02 0.000E+00 0.000E+00   -1.0
205   942400 2.896E+02 4.478E-04 1.073E-05 2.797E-01 0.000E+00 0.000E+00   -1.0
205   942410 1.332E+02 7.518E-03 2.421E-05 3.929E+02 0.000E+00 0.000E+00   -1.0
205   942420 3.960E+01 2.307E-03 2.268E-05 1.616E-01 0.000E+00 0.000E+00   -1.0
205   952410 2.794E+02 3.280E-04 1.532E-06 1.723E+00 1.307E+01 0.000E+00   -1.0
205   952430 7.896E+01 2.074E-04 0.000E+00 2.271E-01 4.726E+01 0.000E+00   -1.0
205   962420 8.220E+00 5.295E-05 0.000E+00 1.045E+00 0.000E+00 0.000E+00   -1.0
205   962440 1.566E+01 1.048E-03 0.000E+00 6.523E-01 0.000E+00 0.000E+00   -1.0
206   360830 6.848E+01 2.054E-03 3.110E-06 7.961E-05 0.000E+00 0.000E+00    1.0
 06      4.73E-07 5.12E-05 3.65E-06 1.40E-07 9.47E-05 1.01E-06 9.90E-07 9.90E-07
206   360850 5.702E-01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00    1.0
206      6.02E-04 2.14E-02 2.28E-03 8.55E-03 7.01E-03 5.76E-04 5.84E-04 5.84E-04
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Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Cycle 145A comp. 9360463

102

Doug Zeek 4/12/10

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206   430990 1.350E+01 6.130E-04 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      2.98E-09 8.61E-06 4.16E-05 3.24E-09 6.23E-06 2.04E-07 2.03E-07 2.03E-07
206   531270 6.295E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      3.14E-11 4.55E-06 8.04E-08 1.84E-04 3.75E-07 5.63E-10 5.62E-10 5.62E-10
206   531290 9.370E+00 0.000E+00 0.000E+00 0.000E+00 2.047E+00 0.000E+00     1.0
206      3.29E-08 2.22E-03 1.80E-04 5.46E-03 1.90E-04 1.60E-06 1.60E-06 1.60E-06
206   541310 5.769E+01 6.436E-03 1.639E-06 2.946E-06 0.000E+00 0.000E+00     1.0
206      1.08E-08 4.29E-05 1.04E-06 3.12E-04 8.21E-06 6.65E-07 6.64E-07 6.64E-07
206   541350 9.800E+05 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      2.01E-02 5.38E-01 9.78E-02 7.85E-02 4.61E-01 9.46E-02 9.44E-02 9.44E-02
206   551350 4.430E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      2.10E-05 1.05E-02 9.01E-04 1.89E-04 4.07E-03 4.49E-04 4.48E-04 4.48E-04
206   551360 1.501E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      1.39E-04 1.12E-01 7.26E-03 1.30E-02 1.11E-01 1.74E-02 1.74E-02 1.74E-02
206   591430 3.286E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      3.99E-07 1.51E-04 2.95E-06 2.80E-07 9.17E-06 2.69E-06 2.69E-06 2.69E-06
206   601470 3.263E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      2.07E-05 6.62E-03 2.96E-04 3.11E-05 6.51E-04 2.45E-04 2.45E-04 2.45E-04
206   621470 4.137E+01 7.049E-03 6.513E-05 4.509E-06 0.000E+00 0.000E+00     1.0
206      0.0      2.02E-10 1.01E-06 0.0      2.42E-12 0.0      0.0      0.0
206   601480 1.387E+00 3.678E-04 7.255E-07 1.472E-08 0.000E+00 0.000E+00     1.0
206      3.04E-04 2.74E-02 3.07E-03 5.53E-04 6.00E-03 2.64E-03 2.63E-03 2.63E-03
206   611480 1.825E+03 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      2.17E-08 9.47E-07 5.10E-06 7.02E-08 2.07E-06 5.43E-07 5.42E-07 5.42E-07
206   611490 4.578E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      8.07E-07 4.79E-04 3.12E-05 4.51E-06 1.06E-04 2.49E-05 2.48E-05 2.48E-05
206   621490 2.480E+04 4.597E-03 4.505E-05 4.505E-05 0.000E+00 0.000E+00     1.0
206      3.62E-11 2.98E-07 6.53E-09 4.18E-10 1.91E-08 3.48E-09 3.48E-09 3.48E-09
206   611510 2.701E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
206      6.69E-05 1.12E-02 1.77E-03 8.93E-04 7.00E-03 2.97E-03 2.97E-03 2.97E-03
206   621510 3.558E+03 1.563E-02 9.878E-06 8.855E-07 0.000E+00 0.000E+00     1.0
206      3.75E-08 8.39E-05 3.80E-06 3.22E-04 2.47E-05 6.19E-06 6.18E-06 6.18E-06
206   631510 2.571E+03 1.165E-03 3.891E-05 1.983E-05 2.964E+02 0.000E+00     1.0
206      0.0      1.53E-08 4.99E-05 9.06E-08 1.50E-09 1.83E-10 1.83E-10 1.83E-10
206   631520 6.302E+02 4.291E-03 5.077E-05 6.653E-05 0.000E+00 0.000E+00     1.0
206      1.16E-11 2.04E-07 3.33E-09 5.78E-10 4.55E-08 5.44E-09 5.43E-09 5.43E-09
206   641520 1.457E+01 0.000E+00 6.475E-04 0.000E+00 0.000E+00 0.000E+00     1.0
206      0.0      2.49E-11 6.68E-13 0.0      2.15E-12 0.0      0.0      0.0
206   641550 1.397E+04 0.000E+00 8.185E-06 0.000E+00 0.000E+00 0.000E+00     1.0
206      8.08E-12 3.97E-07 6.31E-09 1.18E-09 2.50E-07 1.93E-08 1.96E-08 1.96E-08
206   641570 5.962E+04 0.000E+00 5.058E-05 0.000E+00 0.000E+00 0.000E+00     1.0
206      1.55E-09 1.76E-05 4.12E-06 2.55E-07 1.38E-05 4.17E-06 4.17E-06 4.17E-06
206   661640 7.638E+02 2.360E-03 6.038E-05 7.650E-06 1.434E+02 0.000E+00     1.0
206      8.36E-10 2.64E-07 8.99E-08 1.15E-06 8.17E-06 1.31E-06 1.30E-06 1.30E-06
  1  10010  0.0000E+00  10020  0.0000E+00  10030  0.0000E+00  10040  0.0000E+00
  1  20030  0.0000E+00  20040  0.0000E+00  20060  0.0000E+00  30060  0.0000E+00
  1  30070  0.0000E+00  30080  0.0000E+00  40080  0.0000E+00  40090  0.0000E+00
  1  40100  0.0000E+00  40110  0.0000E+00  50100  0.0000E+00  50110  0.0000E+00
  1  50120  0.0000E+00  60120  0.0000E+00  60130  0.0000E+00  60140  0.0000E+00
  1  60150  0.0000E+00  70130  0.0000E+00  70140  0.0000E+00  70150  0.0000E+00
  1  70160  0.0000E+00  80160  0.0000E+00  80170  0.0000E+00  80180  0.0000E+00
  1  80190  0.0000E+00  90190  0.0000E+00  90200  0.0000E+00 100200  0.0000E+00
  1 100210  0.0000E+00 100220  0.0000E+00 100230  0.0000E+00 110220  0.0000E+00
  1 110230  0.0000E+00 110240  0.0000E+00 110241  0.0000E+00 110250  0.0000E+00
  1 120240  0.0000E+00 120250  0.0000E+00 120260  0.0000E+00 120270  0.0000E+00
  1 120280  0.0000E+00 130270  0.0000E+00 130280  0.0000E+00 130290  0.0000E+00
  1 130300  0.0000E+00 140280  0.0000E+00 140290  0.0000E+00 140300  0.0000E+00
```

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Cycle 145A shho. 9502363 Doug Pack 4/12/10

→ Time step 63

→ Flux = 3.94622E-5

$$\frac{5.08129E-2}{3.94622E-5} = 1.2876E+3$$

```
-1
-1
-1
TIT   HAFNIUM SHROUD and B-10 GRAPHITE HKDERS JMOCUP CORE DEPLETION
BAS   HAFNIUM SHROUD and B-10 GRAPHITE HKDERS JMOCUP CORE DEPLETION
LIP   0 0 0
LPU    30070   50100  721740  721760  721770
      721780  721790  721800  731810  741820
      741830  741840                      -1
LIB   0 1 2 3   -204   205   206     9 50 0 4 0
OPTL  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
OPTA  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
OPTF  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
CUT   5 1.0E-24  28 1.0E-75   -1
INP   1  2      -1  -1   1   1
BUP
 IRF   1.34259E-01  3.24130E+14     1     2   4   2
 IRF   2.68519E-01  3.24130E+14     2     3   4   0
 IRF   4.02778E-01  3.24130E+14     3     4   4   0
 IRF   5.37037E-01  3.24130E+14     4     5   4   0
 IRF   6.71296E-01  3.24130E+14     5     6   4   0
 IRF   8.05556E-01  3.24130E+14     6     7   4   0
 IRF   9.39815E-01  3.24130E+14     7     8   4   0
 IRF   1.07407E+00  3.24130E+14     8     9   4   0
 IRF   1.20833E+00  3.24130E+14     9    10   4   0
PCH   10 10 10
OUT   10  1  0  0
BUP
                  102                 107        18
                                                 19 & 20
STP    4
204    30070 1.524E-02 0.000E+00 7.908E-03 0.000E+00 0.000E+00 0.000E+00   -1.0
204    50100 4.598E-02 0.000E+00 1.288E+03 2.480E-03 0.000E+00 0.000E+00   -1.0
204   721740 1.817E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00   -1.0
204   721760 2.418E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00   -1.0
204   721770 2.797E+02 0.000E+00 0.000E+00 0.000E+00 6.244E-01 0.000E+00   -1.0
204   721780 5.959E+01 0.000E+00 0.000E+00 0.000E+00 3.386E+01 0.000E+00   -1.0
204   721790 2.398E+01 0.000E+00 0.000E+00 0.000E+00 1.398E-01 0.000E+00   -1.0
204   721800 4.843E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00   -1.0
204   731810 2.516E+01 0.000E+00 0.000E+00 0.000E+00 9.392E-03 0.000E+00   -1.0
204   741820 2.312E+01 0.000E+00 0.000E+00 0.000E+00 4.569E-02 0.000E+00   -1.0
204   741830 1.147E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00   -1.0
204   741840 1.028E+00 0.000E+00 0.000E+00 0.000E+00 5.392E-04 0.000E+00   -1.0
  1    10010 9.6171E-12  10020 2.5191E-16  10030 5.5805E-24  10040 6.2711E-17
  1    20030 1.0657E-26  20040 4.9387E-06  20060 1.8006E-34  30060 1.5711E-28
  1    30070 1.7350E-02  30080 9.9089E-14  40080 2.3536E-19  40090 1.2745E-23
  1    40100 9.6175E-12  40110 5.4982E-24  50100 1.4637E-06  50110 1.7831E-10
  1    50120 8.8531E-25  60120 7.1949E-17  60130 1.0177E-23  60140 3.4507E-31
  1    60150 0.0000E+00  70130 0.0000E+00  70140 0.0000E+00  70150 0.0000E+00
  1    70160 0.0000E+00  80160 0.0000E+00  80170 0.0000E+00  80180 0.0000E+00
  1    80190 0.0000E+00  90190 0.0000E+00  90200 0.0000E+00 100200 0.0000E+00
  1   100210 0.0000E+00 100220 0.0000E+00 100230 0.0000E+00 110220 0.0000E+00
  1   110230 0.0000E+00 110240 0.0000E+00 110241 0.0000E+00 110250 0.0000E+00
  1   120240 0.0000E+00 120250 0.0000E+00 120260 0.0000E+00 120270 0.0000E+00
  1   120280 0.0000E+00 130270 0.0000E+00 130280 0.0000E+00 130290 0.0000E+00
  1   130300 0.0000E+00 140280 0.0000E+00 140290 0.0000E+00 140300 0.0000E+00
  1   140310 0.0000E+00 140320 0.0000E+00 150310 0.0000E+00 150320 0.0000E+00
  1   150330 0.0000E+00 150340 0.0000E+00 160320 0.0000E+00 160330 0.0000E+00
  1   160340 0.0000E+00 160350 0.0000E+00 160360 0.0000E+00 160370 0.0000E+00
```

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 | ECAR Rev. No.: 0 | Project File No.: 23843 | Date: 05/14/2010

Cycle 145A cell.608402 Doug Sterbentz 4/12/10

→ Time step 2

→ Flux = 4.46046 E-5

```
 -1
 -1
 -1
 TIT   ATR REACTOR JMOCUP CORE DEPLETION
 BAS   ATR REACTOR JMOCUP CORE DEPLETION
 LIP   0 0 0
 LPU    50100       -1
 LPU   922340  922350  922360  922370  922380
       932370  942390  942400  942410      -1
 LPU   360830  420950  441010  451030  451050
       481130  541310  541330  551330  541350
       571400  581410  591430  601430  601450
       611470  611490  621490  611510  621510
       621520  631530  63155   641570      -1
 LIB   0 1 2 3    -204 -205 -206    9 50 0 4 0
 OPTL  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
 OPTA  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
 OPTF  8 8 8 8 5   8 8 8 8 8   8 8 8 8 8   8 8 8 8 8   8 8 8 8
 CUT   5 1.0E-24  28 1.0E-75   -1
 INP   1  2       -1  -1   1   1
 BUP
  IRP   5.09259E-02  4.18602E-02      1      2   4   2
  IRP   1.01852E-01  4.18602E-02      2      3   4   0
  IRP   1.52778E-01  4.18602E-02      3      4   4   0
  IRP   2.03704E-01  4.18602E-02      4      5   4   0
  IRP   2.54630E-01  4.18602E-02      5      6   4   0
  IRP   3.05556E-01  4.18602E-02      6      7   4   0
  IRP   3.56482E-01  4.18602E-02      7      8   4   0
  IRP   4.07407E-01  4.18602E-02      8      9   4   0
  IRP   4.58333E-01  4.18602E-02      9     10   4   0
 PCH   10 10 10
 OUT   10  1  0  0
BUP
 STP    4
 204    50100 4.598E-02 0.000E+00 4.061E+02 2.480E-03 0.000E+00 0.000E+00    -1.0
 205   922340 2.682E+01 4.266E-04 1.349E-05 5.367E-01 0.000E+00 0.000E+00    -1.0
 205   922350 1.278E+01 2.696E-03 1.160E-06 5.970E+01 0.000E+00 0.000E+00    -1.0
 205   922360 9.076E+00 2.644E-03 2.207E-05 3.197E-01 0.000E+00 0.000E+00    -1.0
 205   922370 5.140E+01 0.000E+00 0.000E+00 6.602E-01 0.000E+00 0.000E+00    -1.0
 205   922380 7.508E+00 5.525E-03 4.597E-05 1.017E-01 0.000E+00 0.000E+00    -1.0
 205   932370 3.793E+01 2.746E-04 2.912E-06 5.275E-01 0.000E+00 7.877E-04    -1.0
 205   942390 6.242E+01 1.120E-03 8.560E-07 1.200E+02 0.000E+00 0.000E+00    -1.0
 205   942400 2.471E+02 4.478E-04 1.073E-05 5.953E-01 0.000E+00 0.000E+00    -1.0
 205   942410 4.954E+01 7.518E-03 2.421E-05 1.362E+02 0.000E+00 0.000E+00    -1.0
 206   360830 2.431E+01 2.054E-03 3.110E-06 7.961E-05 0.000E+00 0.000E+00     1.0
 206      4.73E-07 5.12E-05 3.65E-06 1.40E-07 9.47E-05 1.01E-06 9.90E-07 9.90E-07
 206   420950 4.659E+00 0.000E+00 1.134E-03 3.991E-05 0.000E+00 0.000E+00     1.0
 206      1.90E-11 1.46E-07 2.87E-09 1.17E-11 1.09E-07 1.07E-09 1.07E-09 1.07E-09
 206   441010 3.215E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00     1.0
 206      9.65E-11 2.21E-06 4.91E-08 1.13E-09 2.55E-06 3.84E-08 3.83E-08 3.83E-08
 206   451030 4.325E+01 2.237E-04 0.000E+00 0.000E+00 2.873E+00 0.000E+00     1.0
 206      0.0        7.35E-10 3.70E-07 3.66E-11 6.90E-08 5.60E-05 5.54E-05 5.54E-05
 206   451050 1.922E+03 0.000E+00 0.000E+00 0.000E+00 4.945E+02 0.000E+00     1.0
 206      4.09E-10 3.45E-07 5.20E-03 4.41E-06 6.55E-05 1.75E-06 1.78E-06 1.78E-06
 '06   481130 3.549E+03 1.471E-03 0.000E+00 2.065E-06 0.000E+00 0.000E+00     1.0
 206      2.89E-09 3.08E-07 1.67E-08 8.08E-10 1.51E-06 2.52E-07 3.16E-07 3.16E-07
 206   541310 3.612E+01 6.436E-03 1.639E-06 2.946E-06 0.000E+00 0.000E+00     1.0
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Handwritten annotations: "162", "107", "18 19:20" above the STP data columns; boxed calculation: $\frac{1.81132E-2}{4.46046E-5} = 4.0608E+2$

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Cycle 145A cell.608402 4/12/10

```
206      1.08E-08 4.29E-05 1.04E-06 3.12E-04 8.21E-06 6.65E-07 6.64E-07 6.64E-07
206   541330 2.781E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00    1.0
206      5.43E-05 1.53E-02 8.79E-04 3.32E-03 1.02E-02 1.06E-03 1.06E-03 1.06E-03
206   551330 1.312E+01 6.130E-03 1.103E-06 8.514E-05 1.082E+00 0.000E+00    1.0
206      7.46E-09 3.69E-05 4.46E-05 1.68E-05 1.52E-05 4.27E-07 4.26E-07 4.26E-07
206   541350 2.826E+05 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00    1.0
206      2.01E-02 5.38E-01 9.78E-02 7.85E-02 4.61E-01 9.46E-02 9.44E-02 9.44E-02
206   571400 2.259E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00    1.0
206      8.88E-05 2.27E-02 6.04E-03 2.56E-03 2.30E-02 5.86E-03 5.84E-03 5.84E-03
206   581410 3.420E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00    1.0
206      7.67E-07 1.00E-03 2.43E-05 3.05E-06 9.09E-05 2.41E-05 2.41E-05 2.41E-05
206   591430 1.377E+01 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00    1.0
206      3.99E-07 1.51E-04 2.95E-06 2.80E-07 9.17E-06 2.69E-06 2.69E-06 2.69E-06
206   601430 3.368E+01 8.888E-03 5.293E-05 2.651E-06 0.000E+00 0.000E+00    1.0
206      0.0         2.46E-08 2.83E-10 6.91E-12 4.84E-10 1.20E-10 1.20E-10 1.20E-10
206   601450 1.048E+01 1.165E-02 1.897E-05 8.002E-07 0.000E+00 0.000E+00    1.0
206      6.81E-09 3.27E-05 4.04E-07 2.95E-08 1.20E-06 1.92E-07 1.91E-07 1.91E-07
206   611470 7.532E+01 3.065E-03 6.188E-06 1.661E-06 3.212E+01 0.000E+00    1.0
206      7.78E-10 3.33E-06 2.73E-07 9.06E-05 2.10E-07 2.35E-08 2.35E-08 2.35E-08
206   611490 1.539E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00    1.0
206      8.07E-07 4.79E-04 3.12E-05 4.51E-06 1.06E-04 2.49E-05 2.48E-05 2.48E-05
206   621490 7.415E+03 4.597E-03 4.505E-05 4.505E-05 0.000E+00 0.000E+00    1.0
206      3.62E-11 2.98E-07 6.53E-09 4.18E-10 1.91E-08 3.48E-09 3.48E-09 3.48E-09
206   611510 1.190E+02 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00    1.0
206      6.69E-05 1.12E-02 1.77E-03 8.93E-04 7.00E-03 2.97E-03 2.97E-03 2.97E-03
206   621510 1.083E+03 1.563E-02 9.878E-06 8.855E-07 0.000E+00 0.000E+00    1.0
206      3.75E-08 8.39E-05 3.80E-06 3.22E-04 2.47E-05 6.19E-06 6.18E-06 6.18E-06
206   621520 9.905E+01 1.870E-03 5.569E-07 7.858E-08 0.000E+00 0.000E+00    1.0
206      5.69E-07 6.41E-04 4.65E-05 1.45E-05 3.29E-04 8.19E-05 8.17E-05 8.17E-05
206   631530 6.650E+01 1.808E-03 0.000E+00 0.000E+00 0.000E+00 0.000E+00    1.0
206      6.24E-10 6.26E-04 6.02E-05 3.85E-08 1.76E-06 3.01E-07 2.99E-07 2.99E-07
206   631550 4.291E+02 2.360E-03 4.021E-07 3.302E-07 0.000E+00 0.000E+00    1.0
206      5.90E-08 1.61E-04 1.25E-05 5.01E-06 2.38E-04 4.85E-05 4.92E-05 4.92E-05
206   641570 1.676E+04 0.000E+00 5.058E-05 0.000E+00 0.000E+00 0.000E+00    1.0
206      1.55E-09 1.76E-05 4.12E-06 2.55E-07 1.38E-05 4.17E-06 4.17E-06 4.17E-06
  1  10010  7.2288E-08  10020  6.2876E-15  10030  6.0201E-25  10040  3.1626E-21
  1  20030  9.4937E-30  20040  2.8076E-06  20060  0.0000E+00  30060  0.0000E+00
  1  30070  1.5457E-06  30080  1.0658E-18  40080  2.5315E-24  40090  3.0632E-28
  1  40100  9.4391E-12  40110  3.0548E-24  50100  5.3526E-04  50110  1.7500E-10
  1  50120  4.9186E-25  60120  3.3262E-19  60130  2.4458E-28  60140  0.0000E+00
  1  60150  0.0000E+00  70130  0.0000E+00  70140  0.0000E+00  70150  0.0000E+00
  1  70160  0.0000E+00  80160  0.0000E+00  80170  0.0000E+00  80180  0.0000E+00
  1  80190  0.0000E+00  90190  0.0000E+00  90200  0.0000E+00 100200  0.0000E+00
  1 100210  0.0000E+00 100220  0.0000E+00 100230  0.0000E+00 110220  0.0000E+00
  1 110230  0.0000E+00 110240  0.0000E+00 110241  0.0000E+00 110250  0.0000E+00
  1 120240  0.0000E+00 120250  0.0000E+00 120260  0.0000E+00 120270  0.0000E+00
  1 120280  0.0000E+00 130270  0.0000E+00 130280  0.0000E+00 130290  0.0000E+00
  1 130300  0.0000E+00 140280  0.0000E+00 140290  0.0000E+00 140300  0.0000E+00
  1 140310  0.0000E+00 140320  0.0000E+00 150310  0.0000E+00 150320  0.0000E+00
  1 150330  0.0000E+00 150340  0.0000E+00 160320  0.0000E+00 160330  0.0000E+00
  1 160340  0.0000E+00 160350  0.0000E+00 160360  0.0000E+00 160370  0.0000E+00
  1 170350  0.0000E+00 170360  0.0000E+00 170370  0.0000E+00 170380  0.0000E+00
  1 170381  0.0000E+00 180360  0.0000E+00 180370  0.0000E+00 180380  0.0000E+00
  1 180390  0.0000E+00 180400  0.0000E+00 180410  0.0000E+00 180420  0.0000E+00
  1 190390  0.0000E+00 190400  0.0000E+00 190410  0.0000E+00 190420  0.0000E+00
  1 190430  0.0000E+00 190440  0.0000E+00 200400  0.0000E+00 200410  0.0000E+00
  1 200420  0.0000E+00 200430  0.0000E+00 200440  0.0000E+00 200450  0.0000E+00
```

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Robert L Sant/ZAP/CC01/INEEL/US
04/08/2010 01:23 PM

To James W Sterbentz/BNZ/CC01/INEEL/US@INEL
cc
bcc
Subject Re: Verification Tasks for JMOCUP Verification

Jim,

I completed the MCNP number density check that you requested. In all cases, my calculations agreed with the values in the input file (in four cases, our numbers disagreed in the last [sixth] decimal place, but I attribute this to rounding).

James W Sterbentz/BNZ/CC01/INEEL/US

James W Sterbentz/BNZ/CC01/INEEL/US
04/07/2010 04:13 PM

To Robert L Sant/ZAP/CC01/INEEL/US@INEL
cc
Subject Verification Tasks for JMOCUP Verification

Robert,

Attached is the scope of work we discussed for the verification of the JMOCUP depletion calculation.
Please use charge number: 100599472

Thanks, Jim Sterbentz

Performer: R. Sant
Date: April 7, 2010

Title: JMOCUP Depletion calculation verification

Goal: Check the number densities in the MCNP input files—specifically the number densities in the material cards.

	Cell No.	Material Card No.	Total no. of cells	
ATR Elements:	60001	m2001	840	U-235
	60002	m2002		U-238
	:	:		
	60840	m2840		
Compacts:	90101	m9501	144	U-235
	90102	m9502		U-238

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

	: 93604	: m9644		
Hf Shroud:	9026 9027 : 9049	m9645 m9646 : m9668	24	Hf-177 Hf-178
Borated Graphite Holder:	95001 95002 : 95023	m9669 m9670 : m9691	23	B-10

Calculation: N = MA/V
N= no density (a/b/cm)
M= no. of moles (ORIGEN punch files)
A= 0.60221 (atoms/mole)
V= MCNP cell volume (cm^3)
ATR driver fuel cells (**atrfuelvol**)
TRISO compacts (**compactvol**)
Hf shroud (**hafniumshroud**)
Borated graphite holder (**b10grapvol**)

Cycle 138B

MCNP Input file: **inp.2** (2 stands for timestep no. 2)

ORIGEN2.2 Punch files:

atr driver fuel:	cell.600011.pch cell.600021.pch cell.608401.pch	(bolded no. is the timestep)
TRISO compact:	comp.901011.pch comp.901021.pch comp.936041.pch	
Hafnium shroud:	shho.90261.pch shho.90271.pch	
Borated graph holder:	shho.950011.pch shho.950021.pch	

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Robert L Sant/ZAP/CC01/INEEL/US
04/22/2010 03:13 PM

To James W Sterbentz/BNZ/CC01/INEEL/US@INEL
cc
bcc
Subject Re: AGR-1 JMOCUP Verification - Cycle 145A

I checked the calculations as requested and found the calculations to be correct. There were a few instances where the number in the sixth decimal place differed by one digit, but I attribute this to rounding errors.

James W Sterbentz/BNZ/CC01/INEEL/US

James W Sterbentz/BNZ/CC01/INEEL/US
04/22/2010 12:44 PM

To Robert L Sant/ZAP/CC01/INEEL/US@INEL
cc James W Sterbentz/BNZ/CC01/INEEL/US@INEL
Subject AGR-1 JMOCUP Verification - Cycle 145A

James W Sterbentz/BNZ/CC01/INEEL/US

Robert,

Attached is the scope of work we discussed for the verification of the JMOCUP depletion calculation.
Please use charge number: 100599472

Thanks, Jim Sterbentz

Performer: R. Sant
Date: April 22, 2010

Title: JMOCUP Depletion calculation verification

Goal: Check the number densities in the MCNP input files—specifically the number densities in the material cards.

	Cell No.	Material Card No.	Total no. of cells	
ATR Elements:	60001 60002 : 60840	m2001 m2002 : m2840	840	U-235 U-238
Compacts:	90101	m9501	144	U-235

	90102 : 93604	m9502 : m9644		U-238
Hf Shroud:	9026 9027 : 9049	m9645 m9646 : m9668	24	Hf-177 Hf-178
Borated Graphite Holder:	95001 95002 : 95023	m9669 m9670 : m9691	23	B-10

Calculation: N = MA/V

N= no density (a/b/cm)
M= no. of moles (ORIGEN punch files)
A= 0.60221 (atoms/mole)
V= MCNP cell volume (cm^3)
- ATR driver fuel cells (**atrfuelvol**)
- TRISO compacts (**compactvol**)
- Hf shroud (**hafniumshroud**)
- Borated graphite holder (**b10grapvol**)

Cycle 145A

MCNP Input file: **inp.33** (33 stands for timestep no. 33)

ORIGEN2.2 Punch files:

atr driver fuel:	cell.60001**32**.pch cell.60002**32**.pch cell.60840**32**.pch	(bolded no. is the timestep)
TRISO compact:	comp.90101**32**.pch comp.90102**32**.pch comp.93604**32**.pch	
Hafnium shroud:	shho.9026**32**.pch shho.9027**32**.pch shho.9049**32**.pch	
Borated graph holder:	shho.95001**32**.pch shho.95002**32**.pch shho.95023**32**.pch	

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Robert L Sant/ZAP/CC01/INEEL/US
09/07/2011 10:50 AM

To James W Sterbentz/BNZ/CC01/INEEL/US@INEL
cc
bcc
Subject JMOCUP Verification and MCNP Model Modification Verification

Jim,

This email is specifically to document my technical review, which was performed in July 2011. I did not document those checks in an email to you at that time. Therefore, I am sending you this email to document my review. In addition, you have loose leaf worksheets showing the detailed technical checking of the JMOCUP verification.

My technical review was performed on 7/14/2011 and 7/25/2011, and consisted specifically of the following items. All items were found to be correct.

(1) JMOCUP verification and validation technical check. Random check of MCNP output, one-group cross section calculation, cell power, BOL isotopics, decay time , incorporation of the cross sections into the ORIGEN input files.

(2) Capsule 6 material number (m9672) boron-10 number density change.

(3) Addition of fission products to the MCNP compact material cards (m9501--m9644) to all 144 material card sets (71 fission products total). Plus one additional actinide to the list (Am-242m).

(4) Decay times between power cycles was implemented.

(5) Modification of the northeast lobe experiment to obtain better lobe power splits (Schnitzler created the northeast lobe experiment MCNP cards, which were spliced into the new MCNP ATR core model (inp.1.138B) and used throughout the second or re-run depletion calculation for AGR-1).

(6) KCODE card modification

Robert

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

JMOCUP | V & V ✓ R. Sant 7/14/2011

V&V

✓ (1) New neutron cross section generated (endf7? new plots vs old plots)

✓ R. Sant 7/14 (2) modified JMOCUP modules b8comp.f (V&V)
c8comp.f (V&V)

✓ R. Sant 7/14 X (3) Capsule 6 m9672 B-10 conc change

✓ R. Sant 7/14 X (4) Added addition fission products to MCNP material cards, m9501 — m96... (144 mat'l cards)

✓ R. Sant 7/14 X (4a) Added Am-242m to MCNP material cards

✓ R. Sant 7/14 X (5) Decay time between power cycles was implemented previously the calc. was based on assumption that decay time was negligible and a request for I^{135} (undecayed) at EOC was important.

✓ 138B comp.9360448 (no DEC), comp.9360449 (15d decay)
✓ 139AA ✓140AA ✓141AA ✓142BB ✓143BB ✓144BB
✓ 139BB ✓140BB ✓142AA ✓143AA ✓144AA ✓145AA

X R. Sant 7/25 ✓ X (6) modified NE lobe experiment to obtain better lobe power splits (Schmitzler created the NE lobe experiment model) — we spliced into into inp.1. 138B and used it throughout JMOCUP 2nd calc.

✓ R. Sant 7/25 X (7) Kcode change as well

TOPS 35500

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

✓ R. Sant Check 7/14/2011

Cycle 142BB (XS)

Compact Cell: 91301 | TS | outfile | Flux | tally 204
m9549 | 57 | outp.57 | 2.26319-5

		Reaction Rate (102)	(18 or 19:20)	214 XS
m840	Kr-83	1.04788-3	–	46.301 ✓
m841	Kr-84	2.35150-6	–	0.1639 ✓
⋮	⋮			
m846	Y-91	9.10275-6	–	0.4022 ✓
⋮	⋮			
m872	Te-128	2.48068-6	–	6.10961 ✓
m879	Xe-135	1.48855+1	–	657,722 ✓
⋮	⋮			
m907	Eu-155	3.00786-2	–	1,329 ✓
m914	U-235	5.34272-4	2.79074-3	23.667 / 123.31 ✓
m926	Am-242m	7.21154-3	3.73462-2	318.64 / 1,650.2 ✓
m929	Cm-244	2.60374-4	1.44438-5	11.505 / 0.6382 ✓

/142BB-depletion/fcompin/comp.9130157

Cell Power 1.20998-4 MW vs /fcheck/b8comp2.check.57
1.20998-4 MW ✓

BOL Isotopics /142BB-depletion/fcompin/comp.9130157

		a/b·cm
U235	2.3269-4 moles →	9.2258-5 ✓
U238	1.5257-3 moles →	6.0491-4 ✓
Te-128	6.5253-7 moles →	2.5872-7 ✓

↑ inp.57

DEC 24 days ✓

TOPS 35500

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

✓R. Sant Check
7/14/2011

Cycle 144B

	(XS)	TS	outfile	Flux	tally
Comp. Cell	92204	19	outp.19	4.10478-5 = φ	204
	88-14 m9588				

		Reaction Rate (102)	(18)	214 (XS)
m840	Kr-83	2.33385-3	–	56.957 ✓
m841	Kr-84	4.48404-6	–	0.10924 ✓
m846	Y-91	1.96051-5	–	0.47762 ✓
m872	Te-128	4.10085-6	–	0.099904 ✓
m879	Xe-135	3.44741+1	–	839,852.56 ✓
m907	Eu-155	6.63226-2	–	1,615.7 ✓
m914	U-235	1.19665-3	6.41294-3	29.153 ✓/156.23 ✓
m926	Am-242m	1.64854-2	8.53401-2	401.61 ✓/2,079 ✓
m929	Cm-244	4.92653-4	2.51051-5	12.002 ✓/0.6116 ✓

/144BB-depletion/fcompin/comp.9220419 ↑ check

Cell Power: 1.12686-4 MW vs. /fcheck/b8comp2.check.19
1.12686-4 MW ✓

BOL Isotopics

/144BB-depletion/fcompin/comp.9220419

			a/b·cm
Kr-83	1.1525-6	moles →	4.5695-7 ✓
Y-91	1.5312-6	moles →	6.0709-7 ✓
Xe-135	1.3943-9	moles →	5.5282-10 ✓
Eu-155	7.9155-8	moles →	3.1384-8 ✓
U-235	7.4498-5	moles →	2.9537-5 ✓
Am-242m	4.6145-10	moles →	1.8296-10 ✓
Cm-244	5.0623-8	moles →	2.0071-8 ✓

↑ inp.19 m9588 ↗ check

TOPS 35500

Title: JMOCUP As-Run Daily Depletion Calculation for the AGR-1 Experiment in ATR B-10 Position

ECAR No.: 958 ECAR Rev. No.: 0 Project File No.: 23843 Date: 05/14/2010

Compact Isotopes | XS Check

✓R. Sant 7/14/2011 check

Cycle 138B

(XS)

Compact Cell : 90101 TS 1 outfile outp.1 Flux $\phi = 1.7309-5$ tally 204

			Reaction Rate (102)	Reaction Rate (18) or (19:20)	214 XS
	m840	Kr-83	4.04498-4	—	23.369 ✓
new	(m841)	Kr-84	1.87209-6	—	0.10815 ✓
new	(m846)	Y-91	4.01089-6	—	0.23172 ✓
new	(m872)	Te-128	1.30871-6	—	7.5607-2 ✓
	m879	Xe-135	4.85247	—	280,337.27 ✓
new	(m907)	Eu-155	1.40757-2	—	813.18 ✓
	m914	U-235	2.19991-4	1.00733-3	12.709 ✓ / 58.196 ✓
new	(m926)	Am-242m	2.50038-3	1.30133-2	144.45 ✓ / 751.81 ✓
	m929	Cm-244	2.04754-4	1.13985-5	11.829 / 0.6585 ✓

138B-depletion/fcompin/comp.901011 ✓

(Cell Power) ✓4.57977-6 MW vs /fcheck/b8comp2.check.1
✓4.57977-6 MW

(BOL Isotopics)

/138B-depletion/fcompin/comp.90101 a/b/cm

U235 3.88869-4 moles → 1.5418-4 ✓
U238 1.56150-3 moles → 6.1911-4 ✓

inp.1 m9501

$$\text{moles} \cdot 0.60221 \frac{a}{\text{moles}} \cdot \frac{1}{V(cm^3)} = a/b \cdot cm$$

$V = 1.51888\ cm^3$

TOPS 35500