INL/EXT-21-64305

Quantity of ^{135}I Released from the AGR-5/6/7 Experiment

September 2021

D. M. Scates
J. W. Sterbentz
E. L. Reber
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Idaho National Laboratory

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Idaho National Laboratory
Advanced Reactor Technologies
Idaho Falls, Idaho 83415

http://www.art.inl.gov

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INL ART Program

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Mitchell Plummer	9/3/2021
Mitchell A. Plummer ART Data Streams Technical Lead	Date
M. Davenport	9/9/2021
Michael Davenport ART Irradiation Project Manager	Date
Paul Demkowicz	9/9/2021
Paul Demkowicz AGR Program Technical Director	Date
Michelle Sharp	9/3/2021
Michelle T. Sharp INL Quality Assurance	Date

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Abstract

A series of four Advanced Reactor Technologies experiments have been conducted in the Advanced Test Reactor at Idaho National Laboratory. From 2006 through 2020, these experiments supported the development and qualification of the new U.S. tristructural isotropic (TRISO) particle fuel for Very High Temperature Reactors. Each Advanced Gas Reactor experiment consisted of multiple fueled capsules, each plumbed for independent temperature control using a mix of helium and neon gases. The gas leaving a capsule was routed to individual Fission Product Monitor (FPM) detectors. For intact fuel particles, the TRISO particle coatings provide a substantial barrier to fission product release. However, particles with failed coatings, whether because of a minute percentage of initially defective particles, those that fail during irradiation, or those designed-to-fail particles, can release fission products to the flowing gas stream. Because reactive fission product elements like iodine and cesium quickly deposit on cooler capsule components and piping structures as the effluent gas leaves the reactor core, only the noble fission gas isotopes of Kr and Xe tend to reach FPM detectors. The FPM system utilizes High Purity Germanium (HPGe) detectors coupled with a thallium-activated sodium iodide NaI(Tl) scintillator. The HPGe detector provides individual isotopic information, while the NaI(Tl) scintillator is used as a gross count rate meter. During irradiation, the ^{135m}Xe concentration reaching the FPM detectors is from both direct fission and by decay of the accumulated ^{135}I. About 2.5 hours after irradiation (ten 15.3 minute ^{135m}Xe half-lives) the directly produced ^{135m}Xe has decayed and only the longer lived ^{135}I remains as a source. Decay systematics dictate that ^{135m}Xe will be in secular equilibrium with its ^{135}I parent, such that its production rate very nearly equals the decay rate of the parent, and its concentration in the flowing gas stream will appear to decay with the parent half-life. This equilibrium condition enables the determination of the amount of ^{135}I released from the fuel particles by measurement of the ^{135m}Xe at the FPM following reactor shutdown. In this paper, the ^{135}I released will be reported.

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ACRONYMS

AGR	Advanced Gas Reactor
ART	Advanced Reactor Technologies
ATR	Advanced Test Reactor
EOC	end of cycle
FPM	Fission Product Monitor
FPMS	Fission Product Monitor System
HPGe	High Purity Germanium
INL	Idaho National Laboratory
JMOCUP	Jim Sterbentz's MCNP ORIGEN Coupled Utility Program
MCNP	Monte Carlo N-Particle
NDMAS	Nuclear Data Management and Analysis System
ORIGEN	Oak Ridge Isotope Generation
TRISO	tristructural isotropic

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Quantity of ^{135}I Released from the AGR-5/6/7 Experiment

1. INTRODUCTION

Advanced Gas Reactor (AGR)-5/6/7 was the final experiment of the Advanced Reactor Technologies (ART) series of in-core, tristructural isotropic (TRISO)-coated fuel experiments irradiated within the Advanced Test Reactor (ATR), located at Idaho National Laboratory (INL). Each one of these three experiments had multi-year irradiations and will provide researchers with decades worth of information to analyze.

Each capsule of every Advanced Gas Reactor (AGR) experiment test train was plumbed for temperature control with an independent mix of helium and neon gas. The effluent gas leaving an experiment capsule was routed to individual Fission Product Monitor (FPM) detectors, where capsule-specific isotopic information was collected and analyzed. For intact fuel particles, the TRISO particle coatings provide a substantial barrier to fission product release. However, particles with failed coatings, including failures that occurred during irradiation and defects that occurred during fabrication, can release fission products to the flowing effluent gas stream. Because reactive fission product elements like iodine and cesium readily are deposited onto the relatively cooler capsule components and piping surfaces, only the noble fission gas isotopes of krypton and xenon tend to reach FPM detectors.

This paper examines the ^{135}I released in the AGR-5/6/7 experiment and discusses how ^{135}I concentrations are determined from measured ^{135m}Xe concentrations. Once the ^{135}I is determined, it is then compared to the end-of-cycle (EOC)-computed ^{135}I inventories. These comparisons provide a measure of fuel integrity.

2. BACKGROUND

Iodine-135 is a radioactive fission product that decays by beta particle emission with a 6.57-hour half-life. It decays to excited states of ^{135}Xe. Among the populated states of ^{135}Xe, the isomeric state of ^{135m}Xe decays to the ^{135}Xe ground state with a half-life of 15.3 minutes with an emission of a 526.6-keV photon.

The 15.3 minute isomeric state is populated through a 15.5% branch of ^{135}I and is amenable to determination by gamma-ray spectroscopy using the 526.6-keV gamma line. This decay scheme is depicted in simplified form in Figure 1 [1].

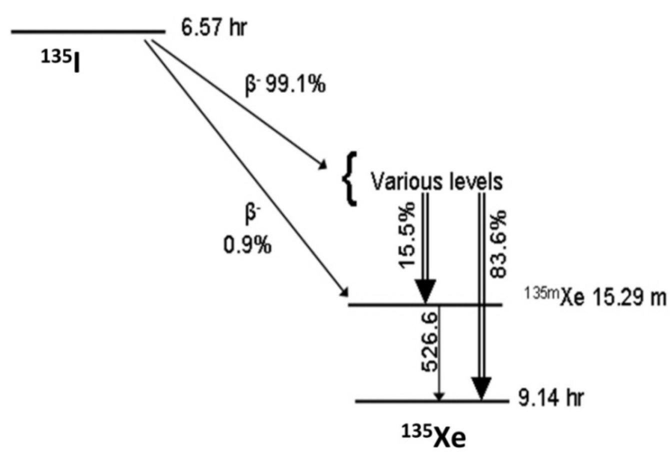

Figure 1. Simplified decay scheme of ^{135}I.

During irradiation, ^{135}Xe and ^{135m}Xe concentrations at the FPM system result both from direct fission yield and from the decay of ^{135}I. When irradiation stops, the only source of ^{135m}Xe is the decay of ^{135}I accumulated during irradiation. The ^{135m}Xe production rate will equal the decay rate of the ^{135}I parent. After several ^{135m}Xe half-lives, it will be in secular equilibrium with its ^{135}I parent. This enables the determination of the amount of ^{135}I released from the fuel particles and deposited in upstream structures from quantification of the ^{135m}Xe concentrations in the flowing gas stream following reactor shutdown [2,12].

3. TECHNIQUES AND METHODS

3.1 Equipment and Measurements

The FPM system (FPMS) is a collection of FPM detectors, one for each experiment capsule, plus at least one spare. The first experiments, AGR-1 and AGR-2 consisted of six capsules per experiment, with an individual FPM for each capsule with one spare for a total of seven FPM stations. AGR-3/4 consisted of 12 capsules with an individual FPM for each capsule with two spares for a total of 14 FPM stations and AGR-5/6/7 consisted of five instrumented capsules in the experiment, with an individual FPM for each capsule and two on-line spares (Figure 2). Each FPM consisted of a NaI(Tl) scintillation detector for gross radiation count rate information and a High Purity Germanium (HPGe) gamma-ray spectrometer to measure fission product decay activities as the effluent gas flowed through a baffled, 58-ml-sample chamber located within the lead shielding of the FPMS. Combined with effluent flow rates and transport volumes for the respective capsules, these activities can be related back to release rates at the respective capsule for the observed fission product isotopes. In this paper we discuss ratios of these indirectly measured release rates to modeled release rates or similarly of measured -to modeled -capsule inventories. The NaI detector is used to monitor the gross gamma counting rate of the effluent gas flowing through the lines before it reaches the sample chamber. Data from the HPGe and NaI detectors are collected by a Multi-Channel Analyzer (provided by the DSPEC-502) and Multi-Channel Scalar (provided by the MultiPort II), respectively. The accumulated data is transmitted to the host computer under the control of the FPMS software. The FPMS control program monitors the operation of each of the seven FPM stations continually. The usual measurement protocol acquires gamma-ray spectra with counting times of eight hours. This gives adequate measurement sensitivity and provides three sets of results each day that are used to compute daily capsule release activity values [3,4,5].

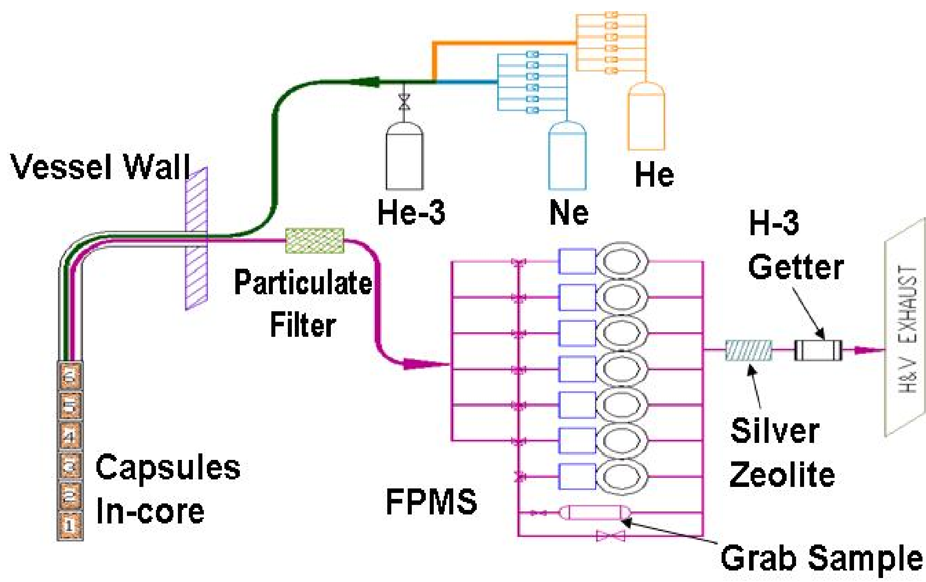

Figure 2. Simplified gas flow path for the AGR-1, AGR-2, and AGR-5/6/7 experiments. Note that AGR-5/6/7 only had five capsules not six.

Transport times from each capsule to its respective FPM are estimated using capsule-specific effluent flow rates and transport volumes, the volumes through which the effluent flows between the capsule and the FPM. These were determined early in each AGR experiment from data acquired in a series of neon-injection test measurements [14]. Capsule specific outlet flow meters are located upstream of the fission product monitors and measure the flow of effluent as it leaves the specified capsule. Later in the experiment series a set of flow meters was added on the outlet line of the FPM to be used as verification of outlet flow through the capsule and through the FPM. Capsule- and experiment- specific outlet flow rates are continuously recorded by the ATR distributive control system (DCS) and are stored in the Nuclear Data Management and Analysis System (NDMAS) database. The capsule specific outlet flow values and transport volumes are used to compute the releases and hence the release ratios discussed in this paper.

At the end of each ATR irradiation cycle, the FPMS was kept running for a minimum of 48 hours, long enough to observe ^{135m}Xe generated from the decay of the accumulated ^{135}I inventory. Eight-hour (real-time) spectra were recorded and analyzed for this time duration following reactor shutdown. By 2.5 hours following reactor shutdown, (ten ^{135m}Xe half-lives), any measurable ^{135m}Xe produced by fission has decayed away. Any ^{135m}Xe detected in the spectra acquired after that is clearly from decay of ^{135}I. ^{135m}Xe continued to be detected 40 hours following reactor shutdown and, in some instances, longer, as shown in Figure 3.

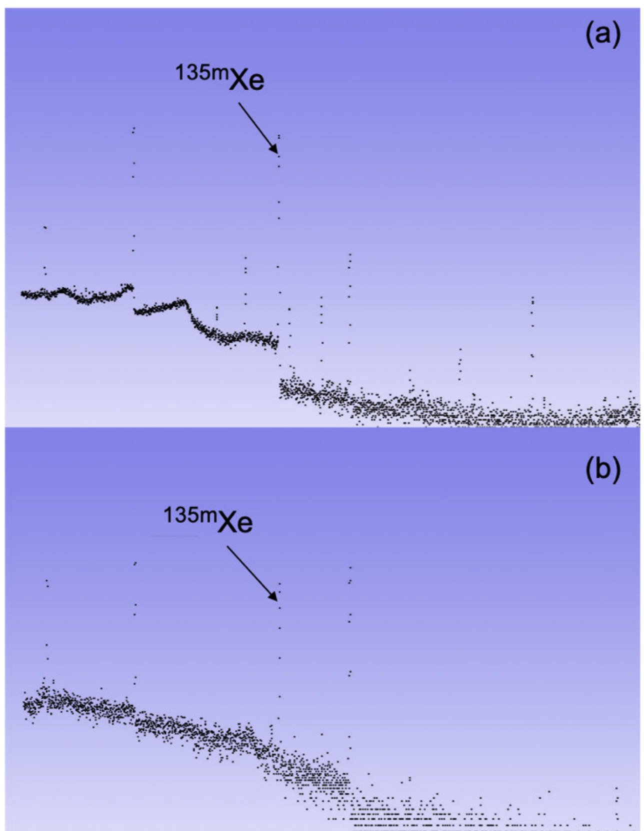

Figure 3. ^{135m}Xe clearly visible at the fission gas monitor chamber for AGR-5/6/7, Capsule 1, (a) 8 hours and (b) 42 hours after reactor shutdown.

3.2 Calculations and Corrections

Computing end-of-cycle ^{135}I from the measured ^{135m}Xe activities requires correction for decay of both species, of ^{135}I following shutdown and of ^{135m}Xe as it was transported by the gas from its source near the test capsule, the presumed point of equilibrium with its ^{135}I parent. Figure 4 is provided to facilitate the following discussion [2,11].

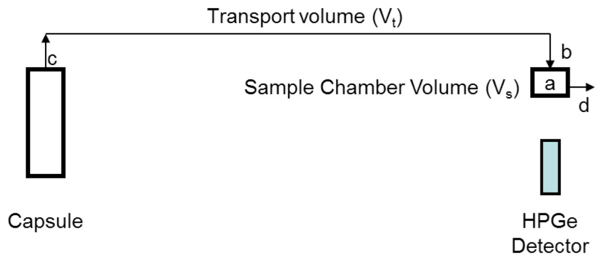

Figure 4. Single capsule flow diagram.

Released ^{135}I is presumed to be firmly deposited near the capsule and does not move downstream. Daughter ^{135m}Xe is in secular equilibrium with its ^{135}I parent at the exit of the fuel capsule (c). The sweep gas, flowing at a rate given by the capsule outlet flow meter, carries the ^{135m}Xe through the transport line volume (V_t) to the entrance of the sample counting chamber (b), then through the sample volume (V_s) filling the baffled sample chamber (a), and then flowing out of the sample chamber at (d). As the sweep gas flows continuously, the FPM detector acquires repeated 8-hour spectra without interruption until manually stopped. Immediately after reactor shutdown, helium gas flows through the AGR test train capsules, carrying capsule specific effluent to the respective FPM for up to 72 hours or as directed by research staff [2,11].

3.3 Secular Equilibrium

It is important to understand the effect of the secular equilibrium relationship between ^{135}I and its ^{135m}Xe daughter to formulate the required corrections properly. Collocated the ^{135m}Xe (half-life equal to 15.3 minutes) is assumed to be (after 2.5 hours following reactor shutdown) in secular equilibrium with its ^{135}I (half-life equal to 6.6 hours) parent in the capsule. Secular equilibrium is established such that the ^{135m}Xe and ^{135}I activities are nearly equal, and the ^{135m}Xe activity decays with an apparent half-life equal to that of its long-lived ^{135}I parent. However, if the two were separated, as would be the case if one took a grab sample of the noble gases, then the ^{135m}Xe decays with its own 15.3 minute half-life. In the case of online measurements, the situation is somewhat different since the activity at any downstream point is renewed by fresh releases from the upstream equilibrium parent. In practice this means that at a downstream point, Position b in Figure 4, the measured ^{135m}Xe activity changes in time according to the 6.6-hour ^{135}I half-life, but the absolute activity of ^{135m}Xe at any downstream point will be a function of the transport time from the capsule and a decay constant dominated by the 15.3 minute ^{135m}Xe half-life. In other words, picking two positions along the downstream sample line separated in transport time by 15.3 minutes, the ^{135m}Xe concentrations at both points will vary in time with the ^{135}I parent half-life of 6.6 hours; however, at any given moment the ^{135m}Xe concentration at the second point would be very close to half of the concentration measured at the first point [2,11].

3.4 Extrapolation and Corrections

The corrections [2,11] that need to be applied to the measured ^{135m}Xe data to correct its measured activities at the detector to concentrations at the capsule exit can be specified as:

$$C_{Cap}(t_r) = \frac{A(t_r)}{V_s} * f_1 * f_2 * f_3 \qquad (1)$$

where:

$C_{cap}(t_r)$ = the desired ^{135m}Xe concentration (Bq/cm^3) at the capsule exit at a time t_r after reactor shutdown.

$A(t_r)$ = the activity (Bq) of ^{135m}Xe calculated from a spectrum that started at time t_r after reactor shutdown.

V_s = the sample volume viewed by the spectrometer.

f_1 = Factor to correct the activity reported by the spectral analysis code to the start of the spectral acquisition.

f_2 = Factor to correct for decay of the ^{135m}Xe during transport through volume V_t between the capsule outlet and the sample chamber inlet.

f_3 = Factor to correct for decay during hold-up in the sample chamber volume V_s.

3.4.1 Correction for Activity *(f_1)*

The reported activity is the average activity over the specified counting interval. If the half-life of the species under study is not long relative to the duration of the spectral acquisition, then a correction must be applied for this decay. The correction factor *(f_1)* is computed as:

$$f_1 = \frac{\lambda_I * RT}{(1 - e^{-\lambda_I * RT})} \tag{2}$$

where:

λ_I = the ^{135}I decay constant of $2.931 \times 10^{-5}\ s^{-1}$

RT = the spectral acquisition time (real time) in seconds.

Note that since the activity at the detector varies with the ^{135}I half-life, the ^{135}I decay constant is appropriate for this correction. The spectral acquisition times (RT) for all AGR experiments were 8 hours or 2.88×10^4 s, thus f_1 equals 1.481 and any uncertainties are negligible [2,11].

3.4.2 Correction for Decay during Transport *(f_2)*

As the ^{135m}Xe is swept from the capsule and transported to the sample chamber inlet it appears to decay with a decay constant equal to the difference between the ^{135m}Xe decay constant and the ^{135}I decay constant. This accounts for the decay of the source when the daughter was swept from it. The transport time is determined by the capsule outlet flow rate and the transport volume (V_t). Capsule and experiment specific outlet flow rates are continuously recorded by the ATR distributive control system and then are transferred to the Nuclear Data Management and Analysis System (NDMAS) database.

The correction factor f_2 can be computed as:

$$f_2 = e^{\frac{(\lambda_{Xe} - \lambda_I) * V_t}{Q}} \tag{3}$$

where:

λ_{Xe} = ^{135m}Xe decay constant

λ_I = ^{135}I decay constant

V_t = capsule-specific transport volume (cm^3)

Q = average capsule outlet flow rate during the spectral measurement.

The relative variance of f_2 can be estimated by normal error propagation techniques [2,11].

The decay correction procedure outlined above presumes that the ^{135}I producing the ^{135m}Xe is located in the capsule or its immediate surroundings. While this is a convenient assumption, due to the volatility of certain iodine species (for example I_2), deposition might occur well downstream from the capsule. Scoping calculations [6] imply that the drop in temperature when the effluent line leaves the reactor vessel and the relatively warm (50°C to 70°C) primary coolant will cause deposition of the elemental iodine still being carried in the effluent stream. At a nominal flow rate of 0.5 cm^3/s this location is about 8 to 12 seconds downstream of the average capsule. For the 15.3 minute ^{135m}Xe half-life, an 8 to 12 second difference in decay time alters the concentration by less than 1%. Thus, if all the previously released ^{135}I were deposited at the reactor vessel exit, some 8 to 12 seconds closer to the spectrometers than was assumed, then the f_2 correction factor would have less than a 1% bias [2,11]. Because of the somewhat speculative nature of this uncertainty, it has not been propagated to the tabular results in this paper.

3.4.3 Correction for Holdup in the Sample Chamber *(f_3)*

The sample chamber (a) in Figure 2, viewed by the detector, has a volume V_s. If either V_s is very small, or the half-life of the radioisotope of interest is very long, then the mean concentration measured by the detector is nearly identical to that entering the chamber at Point b in Figure 2. However, if the sample volume is large and/or the species half-life is short, then the mean concentration measured by the detector will be lower than that entering due to decay of the species in the sample chamber [2,11].

The correction factor f_3 that corrects for this effect can be formulated as:

$$f_3 = \frac{(\lambda_{Xe} - \lambda_I) * V_s}{Q * \left(1 - e^{\frac{-(\lambda_{Xe} - \lambda_I) * V_S}{Q}} \right)} \tag{4}$$

For the measurements performed here, $V_S = 58 \pm 2$ cm^3. As with the previous correction, the effective decay constant is the difference at which the measured ^{135m}Xe appears to be decaying.

3.4.4 Calculation of the Daughter ^{135m}Xe Concentrations at the Capsule Release Point

Having computed the needed correction factors, the daughter ^{135m}Xe concentrations at the capsules can be calculated using Equation [1].

Since all the operands in this equation are multiplicative, and assuming the parameters are non-correlated (a reasonable assumption), the relative uncertainty in the value can be computed by quadrature propagation of the individual relative uncertainties.

Thus, the ^{135m}Xe activity was determined for each spectrum that started at least 2.5 hours after reactor shutdown. Activities at the capsule source at the respective start of acquisition times were calculated for each spectrum using Equation [1]. These values are examined to verify they follow the expected ^{135}I decay as a function of time following reactor shutdown. Each value is decay corrected to reactor shutdown, providing several values for each capsule at the end of each irradiation cycle. An uncertainty is also calculated for each value using normal error propagation methods and estimates of uncertainties in the transport volumes, the spectrum activities, and the flow rates. Because the activities decay with time after shutdown, the uncertainties grow for later and later spectra. Thus, activity at shutdown is computed as the weighted average with each value weighted by the inverse square of its uncertainty. This automatically devalues less-accurate data and is equivalent to the more laborious initial determination [2,11].

To expedite the delivery of the iodine data to the project at the end of each AGR irradiation cycle these calculations were incorporated into a semi-automatic processing code called Analyze_I135 (Figure 5). This code reads in the isotopic information files and the capsule specific flow information from the NDMAS database to compute the extrapolated ^{135}I values. A sample Analyze_I135 output file can be found in Appendix A and summarized release fractions per experiment can be found in Appendix C.

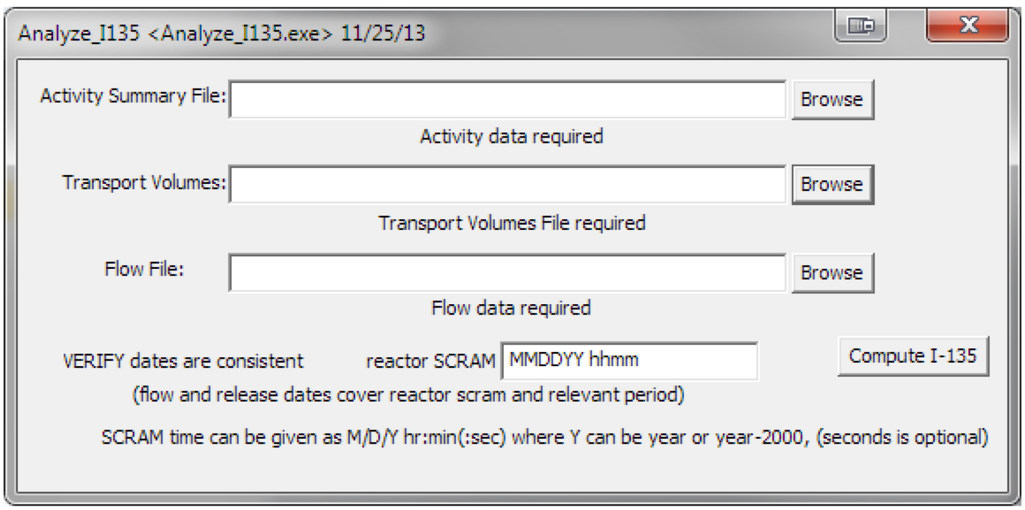

Figure 5. Screen capture of Analyze_I135, a semi-automatic, post-irradiation cycle data processing software.

4. END-OF-CYCLE ^{135}I CALCULATIONAL METHODOLOGY

The physics methodology used to model the TRISO particle fuel depletion for the AGR experiment series is a Monte Carlo depletion methodology. The specific method employs the INL JMOCUP (Jim Sterbentz's MCNP-ORIGEN Coupled Utility Program) [7, 8,13] utility code that links the standard and well-known Monte Carlo N-Particle (MCNP)5 [9] and ORIGEN2.2 (Oak Ridge Isotope Generation) [10,11]] computer codes. The MCNP5 code performs the neutron and gamma transport calculation and the ORIGEN2.2 code solves the coupled time-dependent ordinary differential equations governing the nuclide buildup, depletion, and decay. The JMOCUP utility links the MCNP5 and ORIGEN2.2 inputs and outputs in a back-and-forth manner as the depletion calculation steps through each irradiation cycle.

The JMOCUP method fully simulates the ATR under as-run operating conditions. For the AGR experiment series, the JMOCUP utility depletes the ATR driver core fuel elements, the AGR TRISO particle fuel compacts, and the hafnium shroud surrounding the AGR capsules. In addition, the utility modifies the MCNP5 input model at each time-step to simulate the daily core and lobe power changes as well as rotations in the ATR outer shim control cylinders and neck shim rod configuration to maintain a critical reactor configuration and thereby simulate the actual as-run ATR operating conditions.

The depletion calculation is somewhat overburdened in that daily time steps are used to achieve a high-resolution depletion calculation. In general, reactor core depletion calculations do not require daily time steps to achieve desired computational accuracy for burnup estimates. However, the daily heat rates provided by the physics calculation plus the measured daily helium-neon gas mixtures used to control the AGR experiment capsule temperatures are needed as input for the AGR experiment thermal model and the daily temperature predictions. The thermal model is used to predict compact centerline, capsule component, and thermocouple temperatures on a daily basis, since TRISO particle temperature is an important variable to know and control in the evaluation of the particle fuel performance. All other calculated physics parameters (Release-to-Birth ratio (R/B), percent of fissions per initial heavy metal atom (FIMA) burnup, fission product and actinide concentrations, and fast fluence estimates) simply benefit from the high-resolution calculation.

End-of-cycle (EOC) ^{135}I concentrations are calculated as part of the JMOCUP depletion calculation and are listed in Appendix B for all cycles of AGR-5/6/7. Of particular interest are the specific ^{135}I concentrations in each TRISO particle compact prior to the end of each ATR power cycle. The ^{135}I tends to build up and reach a maximum concentration at the end of each cycle; the concentrations are readily extracted from the ORIGEN2.2 output in units of moles/compact.

5. ^{135}I RESULTS

The ratio of extrapolated ^{135}I to EOC ^{135}I calculated concentration as a function of AGR-5/6/7 operating intervals are presented in Figure 6. The ratio for Capsule 2 during irradiation Interval 1, Cycle 162B is elevated because of flow rate issues after reactor shutdown. Ratios calculated during the first five irradiation intervals, show low values that indicate no fuel particle failures during that time. The values presented are higher than that of AGR-1 because of higher exposed kernel fractions. In-pile failures started to occur in Capsule 1 during Cycle 166A (irradiation Interval 6) and a gas line problem in this capsule caused fission gas leakage at varying degrees into the other four capsules. This is captured as elevated ratios in Figure 6 during the last four irradiation intervals. Additionally, it is believed that in-pile failures may have occurred in Capsules 2 and 3, which also come across as elevated ratios in Figure 6.

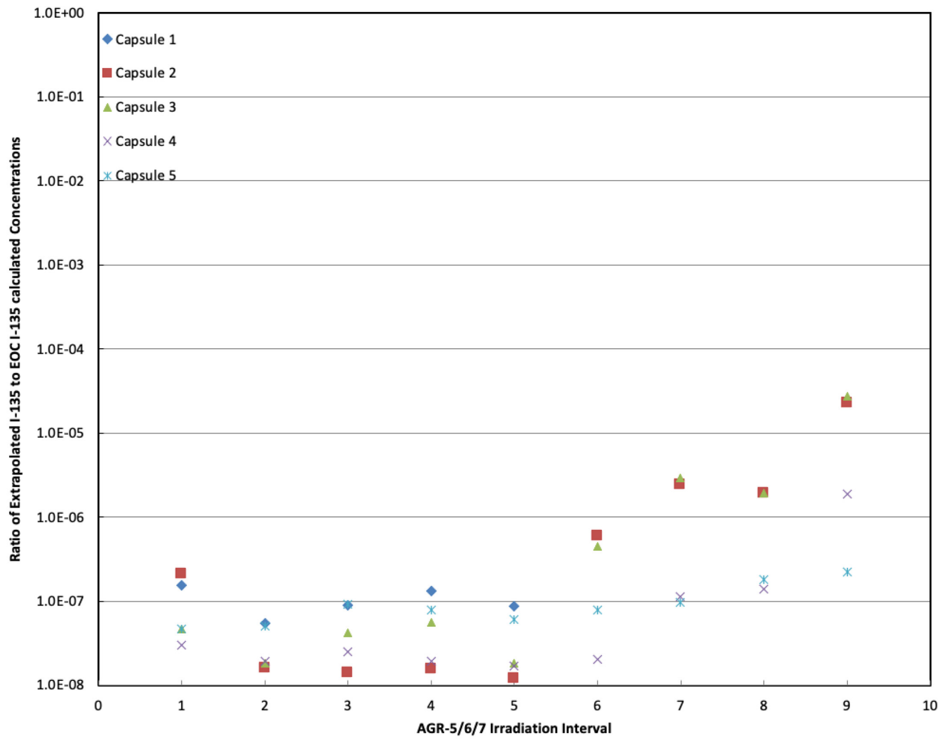

Figure 6. Ratio of extrapolated ^{135}I to EOC ^{135}I calculated concentrations for AGR-5/6/7 indicative of contamination.

6. CONCLUSION

Four ART experiments using TRISO fuel have been conducted in ATR at INL. From 2006 through 2020, these experiments supported the development and qualification effort of the U.S. TRISO particle fuel for the ART program. During these multi-year experiments, capsule specific activities for xenon and krypton species were measured during irradiation and during reactor shutdown to provide isotopic information that could be used to compute release activities relative to fuel performance.

The concentration of ^{135}I from these AGR experiments was determined from measured ^{135m}Xe after the reactor shutdown. The amount of ^{135}I present can be an indicator of fuel integrity. For AGR-5/6/7, the release fraction for ^{135}I indicated that there were no in-pile failed particles during the first five irradiation intervals and only contamination was present.

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Appendix A
Analyze_I135 Sample Output File

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Appendix A
Analyze_I135 Sample Output File

INL developed Analyze_I135 post processing software reads in the isotopic information files produced by the FPMS software suite, capsule specific transport volumes and the capsule specific flow information from the NDMAS database to compute the extrapolated ^{135}I values. The EOC SCRAM date and time are entered manually. The computed ^{135}I values are automatically saved into a comma separated value (.csv) file which can be directly imported into any spreadsheet or text processor.

The Analyze_I135 output file is designed such that capsule specific information is appended to the original file after each irritation, thus all ^{135}I information for each capsule for each cycle or test can be compiled into one output file. The Analyze_I135 output file contains the computed time since reactor shutdown and the activity in µCi for Xe-135m for each activity file that is read from the FPMS software. From this information the extrapolated ^{135}I at shutdown are computed. Table A.1 shows an example Analyze_I135 output file for Capsule 1 from AGR-3/4. Once these values are computed the researcher can take these values and convert them to moles and couple them with the EOC ^{135}I computed concentrations to derive the release fraction of ^{135}I. The complete set of output files were sent to NDMAS staff in an excel spreadsheet format.

Table A-1. Sample output file for AGR-5/6/7 Cycle 164B, Capsule 1 from Analyze_I135.

File E:\AGR34\154A_FPE\154A_Daily_RB\I-135_20130713_1100.csv created by Analyze_I135 <Analyze_I135.exe> ver. 11/25/13

Capsule	del t hrs	Xe-135m Activity Samp Vol uCi	% err	Flow cc/s	Xe-135m Activity At Capsule Bq/cc	% err	Xe-135m Release atoms/s	Released % err	Released I-135 Activity Bq	I-135 Activity uCi	extrapolated to shutdown uCi	error uCi	$x/(\sigma^2)$	$1/(\sigma^2)$
1	9.52	7.52E-01	0	0.213	1775.782	7	500300.1	6	3050611	82.4489	225.1858	14.5429	1.065	0.004728
1	17.52	3.11E-01	1	0.213	733.2265	7	206907.1	6	1261629	34.0981	216.6138	14.0118	1.103	0.005093
1	25.56	1.34E-01	1	0.213	316.154	7	89216.4	7	544002.5	14.7028	218.0644	14.2292	1.077	0.004939
1	33.56	5.71E-02	1	0.213	134.6099	7	38010.6	7	231772	6.2641	216.0951	14.2364	1.066	0.004934
1	41.56	2.39E-02	4	0.214	56.2269	8	15889.3	8	96885.8	2.6185	210.1089	16.4192	0.779	0.003709
1	49.56	1.03E-02	4	0.214	24.1515	7	6834.3	7	41672.4	1.1263	210.2001	15.4284	0.883	0.004201
1	57.56	4.41E-03	6	0.213	10.3638	9	2932	9	17877.7	0.4832	209.7477	18.0134	0.646	0.003082
1	65.59	1.79E-03	11	0.213	4.2048	13	1188.4	12	7246.2	0.1958	198.4839	24.8027	0.323	0.001626
1	73.59	6.80E-04	37	0.213	1.5995	38	452.2	38	2757.4	0.0745	1.76E+02	6.67E+01	0.040	0.000225
1	81.59	1.49E-04	121	0.213	0.3504	121	99	121	603.7	0.0163	8.95E+01	1.08E+02	0.008	8.57E-05

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Appendix B
JMCOUP I135 Concentrations

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Appendix B
JMCOUP I135 Concentrations

B.1 AGR-5/6/7:

AGR-567-as.runs: I-135 Concentration (moles) at the EOC (no decay)

Cycle 162B

TS = 41 (42-1=41 [i.e., second to last timestep])

AGR-567 (calculation with HOMOGENIZED model JMOCUP calculation)
data from: FALCON: /ATR/AGR-567-as.runs/162B/fcompch/iodine2.agr567.162B.ts.41.I135.output

Compact No.	Capsule No.	Level No.	Stack No.	I-135 Conc (moles)
1	1	1	1	2.36375E-08
2	1	2	1	2.86921E-08
3	1	3	1	3.27382E-08
4	1	4	1	3.70151E-08
5	1	5	1	4.05460E-08
6	1	6	1	4.35810E-08
7	1	7	1	4.63900E-08
8	1	8	1	4.91550E-08
9	1	9	1	5.23870E-08
10	1	1	2	2.36894E-08
11	1	2	2	2.83174E-08
12	1	3	2	3.29644E-08
13	1	4	2	3.70799E-08
14	1	5	2	4.09230E-08
15	1	6	2	4.36150E-08
16	1	7	2	4.65610E-08
17	1	8	2	4.93530E-08
18	1	9	2	5.19360E-08
19	1	1	3	2.42004E-08
20	1	2	3	2.87338E-08
21	1	3	3	3.30623E-08
22	1	4	3	3.68738E-08
23	1	5	3	4.05744E-08
24	1	6	3	4.38020E-08

25	1	7	3	4.69370E-08
26	1	8	3	4.92710E-08
27	1	9	3	5.27200E-08
28	1	1	4	2.47200E-08
29	1	2	4	2.94443E-08
30	1	3	4	3.36474E-08
31	1	4	4	3.76537E-08
32	1	5	4	4.00646E-08
33	1	6	4	4.36190E-08
34	1	7	4	4.66910E-08
35	1	8	4	4.92540E-08
36	1	9	4	5.21470E-08
37	1	1	5	2.54892E-08
38	1	2	5	3.05995E-08
39	1	3	5	3.48069E-08
40	1	4	5	3.85592E-08
41	1	5	5	4.09661E-08
42	1	6	5	4.41220E-08
43	1	7	5	4.67030E-08
44	1	8	5	4.93400E-08
45	1	9	5	5.30320E-08
46	1	1	6	2.67071E-08
47	1	2	6	3.15320E-08
48	1	3	6	3.59538E-08
49	1	4	6	3.97361E-08
50	1	5	6	4.20900E-08
51	1	6	6	4.49630E-08
52	1	7	6	4.81490E-08
53	1	8	6	5.03890E-08
54	1	9	6	5.40910E-08
55	1	1	7	2.65103E-08
56	1	2	7	3.14876E-08
57	1	3	7	3.65779E-08
58	1	4	7	4.00407E-08
59	1	5	7	4.21190E-08
60	1	6	7	4.47290E-08
61	1	7	7	4.83160E-08
62	1	8	7	5.10880E-08
63	1	9	7	5.34940E-08
64	1	1	8	2.58959E-08
65	1	2	8	3.06230E-08

66	1	3	8	3.57298E-08
67	1	4	8	3.81620E-08
68	1	5	8	4.09880E-08
69	1	6	8	4.38060E-08
70	1	7	8	4.66470E-08
71	1	8	8	5.00380E-08
72	1	9	8	5.28110E-08
73	1	1	9	2.46258E-08
74	1	2	9	3.01852E-08
75	1	3	9	3.38885E-08
76	1	4	9	3.76316E-08
77	1	5	9	4.10380E-08
78	1	6	9	4.40340E-08
79	1	7	9	4.65660E-08
80	1	8	9	4.99650E-08
81	1	9	9	5.22730E-08
82	1	1	10	2.37517E-08
83	1	2	10	2.86353E-08
84	1	3	10	3.37119E-08
85	1	4	10	3.73767E-08
86	1	5	10	4.07761E-08
87	1	6	10	4.40050E-08
88	1	7	10	4.70530E-08
89	1	8	10	4.97070E-08
90	1	9	10	5.12850E-08
91	2	1	1	4.04960E-08
92	2	2	1	4.23410E-08
93	2	3	1	4.43570E-08
94	2	4	1	4.50210E-08
95	2	5	1	4.55350E-08
96	2	6	1	4.61230E-08
97	2	7	1	4.61140E-08
98	2	8	1	4.56680E-08
99	2	1	2	4.07610E-08
100	2	2	2	4.28300E-08
101	2	3	2	4.44860E-08
102	2	4	2	4.50150E-08
103	2	5	2	4.56990E-08
104	2	6	2	4.61440E-08
105	2	7	2	4.61030E-08
106	2	8	2	4.56450E-08

107	2	1	3	4.11220E-08
108	2	2	3	4.35000E-08
109	2	3	3	4.51660E-08
110	2	4	3	4.59850E-08
111	2	5	3	4.68270E-08
112	2	6	3	4.72400E-08
113	2	7	3	4.74690E-08
114	2	8	3	4.62810E-08
115	2	1	4	4.10942E-08
116	2	2	4	4.32580E-08
117	2	3	4	4.47650E-08
118	2	4	4	4.57840E-08
119	2	5	4	4.62490E-08
120	2	6	4	4.68300E-08
121	2	7	4	4.61480E-08
122	2	8	4	4.61450E-08
123	3	1	1	3.84917E-08
124	3	2	1	4.24620E-08
125	3	3	1	4.36890E-08
126	3	4	1	4.38450E-08
127	3	5	1	4.44130E-08
128	3	6	1	4.41910E-08
129	3	7	1	4.28260E-08
130	3	8	1	4.00112E-08
131	3	1	2	3.89354E-08
132	3	2	2	4.32700E-08
133	3	3	2	4.44640E-08
134	3	4	2	4.47230E-08
135	3	5	2	4.46790E-08
136	3	6	2	4.43420E-08
137	3	7	2	4.32950E-08
138	3	8	2	4.05785E-08
139	3	1	3	3.92866E-08
140	3	2	3	4.33670E-08
141	3	3	3	4.42600E-08
142	3	4	3	4.49100E-08
143	3	5	3	4.46570E-08
144	3	6	3	4.41270E-08
145	3	7	3	4.35960E-08
146	3	8	3	4.02749E-08
147	4	1	1	3.99051E-08

148	4	2	1	4.06950E-08
149	4	3	1	4.04042E-08
150	4	4	1	3.93424E-08
151	4	5	1	3.78937E-08
152	4	6	1	3.61871E-08
153	4	1	2	4.02414E-08
154	4	2	2	4.03950E-08
155	4	3	2	4.00021E-08
156	4	4	2	3.91082E-08
157	4	5	2	3.79783E-08
158	4	6	2	3.62279E-08
159	4	1	3	4.05140E-08
160	4	2	3	4.09960E-08
161	4	3	3	4.10170E-08
162	4	4	3	3.98683E-08
163	4	5	3	3.80663E-08
164	4	6	3	3.67688E-08
165	4	1	4	4.13150E-08
166	4	2	4	4.14320E-08
167	4	3	4	4.10380E-08
168	4	4	4	4.01476E-08
169	4	5	4	3.85253E-08
170	4	6	4	3.67048E-08
171	5	1	1	4.25300E-08
172	5	2	1	4.01033E-08
173	5	3	1	3.66310E-08
174	5	4	1	3.33342E-08
175	5	5	1	2.98350E-08
176	5	6	1	2.60957E-08
177	5	1	2	4.21360E-08
178	5	2	2	3.98228E-08
179	5	3	2	3.64219E-08
180	5	4	2	3.34556E-08
181	5	5	2	2.98646E-08
182	5	6	2	2.62361E-08
183	5	1	3	4.26160E-08
184	5	2	3	3.95005E-08
185	5	3	3	3.74337E-08
186	5	4	3	3.47834E-08
187	5	5	3	3.13994E-08
188	5	6	3	2.80046E-08

189	5	1	4	4.26120E-08
190	5	2	4	4.01765E-08
191	5	3	4	3.76428E-08
192	5	4	4	3.54484E-08
193	5	5	4	3.15722E-08
194	5	6	4	2.77884E-08

B.2 AGR-567-as.runs: I-135 Concentration (moles) at the EOC (no decay)

Cycle 163A (PALM Cycle)

TS = 9 (10-1=9 [i.e., second to last timestep])

AGR-567 (calculation with HOMOGENIZED model JMOCUP calculation)
data from: FALCON: /ATR/AGR-567-as.runs/163A/fcompch/iodine2.agr567.163A.ts.9.I135.output

Compact No.	Capsule No.	Level No.	Stack No.	I-135 Conc (moles)
1	1	1	1	2.64820E-08
2	1	2	1	3.18796E-08
3	1	3	1	3.66435E-08
4	1	4	1	4.15720E-08
5	1	5	1	4.42380E-08
6	1	6	1	4.81230E-08
7	1	7	1	5.08620E-08
8	1	8	1	5.39430E-08
9	1	9	1	5.75510E-08
10	1	1	2	2.73973E-08
11	1	2	2	3.20272E-08
12	1	3	2	3.69065E-08
13	1	4	2	4.07127E-08
14	1	5	2	4.46470E-08
15	1	6	2	4.80020E-08
16	1	7	2	5.09690E-08
17	1	8	2	5.46010E-08
18	1	9	2	5.82300E-08
19	1	1	3	2.79722E-08
20	1	2	3	3.27541E-08
21	1	3	3	3.82672E-08
22	1	4	3	4.21610E-08
23	1	5	3	4.57680E-08
24	1	6	3	4.89260E-08
25	1	7	3	5.27120E-08
26	1	8	3	5.60530E-08
27	1	9	3	5.89860E-08

28	1	1	4	2.90789E-08
29	1	2	4	3.42060E-08
30	1	3	4	3.94109E-08
31	1	4	4	4.36260E-08
32	1	5	4	4.65790E-08
33	1	6	4	4.97440E-08
34	1	7	4	5.32670E-08
35	1	8	4	5.63670E-08
36	1	9	4	6.00920E-08
37	1	1	5	3.08380E-08
38	1	2	5	3.54122E-08
39	1	3	5	4.20630E-08
40	1	4	5	4.53890E-08
41	1	5	5	4.77770E-08
42	1	6	5	5.13510E-08
43	1	7	5	5.52180E-08
44	1	8	5	5.77650E-08
45	1	9	5	6.13380E-08
46	1	1	6	3.19646E-08
47	1	2	6	3.68467E-08
48	1	3	6	4.20875E-08
49	1	4	6	4.66860E-08
50	1	5	6	4.87130E-08
51	1	6	6	5.19500E-08
52	1	7	6	5.55550E-08
53	1	8	6	5.94960E-08
54	1	9	6	6.21510E-08
55	1	1	7	3.12980E-08
56	1	2	7	3.66226E-08
57	1	3	7	4.22710E-08
58	1	4	7	4.62810E-08
59	1	5	7	4.84100E-08
60	1	6	7	5.16340E-08
61	1	7	7	5.57390E-08
62	1	8	7	5.80350E-08
63	1	9	7	6.20080E-08
64	1	1	8	2.96320E-08
65	1	2	8	3.56871E-08
66	1	3	8	4.09483E-08
67	1	4	8	4.58070E-08
68	1	5	8	4.74370E-08

69	1	6	8	4.97080E-08
70	1	7	8	5.42160E-08
71	1	8	8	5.70360E-08
72	1	9	8	6.11620E-08
73	1	1	9	2.89171E-08
74	1	2	9	3.50421E-08
75	1	3	9	4.00655E-08
76	1	4	9	4.33650E-08
77	1	5	9	4.58710E-08
78	1	6	9	4.99470E-08
79	1	7	9	5.30800E-08
80	1	8	9	5.63640E-08
81	1	9	9	5.90230E-08
82	1	1	10	2.75121E-08
83	1	2	10	3.27953E-08
84	1	3	10	3.73832E-08
85	1	4	10	4.21130E-08
86	1	5	10	4.50440E-08
87	1	6	10	4.85540E-08
88	1	7	10	5.25970E-08
89	1	8	10	5.55700E-08
90	1	9	10	5.83260E-08
91	2	1	1	4.62540E-08
92	2	2	1	4.80660E-08
93	2	3	1	5.12190E-08
94	2	4	1	5.11880E-08
95	2	5	1	5.17300E-08
96	2	6	1	5.21100E-08
97	2	7	1	5.24590E-08
98	2	8	1	5.17680E-08
99	2	1	2	4.61110E-08
100	2	2	2	4.96490E-08
101	2	3	2	5.07730E-08
102	2	4	2	5.12200E-08
103	2	5	2	5.22840E-08
104	2	6	2	5.28830E-08
105	2	7	2	5.30480E-08
106	2	8	2	5.25500E-08
107	2	1	3	4.88980E-08
108	2	2	3	5.15250E-08
109	2	3	3	5.32260E-08

110	2	4	3	5.45010E-08
111	2	5	3	5.55600E-08
112	2	6	3	5.65510E-08
113	2	7	3	5.57060E-08
114	2	8	3	5.57300E-08
115	2	1	4	4.81110E-08
116	2	2	4	5.06800E-08
117	2	3	4	5.29590E-08
118	2	4	4	5.35310E-08
119	2	5	4	5.44140E-08
120	2	6	4	5.53150E-08
121	2	7	4	5.51420E-08
122	2	8	4	5.41570E-08
123	3	1	1	4.50530E-08
124	3	2	1	5.03140E-08
125	3	3	1	5.13710E-08
126	3	4	1	5.22010E-08
127	3	5	1	5.14550E-08
128	3	6	1	5.03540E-08
129	3	7	1	4.90160E-08
130	3	8	1	4.58390E-08
131	3	1	2	4.62260E-08
132	3	2	2	5.20260E-08
133	3	3	2	5.26410E-08
134	3	4	2	5.34640E-08
135	3	5	2	5.30360E-08
136	3	6	2	5.27430E-08
137	3	7	2	5.04120E-08
138	3	8	2	4.67980E-08
139	3	1	3	4.66800E-08
140	3	2	3	5.12750E-08
141	3	3	3	5.29700E-08
142	3	4	3	5.33550E-08
143	3	5	3	5.27610E-08
144	3	6	3	5.18280E-08
145	3	7	3	5.05780E-08
146	3	8	3	4.68670E-08
147	4	1	1	4.50690E-08
148	4	2	1	4.47850E-08
149	4	3	1	4.37630E-08
150	4	4	1	4.30720E-08

151	4	5	1	4.14540E-08
152	4	6	1	3.85967E-08
153	4	1	2	4.49520E-08
154	4	2	2	4.55470E-08
155	4	3	2	4.47160E-08
156	4	4	2	4.37150E-08
157	4	5	2	4.21160E-08
158	4	6	2	3.97846E-08
159	4	1	3	4.82430E-08
160	4	2	3	4.78100E-08
161	4	3	3	4.73980E-08
162	4	4	3	4.60230E-08
163	4	5	3	4.45350E-08
164	4	6	3	4.15360E-08
165	4	1	4	4.73410E-08
166	4	2	4	4.73630E-08
167	4	3	4	4.67310E-08
168	4	4	4	4.54550E-08
169	4	5	4	4.29690E-08
170	4	6	4	4.12430E-08
171	5	1	1	4.49960E-08
172	5	2	1	4.17280E-08
173	5	3	1	3.83096E-08
174	5	4	1	3.50409E-08
175	5	5	1	3.07769E-08
176	5	6	1	2.78122E-08
177	5	1	2	4.50350E-08
178	5	2	2	4.20110E-08
179	5	3	2	3.88591E-08
180	5	4	2	3.54898E-08
181	5	5	2	3.15521E-08
182	5	6	2	2.74703E-08
183	5	1	3	4.71960E-08
184	5	2	3	4.44640E-08
185	5	3	3	4.09670E-08
186	5	4	3	3.89663E-08
187	5	5	3	3.46805E-08
188	5	6	3	3.11074E-08
189	5	1	4	4.65010E-08
190	5	2	4	4.37010E-08
191	5	3	4	4.05103E-08

192	5	4	4	3.82891E-08
193	5	5	4	3.37266E-08
194	5	6	4	2.98719E-08

B.3 AGR-567-as.runs: I-135 Concentration (moles) at the EOC (no decay)

Cycle 164A

TS = 60 (61-1=60 [i.e., second to last timestep])

AGR-567 (calculation with HOMOGENIZED model JMOCUP calculation)
data from: FALCON: /ATR/AGR-567-as.runs/164A/fcompch/iodine2.agr567.164A.ts.60.I135.output

Compact No.	Capsule No.	Level No.	Stack No.	I-135 Conc (moles)
1	1	1	1	2.38287E-08
2	1	2	1	2.87046E-08
3	1	3	1	3.25157E-08
4	1	4	1	3.63268E-08
5	1	5	1	4.02584E-08
6	1	6	1	4.27500E-08
7	1	7	1	4.59360E-08
8	1	8	1	4.84420E-08
9	1	9	1	5.07350E-08
10	1	1	2	2.40001E-08
11	1	2	2	2.86895E-08
12	1	3	2	3.27866E-08
13	1	4	2	3.62278E-08
14	1	5	2	4.01813E-08
15	1	6	2	4.31050E-08
16	1	7	2	4.58180E-08
17	1	8	2	4.85750E-08
18	1	9	2	5.14790E-08
19	1	1	3	2.44497E-08
20	1	2	3	2.90094E-08
21	1	3	3	3.29817E-08
22	1	4	3	3.69163E-08
23	1	5	3	3.98714E-08
24	1	6	3	4.36330E-08
25	1	7	3	4.59890E-08
26	1	8	3	4.83440E-08
27	1	9	3	5.09960E-08

28	1	1	4	2.51684E-08
29	1	2	4	2.99207E-08
30	1	3	4	3.44643E-08
31	1	4	4	3.71623E-08
32	1	5	4	3.99752E-08
33	1	6	4	4.37480E-08
34	1	7	4	4.59920E-08
35	1	8	4	4.82340E-08
36	1	9	4	5.08030E-08
37	1	1	5	2.62659E-08
38	1	2	5	3.06666E-08
39	1	3	5	3.57141E-08
40	1	4	5	3.85689E-08
41	1	5	5	4.12230E-08
42	1	6	5	4.38770E-08
43	1	7	5	4.62680E-08
44	1	8	5	4.97700E-08
45	1	9	5	5.22730E-08
46	1	1	6	2.68391E-08
47	1	2	6	3.17096E-08
48	1	3	6	3.64878E-08
49	1	4	6	3.94951E-08
50	1	5	6	4.25040E-08
51	1	6	6	4.44630E-08
52	1	7	6	4.73130E-08
53	1	8	6	5.01680E-08
54	1	9	6	5.28050E-08
55	1	1	7	2.71056E-08
56	1	2	7	3.19401E-08
57	1	3	7	3.62576E-08
58	1	4	7	3.90804E-08
59	1	5	7	4.22490E-08
60	1	6	7	4.43670E-08
61	1	7	7	4.73040E-08
62	1	8	7	5.03270E-08
63	1	9	7	5.26620E-08
64	1	1	8	2.62098E-08
65	1	2	8	3.11783E-08
66	1	3	8	3.51033E-08
67	1	4	8	3.85991E-08
68	1	5	8	4.14330E-08

69	1	6	8	4.34330E-08
70	1	7	8	4.67830E-08
71	1	8	8	4.91180E-08
72	1	9	8	5.21730E-08
73	1	1	9	2.52314E-08
74	1	2	9	2.98380E-08
75	1	3	9	3.44204E-08
76	1	4	9	3.76930E-08
77	1	5	9	4.06441E-08
78	1	6	9	4.30840E-08
79	1	7	9	4.62000E-08
80	1	8	9	4.87360E-08
81	1	9	9	5.13510E-08
82	1	1	10	2.41269E-08
83	1	2	10	2.92172E-08
84	1	3	10	3.32063E-08
85	1	4	10	3.66330E-08
86	1	5	10	4.04849E-08
87	1	6	10	4.34970E-08
88	1	7	10	4.60340E-08
89	1	8	10	4.83420E-08
90	1	9	10	5.12610E-08
91	2	1	1	3.93248E-08
92	2	2	1	4.18140E-08
93	2	3	1	4.28770E-08
94	2	4	1	4.32700E-08
95	2	5	1	4.35500E-08
96	2	6	1	4.37840E-08
97	2	7	1	4.41290E-08
98	2	8	1	4.35580E-08
99	2	1	2	3.97804E-08
100	2	2	2	4.14960E-08
101	2	3	2	4.27470E-08
102	2	4	2	4.32550E-08
103	2	5	2	4.37640E-08
104	2	6	2	4.39290E-08
105	2	7	2	4.41300E-08
106	2	8	2	4.40300E-08
107	2	1	3	4.07417E-08
108	2	2	3	4.24540E-08
109	2	3	3	4.39060E-08

110	2	4	3	4.44600E-08
111	2	5	3	4.47540E-08
112	2	6	3	4.51220E-08
113	2	7	3	4.51250E-08
114	2	8	3	4.47850E-08
115	2	1	4	4.00526E-08
116	2	2	4	4.21890E-08
117	2	3	4	4.30860E-08
118	2	4	4	4.38040E-08
119	2	5	4	4.46810E-08
120	2	6	4	4.50190E-08
121	2	7	4	4.49580E-08
122	2	8	4	4.45400E-08
123	3	1	1	3.84810E-08
124	3	2	1	4.16820E-08
125	3	3	1	4.26800E-08
126	3	4	1	4.27870E-08
127	3	5	1	4.29830E-08
128	3	6	1	4.24800E-08
129	3	7	1	4.12730E-08
130	3	8	1	3.88182E-08
131	3	1	2	3.87427E-08
132	3	2	2	4.22310E-08
133	3	3	2	4.30060E-08
134	3	4	2	4.29760E-08
135	3	5	2	4.30600E-08
136	3	6	2	4.27320E-08
137	3	7	2	4.17410E-08
138	3	8	2	3.89474E-08
139	3	1	3	3.91591E-08
140	3	2	3	4.23380E-08
141	3	3	3	4.30850E-08
142	3	4	3	4.32460E-08
143	3	5	3	4.31400E-08
144	3	6	3	4.26450E-08
145	3	7	3	4.17940E-08
146	3	8	3	3.93332E-08
147	4	1	1	3.80986E-08
148	4	2	1	3.86205E-08
149	4	3	1	3.79644E-08
150	4	4	1	3.73281E-08

151	4	5	1	3.61778E-08
152	4	6	1	3.43734E-08
153	4	1	2	3.86412E-08
154	4	2	2	3.86536E-08
155	4	3	2	3.79365E-08
156	4	4	2	3.73154E-08
157	4	5	2	3.60021E-08
158	4	6	2	3.49567E-08
159	4	1	3	3.85703E-08
160	4	2	3	3.95350E-08
161	4	3	3	3.88328E-08
162	4	4	3	3.80292E-08
163	4	5	3	3.68782E-08
164	4	6	3	3.51624E-08
165	4	1	4	3.91386E-08
166	4	2	4	3.96351E-08
167	4	3	4	3.88377E-08
168	4	4	4	3.77642E-08
169	4	5	4	3.65421E-08
170	4	6	4	3.55077E-08
171	5	1	1	4.05100E-08
172	5	2	1	3.81472E-08
173	5	3	1	3.54787E-08
174	5	4	1	3.19952E-08
175	5	5	1	2.87258E-08
176	5	6	1	2.54655E-08
177	5	1	2	4.04925E-08
178	5	2	2	3.80516E-08
179	5	3	2	3.56161E-08
180	5	4	2	3.21855E-08
181	5	5	2	2.90616E-08
182	5	6	2	2.53908E-08
183	5	1	3	4.14010E-08
184	5	2	3	3.94987E-08
185	5	3	3	3.62465E-08
186	5	4	3	3.40883E-08
187	5	5	3	3.09978E-08
188	5	6	3	2.70160E-08
189	5	1	4	4.13360E-08
190	5	2	4	3.93633E-08
191	5	3	4	3.62098E-08

192	5	4	4	3.41390E-08
193	5	5	4	3.02549E-08
194	5	6	4	2.69993E-08

B.4 AGR-567-as.runs: I-135 Concentration (moles) at the EOC (no decay)

Cycle 164B

TS = 68 (69-1=68 [i.e., second to last timestep])

AGR-567 (calculation with HOMOGENIZED model JMOCUP calculation)
data from: FALCON: /ATR/AGR-567-as.runs/164B/fcompch/iodine2.agr567.164B.ts.68.I135.output

Compact No.	Capsule No.	Level No.	Stack No.	I-135 Conc (moles)
1	1	1	1	2.34280E-08
2	1	2	1	2.74424E-08
3	1	3	1	3.16265E-08
4	1	4	1	3.51610E-08
5	1	5	1	3.77230E-08
6	1	6	1	3.97984E-08
7	1	7	1	4.15210E-08
8	1	8	1	4.39710E-08
9	1	9	1	4.55420E-08
10	1	1	2	2.37981E-08
11	1	2	2	2.75807E-08
12	1	3	2	3.11167E-08
13	1	4	2	3.51641E-08
14	1	5	2	3.75388E-08
15	1	6	2	3.96744E-08
16	1	7	2	4.21670E-08
17	1	8	2	4.44480E-08
18	1	9	2	4.53550E-08
19	1	1	3	2.40938E-08
20	1	2	3	2.78537E-08
21	1	3	3	3.17025E-08
22	1	4	3	3.52413E-08
23	1	5	3	3.79103E-08
24	1	6	3	3.99871E-08
25	1	7	3	4.24020E-08
26	1	8	3	4.43170E-08
27	1	9	3	4.63620E-08

28	1	1	4	2.45582E-08
29	1	2	4	2.90140E-08
30	1	3	4	3.30251E-08
31	1	4	4	3.58330E-08
32	1	5	4	3.81677E-08
33	1	6	4	4.03949E-08
34	1	7	4	4.30420E-08
35	1	8	4	4.47190E-08
36	1	9	4	4.62500E-08
37	1	1	5	2.54652E-08
38	1	2	5	3.01105E-08
39	1	3	5	3.36650E-08
40	1	4	5	3.66380E-08
41	1	5	5	3.89428E-08
42	1	6	5	4.11760E-08
43	1	7	5	4.36890E-08
44	1	8	5	4.54420E-08
45	1	9	5	4.64640E-08
46	1	1	6	2.62801E-08
47	1	2	6	3.04191E-08
48	1	3	6	3.40529E-08
49	1	4	6	3.71796E-08
50	1	5	6	3.92630E-08
51	1	6	6	4.10784E-08
52	1	7	6	4.42000E-08
53	1	8	6	4.57440E-08
54	1	9	6	4.67060E-08
55	1	1	7	2.56670E-08
56	1	2	7	3.02663E-08
57	1	3	7	3.42625E-08
58	1	4	7	3.71943E-08
59	1	5	7	3.88469E-08
60	1	6	7	4.20520E-08
61	1	7	7	4.37640E-08
62	1	8	7	4.51590E-08
63	1	9	7	4.72980E-08
64	1	1	8	2.54070E-08
65	1	2	8	2.94431E-08
66	1	3	8	3.37643E-08
67	1	4	8	3.67274E-08
68	1	5	8	3.93544E-08

69	1	6	8	4.07930E-08
70	1	7	8	4.28720E-08
71	1	8	8	4.46250E-08
72	1	9	8	4.68660E-08
73	1	1	9	2.47066E-08
74	1	2	9	2.85723E-08
75	1	3	9	3.21056E-08
76	1	4	9	3.58099E-08
77	1	5	9	3.81886E-08
78	1	6	9	4.02649E-08
79	1	7	9	4.22360E-08
80	1	8	9	4.48430E-08
81	1	9	9	4.63800E-08
82	1	1	10	2.41537E-08
83	1	2	10	2.74285E-08
84	1	3	10	3.16737E-08
85	1	4	10	3.54683E-08
86	1	5	10	3.79973E-08
87	1	6	10	4.03458E-08
88	1	7	10	4.24270E-08
89	1	8	10	4.44250E-08
90	1	9	10	4.58520E-08
91	2	1	1	3.43665E-08
92	2	2	1	3.55390E-08
93	2	3	1	3.60575E-08
94	2	4	1	3.61832E-08
95	2	5	1	3.67187E-08
96	2	6	1	3.68847E-08
97	2	7	1	3.63368E-08
98	2	8	1	3.59165E-08
99	2	1	2	3.43827E-08
100	2	2	2	3.59189E-08
101	2	3	2	3.64121E-08
102	2	4	2	3.66131E-08
103	2	5	2	3.67639E-08
104	2	6	2	3.66402E-08
105	2	7	2	3.66575E-08
106	2	8	2	3.64529E-08
107	2	1	3	3.50052E-08
108	2	2	3	3.64027E-08
109	2	3	3	3.71022E-08

110	2	4	3	3.75947E-08
111	2	5	3	3.79964E-08
112	2	6	3	3.78420E-08
113	2	7	3	3.75859E-08
114	2	8	3	3.71386E-08
115	2	1	4	3.51387E-08
116	2	2	4	3.57537E-08
117	2	3	4	3.66805E-08
118	2	4	4	3.74759E-08
119	2	5	4	3.72877E-08
120	2	6	4	3.76812E-08
121	2	7	4	3.74482E-08
122	2	8	4	3.69212E-08
123	3	1	1	3.28456E-08
124	3	2	1	3.48925E-08
125	3	3	1	3.52918E-08
126	3	4	1	3.53792E-08
127	3	5	1	3.53167E-08
128	3	6	1	3.53896E-08
129	3	7	1	3.43856E-08
130	3	8	1	3.29189E-08
131	3	1	2	3.32386E-08
132	3	2	2	3.54360E-08
133	3	3	2	3.57101E-08
134	3	4	2	3.62812E-08
135	3	5	2	3.56801E-08
136	3	6	2	3.61410E-08
137	3	7	2	3.52954E-08
138	3	8	2	3.34801E-08
139	3	1	3	3.28907E-08
140	3	2	3	3.49081E-08
141	3	3	3	3.58758E-08
142	3	4	3	3.56947E-08
143	3	5	3	3.58378E-08
144	3	6	3	3.60251E-08
145	3	7	3	3.49639E-08
146	3	8	3	3.36606E-08
147	4	1	1	3.26142E-08
148	4	2	1	3.34145E-08
149	4	3	1	3.34498E-08
150	4	4	1	3.28069E-08

151	4	5	1	3.18959E-08
152	4	6	1	3.01934E-08
153	4	1	2	3.33007E-08
154	4	2	2	3.32362E-08
155	4	3	2	3.32597E-08
156	4	4	2	3.23406E-08
157	4	5	2	3.18963E-08
158	4	6	2	3.12160E-08
159	4	1	3	3.34604E-08
160	4	2	3	3.46237E-08
161	4	3	3	3.35789E-08
162	4	4	3	3.33586E-08
163	4	5	3	3.24547E-08
164	4	6	3	3.13344E-08
165	4	1	4	3.36546E-08
166	4	2	4	3.38484E-08
167	4	3	4	3.42849E-08
168	4	4	4	3.31370E-08
169	4	5	4	3.22884E-08
170	4	6	4	3.10758E-08
171	5	1	1	3.80091E-08
172	5	2	1	3.65709E-08
173	5	3	1	3.35436E-08
174	5	4	1	3.12700E-08
175	5	5	1	2.83931E-08
176	5	6	1	2.52524E-08
177	5	1	2	3.80231E-08
178	5	2	2	3.64305E-08
179	5	3	2	3.43087E-08
180	5	4	2	3.12119E-08
181	5	5	2	2.84784E-08
182	5	6	2	2.46152E-08
183	5	1	3	3.84904E-08
184	5	2	3	3.70460E-08
185	5	3	3	3.52186E-08
186	5	4	3	3.22823E-08
187	5	5	3	2.98026E-08
188	5	6	3	2.63677E-08
189	5	1	4	3.88520E-08
190	5	2	4	3.72964E-08
191	5	3	4	3.50852E-08

192	5	4	4	3.25837E-08
193	5	5	4	2.97689E-08
194	5	6	4	2.62469E-08

B.5 AGR-567-as.runs: I-135 Concentration (moles) at the EOC (no decay)

Cycle 165A (PALM)

TS = 16 (17-1=16 [i.e., second to last timestep])

AGR-567 (calculation with HOMOGENIZED model JMOCUP calculation)
data from: FALCON: /ATR/AGR-567-as.runs/165A/fcompch/iodine2.agr567.165A.ts.16.I135.output

Compact No.	Capsule No.	Level No.	Stack No.	I-135 Conc (moles)
1	1	1	1	2.72695E-08
2	1	2	1	3.22065E-08
3	1	3	1	3.60146E-08
4	1	4	1	3.99625E-08
5	1	5	1	4.27980E-08
6	1	6	1	4.51010E-08
7	1	7	1	4.70030E-08
8	1	8	1	4.86320E-08
9	1	9	1	5.24040E-08
10	1	1	2	2.68290E-08
11	1	2	2	3.20649E-08
12	1	3	2	3.60493E-08
13	1	4	2	3.93053E-08
14	1	5	2	4.32080E-08
15	1	6	2	4.59380E-08
16	1	7	2	4.76510E-08
17	1	8	2	4.86680E-08
18	1	9	2	5.14530E-08
19	1	1	3	2.75223E-08
20	1	2	3	3.23712E-08
21	1	3	3	3.68454E-08
22	1	4	3	3.99863E-08
23	1	5	3	4.30370E-08
24	1	6	3	4.66230E-08
25	1	7	3	4.78330E-08
26	1	8	3	5.01350E-08
27	1	9	3	5.23890E-08

28	1	1	4	2.87898E-08
29	1	2	4	3.36080E-08
30	1	3	4	3.76283E-08
31	1	4	4	4.06610E-08
32	1	5	4	4.36220E-08
33	1	6	4	4.78070E-08
34	1	7	4	4.91710E-08
35	1	8	4	5.07660E-08
36	1	9	4	5.25230E-08
37	1	1	5	2.96583E-08
38	1	2	5	3.45225E-08
39	1	3	5	3.88772E-08
40	1	4	5	4.21780E-08
41	1	5	5	4.38050E-08
42	1	6	5	4.72630E-08
43	1	7	5	4.95370E-08
44	1	8	5	5.15620E-08
45	1	9	5	5.36280E-08
46	1	1	6	3.09784E-08
47	1	2	6	3.55130E-08
48	1	3	6	3.89934E-08
49	1	4	6	4.30440E-08
50	1	5	6	4.56540E-08
51	1	6	6	4.76230E-08
52	1	7	6	5.03320E-08
53	1	8	6	5.25950E-08
54	1	9	6	5.38550E-08
55	1	1	7	3.01992E-08
56	1	2	7	3.52761E-08
57	1	3	7	3.86598E-08
58	1	4	7	4.18640E-08
59	1	5	7	4.54050E-08
60	1	6	7	4.70000E-08
61	1	7	7	4.93730E-08
62	1	8	7	5.13740E-08
63	1	9	7	5.35720E-08
64	1	1	8	2.92032E-08
65	1	2	8	3.36995E-08
66	1	3	8	3.83567E-08
67	1	4	8	4.22000E-08
68	1	5	8	4.47350E-08

69	1	6	8	4.67330E-08
70	1	7	8	4.80220E-08
71	1	8	8	5.05400E-08
72	1	9	8	5.31150E-08
73	1	1	9	2.80744E-08
74	1	2	9	3.32423E-08
75	1	3	9	3.78202E-08
76	1	4	9	4.14320E-08
77	1	5	9	4.39180E-08
78	1	6	9	4.61520E-08
79	1	7	9	4.83020E-08
80	1	8	9	5.08760E-08
81	1	9	9	5.21970E-08
82	1	1	10	2.74375E-08
83	1	2	10	3.26235E-08
84	1	3	10	3.61393E-08
85	1	4	10	3.95787E-08
86	1	5	10	4.35460E-08
87	1	6	10	4.51860E-08
88	1	7	10	4.78830E-08
89	1	8	10	4.96450E-08
90	1	9	10	5.21340E-08
91	2	1	1	3.90271E-08
92	2	2	1	3.97652E-08
93	2	3	1	4.09440E-08
94	2	4	1	4.13400E-08
95	2	5	1	4.19330E-08
96	2	6	1	4.22620E-08
97	2	7	1	4.16080E-08
98	2	8	1	4.12230E-08
99	2	1	2	3.94615E-08
100	2	2	2	4.08850E-08
101	2	3	2	4.14830E-08
102	2	4	2	4.13780E-08
103	2	5	2	4.18100E-08
104	2	6	2	4.23670E-08
105	2	7	2	4.19980E-08
106	2	8	2	4.20470E-08
107	2	1	3	4.08600E-08
108	2	2	3	4.18670E-08
109	2	3	3	4.29700E-08

110	2	4	3	4.30290E-08
111	2	5	3	4.31530E-08
112	2	6	3	4.38020E-08
113	2	7	3	4.33730E-08
114	2	8	3	4.29960E-08
115	2	1	4	4.01723E-08
116	2	2	4	4.17450E-08
117	2	3	4	4.26080E-08
118	2	4	4	4.24600E-08
119	2	5	4	4.26980E-08
120	2	6	4	4.25720E-08
121	2	7	4	4.28750E-08
122	2	8	4	4.27290E-08
123	3	1	1	3.77192E-08
124	3	2	1	4.00126E-08
125	3	3	1	4.12340E-08
126	3	4	1	4.12000E-08
127	3	5	1	4.09310E-08
128	3	6	1	4.10540E-08
129	3	7	1	3.96354E-08
130	3	8	1	3.82921E-08
131	3	1	2	3.87780E-08
132	3	2	2	4.13370E-08
133	3	3	2	4.21610E-08
134	3	4	2	4.24770E-08
135	3	5	2	4.21890E-08
136	3	6	2	4.17380E-08
137	3	7	2	4.06269E-08
138	3	8	2	3.94526E-08
139	3	1	3	3.88279E-08
140	3	2	3	4.06279E-08
141	3	3	3	4.17590E-08
142	3	4	3	4.18040E-08
143	3	5	3	4.17320E-08
144	3	6	3	4.18720E-08
145	3	7	3	4.09570E-08
146	3	8	3	3.94726E-08
147	4	1	1	3.81071E-08
148	4	2	1	3.76446E-08
149	4	3	1	3.81799E-08
150	4	4	1	3.73164E-08

151	4	5	1	3.63940E-08
152	4	6	1	3.53882E-08
153	4	1	2	3.83435E-08
154	4	2	2	3.84328E-08
155	4	3	2	3.81694E-08
156	4	4	2	3.78870E-08
157	4	5	2	3.63672E-08
158	4	6	2	3.55659E-08
159	4	1	3	3.96157E-08
160	4	2	3	3.96295E-08
161	4	3	3	3.90214E-08
162	4	4	3	3.83463E-08
163	4	5	3	3.69693E-08
164	4	6	3	3.62752E-08
165	4	1	4	3.89026E-08
166	4	2	4	3.90473E-08
167	4	3	4	3.90159E-08
168	4	4	4	3.87185E-08
169	4	5	4	3.72750E-08
170	4	6	4	3.62451E-08
171	5	1	1	4.35660E-08
172	5	2	1	4.08122E-08
173	5	3	1	3.79928E-08
174	5	4	1	3.58684E-08
175	5	5	1	3.21836E-08
176	5	6	1	2.81754E-08
177	5	1	2	4.35310E-08
178	5	2	2	4.13300E-08
179	5	3	2	3.88497E-08
180	5	4	2	3.53717E-08
181	5	5	2	3.22733E-08
182	5	6	2	2.83412E-08
183	5	1	3	4.45760E-08
184	5	2	3	4.22560E-08
185	5	3	3	3.98317E-08
186	5	4	3	3.76643E-08
187	5	5	3	3.42926E-08
188	5	6	3	3.01260E-08
189	5	1	4	4.45110E-08
190	5	2	4	4.20580E-08
191	5	3	4	3.87152E-08

192	5	4	4	3.69273E-08
193	5	5	4	3.32447E-08
194	5	6	4	2.95795E-08

B.6 AGR-567-as.runs: I-135 Concentration (moles) at the EOC (no decay)

Cycle 166A

TS = 65 (66-1=65 [i.e., second to last timestep])

AGR-567 (calculation with HOMOGENIZED model JMOCUP calculation)
data from: FALCON: /ATR/AGR-567-as.runs/166A/fcompch/iodine2.agr567.166A.ts.65.I135.output

Compact No.	Capsule No.	Level No.	Stack No.	I-135 Conc (moles)
1	1	1	1	2.22895E-08
2	1	2	1	2.60900E-08
3	1	3	1	2.96641E-08
4	1	4	1	3.25673E-08
5	1	5	1	3.58139E-08
6	1	6	1	3.76383E-08
7	1	7	1	3.93027E-08
8	1	8	1	4.10800E-08
9	1	9	1	4.24110E-08
10	1	1	2	2.18742E-08
11	1	2	2	2.57969E-08
12	1	3	2	2.96661E-08
13	1	4	2	3.29778E-08
14	1	5	2	3.52749E-08
15	1	6	2	3.76742E-08
16	1	7	2	3.98981E-08
17	1	8	2	4.09970E-08
18	1	9	2	4.23820E-08
19	1	1	3	2.27760E-08
20	1	2	3	2.59116E-08
21	1	3	3	3.00731E-08
22	1	4	3	3.30323E-08
23	1	5	3	3.58672E-08
24	1	6	3	3.81308E-08
25	1	7	3	4.03424E-08
26	1	8	3	4.12780E-08
27	1	9	3	4.24310E-08

28	1	1	4	2.33651E-08
29	1	2	4	2.66394E-08
30	1	3	4	3.03396E-08
31	1	4	4	3.44520E-08
32	1	5	4	3.63475E-08
33	1	6	4	3.94611E-08
34	1	7	4	4.06930E-08
35	1	8	4	4.22910E-08
36	1	9	4	4.36250E-08
37	1	1	5	2.39953E-08
38	1	2	5	2.73350E-08
39	1	3	5	3.12822E-08
40	1	4	5	3.52848E-08
41	1	5	5	3.75513E-08
42	1	6	5	3.98902E-08
43	1	7	5	4.17210E-08
44	1	8	5	4.35780E-08
45	1	9	5	4.44830E-08
46	1	1	6	2.39528E-08
47	1	2	6	2.76278E-08
48	1	3	6	3.16441E-08
49	1	4	6	3.50302E-08
50	1	5	6	3.81903E-08
51	1	6	6	4.04725E-08
52	1	7	6	4.22730E-08
53	1	8	6	4.43390E-08
54	1	9	6	4.52840E-08
55	1	1	7	2.37715E-08
56	1	2	7	2.81167E-08
57	1	3	7	3.15753E-08
58	1	4	7	3.49444E-08
59	1	5	7	3.81773E-08
60	1	6	7	4.07929E-08
61	1	7	7	4.27540E-08
62	1	8	7	4.40650E-08
63	1	9	7	4.50660E-08
64	1	1	8	2.35214E-08
65	1	2	8	2.67680E-08
66	1	3	8	3.12172E-08
67	1	4	8	3.43339E-08
68	1	5	8	3.81505E-08

69	1	6	8	4.02876E-08
70	1	7	8	4.17380E-08
71	1	8	8	4.29490E-08
72	1	9	8	4.42870E-08
73	1	1	9	2.29736E-08
74	1	2	9	2.70491E-08
75	1	3	9	3.02963E-08
76	1	4	9	3.34139E-08
77	1	5	9	3.65543E-08
78	1	6	9	3.94079E-08
79	1	7	9	4.09760E-08
80	1	8	9	4.23450E-08
81	1	9	9	4.39950E-08
82	1	1	10	2.23516E-08
83	1	2	10	2.58521E-08
84	1	3	10	2.95137E-08
85	1	4	10	3.25823E-08
86	1	5	10	3.60562E-08
87	1	6	10	3.82164E-08
88	1	7	10	4.03829E-08
89	1	8	10	4.13050E-08
90	1	9	10	4.28480E-08
91	2	1	1	3.16132E-08
92	2	2	1	3.23918E-08
93	2	3	1	3.31102E-08
94	2	4	1	3.30625E-08
95	2	5	1	3.29524E-08
96	2	6	1	3.34600E-08
97	2	7	1	3.32479E-08
98	2	8	1	3.29806E-08
99	2	1	2	3.16897E-08
100	2	2	2	3.21897E-08
101	2	3	2	3.24140E-08
102	2	4	2	3.28811E-08
103	2	5	2	3.28960E-08
104	2	6	2	3.32581E-08
105	2	7	2	3.31519E-08
106	2	8	2	3.31640E-08
107	2	1	3	3.30312E-08
108	2	2	3	3.37826E-08
109	2	3	3	3.40218E-08

110	2	4	3	3.46083E-08
111	2	5	3	3.47611E-08
112	2	6	3	3.48765E-08
113	2	7	3	3.45619E-08
114	2	8	3	3.44788E-08
115	2	1	4	3.31205E-08
116	2	2	4	3.35572E-08
117	2	3	4	3.41925E-08
118	2	4	4	3.44559E-08
119	2	5	4	3.46943E-08
120	2	6	4	3.45888E-08
121	2	7	4	3.47556E-08
122	2	8	4	3.45511E-08
123	3	1	1	3.12960E-08
124	3	2	1	3.22753E-08
125	3	3	1	3.27659E-08
126	3	4	1	3.25693E-08
127	3	5	1	3.24680E-08
128	3	6	1	3.22664E-08
129	3	7	1	3.19573E-08
130	3	8	1	3.12050E-08
131	3	1	2	3.21369E-08
132	3	2	2	3.34730E-08
133	3	3	2	3.36110E-08
134	3	4	2	3.33594E-08
135	3	5	2	3.29919E-08
136	3	6	2	3.32229E-08
137	3	7	2	3.27380E-08
138	3	8	2	3.17230E-08
139	3	1	3	3.21552E-08
140	3	2	3	3.29921E-08
141	3	3	3	3.34431E-08
142	3	4	3	3.33099E-08
143	3	5	3	3.34037E-08
144	3	6	3	3.30618E-08
145	3	7	3	3.27297E-08
146	3	8	3	3.15634E-08
147	4	1	1	3.03624E-08
148	4	2	1	3.02115E-08
149	4	3	1	3.03558E-08
150	4	4	1	2.94983E-08

151	4	5	1	2.92914E-08
152	4	6	1	2.83058E-08
153	4	1	2	3.02815E-08
154	4	2	2	3.08172E-08
155	4	3	2	3.02976E-08
156	4	4	2	2.99848E-08
157	4	5	2	2.94798E-08
158	4	6	2	2.86958E-08
159	4	1	3	3.19804E-08
160	4	2	3	3.19865E-08
161	4	3	3	3.20461E-08
162	4	4	3	3.15648E-08
163	4	5	3	3.12723E-08
164	4	6	3	3.03471E-08
165	4	1	4	3.22088E-08
166	4	2	4	3.22225E-08
167	4	3	4	3.18403E-08
168	4	4	4	3.12972E-08
169	4	5	4	3.09277E-08
170	4	6	4	2.99042E-08
171	5	1	1	3.61125E-08
172	5	2	1	3.36306E-08
173	5	3	1	3.14579E-08
174	5	4	1	2.90111E-08
175	5	5	1	2.63279E-08
176	5	6	1	2.30911E-08
177	5	1	2	3.54934E-08
178	5	2	2	3.38996E-08
179	5	3	2	3.17422E-08
180	5	4	2	2.91499E-08
181	5	5	2	2.63234E-08
182	5	6	2	2.28669E-08
183	5	1	3	3.80647E-08
184	5	2	3	3.62000E-08
185	5	3	3	3.36334E-08
186	5	4	3	3.03510E-08
187	5	5	3	2.67515E-08
188	5	6	3	2.41110E-08
189	5	1	4	3.80329E-08
190	5	2	4	3.59989E-08
191	5	3	4	3.39768E-08

192	5	4	4	3.05275E-08
193	5	5	4	2.76826E-08
194	5	6	4	2.42745E-08

B.7 AGR-567-as.runs: I-135 Concentration (moles) at the EOC (no decay)

Cycle 166B

TS = 62 (63-1=62 [i.e., second to last timestep])

AGR-567 (calculation with HOMOGENIZED model JMOCUP calculation)
data from: FALCON: /ATR/AGR-567-as.runs/166B/fcompch/iodine2.agr567.166B.ts.62.I135.output

Compact No.	Capsule No.	Level No.	Stack No.	I-135 Conc (moles)
1	1	1	1	2.18661E-08
2	1	2	1	2.51889E-08
3	1	3	1	2.87956E-08
4	1	4	1	3.08722E-08
5	1	5	1	3.34569E-08
6	1	6	1	3.48442E-08
7	1	7	1	3.63948E-08
8	1	8	1	3.71149E-08
9	1	9	1	3.80440E-08
10	1	1	2	2.19349E-08
11	1	2	2	2.54755E-08
12	1	3	2	2.86435E-08
13	1	4	2	3.09304E-08
14	1	5	2	3.32566E-08
15	1	6	2	3.47363E-08
16	1	7	2	3.59460E-08
17	1	8	2	3.71684E-08
18	1	9	2	3.79581E-08
19	1	1	3	2.21044E-08
20	1	2	3	2.55468E-08
21	1	3	3	2.89602E-08
22	1	4	3	3.13406E-08
23	1	5	3	3.38353E-08
24	1	6	3	3.52454E-08
25	1	7	3	3.61092E-08
26	1	8	3	3.71947E-08
27	1	9	3	3.83433E-08

28	1	1	4	2.25469E-08
29	1	2	4	2.56289E-08
30	1	3	4	2.92061E-08
31	1	4	4	3.18378E-08
32	1	5	4	3.40871E-08
33	1	6	4	3.66666E-08
34	1	7	4	3.73392E-08
35	1	8	4	3.83374E-08
36	1	9	4	3.93675E-08
37	1	1	5	2.33968E-08
38	1	2	5	2.64778E-08
39	1	3	5	3.00359E-08
40	1	4	5	3.30166E-08
41	1	5	5	3.52969E-08
42	1	6	5	3.69280E-08
43	1	7	5	3.89301E-08
44	1	8	5	3.91861E-08
45	1	9	5	4.02667E-08
46	1	1	6	2.36024E-08
47	1	2	6	2.71690E-08
48	1	3	6	3.00477E-08
49	1	4	6	3.34664E-08
50	1	5	6	3.56176E-08
51	1	6	6	3.71686E-08
52	1	7	6	3.91181E-08
53	1	8	6	4.00027E-08
54	1	9	6	4.06990E-08
55	1	1	7	2.38294E-08
56	1	2	7	2.71740E-08
57	1	3	7	3.04287E-08
58	1	4	7	3.30439E-08
59	1	5	7	3.58436E-08
60	1	6	7	3.74514E-08
61	1	7	7	3.88721E-08
62	1	8	7	4.03673E-08
63	1	9	7	4.08290E-08
64	1	1	8	2.31670E-08
65	1	2	8	2.68589E-08
66	1	3	8	3.00818E-08
67	1	4	8	3.30049E-08
68	1	5	8	3.47141E-08

69	1	6	8	3.73330E-08
70	1	7	8	3.83332E-08
71	1	8	8	3.93839E-08
72	1	9	8	4.01524E-08
73	1	1	9	2.23144E-08
74	1	2	9	2.63142E-08
75	1	3	9	2.90790E-08
76	1	4	9	3.14249E-08
77	1	5	9	3.39022E-08
78	1	6	9	3.62014E-08
79	1	7	9	3.73357E-08
80	1	8	9	3.82972E-08
81	1	9	9	3.98033E-08
82	1	1	10	2.21502E-08
83	1	2	10	2.57151E-08
84	1	3	10	2.87620E-08
85	1	4	10	3.11001E-08
86	1	5	10	3.33191E-08
87	1	6	10	3.56168E-08
88	1	7	10	3.68125E-08
89	1	8	10	3.76238E-08
90	1	9	10	3.87078E-08
91	2	1	1	2.80281E-08
92	2	2	1	2.83861E-08
93	2	3	1	2.85984E-08
94	2	4	1	2.84752E-08
95	2	5	1	2.86674E-08
96	2	6	1	2.87640E-08
97	2	7	1	2.86116E-08
98	2	8	1	2.86749E-08
99	2	1	2	2.82369E-08
100	2	2	2	2.81464E-08
101	2	3	2	2.86907E-08
102	2	4	2	2.83761E-08
103	2	5	2	2.89792E-08
104	2	6	2	2.85943E-08
105	2	7	2	2.82301E-08
106	2	8	2	2.85994E-08
107	2	1	3	2.96478E-08
108	2	2	3	2.96624E-08
109	2	3	3	2.98592E-08

110	2	4	3	2.99091E-08
111	2	5	3	3.01512E-08
112	2	6	3	3.01263E-08
113	2	7	3	2.98257E-08
114	2	8	3	3.01132E-08
115	2	1	4	2.96980E-08
116	2	2	4	3.00078E-08
117	2	3	4	3.01286E-08
118	2	4	4	3.01910E-08
119	2	5	4	3.03487E-08
120	2	6	4	2.99684E-08
121	2	7	4	2.96048E-08
122	2	8	4	2.98110E-08
123	3	1	1	2.71453E-08
124	3	2	1	2.80078E-08
125	3	3	1	2.85598E-08
126	3	4	1	2.83555E-08
127	3	5	1	2.81488E-08
128	3	6	1	2.82419E-08
129	3	7	1	2.81902E-08
130	3	8	1	2.73487E-08
131	3	1	2	2.81181E-08
132	3	2	2	2.89318E-08
133	3	3	2	2.91088E-08
134	3	4	2	2.87820E-08
135	3	5	2	2.91289E-08
136	3	6	2	2.86071E-08
137	3	7	2	2.88924E-08
138	3	8	2	2.81765E-08
139	3	1	3	2.82303E-08
140	3	2	3	2.90018E-08
141	3	3	3	2.89083E-08
142	3	4	3	2.90636E-08
143	3	5	3	2.91709E-08
144	3	6	3	2.90652E-08
145	3	7	3	2.92361E-08
146	3	8	3	2.82636E-08
147	4	1	1	2.69875E-08
148	4	2	1	2.69601E-08
149	4	3	1	2.73948E-08
150	4	4	1	2.65903E-08

151	4	5	1	2.64786E-08
152	4	6	1	2.58277E-08
153	4	1	2	2.73421E-08
154	4	2	2	2.71609E-08
155	4	3	2	2.71145E-08
156	4	4	2	2.69331E-08
157	4	5	2	2.64107E-08
158	4	6	2	2.60919E-08
159	4	1	3	2.89181E-08
160	4	2	3	2.85553E-08
161	4	3	3	2.83566E-08
162	4	4	3	2.86304E-08
163	4	5	3	2.81337E-08
164	4	6	3	2.75378E-08
165	4	1	4	2.86005E-08
166	4	2	4	2.84965E-08
167	4	3	4	2.88750E-08
168	4	4	4	2.83656E-08
169	4	5	4	2.80498E-08
170	4	6	4	2.74852E-08
171	5	1	1	3.38661E-08
172	5	2	1	3.21556E-08
173	5	3	1	3.02736E-08
174	5	4	1	2.84069E-08
175	5	5	1	2.50899E-08
176	5	6	1	2.27111E-08
177	5	1	2	3.39934E-08
178	5	2	2	3.25026E-08
179	5	3	2	3.01073E-08
180	5	4	2	2.78183E-08
181	5	5	2	2.50460E-08
182	5	6	2	2.22630E-08
183	5	1	3	3.60181E-08
184	5	2	3	3.47112E-08
185	5	3	3	3.23392E-08
186	5	4	3	2.99477E-08
187	5	5	3	2.68357E-08
188	5	6	3	2.37607E-08
189	5	1	4	3.55762E-08
190	5	2	4	3.39038E-08
191	5	3	4	3.22016E-08

192	5	4	4	2.91374E-08
193	5	5	4	2.67242E-08
194	5	6	4	2.42081E-08

B.8 AGR-567-as.runs: I-135 Concentration (moles) at the EOC (no decay)

Cycle 167A
TS = 12 (For this unusual PAL M cycle we use the last timestep, instead of the second to last timestep—core power was steady increasing last 3 days of cycle)

AGR-567 (calculation with HOMOGENIZED model JMOCUP calculation)
data from: FALCON: /ATR/AGR-567-as.runs/167A/fcompch/iodine2.agr567.167A.ts.12.I135.output

Compact No.	Capsule No.	Level No.	Stack No.	I-135 Conc (moles)
1	1	1	1	1.58581E-08
2	1	2	1	1.81648E-08
3	1	3	1	2.02603E-08
4	1	4	1	2.21334E-08
5	1	5	1	2.36318E-08
6	1	6	1	2.47412E-08
7	1	7	1	2.58784E-08
8	1	8	1	2.63215E-08
9	1	9	1	2.71526E-08
10	1	1	2	1.57591E-08
11	1	2	2	1.83171E-08
12	1	3	2	2.05603E-08
13	1	4	2	2.25316E-08
14	1	5	2	2.38768E-08
15	1	6	2	2.49364E-08
16	1	7	2	2.58596E-08
17	1	8	2	2.62127E-08
18	1	9	2	2.67468E-08
19	1	1	3	1.64563E-08
20	1	2	3	1.90623E-08
21	1	3	3	2.11560E-08
22	1	4	3	2.27279E-08
23	1	5	3	2.45202E-08
24	1	6	3	2.60177E-08
25	1	7	3	2.65436E-08
26	1	8	3	2.71817E-08
27	1	9	3	2.75276E-08

28	1	1	4	1.68131E-08
29	1	2	4	1.94637E-08
30	1	3	4	2.17478E-08
31	1	4	4	2.38487E-08
32	1	5	4	2.54292E-08
33	1	6	4	2.67394E-08
34	1	7	4	2.76619E-08
35	1	8	4	2.82241E-08
36	1	9	4	2.84176E-08
37	1	1	5	1.76518E-08
38	1	2	5	1.98499E-08
39	1	3	5	2.22785E-08
40	1	4	5	2.46002E-08
41	1	5	5	2.63497E-08
42	1	6	5	2.73848E-08
43	1	7	5	2.84895E-08
44	1	8	5	2.88531E-08
45	1	9	5	2.90450E-08
46	1	1	6	1.81080E-08
47	1	2	6	2.05705E-08
48	1	3	6	2.23339E-08
49	1	4	6	2.42826E-08
50	1	5	6	2.61220E-08
51	1	6	6	2.72249E-08
52	1	7	6	2.89044E-08
53	1	8	6	2.91324E-08
54	1	9	6	2.93009E-08
55	1	1	7	1.76467E-08
56	1	2	7	2.01599E-08
57	1	3	7	2.22022E-08
58	1	4	7	2.42902E-08
59	1	5	7	2.57808E-08
60	1	6	7	2.70985E-08
61	1	7	7	2.81456E-08
62	1	8	7	2.87353E-08
63	1	9	7	2.91187E-08
64	1	1	8	1.69531E-08
65	1	2	8	1.97961E-08
66	1	3	8	2.16613E-08
67	1	4	8	2.34425E-08
68	1	5	8	2.55288E-08

69	1	6	8	2.67642E-08
70	1	7	8	2.76411E-08
71	1	8	8	2.82863E-08
72	1	9	8	2.81251E-08
73	1	1	9	1.65095E-08
74	1	2	9	1.87829E-08
75	1	3	9	2.09397E-08
76	1	4	9	2.25938E-08
77	1	5	9	2.48900E-08
78	1	6	9	2.58597E-08
79	1	7	9	2.65891E-08
80	1	8	9	2.71238E-08
81	1	9	9	2.75517E-08
82	1	1	10	1.62375E-08
83	1	2	10	1.84360E-08
84	1	3	10	2.03146E-08
85	1	4	10	2.22846E-08
86	1	5	10	2.38879E-08
87	1	6	10	2.47192E-08
88	1	7	10	2.61955E-08
89	1	8	10	2.67915E-08
90	1	9	10	2.71877E-08
91	2	1	1	1.95547E-08
92	2	2	1	1.95243E-08
93	2	3	1	1.97062E-08
94	2	4	1	1.97509E-08
95	2	5	1	1.96657E-08
96	2	6	1	1.97678E-08
97	2	7	1	1.95809E-08
98	2	8	1	1.97130E-08
99	2	1	2	1.99630E-08
100	2	2	2	2.01312E-08
101	2	3	2	2.02564E-08
102	2	4	2	1.99273E-08
103	2	5	2	2.01604E-08
104	2	6	2	2.00888E-08
105	2	7	2	1.97302E-08
106	2	8	2	1.98478E-08
107	2	1	3	2.15358E-08
108	2	2	3	2.17087E-08
109	2	3	3	2.17659E-08

110	2	4	3	2.17528E-08
111	2	5	3	2.17237E-08
112	2	6	3	2.14251E-08
113	2	7	3	2.11526E-08
114	2	8	3	2.12992E-08
115	2	1	4	2.07442E-08
116	2	2	4	2.10334E-08
117	2	3	4	2.10908E-08
118	2	4	4	2.11093E-08
119	2	5	4	2.09185E-08
120	2	6	4	2.11162E-08
121	2	7	4	2.09828E-08
122	2	8	4	2.10235E-08
123	3	1	1	1.88924E-08
124	3	2	1	1.94527E-08
125	3	3	1	1.94020E-08
126	3	4	1	1.95258E-08
127	3	5	1	1.92536E-08
128	3	6	1	1.94984E-08
129	3	7	1	1.94028E-08
130	3	8	1	1.90264E-08
131	3	1	2	1.98754E-08
132	3	2	2	2.02723E-08
133	3	3	2	2.00470E-08
134	3	4	2	2.01620E-08
135	3	5	2	2.01729E-08
136	3	6	2	2.01078E-08
137	3	7	2	2.00953E-08
138	3	8	2	2.00306E-08
139	3	1	3	1.94968E-08
140	3	2	3	1.98816E-08
141	3	3	3	1.99973E-08
142	3	4	3	1.99130E-08
143	3	5	3	2.01521E-08
144	3	6	3	2.01737E-08
145	3	7	3	2.00736E-08
146	3	8	3	1.99119E-08
147	4	1	1	1.87713E-08
148	4	2	1	1.88890E-08
149	4	3	1	1.90962E-08
150	4	4	1	1.87825E-08

151	4	5	1	1.88746E-08
152	4	6	1	1.83662E-08
153	4	1	2	1.92463E-08
154	4	2	2	1.94267E-08
155	4	3	2	1.93797E-08
156	4	4	2	1.92816E-08
157	4	5	2	1.90116E-08
158	4	6	2	1.88954E-08
159	4	1	3	2.08590E-08
160	4	2	3	2.07094E-08
161	4	3	3	2.06012E-08
162	4	4	3	2.05186E-08
163	4	5	3	2.04702E-08
164	4	6	3	2.01357E-08
165	4	1	4	2.01256E-08
166	4	2	4	2.01526E-08
167	4	3	4	2.00935E-08
168	4	4	4	2.02541E-08
169	4	5	4	2.00988E-08
170	4	6	4	1.95351E-08
171	5	1	1	2.42902E-08
172	5	2	1	2.34102E-08
173	5	3	1	2.22284E-08
174	5	4	1	2.06138E-08
175	5	5	1	1.84304E-08
176	5	6	1	1.64227E-08
177	5	1	2	2.44677E-08
178	5	2	2	2.35474E-08
179	5	3	2	2.20305E-08
180	5	4	2	2.10213E-08
181	5	5	2	1.89660E-08
182	5	6	2	1.69447E-08
183	5	1	3	2.65899E-08
184	5	2	3	2.49904E-08
185	5	3	3	2.39295E-08
186	5	4	3	2.21273E-08
187	5	5	3	1.99050E-08
188	5	6	3	1.79660E-08
189	5	1	4	2.55775E-08
190	5	2	4	2.48323E-08
191	5	3	4	2.36150E-08

192	5	4	4	2.19803E-08
193	5	5	4	1.95504E-08
194	5	6	4	1.74474E-08

B.9 AGR-567-as.runs: I-135 Concentration (moles) at the EOC (no decay)

Cycle 168A

TS = 67 (68-1=67 [i.e., second to last timestep])

AGR-567 (calculation with HOMOGENIZED model JMOCUP calculation)
data from: FALCON: /ATR/AGR-567-as.runs/168A/fcompch/iodine2.agr567.168A.ts.67.I135.output

Compact No.	Capsule No.	Level No.	Stack No.	I-135 Conc (moles)
1	1	1	1	2.21885E-08
2	1	2	1	2.54967E-08
3	1	3	1	2.87360E-08
4	1	4	1	3.11246E-08
5	1	5	1	3.27368E-08
6	1	6	1	3.42603E-08
7	1	7	1	3.50683E-08
8	1	8	1	3.55313E-08
9	1	9	1	3.65264E-08
10	1	1	2	2.20540E-08
11	1	2	2	2.59329E-08
12	1	3	2	2.83316E-08
13	1	4	2	3.10181E-08
14	1	5	2	3.31170E-08
15	1	6	2	3.41671E-08
16	1	7	2	3.49088E-08
17	1	8	2	3.55817E-08
18	1	9	2	3.66535E-08
19	1	1	3	2.26618E-08
20	1	2	3	2.57525E-08
21	1	3	3	2.84459E-08
22	1	4	3	3.14240E-08
23	1	5	3	3.30348E-08
24	1	6	3	3.46266E-08
25	1	7	3	3.51831E-08
26	1	8	3	3.56625E-08
27	1	9	3	3.68797E-08

28	1	1	4	2.30528E-08
29	1	2	4	2.59984E-08
30	1	3	4	2.89283E-08
31	1	4	4	3.15632E-08
32	1	5	4	3.30518E-08
33	1	6	4	3.53887E-08
34	1	7	4	3.57625E-08
35	1	8	4	3.60095E-08
36	1	9	4	3.72807E-08
37	1	1	5	2.35899E-08
38	1	2	5	2.69373E-08
39	1	3	5	2.97102E-08
40	1	4	5	3.17122E-08
41	1	5	5	3.39689E-08
42	1	6	5	3.57379E-08
43	1	7	5	3.63506E-08
44	1	8	5	3.66757E-08
45	1	9	5	3.78344E-08
46	1	1	6	2.38435E-08
47	1	2	6	2.76222E-08
48	1	3	6	3.00344E-08
49	1	4	6	3.21095E-08
50	1	5	6	3.40639E-08
51	1	6	6	3.59791E-08
52	1	7	6	3.66482E-08
53	1	8	6	3.73633E-08
54	1	9	6	3.82433E-08
55	1	1	7	2.37644E-08
56	1	2	7	2.69679E-08
57	1	3	7	2.97249E-08
58	1	4	7	3.21206E-08
59	1	5	7	3.42890E-08
60	1	6	7	3.57705E-08
61	1	7	7	3.68631E-08
62	1	8	7	3.71769E-08
63	1	9	7	3.84877E-08
64	1	1	8	2.36242E-08
65	1	2	8	2.65244E-08
66	1	3	8	2.97010E-08
67	1	4	8	3.21289E-08
68	1	5	8	3.39874E-08

69	1	6	8	3.54420E-08
70	1	7	8	3.63949E-08
71	1	8	8	3.69444E-08
72	1	9	8	3.79673E-08
73	1	1	9	2.30247E-08
74	1	2	9	2.63620E-08
75	1	3	9	2.91007E-08
76	1	4	9	3.17824E-08
77	1	5	9	3.31069E-08
78	1	6	9	3.48472E-08
79	1	7	9	3.60268E-08
80	1	8	9	3.63066E-08
81	1	9	9	3.76276E-08
82	1	1	10	2.25517E-08
83	1	2	10	2.59616E-08
84	1	3	10	2.86382E-08
85	1	4	10	3.10685E-08
86	1	5	10	3.29512E-08
87	1	6	10	3.45483E-08
88	1	7	10	3.51005E-08
89	1	8	10	3.58538E-08
90	1	9	10	3.70093E-08
91	2	1	1	2.79561E-08
92	2	2	1	2.78051E-08
93	2	3	1	2.81819E-08
94	2	4	1	2.82807E-08
95	2	5	1	2.81721E-08
96	2	6	1	2.84358E-08
97	2	7	1	2.82234E-08
98	2	8	1	2.84353E-08
99	2	1	2	2.79617E-08
100	2	2	2	2.80105E-08
101	2	3	2	2.81444E-08
102	2	4	2	2.80711E-08
103	2	5	2	2.79651E-08
104	2	6	2	2.80023E-08
105	2	7	2	2.80061E-08
106	2	8	2	2.85186E-08
107	2	1	3	2.84150E-08
108	2	2	3	2.85384E-08
109	2	3	3	2.87404E-08

110	2	4	3	2.88423E-08
111	2	5	3	2.87447E-08
112	2	6	3	2.85556E-08
113	2	7	3	2.86394E-08
114	2	8	3	2.87087E-08
115	2	1	4	2.82326E-08
116	2	2	4	2.86364E-08
117	2	3	4	2.86802E-08
118	2	4	4	2.88335E-08
119	2	5	4	2.85391E-08
120	2	6	4	2.85762E-08
121	2	7	4	2.84757E-08
122	2	8	4	2.91041E-08
123	3	1	1	2.71592E-08
124	3	2	1	2.75661E-08
125	3	3	1	2.76929E-08
126	3	4	1	2.78005E-08
127	3	5	1	2.77819E-08
128	3	6	1	2.74453E-08
129	3	7	1	2.75195E-08
130	3	8	1	2.73043E-08
131	3	1	2	2.76831E-08
132	3	2	2	2.80025E-08
133	3	3	2	2.76008E-08
134	3	4	2	2.81857E-08
135	3	5	2	2.81248E-08
136	3	6	2	2.78451E-08
137	3	7	2	2.77292E-08
138	3	8	2	2.74482E-08
139	3	1	3	2.78616E-08
140	3	2	3	2.80459E-08
141	3	3	3	2.78629E-08
142	3	4	3	2.83143E-08
143	3	5	3	2.81999E-08
144	3	6	3	2.80835E-08
145	3	7	3	2.77568E-08
146	3	8	3	2.77025E-08
147	4	1	1	2.71605E-08
148	4	2	1	2.70180E-08
149	4	3	1	2.70446E-08
150	4	4	1	2.63521E-08

151	4	5	1	2.60912E-08
152	4	6	1	2.59654E-08
153	4	1	2	2.70938E-08
154	4	2	2	2.69014E-08
155	4	3	2	2.69805E-08
156	4	4	2	2.62787E-08
157	4	5	2	2.63826E-08
158	4	6	2	2.61885E-08
159	4	1	3	2.79833E-08
160	4	2	3	2.75502E-08
161	4	3	3	2.76196E-08
162	4	4	3	2.69717E-08
163	4	5	3	2.70568E-08
164	4	6	3	2.68554E-08
165	4	1	4	2.77923E-08
166	4	2	4	2.76596E-08
167	4	3	4	2.71842E-08
168	4	4	4	2.73130E-08
169	4	5	4	2.68947E-08
170	4	6	4	2.66000E-08
171	5	1	1	3.38949E-08
172	5	2	1	3.25905E-08
173	5	3	1	3.09883E-08
174	5	4	1	2.81629E-08
175	5	5	1	2.63482E-08
176	5	6	1	2.36755E-08
177	5	1	2	3.42030E-08
178	5	2	2	3.25205E-08
179	5	3	2	3.09657E-08
180	5	4	2	2.84235E-08
181	5	5	2	2.60674E-08
182	5	6	2	2.33811E-08
183	5	1	3	3.53445E-08
184	5	2	3	3.37290E-08
185	5	3	3	3.18286E-08
186	5	4	3	2.95712E-08
187	5	5	3	2.72524E-08
188	5	6	3	2.38362E-08
189	5	1	4	3.52616E-08
190	5	2	4	3.36025E-08
191	5	3	4	3.16408E-08

192	5	4	4	2.96811E-08
193	5	5	4	2.68573E-08
194	5	6	4	2.43342E-08

Appendix C
End-of-Cycle Release Fractions of ^{135}I

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Appendix C
End-of-Cycle Release Fractions of ^{135}I

Release Fraction of Extrapolated ^{135}I to EOC ^{135}I Calculated Concentrations

Table C-1. Release fractions for AGR-5/6/7 for irradiation intervals 1–9.

Cycle	Interval	Capsule 1	Capsule 2	Capsule 3	Capsule 4	Capsule 5
162B	1	3.61E-06	1.44E-06	1.03E-06	9.45E-07	8.45E-07
163A	2	4.13E-06	1.67E-06	1.21E-06	1.06E-06	9.09E-07
164A	3	3.59E-06	1.39E-06	9.99E-07	9.01E-07	8.19E-07
164B	4	3.35E-06	1.17E-06	8.38E-07	7.87E-07	7.85E-07
165A	5	3.83E-06	1.34E-06	9.76E-07	9.07E-07	8.92E-07
166A	6	3.17E-06	1.07E-06	7.83E-07	7.35E-07	7.39E-07
166B	7	2.96E-06	9.35E-07	6.85E-07	6.61E-07	7.10E-07
167A	8	2.15E-06	6.58E-07	4.75E-07	4.72E-07	5.21E-07
168A	9	2.88E-06	9.08E-07	6.67E-07	6.47E-07	7.14E-07

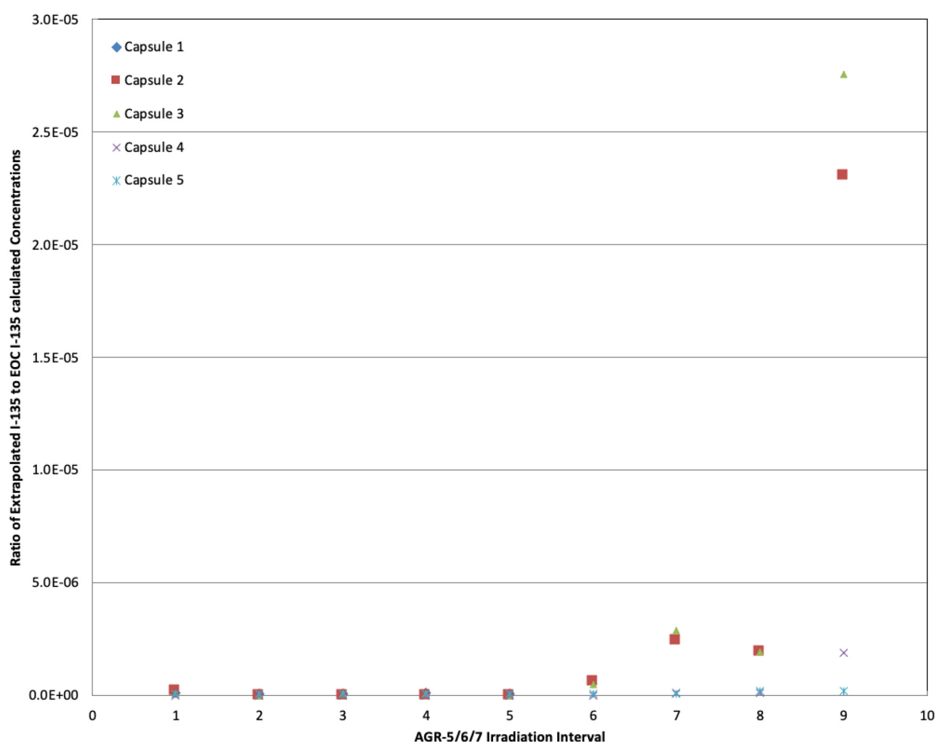

Figure C-1. I-1^{135}I 35 release fraction versus operating intervals for experiment AGR-5/6/7. The low release fraction indicates good fuel performance from operating Cycles 162B through 165A. After Cycle 165A contamination of failed fuel from Capsule 1 into other capsules was evident and the possibility of additional fuel failures in Capsules 2 and 3 are captured in this plot. All data after interval 5 are used for trending purposes.