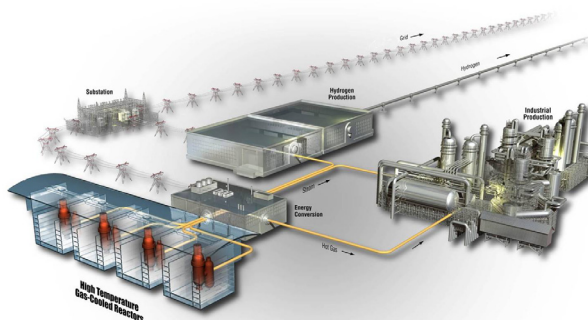


Quantity of ^{135}I Released from the AGR-1, AGR-2, and AGR-3/4 Experiments and Discovery of ^{131}I at the FPMS Traps during the AGR-3/4 Experiment

D.M. Scates
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September 2014

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September 2014

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VHTR Program

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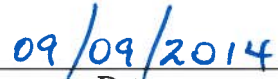
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ABSTRACT

A series of three Advanced Gas Reactor (AGR) experiments have been conducted in the Advanced Test Reactor (ATR) at Idaho National Laboratory (INL). From 2006 through 2014, these experiments supported the development and qualification of the new U.S. tristructural isotropic (TRISO) particle fuel for Very High Temperature Reactors (VHTR). Each AGR 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 which fail during irradiation, or those designed-to-fail (DTF) 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 and compared to similar releases for noble gases as well as the unexpected finding of ^{131}I deposition from intentional impure gas injection into capsule 11 of experiment AGR-3/4.

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ACRONYMS

AGR	Advanced Gas Reactor
AIM	Acquisition Interface Module
ATR	Advanced Test Reactor
DTF	designed-to-fail
EOC	end of cycle
FPM	Fission Product Monitor
FPMS	Fission Product Monitor System
HPGe	High Purity Germanium
INL	Idaho National Laboratory
MCA	Multi-Channel Analyzer
MCS	Multi-channel Scalar
NDMAS	Nuclear Data Management and Analysis System
TRISO	tristructural isotropic
VHTR	Very High Temperature Reactor

Quantity of ^{135}I Released from the AGR-1, AGR-2, and AGR-3/4 Experiments and Discovery of ^{131}I at the FPMS Traps during the AGR-3/4 Experiment

1. INTRODUCTION

AGR-1, 2 and 3/4 are the first of the Advanced Gas Reactor (AGR) 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 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, whether those which fail during irradiation or a minute percentage of particles that was initially defective, can release fission products to the flowing effluent gas stream. Because reactive fission product elements like iodine and cesium readily 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 released ^{135}I from these three experiments and discusses how ^{135}I concentrations are determined from measured $^{135\text{m}}\text{Xe}$ concentrations. Once the ^{135}I is determined, it is then compared to the end of cycle (EOC) computed ^{135}I inventories. From these comparisons one can infer fuel integrity. This paper also briefly discusses the surprise finding of ^{131}I in three of the FPM sample chambers.

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 with a half-life of 9.1 hours. Among the populated states of ^{135}Xe , the isomeric state of $^{135\text{m}}\text{Xe}$ 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].

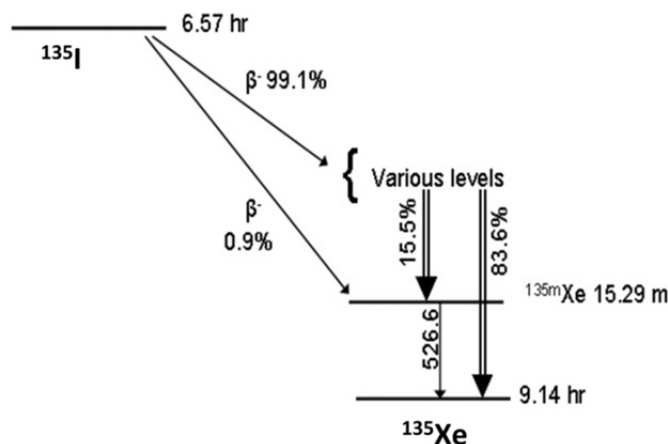


Figure 1. Simplified decay scheme of ^{135}I .

During irradiation, ^{135}Xe and $^{135\text{m}}\text{Xe}$ 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 $^{135\text{m}}\text{Xe}$ is the decay of ^{135}I accumulated during irradiation. The $^{135\text{m}}\text{Xe}$ production rate will equal the decay rate of the ^{135}I parent. After several $^{135\text{m}}\text{Xe}$ 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 $^{135\text{m}}\text{Xe}$ concentrations in the flowing gas stream following reactor shutdown [2].

3. TECHNIQUES AND METHODS

3.1 Equipment and Measurements

The FPM System (FPMS) is a collection of seven FPM detectors, one for each experiment capsule, plus a spare. The first experiments, AGR-1 and AGR-2 consisted of 6 capsules per experiment, with an individual FPM for each capsule with one spare for a total of 7 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 (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. In concert 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 to modeled release rates, or similarly of measured to modeled capsule inventories. The NaI detector is used to monitor the gross gamma counting rate from the effluent gas flowing through the lines before they reach the sample chamber. The digitized results from the HPGe and NaI detectors are histogrammed by a Multi-Channel Analyzer (MCA) (provided by the Acquisition Interface Module (AIM)) and Multi-Channel Scalar (MCS) (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 which are used to compute daily capsule release activity values [3,4,5].

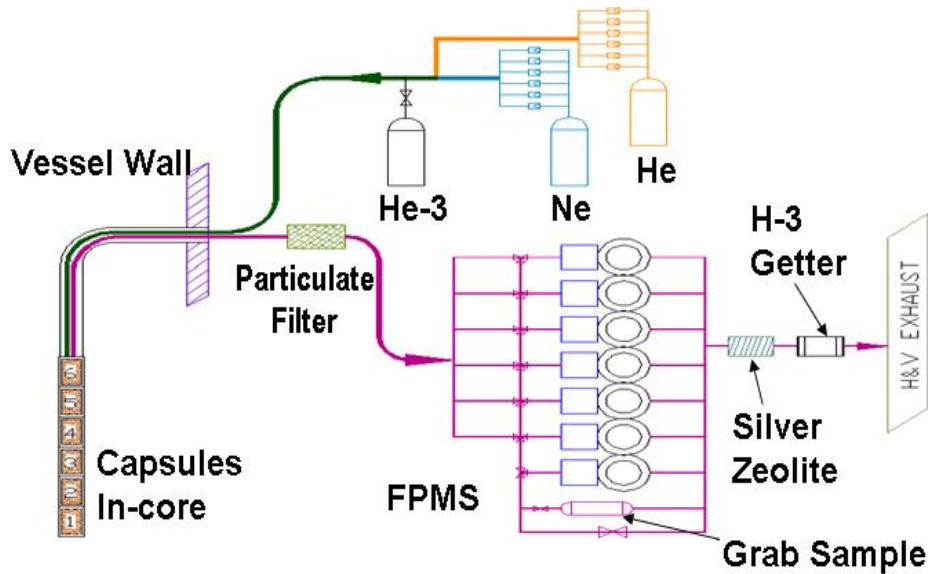


Figure 2. Simplified gas flow path for the AGR-1 and AGR-2 experiments. The AGR-3/4 experiment had 12 capsules in core and 14 dedicated FPMs. Each AGR experiment had one on-line spare FPM per six test train capsules.

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. 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. 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 which is 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.

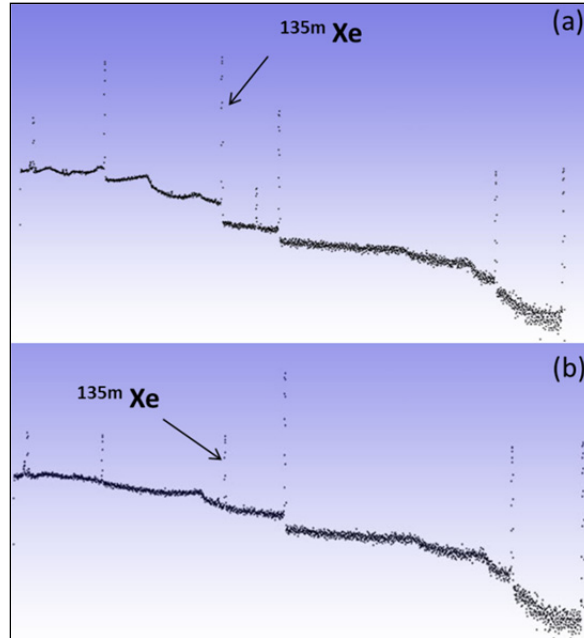


Figure 3. ^{135m}Xe clearly visible at the FGM chamber for AGR-3/4, Capsule 6, 11 hours (a) and 47 hours (b) after reactor shutdown.

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].

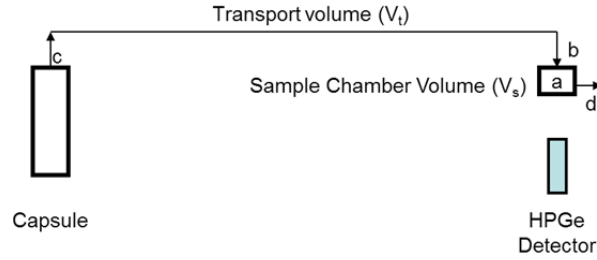


Figure 4. Single capsule flow diagram.

Released ^{135}I is presumed to be firmly deposited near the capsule and does not move downstream. Daughter $^{135\text{m}}\text{Xe}$ 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 $^{135\text{m}}\text{Xe}$ 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 continuously flows, 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].

3.3 Secular Equilibrium

It is important to understand the effect of the secular equilibrium relationship between ^{135}I and its $^{135\text{m}}\text{Xe}$ daughter in order to formulate the required corrections properly. Collocated the $^{135\text{m}}\text{Xe}$ (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 $^{135\text{m}}\text{Xe}$ and ^{135}I activities are nearly equal, and the $^{135\text{m}}\text{Xe}$ 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 $^{135\text{m}}\text{Xe}$ decays with its own 15.3 minute half-life. In the case of on-line 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 $^{135\text{m}}\text{Xe}$ activity changes in time according to the 6.6 hour ^{135}I half-life, but the absolute activity of $^{135\text{m}}\text{Xe}$ 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 $^{135\text{m}}\text{Xe}$ half-life. In other words, picking two positions along the downstream sample line separated in transport time by 15.3 minutes, the $^{135\text{m}}\text{Xe}$ 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 $^{135\text{m}}\text{Xe}$ concentration at the second point would be very close to half of the concentration measured at the first point [2].

3.4 Extrapolation and Corrections

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

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

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)

Because of the on-line nature of the FPMS data, the decay correction in the automatic analysis software is turned off. 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:

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

where:

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

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 $2.88 \times 10^4 \text{ s}$, thus f_1 equals 1.481 and any uncertainties are negligible [2].

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 (DCS) and then are transferred to the Nuclear Data Management and Analysis System (NDMAS) database. Capsule-specific transport volumes were determined by neon injection testing at the beginning of each AGR experiment. AGR-1, 2, and 3/4, each has specific transport volumes.

The correction factor f_2 can be computed as:

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

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].

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 $0.5\text{cm}^3/\text{s}$ 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 of 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]. 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].

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

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

For the measurements performed here, $V_s = 58 \pm 2 \text{ cm}^3$. 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 of 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].

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.

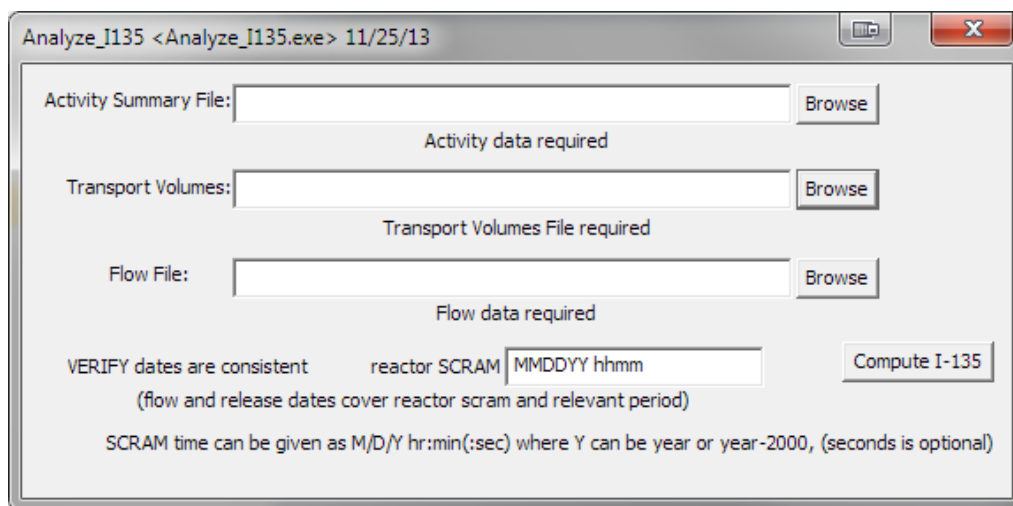


Figure 5. Screen capture of Analyze_I135, a semi-automatic, post-irradiation cycle data processing software.

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-ORIGEN2 Coupled Utility Program) [7, 8] utility code which links the standard and well-known MCNP5 [9] and ORIGEN2.2 (Oak Ridge Isotope Generation) [10] 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 in order 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 (R/B, %FIMA burnup, fission product and actinide concentrations, and fast fluence estimates) simply benefit from the high-resolution calculation.

EOC ^{135}I concentrations are calculated as part of the JMOCUP depletion calculation and are listed in Appendix B for all cycles of AGR-1, AGR-2 and AGR-3/4. 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 EOC release fractions of ^{135}I as a function of reciprocal fuel temperature are presented in Figure 6 for AGR-1 and Figure 7 for AGR-2 and AGR-3/4. In addition, the release rate to birth rate ratio for $^{135\text{m}}\text{Xe}$ just prior to EOC is also plotted in Figures 6 and 7. The ^{135}I and $^{135\text{m}}\text{Xe}$ exhibit similar behavior with respect to temperature. The low values indicate there was no fuel particle failure. The effective activation energy (Q_A) for the $^{135\text{m}}\text{Xe}$ R/B and of the ^{135}I release fraction are similar, $Q_A=32\text{kJ/mole}$ and $Q_A=41\text{kJ/mole}$ respectively for AGR-1.

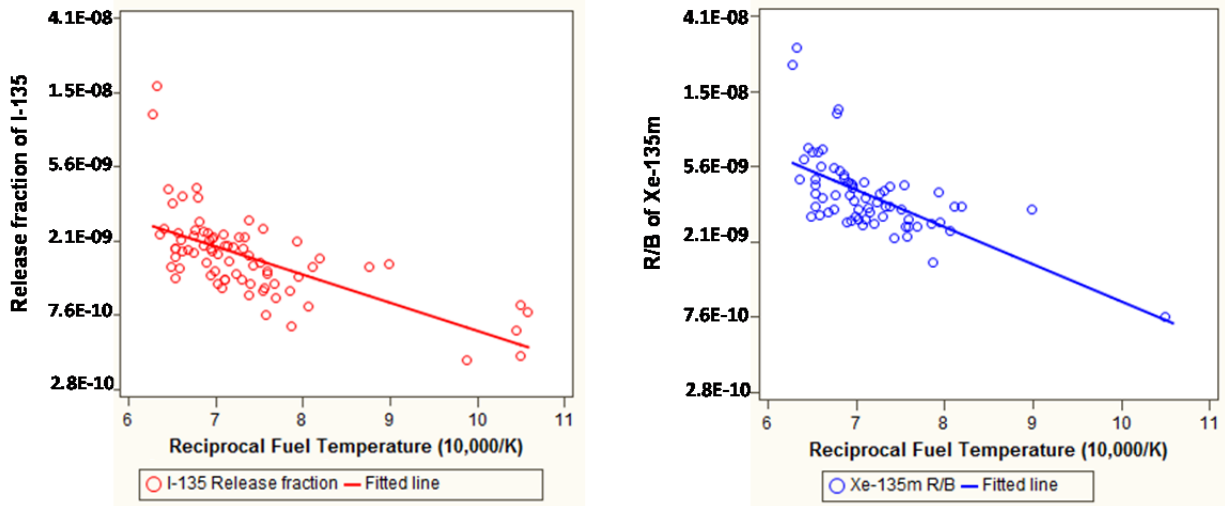


Figure 6. Release fraction of ^{135}I for AGR-1 and R/B for $^{135\text{m}}\text{Xe}$ for AGR-1 indicative of contamination.

For AGR-2 and AGR-3/4, the data trends with the preliminary capsule temperature data as well in Figure 7. It is believed that the AGR-2 experiment had an exposed fuel kernel in each capsule thus the higher release fraction and R/B ratio than that of AGR-1. Because of experiment gas flow issues during AGR-2, only the first three irradiation cycles (June 2010–January 2011) of AGR-2 data are presented in

Figure 7. AGR-3/4 contained approximately one percent of designed-to-fail (DTF) fuel particles, or approximately 960 DTF in approximately 91,000 driver particles. The first observable failures occurred within the first two weeks of irradiation starting in December of 2011. DTF fuel failures were observed until the end of the experiment in April 2014. Figure 7, captures the logarithm of the per failed particle quantity for ^{135m}Xe and ^{135}I , for AGR-3/4 and AGR-2 fuel with the exposed kernel in AGR-2 treated as a pre-experiment failure. The slope of the fitted line for ^{135m}Xe R/B per failure and the slope of the ^{135}I release fraction per failure trend similarly, with an effective activation energy, $Q_A=78\text{kJ/mole}$ and $Q_A=103\text{kJ/mole}$, respectively. This indicates that the measurement of ^{135m}Xe is a good indicator of ^{135}I presence and thus of fuel performance.

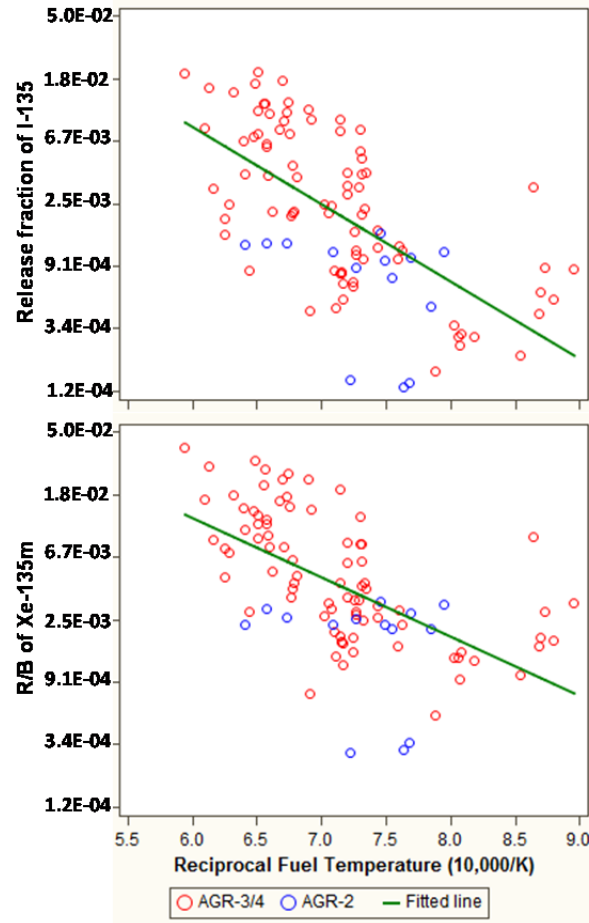


Figure 7. Release fraction of ^{135}I for AGR-2 and AGR-3/4 showing R/B per failed particle for ^{135m}Xe which seems to be an indicator for the presence of ^{135}I .

Because of plate-out issues, ^{135}I cannot easily be measured, however ^{135m}Xe is easily measured with the FPMS. In both Figure 6 and Figure 7, the ^{135}I release fraction is a factor of 2 less than the ^{135m}Xe R/B. These similarities indicate that ^{135m}Xe may be a good surrogate for ^{135}I for all three experiments, AGR-1, AGR-2, and AGR-3/4.

6. UNEXPECTED ^{131}I

An additional goal of the AGR-3/4 experiment was to study the effect of an impure gas mixture on failed TRISO fuel. The design called for injecting 0.5 sccm of impure gas in with the 30sccm of existing blended neon/helium gas mixture. The desired amounts of impurities in the flow to capsule 11 were: 50 ppmv hydrogen, 50 ppmv carbon monoxide, and 10 ppmv of water, with 29.5 sccm helium/neon. The

mixing ratio of impure gas to neon/helium gas was approximately 1 to 60 (0.5 sccm to 30 sccm). Investigation began in irradiation cycle 5. Injection was carried out briefly to establish design functionality starting on August 26, 2013 and ending on September 5, 2013. The injection resumed in earnest, officially starting on September 9, 2013.

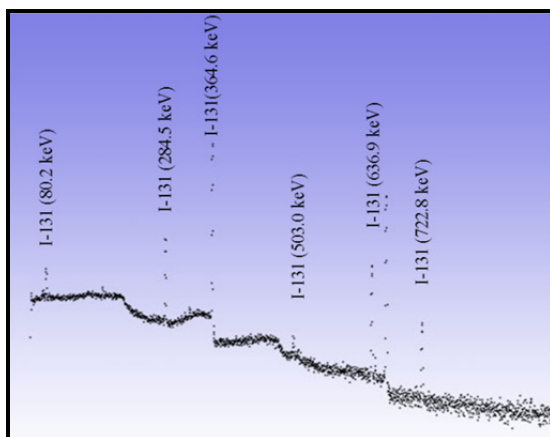


Figure 8. Iodine-131 from AGR-3/4 Capsule 11. ^{131}I is measured at the FGM sample chamber. This eight hour measurement was acquired on November 2, 2013; seventeen days post-irradiation of cycle 5 and 6 days prior to the start of irradiation cycle 6, and clearly shows the 6 strongest lines.

Iodine-131 was first identified in spectra from the capsule 11 outlet flow several days after the end of irradiation cycle 5. Spectra observed this long after reactor shutdown typically only show the usual background lines and the long lived ^{137}Cs which accumulates in the FPM sample chamber from the decay of ^{137}Xe . Interestingly, viewing six spectral lines from ^{131}I shown in Figure 8, and at appropriate relative intensities, was entirely unexpected. During irradiation these lines are mostly obscured by the gamma lines from the mobile krypton and xenon isotopes. At this activity level, these lines soon become apparent since most of the krypton and xenon isotopes decay away. Thus, even weaker activities readily show the strongest ^{131}I line at 364.6 keV, once the nearby lines from the short lived ^{89}Kr and ^{138}Cs decay away.

Review of all capsule 11 data for evidence of ^{131}I revealed another surprise seen in Figures 9 and 10. ^{131}I was present in the sample chamber of FPM 11 as early as irradiation cycle 2. An activity level of approximately 0.10 μCi was measured when the reactor was scrammed around mid-cycle on March 22 and again on March 27, 2012. Also, an activity level of approximately 0.14 μCi was measured at the end of the cycle on May 5, 2012.

The question arises, is this iodine specie flowing through the chamber like the krypton and xenon isotopes or is it stuck to the surface of the chamber? Figure 10 shows a small excess decrease in the ^{131}I activity in October 2013 during the shutdown following irradiation cycle 5. Over the course of 16 days during shutdown, the activity values shift from the upper decay line down by an extra 15% to the lower decay line. This means that while 75% decayed in two half-lives, only some 15% was removed from the source by desorption into the effluent gas. If the ^{131}I is 5 times more likely to decay as to desorb, then it's mostly fixed to the surface somewhere.

If the iodine is adhered at some upstream location, it seems likely to be similarly adhered at all points between the capsule and the FPM.

During irradiation cycle 5 the ^{131}I inventory in the FPM 11 sample chamber peaked at about 6.2 μCi , some 50 times the activity observed at the end of the 2nd irradiation cycle. This value can seem large, but in comparison to the expected inventory of ^{131}I it represents only 0.6 ppm reaching the FPM in this added impurity situation. When compared to the inventory just from failed fuel particles it is about 60 ppm.

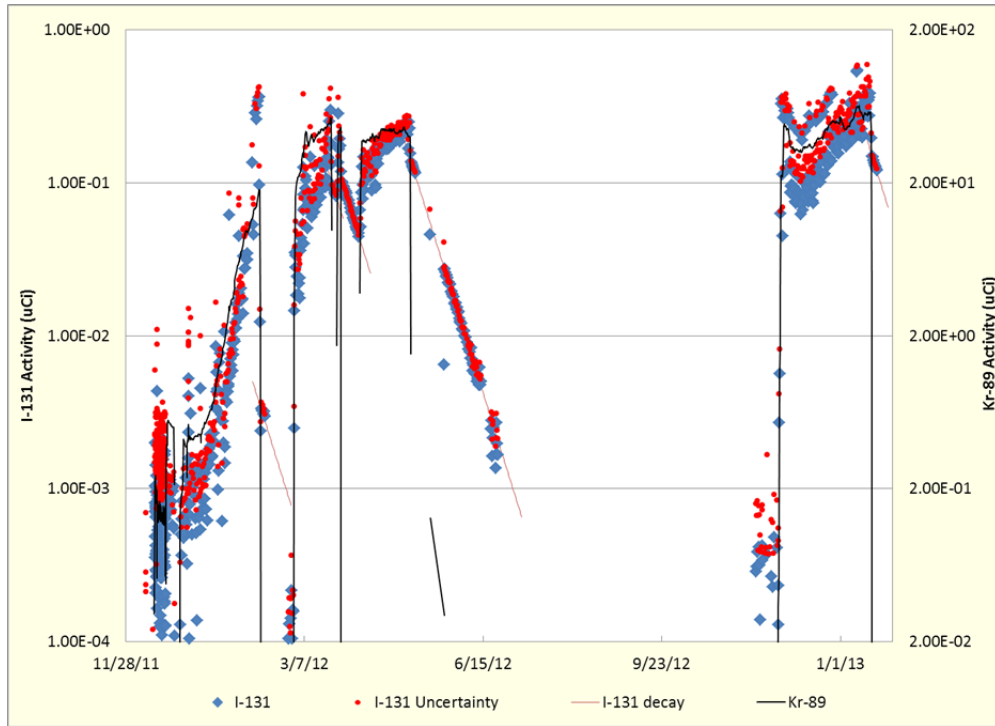


Figure 9. ^{131}I accumulation in FPM 11 for the first three irradiation cycles of AGR-3/4. The ^{131}I uncertainty is extremely small when close to the measured ^{131}I values as following end of cycle 2. These post EOC data trend with the decay rate of ^{131}I . Kr-89 is plotted to serve as visual aid in regards to when the reactor is running.

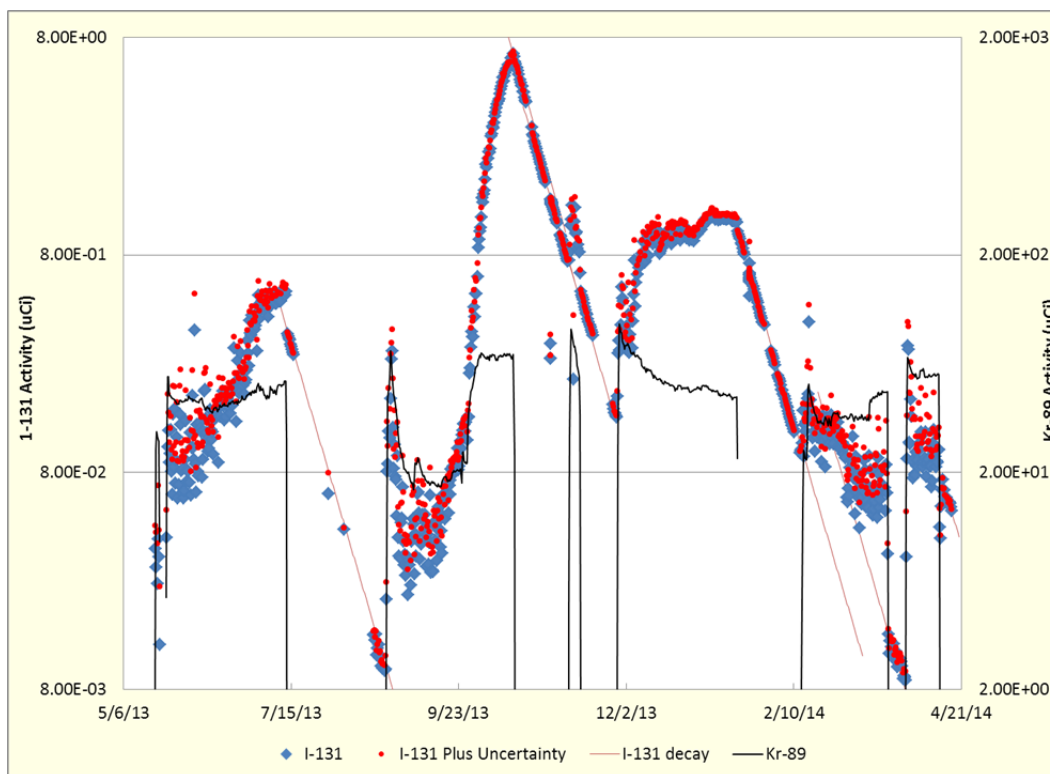


Figure 10. ^{131}I accumulation in FPM 11 of AGR-3/4 capsule 11 over the last 4 irradiation cycles. ^{131}I maximum plate-out within the FGMS sample chamber occurred during cycle 5.

The phenomenal increase in ^{131}I in FPM 11 with the addition of the impurities in irradiation cycle 5 strongly suggested that the impurities were helping to mobilize some of the ^{131}I capsule inventory. As a check, impurity addition was halted on February 21, 2014, 8 days into irradiation cycle 7. When the reactor was shut down mid cycle on March 21, the FPM 11 inventory was about 0.014 uCi. Decay corrected back to shutoff of the impurities on February 21, this would be about 0.17 uCi, consistent with the activity calculated from the 364.6 keV line after correction for ^{89}Kr and ^{138}Cs . The impurities were restored on March 28, 2014 when the reactor was restarted. When cycle 7 concluded on April 12, the inventory was at 0.078 uCi showing that iodine was again being mobilized, though at a lower level than at the end of cycle 6, for which mobilization was lower than for cycle 5.

The early arrival of ^{131}I at FPM 11 in irradiation cycle 2 prompted review of the data for all of the other capsules. Of the 11 other capsules only capsules 7 and 8 showed ^{131}I in the FPM sample chamber. FPM 7 and FPM 8 respectively had inventories of 1.9 and 1.8 μCi at the end of the first irradiation cycle. Both had significantly diminished activity afterwards as depicted in Figures 11 and 12 for FPM 7 and Figures 13 and 14 for FPM 8. For FPM 7, there was evidence of small additions to the sample chamber inventory early in cycle 2, at the mid cycle shutdowns on March 22 and March 27, 2012, about 0.06 and 0.02 μCi respectively. There was no convincing evidence for later additions to the FPM 7 inventory. For FPM 8, there were inventory additions totaling 0.31 μCi in irradiation cycle 2 and 0.05 μCi in irradiation cycle 6. The FPM 8 inventory at the end of cycle 6 amounts to 4 ppb of the capsule inventory and 0.4 ppm of the failed particle inventory.

Iodine-131 was clearly present in both FPM 7 and 8 after the first irradiation cycle, yet an impure gas mixture was never injected into those capsules. Our assumption is that some moisture was initially present in the graphite of these two capsules and off-gassed during the first few irradiation cycles providing mobility to the iodine inventory.

Release fractions of ^{131}I for each capsule at the end of each irradiation cycle are all below 1 ppm. When normalized such that only the inventory from failed particles is considered the release fraction values range from 0.1 to 60 ppm. These low values speak to the outstanding detection capability for the FPMS. ^{131}I plate-out is dominating the behavior but the overall release of ^{131}I is very small.

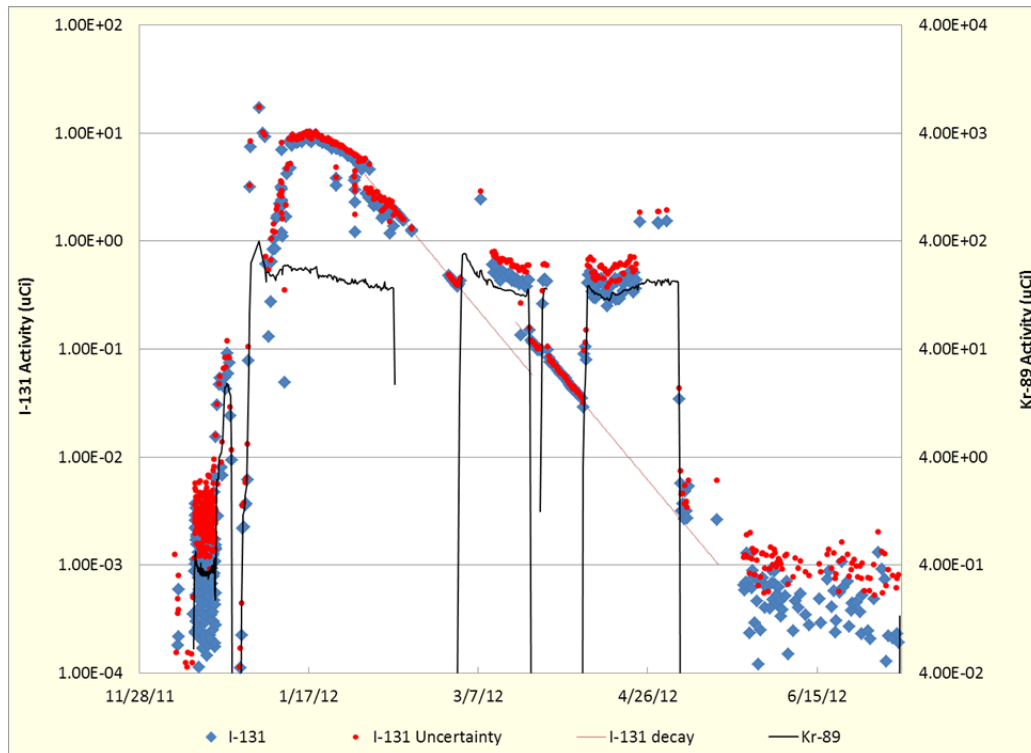


Figure 11. ^{131}I accumulation in FPM 7 for the first 2 irradiation cycles of AGR-3/4.

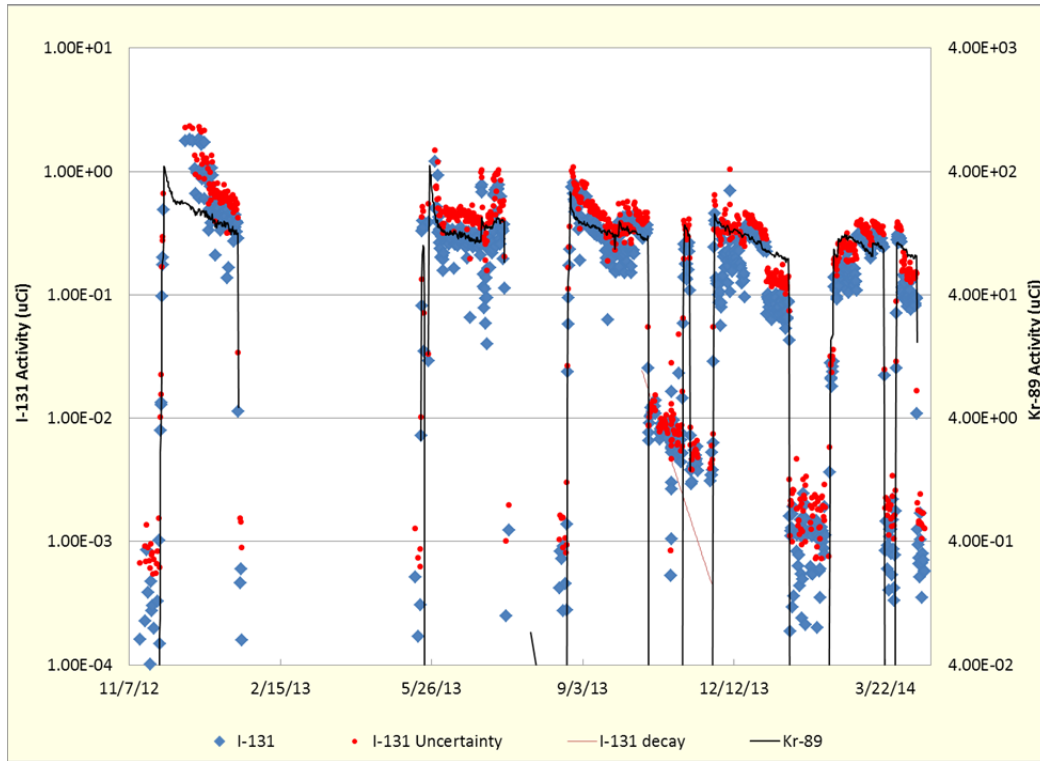


Figure 12. ^{131}I accumulation in FPM 7 for the last 5 irradiation cycles of AGR-3/4.

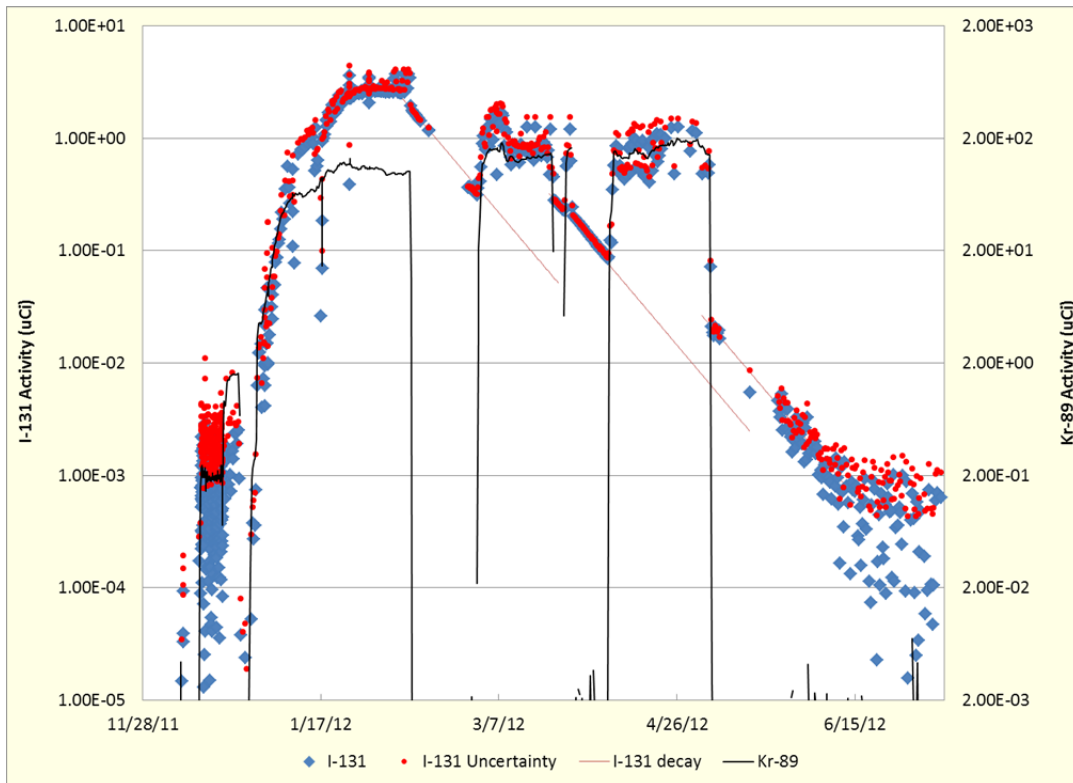


Figure 13. ^{131}I accumulation in FPM 8 for the first 2 irradiation cycles of AGR-3/4.

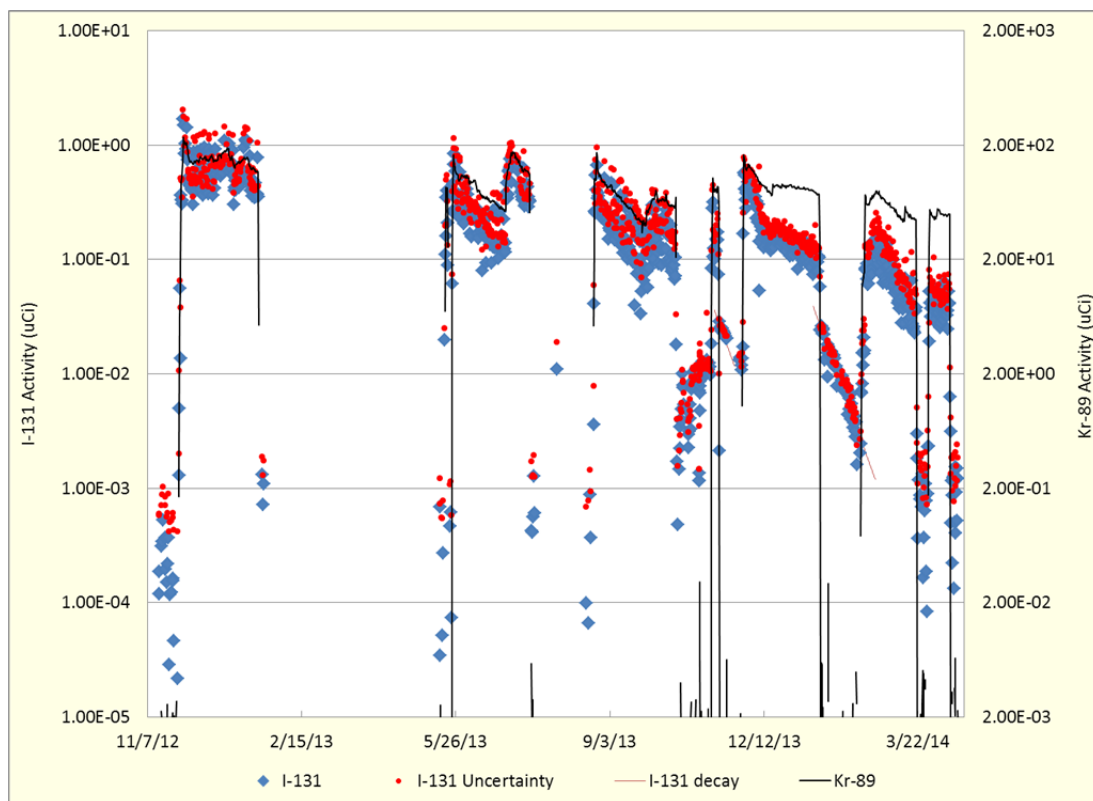


Figure 14. ^{131}I accumulation in FPM 8 for the last 5 irradiation cycles of AGR-3/4.

7. CONCLUSION

Three Advanced Gas Reactor experiments using TRISO fuel have been conducted in ATR at INL. From 2006 through 2014, these experiments supported the development and qualification effort of the U.S. TRISO particle fuel for Very High Temperature Reactors. 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 three AGR experiments was determined from measured $^{135\text{m}}\text{Xe}$ after the reactor shutdown. The amount of ^{135}I present can be an indicator of fuel integrity. For AGR-1, the release fraction for ^{135}I indicated that there were no failed particles and only contamination was present. Experiment temperature influenced the amounts of ^{135}I observed. In the case of AGR-2 and AGR-3/4, the release fraction was higher because of initially exposed fuel kernels in AGR-2 and failure of designed-to-fail (DTF) fuel in the AGR-3/4 experiment.

To study the effect of moisture on failed TRISO fuel, an impure gas mixture was injected into capsule 11 in the AGR-3/4 experiment. As moisture began to build up in capsule 11, the failed kernel may have become hydrolyzed and some of the ^{131}I mobilized and carried downstream to the FPM sample chamber. Small amounts of moisture were apparently present at the beginning of irradiation for capsules 7 and 8 in excess of test specifications; however exact moisture concentrations are unknown. The presence of ^{131}I is unmistakably visible in FPM sample chambers for capsules 7, 8 and 11 and there is no evidence of ^{131}I in the other capsule specific FPM sample chambers. ^{131}I release fractions were all below 1 ppm.

8. REFERENCES

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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 End of Cycle 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 irradiation, 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. Figure 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 .

A. 1 Sample output file for AGR-3/4, Capsule 1 from Analyze_I135.

File E:\AGR34\155B_FPE\I-135_20140412_0500.csv created by Analyze_I135 <Analyze_I135.exe> ver. 11/25/13

Capsule	Xe-135m			Flow	Xe-135m			Released	Released	extrapolated			error	chi2
	del t	Activity	% err		Activity	% err	Release	% err	I-135	I-135	to			
	hrs	Samp Vol			At Capsule				Activity	Activity shutdown				
		μCi			cc/s	Bq/cc	atoms/s		Bq	μCi	μCi			
Written 5/9/2014 11:19:46 by Analyze_I135 <Analyze_I135.exe> ver. 11/25/13 AGR-3/4 Cycle 1518 or later: capsule 1: Vt / unc (in SCC) = 168 wt. avg: 86.4541 std err: 2.4739 Chi2/n: 1.3047														
1	3.36	7.32E-01	1	0.319	1080.93	7	456963.4	7	2786362	75.3071	107.4018	7.5234	7.7527	
1	11.4	2.45E-01	1	0.323	360.8141	7	154168.4	7	940051.6	25.4068	84.597	5.9422	0.0977	
1	19.4	1.06E-01	1	0.322	156.6421	7	66735.9	7	406926.5	10.998	85.1765	6.0411	0.0447	
1	27.4	4.28E-02	2	0.324	62.6974	7	26943.2	7	164287.9	4.4402	79.9851	5.6861	1.2943	
1	35.4	1.82E-02	3	0.321	26.7739	7	11397.8	7	69499	1.8784	78.7014	5.8595	1.7506	
1	43.4	8.84E-03	4	0.313	13.1727	8	5465.6	8	33326.8	0.9007	87.7803	7.1407	0.0345	
1	51.44	3.63E-03	15	0.31	5.4283	17	2228.5	17	13588.3	0.3673	83.5602	14.0952	0.0422	
1	59.44	2.09E-03	13	0.31	3.1211	15	1281.5	15	7814.2	0.2112	111.768	16.4374	2.3717	
1	67.44	8.90E-04	24	0.31	1.3323	26	546.5	26	3332.1	0.0901	1.11E+02	2.83E+01	0.7449	
1	75.44	3.31E-04	61	0.31	0.4961	61	203.4	61	1240.2	0.0335	9.60E+01	5.85E+01	0.0265	
1	83.44	3.84E-04	57	0.308	0.5769	57	235.4	57	1435.4	0.0388	2.58E+02	1.48E+02	1.3469	

Appendix B

JMCOUP I135 Concentrations

B.1 AGR-1:

AGR-1 TRISO Compact Irradiation -- Compact ¹³⁵I Concentration (moles) at the EOC (no decay)

Cycle 138B

Sterbentz Calculation

ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ¹³⁵ I Conc (moles)	Stack No. 3 ¹³⁵ I Conc (moles)	Stack No. 2 ¹³⁵ I Conc (moles)	Total Concentration per capsule (moles)
6	1	9.07785E-09	9.15855E-09	5.78705E-09	9.09022E-08 Capsule 6
6	2	7.95400E-09	8.16470E-09	4.54850E-09	
6	3	7.69200E-09	7.95150E-09	4.25935E-09	
6	4	9.99100E-09	1.02142E-08	6.10350E-09	
5	5	1.15125E-08	1.15895E-08	7.05105E-09	
5	6	1.00980E-08	1.01620E-08	5.54770E-09	1.17322E-07 Capsule 5
5	7	1.05045E-08	1.05720E-08	5.71530E-09	
5	8	1.31050E-08	1.33075E-08	8.15655E-09	
4	9	1.40055E-08	1.40780E-08	8.82950E-09	
4	10	1.16660E-08	1.20505E-08	6.62115E-09	
4	11	1.16890E-08	1.22015E-08	6.67790E-09	1.35973E-07 Capsule 4
4	12	1.44525E-08	1.46025E-08	9.09905E-09	
3	13	1.50345E-08	1.51935E-08	9.47965E-09	
3	14	1.24590E-08	1.26770E-08	6.86990E-09	
3	15	1.23545E-08	1.27435E-08	6.82905E-09	
3	16	1.46135E-08	1.50410E-08	9.28525E-09	1.42580E-07 Capsule 3
2	17	1.41965E-08	1.46915E-08	9.13460E-09	
2	18	1.14505E-08	1.17325E-08	6.48845E-09	
2	19	1.11295E-08	1.13850E-08	6.25625E-09	
2	20	1.30065E-08	1.31570E-08	8.26030E-09	
1	21	1.33730E-08	1.35775E-08	8.80320E-09	1.30889E-07 Capsule 2
1	22	1.06565E-08	1.08120E-08	6.35805E-09	
1	23	1.00595E-08	1.02490E-08	6.00445E-09	
1	24	1.10060E-08	1.14080E-08	7.11240E-09	
					1.19420E-07 Capsule 1

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 139A
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	9.86365E-09	9.22545E-09	6.29380E-09	9.80459E-08 Capsule 6
6	2	9.00905E-09	8.40785E-09	5.12875E-09	
6	3	8.98620E-09	8.36245E-09	4.97540E-09	
6	4	1.08066E-08	1.02953E-08	6.69150E-09	
5	5	1.31015E-08	1.22710E-08	8.07395E-09	
5	6	1.16535E-08	1.11110E-08	6.80490E-09	1.32566E-07 Capsule 5
5	7	1.23410E-08	1.14460E-08	7.09105E-09	
5	8	1.50720E-08	1.40435E-08	9.55695E-09	
4	9	1.58475E-08	1.53310E-08	1.03902E-08	
4	10	1.39875E-08	1.32920E-08	8.42790E-09	
4	11	1.42325E-08	1.35845E-08	8.43330E-09	1.57648E-07 Capsule 4
4	12	1.69655E-08	1.61295E-08	1.10264E-08	
3	13	1.72685E-08	1.65795E-08	1.14160E-08	
3	14	1.47265E-08	1.40645E-08	8.92960E-09	
3	15	1.46175E-08	1.40630E-08	8.84930E-09	
3	16	1.69850E-08	1.64590E-08	1.13558E-08	1.65314E-07 Capsule 3
2	17	1.65320E-08	1.58335E-08	1.10853E-08	
2	18	1.35135E-08	1.31300E-08	8.34790E-09	
2	19	1.29735E-08	1.24950E-08	7.91530E-09	
2	20	1.47570E-08	1.42345E-08	9.73180E-09	
1	21	1.51020E-08	1.43620E-08	1.02009E-08	1.50549E-07 Capsule 2
1	22	1.20310E-08	1.15565E-08	7.67790E-09	
1	23	1.12855E-08	1.09750E-08	7.17620E-09	
1	24	1.23390E-08	1.16335E-08	8.11895E-09	
					1.32458E-07 Capsule 1

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 139B
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	1.33610E-08	1.27080E-08	1.05055E-08	1.42993E-07 Capsule 6
6	2	1.25060E-08	1.15985E-08	9.08645E-09	
6	3	1.23180E-08	1.16085E-08	8.93435E-09	
6	4	1.47875E-08	1.42050E-08	1.13745E-08	
5	5	1.83835E-08	1.75475E-08	1.42185E-08	
5	6	1.70895E-08	1.60245E-08	1.26070E-08	2.01810E-07 Capsule 5
5	7	1.80025E-08	1.68385E-08	1.36625E-08	
5	8	2.09720E-08	1.97150E-08	1.67490E-08	
4	9	2.30010E-08	2.17340E-08	1.89275E-08	
4	10	2.04240E-08	1.92135E-08	1.60250E-08	
4	11	2.11295E-08	2.00180E-08	1.63820E-08	2.43492E-07 Capsule 4
4	12	2.41835E-08	2.28990E-08	1.95545E-08	
3	13	2.48460E-08	2.34450E-08	2.07725E-08	
3	14	2.20365E-08	2.07295E-08	1.76255E-08	
3	15	2.19880E-08	2.09135E-08	1.73280E-08	
3	16	2.46410E-08	2.35370E-08	2.03660E-08	2.58229E-07 Capsule 3
2	17	2.34220E-08	2.23255E-08	1.92505E-08	
2	18	2.03825E-08	1.91125E-08	1.58685E-08	
2	19	1.92420E-08	1.79695E-08	1.48610E-08	
2	20	2.14285E-08	2.01790E-08	1.73580E-08	
1	21	2.08680E-08	1.95515E-08	1.71710E-08	2.31400E-07 Capsule 2
1	22	1.73045E-08	1.62170E-08	1.38865E-08	
1	23	1.63215E-08	1.53640E-08	1.27785E-08	
1	24	1.66425E-08	1.61935E-08	1.35860E-08	
					1.95885E-07 Capsule 1

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 140A
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	9.70280E-09	9.61290E-09	6.85200E-09	1.06137E-07 Capsule 6
6	2	9.46480E-09	9.40050E-09	6.21465E-09	
6	3	9.57935E-09	9.52920E-09	6.38370E-09	
6	4	1.09295E-08	1.08145E-08	7.65295E-09	
5	5	1.36790E-08	1.37220E-08	1.01566E-08	1.54379E-07 Capsule 5
5	6	1.31250E-08	1.31400E-08	9.41140E-09	
5	7	1.39250E-08	1.38855E-08	1.00245E-08	
5	8	1.57515E-08	1.56385E-08	1.19205E-08	
4	9	1.72670E-08	1.70325E-08	1.36580E-08	1.89014E-07 Capsule 4
4	10	1.64975E-08	1.62065E-08	1.22585E-08	
4	11	1.68030E-08	1.65295E-08	1.27140E-08	
4	12	1.79825E-08	1.78110E-08	1.42540E-08	
3	13	1.83335E-08	1.82375E-08	1.47770E-08	1.98542E-07 Capsule 3
3	14	1.74550E-08	1.71010E-08	1.34730E-08	
3	15	1.74845E-08	1.71375E-08	1.34745E-08	
3	16	1.82220E-08	1.82325E-08	1.46135E-08	
2	17	1.73670E-08	1.74085E-08	1.40205E-08	1.79268E-07 Capsule 2
2	18	1.58980E-08	1.58255E-08	1.20330E-08	
2	19	1.52895E-08	1.52950E-08	1.15770E-08	
2	20	1.60300E-08	1.60030E-08	1.25205E-08	
1	21	1.50855E-08	1.51135E-08	1.17855E-08	1.47838E-07 Capsule 1
1	22	1.33620E-08	1.32880E-08	1.02361E-08	
1	23	1.26115E-08	1.23865E-08	9.32150E-09	
1	24	1.26465E-08	1.25580E-08	9.44330E-09	

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 140B
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	1.09900E-08	1.10285E-08	8.03890E-09	1.24277E-07 Capsule 6
6	2	1.08195E-08	1.08430E-08	7.56185E-09	
6	3	1.12765E-08	1.13080E-08	7.86375E-09	
6	4	1.26195E-08	1.27055E-08	9.22155E-09	
5	5	1.58110E-08	1.59705E-08	1.24055E-08	1.83203E-07 Capsule 5
5	6	1.55350E-08	1.55465E-08	1.18205E-08	
5	7	1.65570E-08	1.64995E-08	1.25975E-08	
5	8	1.80170E-08	1.79455E-08	1.44970E-08	
4	9	1.94855E-08	1.96250E-08	1.61300E-08	2.21667E-07 Capsule 4
4	10	1.92185E-08	1.92695E-08	1.55830E-08	
4	11	1.94680E-08	1.95075E-08	1.59020E-08	
4	12	2.00670E-08	2.03485E-08	1.70620E-08	
3	13	2.05050E-08	2.08705E-08	1.79190E-08	2.33430E-07 Capsule 3
3	14	2.02645E-08	2.05850E-08	1.70445E-08	
3	15	1.99980E-08	2.04785E-08	1.69410E-08	
3	16	2.05755E-08	2.06900E-08	1.75585E-08	
2	17	1.97030E-08	1.97760E-08	1.68030E-08	2.13366E-07 Capsule 2
2	18	1.87250E-08	1.88730E-08	1.54625E-08	
2	19	1.81220E-08	1.83565E-08	1.47975E-08	
2	20	1.85020E-08	1.87990E-08	1.54465E-08	
1	21	1.68530E-08	1.72475E-08	1.42110E-08	1.71565E-07 Capsule 1
1	22	1.52510E-08	1.55790E-08	1.25005E-08	
1	23	1.42590E-08	1.45265E-08	1.13125E-08	
1	24	1.42905E-08	1.42260E-08	1.13085E-08	

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 141A
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	1.22405E-08	1.17880E-08	9.33145E-09	1.40669E-07 Capsule 6
6	2	1.24115E-08	1.21130E-08	8.99950E-09	
6	3	1.31275E-08	1.26655E-08	9.40870E-09	
6	4	1.41590E-08	1.37440E-08	1.06800E-08	
5	5	1.72475E-08	1.71705E-08	1.40955E-08	
5	6	1.77445E-08	1.72045E-08	1.40965E-08	2.02619E-07 Capsule 5
5	7	1.84175E-08	1.79650E-08	1.49945E-08	
5	8	1.91535E-08	1.84800E-08	1.60495E-08	
4	9	2.04205E-08	1.97710E-08	1.76960E-08	
4	10	2.07580E-08	2.02055E-08	1.77435E-08	
4	11	2.06850E-08	2.04860E-08	1.78730E-08	2.35753E-07 Capsule 4
4	12	2.09820E-08	2.05525E-08	1.85795E-08	
3	13	2.10895E-08	2.08350E-08	1.88225E-08	
3	14	2.16410E-08	2.11100E-08	1.90160E-08	
3	15	2.15225E-08	2.09960E-08	1.87320E-08	
3	16	2.12950E-08	2.07510E-08	1.89570E-08	2.44768E-07 Capsule 3
2	17	2.04835E-08	2.01910E-08	1.81440E-08	
2	18	2.04790E-08	1.99445E-08	1.76225E-08	
2	19	1.99605E-08	1.95175E-08	1.68590E-08	
2	20	1.95560E-08	1.90165E-08	1.70900E-08	
1	21	1.79155E-08	1.74160E-08	1.52645E-08	2.28864E-07 Capsule 2
1	22	1.67715E-08	1.63745E-08	1.40535E-08	
1	23	1.58885E-08	1.56910E-08	1.29635E-08	
1	24	1.56275E-08	1.50240E-08	1.28390E-08	
					1.85829E-07 Capsule 1

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 142A
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	1.19235E-08	1.20940E-08	9.43605E-09	1.43994E-07 Capsule 6
6	2	1.22090E-08	1.24130E-08	9.50640E-09	
6	3	1.29180E-08	1.34770E-08	1.04105E-08	
6	4	1.38320E-08	1.42860E-08	1.14890E-08	
5	5	1.63175E-08	1.66485E-08	1.44295E-08	
5	6	1.67265E-08	1.73980E-08	1.46620E-08	1.96820E-07 Capsule 5
5	7	1.71090E-08	1.76575E-08	1.51625E-08	
5	8	1.72960E-08	1.77060E-08	1.57065E-08	
4	9	1.77570E-08	1.81960E-08	1.62275E-08	
4	10	1.84245E-08	1.89825E-08	1.70405E-08	
4	11	1.85775E-08	1.91385E-08	1.70435E-08	2.14536E-07 Capsule 4
4	12	1.78145E-08	1.83565E-08	1.69770E-08	
3	13	1.79640E-08	1.85730E-08	1.71245E-08	
3	14	1.86925E-08	1.93245E-08	1.76870E-08	
3	15	1.88340E-08	1.94425E-08	1.78850E-08	
3	16	1.82980E-08	1.87035E-08	1.74675E-08	2.19996E-07 Capsule 3
2	17	1.76650E-08	1.84375E-08	1.68820E-08	
2	18	1.83280E-08	1.90260E-08	1.72140E-08	
2	19	1.83100E-08	1.86450E-08	1.69715E-08	
2	20	1.74270E-08	1.81925E-08	1.62470E-08	
1	21	1.60260E-08	1.65395E-08	1.47725E-08	2.13346E-07 Capsule 2
1	22	1.59405E-08	1.63440E-08	1.42420E-08	
1	23	1.51470E-08	1.57575E-08	1.34140E-08	
1	24	1.46575E-08	1.50850E-08	1.28435E-08	
					1.80769E-07 Capsule 1

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 142B
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	1.26700E-08	1.34500E-08	1.11155E-08	1.62172E-07 Capsule 6
6	2	1.34815E-08	1.39115E-08	1.12275E-08	
6	3	1.44590E-08	1.49875E-08	1.26135E-08	
6	4	1.51250E-08	1.56850E-08	1.34455E-08	
5	5	1.66500E-08	1.73220E-08	1.56155E-08	
5	6	1.72760E-08	1.82265E-08	1.66065E-08	2.04639E-07 Capsule 5
5	7	1.72125E-08	1.82805E-08	1.64690E-08	
5	8	1.69825E-08	1.77900E-08	1.62080E-08	
4	9	1.70355E-08	1.78155E-08	1.69260E-08	
4	10	1.80485E-08	1.89995E-08	1.75825E-08	
4	11	1.79175E-08	1.87050E-08	1.78520E-08	2.13113E-07 Capsule 4
4	12	1.72830E-08	1.78485E-08	1.70990E-08	
3	13	1.70815E-08	1.80635E-08	1.75420E-08	
3	14	1.83695E-08	1.92665E-08	1.81570E-08	
3	15	1.81035E-08	1.91765E-08	1.84210E-08	
3	16	1.74175E-08	1.81510E-08	1.74070E-08	2.17157E-07 Capsule 3
2	17	1.70265E-08	1.78665E-08	1.70300E-08	
2	18	1.81405E-08	1.90880E-08	1.80625E-08	
2	19	1.83160E-08	1.91885E-08	1.82835E-08	
2	20	1.73800E-08	1.82770E-08	1.71470E-08	
1	21	1.59920E-08	1.68960E-08	1.55375E-08	2.15806E-07 Capsule 2
1	22	1.63900E-08	1.71035E-08	1.53505E-08	
1	23	1.60635E-08	1.66490E-08	1.49540E-08	
1	24	1.50675E-08	1.59725E-08	1.42025E-08	
					1.90179E-07 Capsule 1

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 143A
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	1.43540E-08	1.33640E-08	1.26830E-08	1.77570E-07 Capsule 6
6	2	1.56230E-08	1.43205E-08	1.33355E-08	
6	3	1.65415E-08	1.52520E-08	1.45855E-08	
6	4	1.67520E-08	1.56770E-08	1.50820E-08	
5	5	1.70215E-08	1.64720E-08	1.63605E-08	
5	6	1.78405E-08	1.71965E-08	1.73080E-08	2.05429E-07 Capsule 5
5	7	1.78350E-08	1.71510E-08	1.75855E-08	
5	8	1.71810E-08	1.63710E-08	1.71065E-08	
4	9	1.70700E-08	1.63200E-08	1.73050E-08	
4	10	1.80920E-08	1.69510E-08	1.78975E-08	
4	11	1.82245E-08	1.71825E-08	1.81905E-08	2.08276E-07 Capsule 4
4	12	1.71765E-08	1.63010E-08	1.75655E-08	
3	13	1.70120E-08	1.63250E-08	1.75135E-08	
3	14	1.77985E-08	1.71485E-08	1.82100E-08	
3	15	1.81135E-08	1.72660E-08	1.83885E-08	
3	16	1.72865E-08	1.64395E-08	1.75645E-08	2.09066E-07 Capsule 3
2	17	1.72370E-08	1.66420E-08	1.76005E-08	
2	18	1.82870E-08	1.76685E-08	1.85970E-08	
2	19	1.83785E-08	1.77345E-08	1.85915E-08	
2	20	1.75875E-08	1.68805E-08	1.75305E-08	
1	21	1.64585E-08	1.57990E-08	1.63060E-08	2.12735E-07 Capsule 2
1	22	1.70990E-08	1.61165E-08	1.64185E-08	
1	23	1.66935E-08	1.61615E-08	1.60845E-08	
1	24	1.60680E-08	1.53575E-08	1.53215E-08	
					1.93884E-07 Capsule 1

AGR-1 TRISO Compact Irradiation -- Compact ¹³⁵I Concentration (moles) at the EOC (no decay)
Cycle 143B
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ¹³⁵ I Conc (moles)	Stack No. 3 ¹³⁵ I Conc (moles)	Stack No. 2 ¹³⁵ I Conc (moles)	Total Concentration per capsule (moles)
6	1	1.36945E-08	1.46015E-08	1.30805E-08	1.80547E-07 Capsule 6
6	2	1.46855E-08	1.56275E-08	1.42820E-08	
6	3	1.57215E-08	1.65090E-08	1.52785E-08	
6	4	1.54060E-08	1.62405E-08	1.54195E-08	
5	5	1.51370E-08	1.61835E-08	1.57800E-08	
5	6	1.57990E-08	1.67255E-08	1.66205E-08	1.92144E-07 Capsule 5
5	7	1.58290E-08	1.66005E-08	1.67630E-08	
5	8	1.49040E-08	1.58535E-08	1.59485E-08	
4	9	1.44950E-08	1.55410E-08	1.57880E-08	
4	10	1.51990E-08	1.62510E-08	1.66470E-08	
4	11	1.51470E-08	1.62265E-08	1.67050E-08	1.87911E-07 Capsule 4
4	12	1.44500E-08	1.55720E-08	1.58890E-08	
3	13	1.43155E-08	1.53560E-08	1.60240E-08	
3	14	1.50705E-08	1.60570E-08	1.67305E-08	
3	15	1.50945E-08	1.61110E-08	1.68500E-08	
3	16	1.45585E-08	1.54350E-08	1.60500E-08	1.87653E-07 Capsule 3
2	17	1.45490E-08	1.55070E-08	1.60885E-08	
2	18	1.53205E-08	1.63570E-08	1.70055E-08	
2	19	1.55795E-08	1.66230E-08	1.70175E-08	
2	20	1.50165E-08	1.59840E-08	1.61765E-08	
1	21	1.43565E-08	1.52290E-08	1.53535E-08	1.91225E-07 Capsule 2
1	22	1.49870E-08	1.59905E-08	1.58810E-08	
1	23	1.49460E-08	1.59165E-08	1.55305E-08	
1	24	1.43665E-08	1.53860E-08	1.46150E-08	
					1.82558E-07 Capsule 1

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 144A
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	1.50710E-08	1.52885E-08	1.52880E-08	1.97320E-07 Capsule 6
6	2	1.62930E-08	1.64140E-08	1.67035E-08	
6	3	1.68760E-08	1.69030E-08	1.76975E-08	
6	4	1.65740E-08	1.66950E-08	1.75160E-08	
5	5	1.61895E-08	1.64450E-08	1.80365E-08	
5	6	1.67900E-08	1.69910E-08	1.89150E-08	2.05348E-07 Capsule 5
5	7	1.66400E-08	1.67640E-08	1.88630E-08	
5	8	1.58145E-08	1.59305E-08	1.79690E-08	
4	9	1.57415E-08	1.59855E-08	1.79605E-08	
4	10	1.62195E-08	1.64045E-08	1.88240E-08	
4	11	1.60365E-08	1.63715E-08	1.87260E-08	2.01205E-07 Capsule 4
4	12	1.54185E-08	1.57240E-08	1.77925E-08	
3	13	1.52970E-08	1.55885E-08	1.79085E-08	
3	14	1.62035E-08	1.61355E-08	1.87720E-08	
3	15	1.61315E-08	1.64560E-08	1.87840E-08	
3	16	1.54970E-08	1.57170E-08	1.79190E-08	2.00410E-07 Capsule 3
2	17	1.57140E-08	1.57905E-08	1.79500E-08	
2	18	1.64085E-08	1.66210E-08	1.87585E-08	
2	19	1.66230E-08	1.69475E-08	1.90815E-08	
2	20	1.60815E-08	1.60645E-08	1.82995E-08	
1	21	1.54115E-08	1.56910E-08	1.70955E-08	2.04340E-07 Capsule 2
1	22	1.62355E-08	1.63370E-08	1.77825E-08	
1	23	1.63315E-08	1.64860E-08	1.79190E-08	
1	24	1.55115E-08	1.58540E-08	1.68610E-08	
					1.97516E-07 Capsule 1

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 144B
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	1.48110E-08	1.52510E-08	1.65105E-08	1.97329E-07 Capsule 6
6	2	1.57870E-08	1.61720E-08	1.75500E-08	
6	3	1.62565E-08	1.66150E-08	1.82750E-08	
6	4	1.55550E-08	1.63365E-08	1.82090E-08	
5	5	1.48110E-08	1.52180E-08	1.75435E-08	
5	6	1.52400E-08	1.55730E-08	1.82885E-08	1.91530E-07 Capsule 5
5	7	1.50070E-08	1.53765E-08	1.80745E-08	
5	8	1.42130E-08	1.46770E-08	1.75080E-08	
4	9	1.38115E-08	1.40875E-08	1.69395E-08	
4	10	1.40590E-08	1.47105E-08	1.75265E-08	
4	11	1.41430E-08	1.46170E-08	1.75185E-08	1.81868E-07 Capsule 4
4	12	1.37125E-08	1.39585E-08	1.67835E-08	
3	13	1.35545E-08	1.40370E-08	1.68545E-08	
3	14	1.40150E-08	1.44595E-08	1.73750E-08	
3	15	1.40010E-08	1.45400E-08	1.73285E-08	
3	16	1.39220E-08	1.41330E-08	1.70150E-08	1.81235E-07 Capsule 3
2	17	1.39725E-08	1.44220E-08	1.70065E-08	
2	18	1.47035E-08	1.50515E-08	1.79520E-08	
2	19	1.49460E-08	1.53850E-08	1.82205E-08	
2	20	1.46305E-08	1.50840E-08	1.79935E-08	
1	21	1.44625E-08	1.47030E-08	1.69645E-08	1.89368E-07 Capsule 2
1	22	1.51940E-08	1.56220E-08	1.81035E-08	
1	23	1.53460E-08	1.58645E-08	1.81760E-08	
1	24	1.50025E-08	1.54335E-08	1.74220E-08	
					1.92294E-07 Capsule 1

AGR-1 TRISO Compact Irradiation -- Compact ^{135}I Concentration (moles) at the EOC (no decay)
Cycle 145A
Sterbentz Calculation
ICESTORM computer system

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	1	1.40405E-08	1.42115E-08	1.56710E-08	1.82866E-07 Capsule 6
6	2	1.45540E-08	1.49275E-08	1.65270E-08	
6	3	1.48940E-08	1.50930E-08	1.71345E-08	
6	4	1.45435E-08	1.46640E-08	1.66055E-08	
5	5	1.33925E-08	1.36285E-08	1.59740E-08	
5	6	1.37965E-08	1.37690E-08	1.64920E-08	1.72237E-07 Capsule 5
5	7	1.35370E-08	1.36135E-08	1.65345E-08	
5	8	1.29370E-08	1.30090E-08	1.55530E-08	
4	9	1.24850E-08	1.25305E-08	1.50505E-08	
4	10	1.27340E-08	1.28770E-08	1.56285E-08	
4	11	1.26790E-08	1.28315E-08	1.55040E-08	1.62252E-07 Capsule 4
4	12	1.23550E-08	1.24870E-08	1.50895E-08	
3	13	1.24195E-08	1.24920E-08	1.49070E-08	
3	14	1.27650E-08	1.28200E-08	1.55480E-08	
3	15	1.27185E-08	1.28125E-08	1.55205E-08	
3	16	1.24535E-08	1.26850E-08	1.50550E-08	1.62197E-07 Capsule 3
2	17	1.25920E-08	1.28330E-08	1.50940E-08	
2	18	1.31075E-08	1.32310E-08	1.58740E-08	
2	19	1.31860E-08	1.35785E-08	1.60150E-08	
2	20	1.30985E-08	1.33065E-08	1.58210E-08	
1	21	1.31085E-08	1.32460E-08	1.54045E-08	1.67737E-07 Capsule 2
1	22	1.36605E-08	1.39275E-08	1.60570E-08	
1	23	1.41425E-08	1.42905E-08	1.62540E-08	
1	24	1.37980E-08	1.37770E-08	1.57330E-08	
					1.73399E-07 Capsule 1

B.2 AGR-2: Capsules 1 and 4 data are protected information by CRADA restrictions, and cannot be displayed.

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 147A

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/147A-depletion/iodine2.agr2.3rd.147A.ts53.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)	
6	4	2.4755E-08	2.1076E-08	1.5396E-08	2.5389E-07	Capsule 6
6	3	2.2944E-08	1.9610E-08	1.3218E-08		
6	2	2.5040E-08	2.1009E-08	1.4386E-08		
6	1	3.0520E-08	2.6748E-08	1.9191E-08		
5	4	3.2861E-08	2.8072E-08	2.0331E-08		
5	3	3.0124E-08	2.5665E-08	1.6826E-08	3.2099E-07	Capsule 5
5	2	3.1074E-08	2.6079E-08	1.7545E-08		
5	1	3.7122E-08	3.1910E-08	2.3383E-08		
4	4					
4	3					
4	2				2.3090E-07	Capsule 3
4	1					
3	4	2.4566E-08	2.1751E-08	1.6495E-08		
3	3	2.1580E-08	1.8699E-08	1.3449E-08		
3	2	2.1521E-08	1.8380E-08	1.3136E-08		
3	1	2.4096E-08	2.1190E-08	1.6034E-08	3.3448E-07	Capsule 2
2	4	3.7836E-08	3.3152E-08	2.4460E-08		
2	3	3.1710E-08	2.7247E-08	1.8573E-08		
2	2	3.0852E-08	2.6504E-08	1.7909E-08		
2	1	3.4441E-08	2.9988E-08	2.1811E-08		
1	4					
1	3					
1	2					
1	1					

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 148A

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/148A-depletion/fcompch/iodine2.agr2.3rd.148A.ts50.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	1.9910E-08	2.1267E-08	1.3563E-08	2.3437E-07 Capsule 6
6	3	1.9288E-08	2.0757E-08	1.2304E-08	
6	2	2.1303E-08	2.2875E-08	1.3619E-08	
6	1	2.5212E-08	2.6666E-08	1.7608E-08	
5	4	2.7902E-08	3.0504E-08	1.9359E-08	3.1265E-07 Capsule 5
5	3	2.5608E-08	2.8130E-08	1.6788E-08	
5	2	2.7798E-08	2.9688E-08	1.8027E-08	
5	1	3.2124E-08	3.4248E-08	2.2473E-08	
4	4				
4	3				
4	2				
4	1				
3	4	2.2375E-08	2.3734E-08	1.6741E-08	2.3752E-07 Capsule 3
3	3	2.0342E-08	2.2148E-08	1.4536E-08	
3	2	2.0024E-08	2.1555E-08	1.4223E-08	
3	1	2.1811E-08	2.3597E-08	1.6433E-08	
2	4	3.3837E-08	3.6717E-08	2.4455E-08	3.4093E-07 Capsule 2
2	3	2.8991E-08	3.1811E-08	1.9835E-08	
2	2	2.8355E-08	3.0820E-08	1.9170E-08	
2	1	3.1245E-08	3.3557E-08	2.2138E-08	
1	4				
1	3				
1	2				
1	1				

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 148B

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/148B-depletion/fcomppch/iodine2.agr2.3rd.148B.ts52.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	2.7478E-08	3.1355E-08	2.3769E-08	3.5646E-07 Capsule 6
6	3	2.7062E-08	3.1372E-08	2.2333E-08	
6	2	2.9484E-08	3.4712E-08	2.5102E-08	
6	1	3.4213E-08	3.9633E-08	2.9948E-08	
5	4	3.9760E-08	4.4713E-08	3.4663E-08	4.8630E-07 Capsule 5
5	3	3.7519E-08	4.3346E-08	3.2591E-08	
5	2	3.9048E-08	4.5215E-08	3.4331E-08	
5	1	4.4465E-08	5.0656E-08	3.9995E-08	
4	4				3.7464E-07 Capsule 3
4	3				
4	2				
4	1				
3	4	3.1448E-08	3.5082E-08	3.0092E-08	5.3889E-07 Capsule 2
3	3	2.9715E-08	3.3962E-08	2.7962E-08	
3	2	2.9804E-08	3.3833E-08	2.7660E-08	
3	1	3.0727E-08	3.5214E-08	2.9138E-08	
2	4	4.7891E-08	5.4459E-08	4.4657E-08	
2	3	4.2878E-08	4.9276E-08	3.8261E-08	
2	2	4.1344E-08	4.8012E-08	3.6820E-08	
2	1	4.4533E-08	5.0480E-08	4.0277E-08	
1	4				
1	3				
1	2				
1	1				

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 149A

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/149A-depletion/fcompch/iodine2.agr2.3rd.149A.ts37.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	2.4884E-08	2.3970E-08	1.7943E-08	2.9308E-07 Capsule 6
6	3	2.5254E-08	2.4223E-08	1.7358E-08	
6	2	2.8110E-08	2.7166E-08	1.9738E-08	
6	1	3.0688E-08	3.0302E-08	2.3440E-08	
5	4	3.6511E-08	3.5035E-08	2.7851E-08	
5	3	3.5949E-08	3.5607E-08	2.7035E-08	4.1356E-07 Capsule 5
5	2	3.7416E-08	3.6767E-08	2.8672E-08	
5	1	4.0497E-08	4.0256E-08	3.1960E-08	
4	4				
4	3				
4	2				3.0733E-07 Capsule 3
4	1				
3	4	2.7422E-08	2.7007E-08	2.3566E-08	
3	3	2.7496E-08	2.6549E-08	2.2569E-08	
3	2	2.7271E-08	2.6478E-08	2.2414E-08	
3	1	2.6846E-08	2.6817E-08	2.2899E-08	4.4511E-07 Capsule 2
2	4	4.2422E-08	4.1740E-08	3.5109E-08	
2	3	4.0341E-08	3.8881E-08	3.0978E-08	
2	2	3.8720E-08	3.8144E-08	2.9786E-08	
2	1	3.9385E-08	3.8435E-08	3.1164E-08	
1	4				
1	3				
1	2				
1	1				

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 149B

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/149B-depletion/fcomppch/iodine2.agr2.3rd.149B.ts54.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	2.5966E-08	2.6751E-08	2.0629E-08	3.2390E-07 Capsule 6
6	3	2.7171E-08	2.8029E-08	2.0724E-08	
6	2	2.9883E-08	3.0870E-08	2.3387E-08	
6	1	3.1981E-08	3.2088E-08	2.6425E-08	
5	4	3.7108E-08	3.8069E-08	3.0775E-08	
5	3	3.7448E-08	3.8310E-08	3.1476E-08	4.3969E-07 Capsule 5
5	2	3.8994E-08	4.0283E-08	3.2802E-08	
5	1	3.9709E-08	4.0583E-08	3.4129E-08	
4	4				
4	3				
4	2				3.0680E-07 Capsule 3
4	1				
3	4	2.5737E-08	2.6668E-08	2.3665E-08	
3	3	2.6380E-08	2.6922E-08	2.3815E-08	
3	2	2.6459E-08	2.7082E-08	2.3764E-08	
3	1	2.6095E-08	2.6618E-08	2.3594E-08	
2	4	4.1940E-08	4.3033E-08	3.7796E-08	4.7894E-07 Capsule 2
2	3	4.1736E-08	4.2750E-08	3.6501E-08	
2	2	4.0834E-08	4.1807E-08	3.5313E-08	
2	1	4.0171E-08	4.1663E-08	3.5400E-08	
1	4				
1	3				
1	2				
1	1				

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 150B

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/150B-depletion/fcompch/iodine2.agr2.3rd.150B.ts43.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	3.5464E-08	3.3603E-08	2.9819E-08	4.3665E-07 Capsule 6
6	3	3.8087E-08	3.5836E-08	3.1479E-08	
6	2	4.0034E-08	3.8268E-08	3.4619E-08	
6	1	4.2360E-08	4.0313E-08	3.6768E-08	
5	4	4.8615E-08	4.5776E-08	4.3730E-08	
5	3	5.0386E-08	4.7501E-08	4.6020E-08	5.7791E-07 Capsule 5
5	2	5.1527E-08	4.9327E-08	4.6997E-08	
5	1	5.0904E-08	4.9204E-08	4.7926E-08	
4	4				
4	3				
4	2				3.8170E-07 Capsule 3
4	1				
3	4	3.2052E-08	3.0942E-08	3.0923E-08	
3	3	3.3054E-08	3.1867E-08	3.1963E-08	
3	2	3.3226E-08	3.1806E-08	3.1607E-08	
3	1	3.2249E-08	3.0896E-08	3.1115E-08	6.1378E-07 Capsule 2
2	4	5.2735E-08	5.0342E-08	4.9998E-08	
2	3	5.3794E-08	5.1570E-08	5.0518E-08	
2	2	5.3570E-08	5.0912E-08	4.9617E-08	
2	1	5.1899E-08	4.9980E-08	4.8843E-08	
1	4				
1	3				
1	2				
1	1				

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 151A

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/151A-depletion/fcompch/iodine2.agr2.3rd.151A.ts58.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	3.1300E-08	3.5150E-08	3.0619E-08	4.2316E-07 Capsule 6
6	3	3.2816E-08	3.8102E-08	3.2495E-08	
6	2	3.5606E-08	3.9531E-08	3.5198E-08	
6	1	3.5827E-08	4.0152E-08	3.6362E-08	
5	4	3.9447E-08	4.3933E-08	4.1768E-08	
5	3	4.0897E-08	4.5772E-08	4.3245E-08	5.1654E-07 Capsule 5
5	2	4.1701E-08	4.6498E-08	4.4614E-08	
5	1	4.0205E-08	4.4694E-08	4.3764E-08	
4	4				
4	3				
4	2				3.2882E-07 Capsule 3
4	1				
3	4	2.5187E-08	2.7951E-08	2.7657E-08	
3	3	2.6053E-08	2.8960E-08	2.8367E-08	
3	2	2.5961E-08	2.8898E-08	2.8494E-08	
3	1	2.5352E-08	2.8025E-08	2.7911E-08	5.4132E-07 Capsule 2
2	4	4.1346E-08	4.6090E-08	4.5290E-08	
2	3	4.2645E-08	4.7843E-08	4.6938E-08	
2	2	4.3022E-08	4.8323E-08	4.7400E-08	
2	1	4.1380E-08	4.6157E-08	4.4889E-08	
1	4				
1	3				
1	2				
1	1				

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 151B

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/**151B**-depletion/fcompch/iodine2.agr2.3rd.**151B**.ts56.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	3.0642E-08	2.8178E-08	2.6959E-08	3.7010E-07 Capsule 6
6	3	3.2727E-08	2.9899E-08	2.9192E-08	
6	2	3.4023E-08	3.1332E-08	3.0732E-08	
6	1	3.3788E-08	3.1177E-08	3.1447E-08	
5	4	3.5881E-08	3.2551E-08	3.3660E-08	4.2250E-07 Capsule 5
5	3	3.7252E-08	3.4445E-08	3.5649E-08	
5	2	3.7350E-08	3.4436E-08	3.6314E-08	
5	1	3.6421E-08	3.3458E-08	3.5080E-08	
4	4				
4	3				
4	2				
4	1				
3	4	2.2172E-08	2.0910E-08	2.1725E-08	2.6477E-07 Capsule 3
3	3	2.2887E-08	2.1226E-08	2.2524E-08	
3	2	2.3170E-08	2.1306E-08	2.3076E-08	
3	1	2.2616E-08	2.1062E-08	2.2091E-08	
2	4	3.6353E-08	3.3609E-08	3.6260E-08	4.3354E-07 Capsule 2
2	3	3.7965E-08	3.5058E-08	3.7287E-08	
2	2	3.7970E-08	3.5261E-08	3.7333E-08	
2	1	3.6360E-08	3.3925E-08	3.6162E-08	
1	4				
1	3				
1	2				
1	1				

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 152B

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/152B-depletion/fcompch/iodine2.agr2.3rd.152B.ts52.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	2.2611E-08	2.2733E-08	2.0450E-08	2.8053E-07 Capsule 6
6	3	2.4186E-08	2.4222E-08	2.2270E-08	
6	2	2.4280E-08	2.4524E-08	2.2970E-08	
6	1	2.4523E-08	2.4289E-08	2.3469E-08	
5	4	2.5476E-08	2.5172E-08	2.4778E-08	
5	3	2.6603E-08	2.5824E-08	2.6473E-08	3.1105E-07 Capsule 5
5	2	2.6609E-08	2.6425E-08	2.6665E-08	
5	1	2.5662E-08	2.5542E-08	2.5825E-08	
4	4				
4	3				
4	2				1.9924E-07 Capsule 3
4	1				
3	4	1.6563E-08	1.6315E-08	1.6135E-08	
3	3	1.6751E-08	1.6656E-08	1.6349E-08	
3	2	1.7032E-08	1.6851E-08	1.6700E-08	
3	1	1.6576E-08	1.6613E-08	1.6700E-08	3.1943E-07 Capsule 2
2	4	2.5956E-08	2.5436E-08	2.6408E-08	
2	3	2.7153E-08	2.6742E-08	2.7350E-08	
2	2	2.7456E-08	2.7209E-08	2.7441E-08	
2	1	2.6302E-08	2.5923E-08	2.6051E-08	
1	4				
1	3				
1	2				
1	1				

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 153B

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/153B-depletion/fcompch/iodine2.agr2.3rd.153B.ts14.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	1.4022E-08	1.6706E-08	1.6080E-08	1.9273E-07 Capsule 6
6	3	1.4326E-08	1.7198E-08	1.7359E-08	
6	2	1.4506E-08	1.6981E-08	1.7488E-08	
6	1	1.4070E-08	1.6487E-08	1.7502E-08	
5	4	1.4013E-08	1.6539E-08	1.7577E-08	
5	3	1.4427E-08	1.6734E-08	1.8521E-08	1.9371E-07 Capsule 5
5	2	1.4339E-08	1.6720E-08	1.8233E-08	
5	1	1.3538E-08	1.5946E-08	1.7127E-08	
4	4				
4	3				
4	2				1.0896E-07 Capsule 3
4	1				
3	4	8.0347E-09	9.0983E-09	9.6907E-09	
3	3	8.1200E-09	9.3918E-09	1.0211E-08	
3	2	8.1130E-09	9.2516E-09	1.0072E-08	
3	1	8.0212E-09	9.0365E-09	9.9215E-09	1.7796E-07 Capsule 2
2	4	1.2474E-08	1.4385E-08	1.6190E-08	
2	3	1.3230E-08	1.5018E-08	1.7075E-08	
2	2	1.3283E-08	1.5455E-08	1.6935E-08	
2	1	1.2952E-08	1.4775E-08	1.6189E-08	
1	4				
1	3				
1	2				
1	1				

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 154A

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/154A-depletion/fcompch/iodine2.agr2.3rd.154A.ts55.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	2.2628E-08	2.3335E-08	2.1734E-08	2.8522E-07 Capsule 6
6	3	2.4480E-08	2.4692E-08	2.3333E-08	
6	2	2.4554E-08	2.4612E-08	2.3642E-08	
6	1	2.4226E-08	2.4189E-08	2.3799E-08	
5	4	2.4634E-08	2.4906E-08	2.4960E-08	
5	3	2.5353E-08	2.5478E-08	2.6123E-08	3.0246E-07 Capsule 5
5	2	2.5434E-08	2.5513E-08	2.6078E-08	
5	1	2.4265E-08	2.4569E-08	2.5146E-08	
4	4				
4	3				
4	2				1.9606E-07 Capsule 3
4	1				
3	4	1.6037E-08	1.6253E-08	1.6299E-08	
3	3	1.6089E-08	1.6448E-08	1.6577E-08	
3	2	1.6436E-08	1.6518E-08	1.6529E-08	
3	1	1.6199E-08	1.6280E-08	1.6391E-08	3.0814E-07 Capsule 2
2	4	2.4483E-08	2.4718E-08	2.5701E-08	
2	3	2.5644E-08	2.5687E-08	2.7002E-08	
2	2	2.5654E-08	2.6030E-08	2.7047E-08	
2	1	2.4833E-08	2.5372E-08	2.5969E-08	
1	4				
1	3				
1	2				
1	1				

AGR-2: ^{135}I Concentration (moles) at the EOC (no decay)

Cycle 154B

AGR-2 (2nd.3rd calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-2.3rd/154B-depletion/fcompch/iodine2.agr2.3rd.154B.ts54.output

Capsule No. (#)	Compact No. (#)	Stack No. 1 ^{135}I Conc (moles)	Stack No. 2 ^{135}I Conc (moles)	Stack No. 3 ^{135}I Conc (moles)	Total Concentration per capsule (moles)
6	4	2.3834E-08	2.6269E-08	2.5063E-08	3.1279E-07 Capsule 6
6	3	2.4832E-08	2.7494E-08	2.7073E-08	
6	2	2.5136E-08	2.7283E-08	2.7248E-08	
6	1	2.4596E-08	2.7007E-08	2.6951E-08	
5	4	2.4766E-08	2.7016E-08	2.8338E-08	3.2447E-07 Capsule 5
5	3	2.5220E-08	2.7804E-08	2.9386E-08	
5	2	2.5369E-08	2.7585E-08	2.9248E-08	
5	1	2.4484E-08	2.6977E-08	2.8278E-08	
4	4				
4	3				
4	2				
4	1				
3	4	1.6603E-08	1.8249E-08	1.8199E-08	2.1459E-07 Capsule 3
3	3	1.7026E-08	1.8318E-08	1.8641E-08	
3	2	1.6792E-08	1.8496E-08	1.8697E-08	
3	1	1.6754E-08	1.8320E-08	1.8494E-08	
2	4	2.4810E-08	2.6735E-08	2.8498E-08	3.2903E-07 Capsule 2
2	3	2.5459E-08	2.7885E-08	2.9716E-08	
2	2	2.5778E-08	2.8059E-08	3.0209E-08	
2	1	2.5522E-08	2.7514E-08	2.8847E-08	
1	4				
1	3				
1	2				
1	1				

B.3 AGR-3/4 :

AGR-34.particle2b: ¹³¹I Concentration (moles) at the EOC (no decay)

Cycle 151A

AGR-34 (calculation with PARTICLE model JMOCUP calculation)
data from: QUARK: /ATR/AGR-34.particle2b/151A-
depletion/fcompch/iodine2.agr34.particle2b.151A.ts58.1131.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³¹ I Conc (moles)	Total Concentration per capsule (moles)	
12	4	8.34550E-08	3.69011E-07	Capsule 12
12	3	8.89670E-08		
12	2	9.54040E-08		
12	1	1.01185E-07		
11	4	1.48775E-07	6.47256E-07	Capsule 11
11	3	1.58992E-07		
11	2	1.66367E-07		
11	1	1.73122E-07		
10	4	2.08360E-07	8.62990E-07	Capsule 10
10	3	2.15340E-07		
10	2	2.18600E-07		
10	1	2.20690E-07		
9	4	2.48780E-07	1.01594E-06	Capsule 9
9	3	2.53240E-07		
9	2	2.56440E-07		
9	1	2.57480E-07		
8	4	2.67340E-07	1.07649E-06	Capsule 8
8	3	2.70930E-07		
8	2	2.70740E-07		
8	1	2.67480E-07		
7	4	2.73740E-07	1.10465E-06	Capsule 7
7	3	2.77470E-07		
7	2	2.78360E-07		
7	1	2.75080E-07		
6	4	2.83680E-07	1.13588E-06	Capsule 6
6	3	2.84270E-07		
6	2	2.85230E-07		
6	1	2.82700E-07		
5	4	2.79000E-07		
5	3	2.78710E-07		

5	2	2.77970E-07	1.11009E-06	Capsule 5
5	1	2.74410E-07		
4	4	2.70180E-07		
4	3	2.68610E-07		
4	2	2.66220E-07	1.06705E-06	Capsule 4
4	1	2.62040E-07		
3	4	2.41050E-07		
3	3	2.38040E-07		
3	2	2.33140E-07	9.37680E-07	Capsule 3
3	1	2.25450E-07		
2	4	1.95840E-07		
2	3	1.88603E-07		
2	2	1.80397E-07	7.35528E-07	Capsule 2
2	1	1.70688E-07		
1	4	1.20508E-07		
1	3	1.12032E-07		
1	2	1.03357E-07	4.30737E-07	Capsule 1
1	1	9.48400E-08		

AGR-34.particle2b: ¹³¹I Concentration (moles) at the EOC (no decay)

Cycle 151B

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/151B-depletion/fcompch/iodine2.agr34.particle2b.151B.ts56.I131.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³¹ I Conc (moles)	Total Concentration per capsule (moles)	
12	4	8.00620E-08	3.53365E-07	Capsule 12
12	3	8.55210E-08		
12	2	9.09730E-08		
12	1	9.68090E-08		
11	4	1.41698E-07	6.12364E-07	Capsule 11
11	3	1.49767E-07		
11	2	1.57271E-07		
11	1	1.63628E-07		
10	4	1.94807E-07	8.07171E-07	Capsule 10
10	3	2.00764E-07		
10	2	2.04770E-07		
10	1	2.06830E-07		
9	4	2.29330E-07	9.36820E-07	Capsule 9
9	3	2.33400E-07		
9	2	2.35920E-07		
9	1	2.38170E-07		
8	4	2.44430E-07	9.81670E-07	Capsule 8
8	3	2.46490E-07		
8	2	2.46630E-07		
8	1	2.44120E-07		
7	4	2.50700E-07	1.00783E-06	Capsule 7
7	3	2.53200E-07		
7	2	2.52720E-07		
7	1	2.51210E-07		
6	4	2.57000E-07	1.03022E-06	Capsule 6
6	3	2.58210E-07		
6	2	2.57740E-07		
6	1	2.57270E-07		
5	4	2.54580E-07	1.00994E-06	Capsule 5
5	3	2.53270E-07		
5	2	2.52020E-07		
5	1	2.50070E-07		

4	4	2.47570E-07	9.77760E-07	Capsule 4
4	3	2.46520E-07		
4	2	2.43880E-07		
4	1	2.39790E-07		
3	4	2.23030E-07	8.66270E-07	Capsule 3
3	3	2.19690E-07		
3	2	2.14760E-07		
3	1	2.08790E-07		
2	4	1.83222E-07	6.88641E-07	Capsule 2
2	3	1.75806E-07		
2	2	1.69284E-07		
2	1	1.60329E-07		
1	4	1.14379E-07	4.08466E-07	Capsule 1
1	3	1.06273E-07		
1	2	9.79500E-08		
1	1	8.98640E-08		

AGR-34.particle2b: ¹³¹I Concentration (moles) at the EOC (no decay)

Cycle 152B

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/152B-depletion/fcompch/iodine2.agr34.particle2b.152B.ts52.I131.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³¹ I Conc (moles)	Total Concentration per capsule (moles)	
12	4	8.66390E-08	3.83731E-07	Capsule 12
12	3	9.24460E-08		
12	2	9.86630E-08		
12	1	1.05983E-07		
11	4	1.53388E-07	6.64357E-07	Capsule 11
11	3	1.62854E-07		
11	2	1.70664E-07		
11	1	1.77451E-07		
10	4	2.11950E-07	8.77320E-07	Capsule 10
10	3	2.18260E-07		
10	2	2.22310E-07		
10	1	2.24800E-07		
9	4	2.50530E-07	1.02148E-06	Capsule 9
9	3	2.54730E-07		
9	2	2.57170E-07		
9	1	2.59050E-07		
8	4	2.70690E-07	1.08688E-06	Capsule 8
8	3	2.72070E-07		
8	2	2.72700E-07		
8	1	2.71420E-07		
7	4	2.78040E-07	1.11863E-06	Capsule 7
7	3	2.80570E-07		
7	2	2.80870E-07		
7	1	2.79150E-07		
6	4	2.86150E-07	1.14385E-06	Capsule 6
6	3	2.85490E-07		
6	2	2.85990E-07		
6	1	2.86220E-07		

5	4	2.81330E-07	1.12040E-06	Capsule 5
5	3	2.81600E-07		
5	2	2.79990E-07		
5	1	2.77480E-07		
4	4	2.70630E-07		
4	3	2.68810E-07	1.06930E-06	Capsule 4
4	2	2.66900E-07		
4	1	2.62960E-07		
3	4	2.43680E-07		
3	3	2.39880E-07		
3	2	2.33560E-07	9.45040E-07	Capsule 3
3	1	2.27920E-07		
2	4	1.99107E-07		
2	3	1.91529E-07		
2	2	1.84259E-07		
2	1	1.74890E-07	7.49785E-07	Capsule 2
1	4	1.24828E-07		
1	3	1.16020E-07		
1	2	1.07045E-07		
1	1	9.79380E-08	4.45831E-07	Capsule 1

AGR-34.particle2b: ¹³¹I Concentration (moles) at the EOC (no decay)

Cycle 154A

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/154A-

depletion/fcompch/iodine2.agr34.particle2b.154A.ts55.I131.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³¹ I Conc (moles)	Total Concentration per capsule (moles)	
12	4	8.19320E-08	3.63522E-07	Capsule 12
12	3	8.73380E-08		
12	2	9.42290E-08		
12	1	1.00023E-07		
11	4	1.45445E-07	6.26754E-07	Capsule 11
11	3	1.53728E-07		
11	2	1.60913E-07		
11	1	1.66668E-07		
10	4	1.98678E-07	8.21068E-07	Capsule 10
10	3	2.03870E-07		
10	2	2.08250E-07		
10	1	2.10270E-07		
9	4	2.33960E-07	9.54310E-07	Capsule 9
9	3	2.37820E-07		
9	2	2.40180E-07		
9	1	2.42350E-07		
8	4	2.51870E-07	1.01393E-06	Capsule 8
8	3	2.53680E-07		
8	2	2.55120E-07		
8	1	2.53260E-07		
7	4	2.61020E-07	1.04901E-06	Capsule 7
7	3	2.63390E-07		
7	2	2.62920E-07		
7	1	2.61680E-07		
6	4	2.67590E-07	1.06931E-06	Capsule 6
6	3	2.68100E-07		
6	2	2.66910E-07		
6	1	2.66710E-07		
5	4	2.63610E-07		
5	3	2.61250E-07		

5	2	2.60960E-07	1.04535E-06	Capsule 5
5	1	2.59530E-07		
4	4	2.53600E-07		
4	3	2.50950E-07		
4	2	2.49800E-07	1.00109E-06	Capsule 4
4	1	2.46740E-07		
3	4	2.27440E-07		
3	3	2.23820E-07		
3	2	2.20270E-07	8.84850E-07	Capsule 3
3	1	2.13320E-07		
2	4	1.86831E-07		
2	3	1.80302E-07		
2	2	1.73205E-07	7.05589E-07	Capsule 2
2	1	1.65251E-07		
1	4	1.19356E-07		
1	3	1.10083E-07		
1	2	1.02361E-07	4.25413E-07	Capsule 1
1	1	9.36130E-08		

AGR-34.particle2b: ¹³¹I Concentration (moles) at the EOC (no decay)

Cycle 154B

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/154B-depletion/fcompch/iodine2.agr34.particle2b.154B.ts54.I131.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³¹ I Conc (moles)	Total Concentration per capsule (moles)	
12	4	9.09500E-08	4.04779E-07	Capsule 12
12	3	9.82550E-08		
12	2	1.04626E-07		
12	1	1.10948E-07		
11	4	1.58783E-07	6.81180E-07	Capsule 11
11	3	1.67454E-07		
11	2	1.74116E-07		
11	1	1.80827E-07		
10	4	2.11030E-07	8.69800E-07	Capsule 10
10	3	2.17050E-07		
10	2	2.19840E-07		
10	1	2.21880E-07		
9	4	2.42190E-07	9.83800E-07	Capsule 9
9	3	2.45240E-07		
9	2	2.47840E-07		
9	1	2.48530E-07		
8	4	2.57440E-07	1.03266E-06	Capsule 8
8	3	2.58770E-07		
8	2	2.58510E-07		
8	1	2.57940E-07		
7	4	2.64450E-07	1.05975E-06	Capsule 7
7	3	2.65820E-07		
7	2	2.65470E-07		
7	1	2.64010E-07		
6	4	2.69640E-07	1.07884E-06	Capsule 6
6	3	2.69590E-07		
6	2	2.69590E-07		
6	1	2.70020E-07		
5	4	2.66890E-07		

5	3	2.64990E-07	1.06058E-06	Capsule 5
5	2	2.64630E-07		
5	1	2.64070E-07		
4	4	2.59020E-07		
4	3	2.56570E-07	1.02290E-06	Capsule 4
4	2	2.54570E-07		
4	1	2.52740E-07		
3	4	2.37160E-07		
3	3	2.33560E-07	9.26510E-07	Capsule 3
3	2	2.30110E-07		
3	1	2.25680E-07		
2	4	1.99664E-07		
2	3	1.92374E-07	7.55949E-07	Capsule 2
2	2	1.86076E-07		
2	1	1.77835E-07		
1	4	1.29485E-07		
1	3	1.19393E-07	4.62809E-07	Capsule 1
1	2	1.11236E-07		
1	1	1.02695E-07		

AGR-34.particle2b: ¹³¹I Concentration (moles) at the EOC (no decay)

Cycle 155A

AGR-34 (calculation with PARTICLE model JMOCUP calculation)
data from: QUARK: /ATR/AGR-34.particle2b/155A-
depletion/fcompch/iodine2.agr34.particle2b.155A.ts57.1131.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³¹ I Conc (moles)	Total Concentration per capsule (moles)	
12	4	8.37620E-08	3.71012E-07	Capsule 12
12	3	9.00720E-08		
12	2	9.57160E-08		
12	1	1.01462E-07		
11	4	1.44449E-07	6.18057E-07	Capsule 11
11	3	1.52002E-07		
11	2	1.57876E-07		
11	1	1.63730E-07		
10	4	1.90841E-07	7.85519E-07	Capsule 10
10	3	1.95336E-07		
10	2	1.98731E-07		
10	1	2.00611E-07		
9	4	2.19870E-07	8.90000E-07	Capsule 9
9	3	2.21680E-07		
9	2	2.23530E-07		
9	1	2.24920E-07		
8	4	2.34600E-07	9.43170E-07	Capsule 8
8	3	2.35580E-07		
8	2	2.36320E-07		
8	1	2.36670E-07		
7	4	2.41910E-07	9.70360E-07	Capsule 7
7	3	2.42970E-07		
7	2	2.43070E-07		
7	1	2.42410E-07		
6	4	2.47500E-07	9.84810E-07	Capsule 6
6	3	2.45930E-07		
6	2	2.44920E-07		
6	1	2.46460E-07		
5	4	2.43270E-07		

5	3	2.40760E-07	9.65580E-07	Capsule 5
5	2	2.40950E-07		
5	1	2.40600E-07		
4	4	2.35560E-07		
4	3	2.32200E-07	9.27540E-07	Capsule 4
4	2	2.30230E-07		
4	1	2.29550E-07		
3	4	2.14670E-07		
3	3	2.11040E-07	8.37600E-07	Capsule 3
3	2	2.08190E-07		
3	1	2.03700E-07		
2	4	1.81135E-07		
2	3	1.74758E-07	6.86659E-07	Capsule 2
2	2	1.68889E-07		
2	1	1.61877E-07		
1	4	1.19173E-07		
1	3	1.11183E-07	4.28598E-07	Capsule 1
1	2	1.03032E-07		
1	1	9.52100E-08		

AGR-34.particle2b: ¹³¹I Concentration (moles) at the EOC (no decay)

Cycle 155B

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/155B-depletion/fcompch/iodine2.agr34.particle2b.155B.ts53.I131.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³¹ I Conc (moles)	Total Concentration per capsule (moles)	
12	4	7.42040E-08	3.30001E-07	Capsule 12
12	3	7.98240E-08		
12	2	8.51960E-08		
12	1	9.07770E-08		
11	4	1.26575E-07	5.36591E-07	Capsule 11
11	3	1.32052E-07		
11	2	1.37198E-07		
11	1	1.40766E-07		
10	4	1.61412E-07	6.63491E-07	Capsule 10
10	3	1.64915E-07		
10	2	1.67666E-07		
10	1	1.69498E-07		
9	4	1.82568E-07	7.36713E-07	Capsule 9
9	3	1.83079E-07		
9	2	1.84977E-07		
9	1	1.86089E-07		
8	4	1.91489E-07	7.70358E-07	Capsule 8
8	3	1.92154E-07		
8	2	1.93298E-07		
8	1	1.93417E-07		
7	4	1.96509E-07	7.86834E-07	Capsule 7
7	3	1.96936E-07		
7	2	1.96456E-07		
7	1	1.96933E-07		
6	4	2.00929E-07	7.98950E-07	Capsule 6
6	3	1.98738E-07		
6	2	1.98895E-07		
6	1	2.00388E-07		
5	4	1.99312E-07		

5	3	1.97039E-07	7.89047E-07	Capsule 5
5	2	1.95986E-07		
5	1	1.96710E-07		
4	4	1.93421E-07		
4	3	1.91431E-07	7.63919E-07	Capsule 4
4	2	1.89551E-07		
4	1	1.89516E-07		
3	4	1.80067E-07		
3	3	1.76797E-07	7.04362E-07	Capsule 3
3	2	1.74960E-07		
3	1	1.72538E-07		
2	4	1.55304E-07		
2	3	1.50035E-07	5.90859E-07	Capsule 2
2	2	1.45104E-07		
2	1	1.40416E-07		
1	4	1.05032E-07		
1	3	9.78950E-08	3.78695E-07	Capsule 1
1	2	9.16080E-08		
1	1	8.41600E-08		

AGR-34.particle2b: ¹³⁵I Concentration (moles) at the EOC (no decay)

Cycle 151A

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/151A-depletion/fcompch/iodine2.agr34.particle2b.151A.ts58.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³⁵ I Conc (moles)
12	4	6.49700E-09
12	3	6.90620E-09
12	2	7.26010E-09
12	1	7.82450E-09
11	4	1.13079E-08
11	3	1.21450E-08
11	2	1.26436E-08
11	1	1.32662E-08
10	4	1.58026E-08
10	3	1.61787E-08
10	2	1.63552E-08
10	1	1.67988E-08
9	4	1.86372E-08
9	3	1.87788E-08
9	2	1.87492E-08
9	1	1.89652E-08
8	4	1.94247E-08
8	3	1.96946E-08
8	2	1.99845E-08
8	1	1.97668E-08
7	4	1.97713E-08
7	3	2.05140E-08
7	2	2.01800E-08
7	1	1.98669E-08
6	4	2.06350E-08
6	3	2.07240E-08

2.8488E-08 Capsule 12

4.9363E-08 Capsule 11

6.5135E-08 Capsule 10

7.5130E-08 Capsule 9

7.8871E-08 Capsule 8

8.0332E-08 Capsule 7

6	2	2.10150E-08
6	1	2.06670E-08
5	4	2.04510E-08
5	3	2.05880E-08
5	2	2.04540E-08
5	1	2.04680E-08
4	4	1.99811E-08
4	3	2.00340E-08
4	2	1.96831E-08
4	1	1.92843E-08
3	4	1.77806E-08
3	3	1.76916E-08
3	2	1.72976E-08
3	1	1.68497E-08
2	4	1.47388E-08
2	3	1.40988E-08
2	2	1.36053E-08
2	1	1.28198E-08
1	4	9.07500E-09
1	3	8.45100E-09
1	2	7.82280E-09
1	1	7.19260E-09

8.3041E-08 Capsule 6

8.1961E-08 Capsule 5

7.8983E-08 Capsule 4

6.9620E-08 Capsule 3

5.5263E-08 Capsule 2

3.2541E-08 Capsule 1

AGR-34.particle2b: ¹³⁵I Concentration (moles) at the EOC (no decay)

Cycle 151B

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/151B-depletion/fcompch/iodine2.agr34.particle2b.151B.ts56.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³⁵ I Conc (moles)
12	4	6.44170E-09
12	3	6.88330E-09
12	2	7.26940E-09
12	1	7.77870E-09
11	4	1.11495E-08
11	3	1.18328E-08
11	2	1.24116E-08
11	1	1.29500E-08
10	4	1.53864E-08
10	3	1.55822E-08
10	2	1.58838E-08
10	1	1.59878E-08
9	4	1.77346E-08
9	3	1.80534E-08
9	2	1.79645E-08
9	1	1.83108E-08
8	4	1.87140E-08
8	3	1.90214E-08
8	2	1.90123E-08
8	1	1.85209E-08
7	4	1.89230E-08
7	3	1.92004E-08
7	2	1.91361E-08
7	1	1.92653E-08
6	4	1.92902E-08
6	3	1.94887E-08

2.8373E-08 Capsule 12

4.8344E-08 Capsule 11

6.2840E-08 Capsule 10

7.2063E-08 Capsule 9

7.5269E-08 Capsule 8

7.6525E-08 Capsule 7

6	2	1.93284E-08
6	1	1.95013E-08
5	4	1.93104E-08
5	3	1.93136E-08
5	2	1.92998E-08
5	1	1.88882E-08
4	4	1.89641E-08
4	3	1.89340E-08
4	2	1.87129E-08
4	1	1.84951E-08
3	4	1.72090E-08
3	3	1.70745E-08
3	2	1.66421E-08
3	1	1.61254E-08
2	4	1.42364E-08
2	3	1.35954E-08
2	2	1.33545E-08
2	1	1.28508E-08
1	4	8.93880E-09
1	3	8.24760E-09
1	2	7.76760E-09
1	1	7.19410E-09

7.7609E-08 Capsule 6

7.6812E-08 Capsule 5

7.5106E-08 Capsule 4

6.7051E-08 Capsule 3

5.4037E-08 Capsule 2

3.2148E-08 Capsule 1

AGR-34.particle2b: ¹³⁵I Concentration (moles) at the EOC (no decay)

Cycle 152B

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/152B-depletion/fcompch/iodine2.agr34.particle2b.152B.ts52.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³⁵ I Conc (moles)
12	4	6.54370E-09
12	3	6.98540E-09
12	2	7.37400E-09
12	1	8.12200E-09
11	4	1.13500E-08
11	3	1.21780E-08
11	2	1.26415E-08
11	1	1.31929E-08
10	4	1.54486E-08
10	3	1.58173E-08
10	2	1.63234E-08
10	1	1.63785E-08
9	4	1.81881E-08
9	3	1.82256E-08
9	2	1.85912E-08
9	1	1.83372E-08
8	4	1.94300E-08
8	3	1.94278E-08
8	2	1.93434E-08
8	1	1.91600E-08
7	4	1.96689E-08
7	3	1.99756E-08
7	2	1.98361E-08
7	1	1.99586E-08
6	4	2.01690E-08
6	3	2.00720E-08

2.9025E-08 Capsule 12

4.9362E-08 Capsule 11

6.3968E-08 Capsule 10

7.3342E-08 Capsule 9

7.7361E-08 Capsule 8

7.9439E-08 Capsule 7

6	2	2.02680E-08
6	1	2.01600E-08
5	4	2.00548E-08
5	3	2.02680E-08
5	2	2.00634E-08
5	1	1.99354E-08
4	4	1.92561E-08
4	3	1.93554E-08
4	2	1.93880E-08
4	1	1.87760E-08
3	4	1.77084E-08
3	3	1.75880E-08
3	2	1.70503E-08
3	1	1.66660E-08
2	4	1.47254E-08
2	3	1.42395E-08
2	2	1.38397E-08
2	1	1.31531E-08
1	4	9.26840E-09
1	3	8.68770E-09
1	2	8.15640E-09
1	1	7.49330E-09

8.0669E-08 Capsule 6

8.0322E-08 Capsule 5

7.6776E-08 Capsule 4

6.9013E-08 Capsule 3

5.5958E-08 Capsule 2

3.3606E-08 Capsule 1

AGR-34.particle2b: ¹³⁵I Concentration (moles) at the EOC (no decay)

Cycle 154A

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/154A-depletion/fcompch/iodine2.agr34.particle2b.154A.ts55.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³⁵ I Conc (moles)
12	4	6.17350E-09
12	3	6.71810E-09
12	2	7.15110E-09
12	1	7.49920E-09
11	4	1.09776E-08
11	3	1.14940E-08
11	2	1.17465E-08
11	1	1.22319E-08
10	4	1.45314E-08
10	3	1.48440E-08
10	2	1.50551E-08
10	1	1.50831E-08
9	4	1.67686E-08
9	3	1.68257E-08
9	2	1.70516E-08
9	1	1.70931E-08
8	4	1.80077E-08
8	3	1.77983E-08
8	2	1.78377E-08
8	1	1.78403E-08
7	4	1.81467E-08
7	3	1.88974E-08
7	2	1.86827E-08
7	1	1.86918E-08
6	4	1.85563E-08
6	3	1.88497E-08

2.7542E-08 Capsule 12

4.6450E-08 Capsule 11

5.9514E-08 Capsule 10

6.7739E-08 Capsule 9

7.1484E-08 Capsule 8

7.4419E-08 Capsule 7

6	2	1.86198E-08
6	1	1.87567E-08
5	4	1.84838E-08
5	3	1.84327E-08
5	2	1.85205E-08
5	1	1.84558E-08
4	4	1.79319E-08
4	3	1.77394E-08
4	2	1.76032E-08
4	1	1.74379E-08
3	4	1.62376E-08
3	3	1.60453E-08
3	2	1.58898E-08
3	1	1.53793E-08
2	4	1.37712E-08
2	3	1.34614E-08
2	2	1.28229E-08
2	1	1.23587E-08
1	4	8.91260E-09
1	3	8.33480E-09
1	2	7.81220E-09
1	1	7.09700E-09

7.4783E-08 Capsule 6

7.3893E-08 Capsule 5

7.0712E-08 Capsule 4

6.3552E-08 Capsule 3

5.2414E-08 Capsule 2

3.2157E-08 Capsule 1

AGR-34.particle2b: ¹³⁵I Concentration (moles) at the EOC (no decay)

Cycle 154B

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/154B-depletion/fcompch/iodine2.agr34.particle2b.154B.ts54.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³⁵ I Conc (moles)
12	4	6.89840E-09
12	3	7.32460E-09
12	2	7.79720E-09
12	1	8.07500E-09
11	4	1.17508E-08
11	3	1.23506E-08
11	2	1.27551E-08
11	1	1.32246E-08
10	4	1.50271E-08
10	3	1.56910E-08
10	2	1.55273E-08
10	1	1.55473E-08
9	4	1.69201E-08
9	3	1.69656E-08
9	2	1.72321E-08
9	1	1.72646E-08
8	4	1.77927E-08
8	3	1.79911E-08
8	2	1.78664E-08
8	1	1.77889E-08
7	4	1.82527E-08
7	3	1.83818E-08
7	2	1.82436E-08
7	1	1.80323E-08
6	4	1.83828E-08
6	3	1.83713E-08

3.0095E-08 Capsule 12

5.0081E-08 Capsule 11

6.1793E-08 Capsule 10

6.8382E-08 Capsule 9

7.1439E-08 Capsule 8

7.2910E-08 Capsule 7

6	2	1.84553E-08
6	1	1.86520E-08
5	4	1.84043E-08
5	3	1.80698E-08
5	2	1.80536E-08
5	1	1.80860E-08
4	4	1.80093E-08
4	3	1.79851E-08
4	2	1.76307E-08
4	1	1.73532E-08
3	4	1.66510E-08
3	3	1.64858E-08
3	2	1.62931E-08
3	1	1.60335E-08
2	4	1.43471E-08
2	3	1.36625E-08
2	2	1.33166E-08
2	1	1.29038E-08
1	4	9.31130E-09
1	3	8.70650E-09
1	2	8.27300E-09
1	1	7.52630E-09

7.3861E-08 Capsule 6

7.2614E-08 Capsule 5

7.0978E-08 Capsule 4

6.5463E-08 Capsule 3

5.4230E-08 Capsule 2

3.3817E-08 Capsule 1

AGR-34.particle2b: ¹³⁵I Concentration (moles) at the EOC (no decay)

Cycle 155A

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/155A-depletion/fcompch/iodine2.agr34.particle2b.155A.ts57.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³⁵ I Conc (moles)
12	4	6.32480E-09
12	3	6.59440E-09
12	2	7.04870E-09
12	1	7.35480E-09
11	4	1.05877E-08
11	3	1.10658E-08
11	2	1.13716E-08
11	1	1.18534E-08
10	4	1.34214E-08
10	3	1.38969E-08
10	2	1.39741E-08
10	1	1.39885E-08
9	4	1.52843E-08
9	3	1.53043E-08
9	2	1.57024E-08
9	1	1.56492E-08
8	4	1.61184E-08
8	3	1.61401E-08
8	2	1.63030E-08
8	1	1.61557E-08
7	4	1.68791E-08
7	3	1.66069E-08
7	2	1.67390E-08
7	1	1.64800E-08
6	4	1.70501E-08
6	3	1.68931E-08

2.7323E-08 Capsule 12

4.4879E-08 Capsule 11

5.5281E-08 Capsule 10

6.1940E-08 Capsule 9

6.4717E-08 Capsule 8

6.6705E-08 Capsule 7

6	2	1.66953E-08
6	1	1.68629E-08
5	4	1.67983E-08
5	3	1.66902E-08
5	2	1.63564E-08
5	1	1.63115E-08
4	4	1.64730E-08
4	3	1.62388E-08
4	2	1.60961E-08
4	1	1.59619E-08
3	4	1.51490E-08
3	3	1.49318E-08
3	2	1.46640E-08
3	1	1.43717E-08
2	4	1.30097E-08
2	3	1.25956E-08
2	2	1.21510E-08
2	1	1.17519E-08
1	4	8.87310E-09
1	3	8.26560E-09
1	2	7.76450E-09
1	1	7.16890E-09

6.7501E-08 Capsule 6

6.6156E-08 Capsule 5

6.4770E-08 Capsule 4

5.9117E-08 Capsule 3

4.9508E-08 Capsule 2

3.2072E-08 Capsule 1

AGR-34.particle2b: ¹³⁵I Concentration (moles) at the EOC (no decay)

Cycle 155B

AGR-34 (calculation with PARTICLE model JMOCUP calculation)

data from: QUARK: /ATR/AGR-34.particle2b/155B-depletion/fcompch/iodine2.agr34.particle2b.155B.ts53.output

Capsule No. (#)	Level No. (#)	Stack No. 1 ¹³⁵ I Conc (moles)
12	4	6.35060E-09
12	3	6.93440E-09
12	2	7.31210E-09
12	1	7.79910E-09
11	4	1.06711E-08
11	3	1.10133E-08
11	2	1.14667E-08
11	1	1.17644E-08
10	4	1.32109E-08
10	3	1.34495E-08
10	2	1.38217E-08
10	1	1.38807E-08
9	4	1.46162E-08
9	3	1.47943E-08
9	2	1.49822E-08
9	1	1.49405E-08
8	4	1.52806E-08
8	3	1.53582E-08
8	2	1.54590E-08
8	1	1.53836E-08
7	4	1.55219E-08
7	3	1.56576E-08
7	2	1.56666E-08
7	1	1.54803E-08
6	4	1.60211E-08

2.8396E-08 Capsule 12

4.4916E-08 Capsule 11

5.4363E-08 Capsule 10

5.9333E-08 Capsule 9

6.1481E-08 Capsule 8

6.2326E-08 Capsule 7

6	3	1.56628E-08
6	2	1.57634E-08
6	1	1.58281E-08
5	4	1.58106E-08
5	3	1.58264E-08
5	2	1.55418E-08
5	1	1.55293E-08
4	4	1.53698E-08
4	3	1.55010E-08
4	2	1.53190E-08
4	1	1.51600E-08
3	4	1.46765E-08
3	3	1.45341E-08
3	2	1.42996E-08
3	1	1.40617E-08
2	4	1.27529E-08
2	3	1.25753E-08
2	2	1.20573E-08
2	1	1.18353E-08
1	4	8.97530E-09
1	3	8.45740E-09
1	2	7.83170E-09
1	1	7.37550E-09

6.3275E-08 Capsule 6

6.2708E-08 Capsule 5

6.1350E-08 Capsule 4

5.7572E-08 Capsule 3

4.9221E-08 Capsule 2

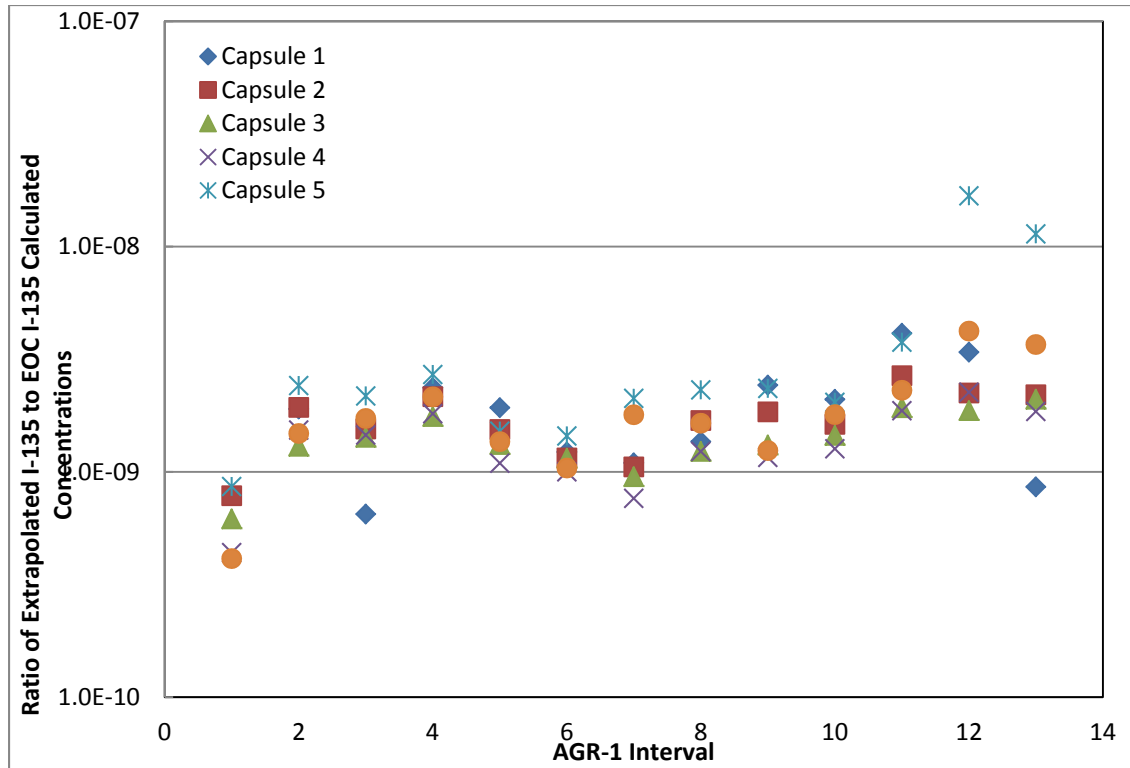
3.2640E-08 Capsule 1

Appendix C

End of Cycle Release Fractions of ^{135}I

Cycle	Release Fraction of Extrapolated ^{135}I to EOC ^{135}I Calculated Concentrations						
	Interval	Capsule 1	Capsule 2	Capsule 3	Capsule 4	Capsule 5	Capsule 6
138B	1		7.85E-10	6.19E-10	4.38E-10	8.61E-10	4.13E-10
139A	2	1.9E-09	1.93E-09	1.3E-09	1.53E-09	2.42E-09	1.48E-09
139B	3	6.5E-10	1.55E-09	1.42E-09	1.46E-09	2.17E-09	1.73E-09
140A	4	2.37E-09	2.16E-09	1.76E-09	1.81E-09	2.71E-09	2.15E-09
140B	5	1.93E-09	1.54E-09	1.32E-09	1.09E-09	1.52E-09	1.36E-09
141A	6	1.23E-09	1.15E-09	1.15E-09	1E-09	1.44E-09	1.04E-09
142A	7	1.1E-09	1.05E-09	9.52E-10	7.64E-10	2.12E-09	1.79E-09
142B	8	1.36E-09	1.69E-09	1.23E-09	1.23E-09	2.31E-09	1.65E-09
143A	9	2.43E-09	1.85E-09	1.32E-09	1.16E-09	2.34E-09	1.24E-09
143B	10	2.1E-09	1.63E-09	1.45E-09	1.27E-09	2.03E-09	1.8E-09
144A	11	4.13E-09	2.67E-09	1.93E-09	1.87E-09	3.76E-09	2.3E-09
144B	12	3.4E-09	2.24E-09	1.87E-09	2.26E-09	1.68E-08	4.22E-09
145A	13	8.58E-10	2.2E-09	2.1E-09	1.85E-09	1.14E-08	3.68E-09

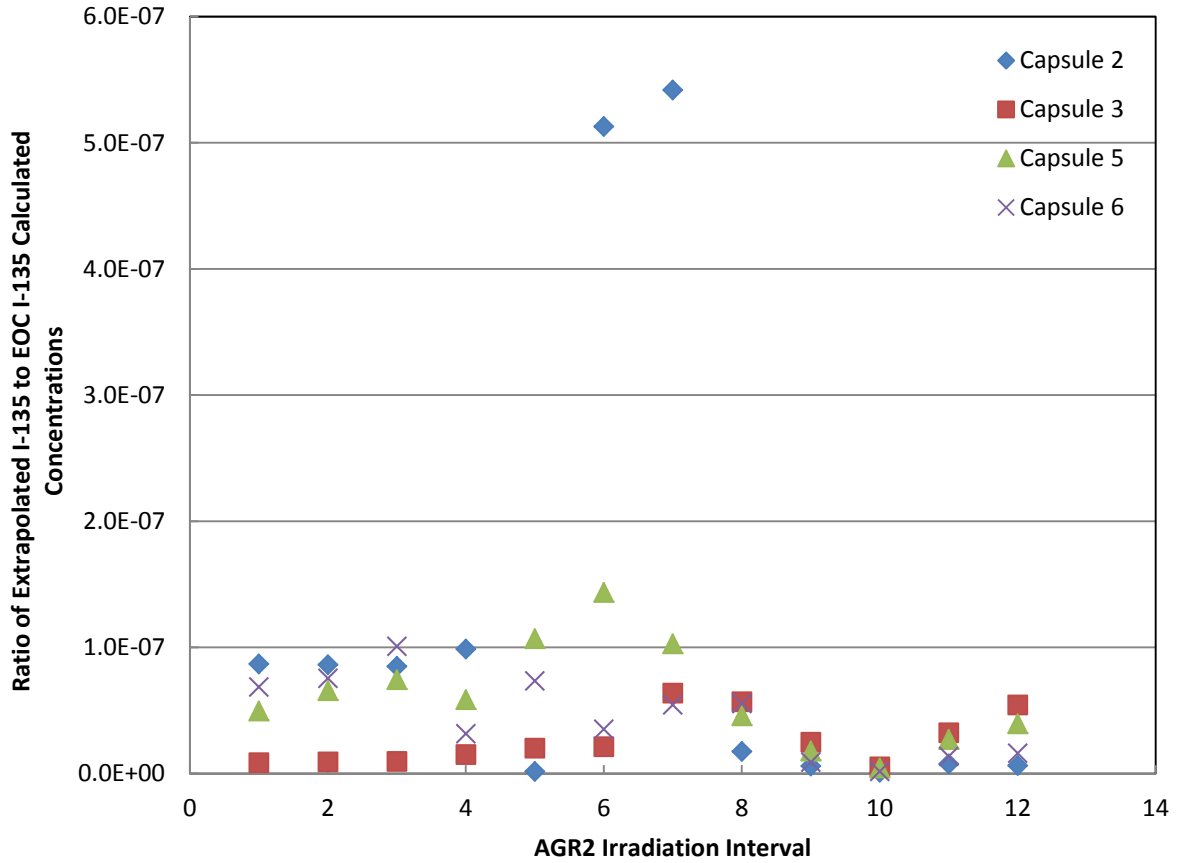
Table C. 1: Release fractions for AGR-1 for irradiation intervals 1-13. Data for irradiation cycle 138B, capsule 1 was not computed as flow data was not recorded.



C. 1: I-1³⁵I 35 release fraction versus operating intervals for experiment AGR-1. The low release fraction indicates good fuel performance.

Release Fraction of Extrapolated ¹³⁵ I to EOC ¹³⁵ I Calculated Concentrations					
Cycle	Interval	Capsule 2	Capsule 3	Capsule 5	Capsule 6
147A	1	8.69382E-08	8.69453E-09	4.96439E-08	6.86963E-08
148A	2	8.62739E-08	9.28375E-09	6.56728E-08	7.54534E-08
148B	3	8.4939E-08	9.69251E-09	7.44954E-08	1.0085E-07
149A	4	9.86695E-08	1.51249E-08	5.86034E-08	3.16018E-08
149B	5	1.72079E-09	2.01319E-08	1.06951E-07	7.34676E-08
150B	6	5.12929E-07	2.13693E-08	1.43611E-07	3.52052E-08
151A	7	5.41872E-07	6.38446E-08	1.02863E-07	5.44225E-08
151B	8	1.74744E-08	5.70225E-08	4.57819E-08	5.54911E-08
152B	9	5.96189E-09	2.49397E-08	1.78448E-08	8.97406E-09
153B	10	1.05394E-09	5.40796E-09	4.4439E-09	1.66538E-09
154A	11	7.66726E-09	3.2364E-08	2.69772E-08	1.36379E-08
154B	12	6.346E-09	5.44716E-08	3.94074E-08	1.61013E-08

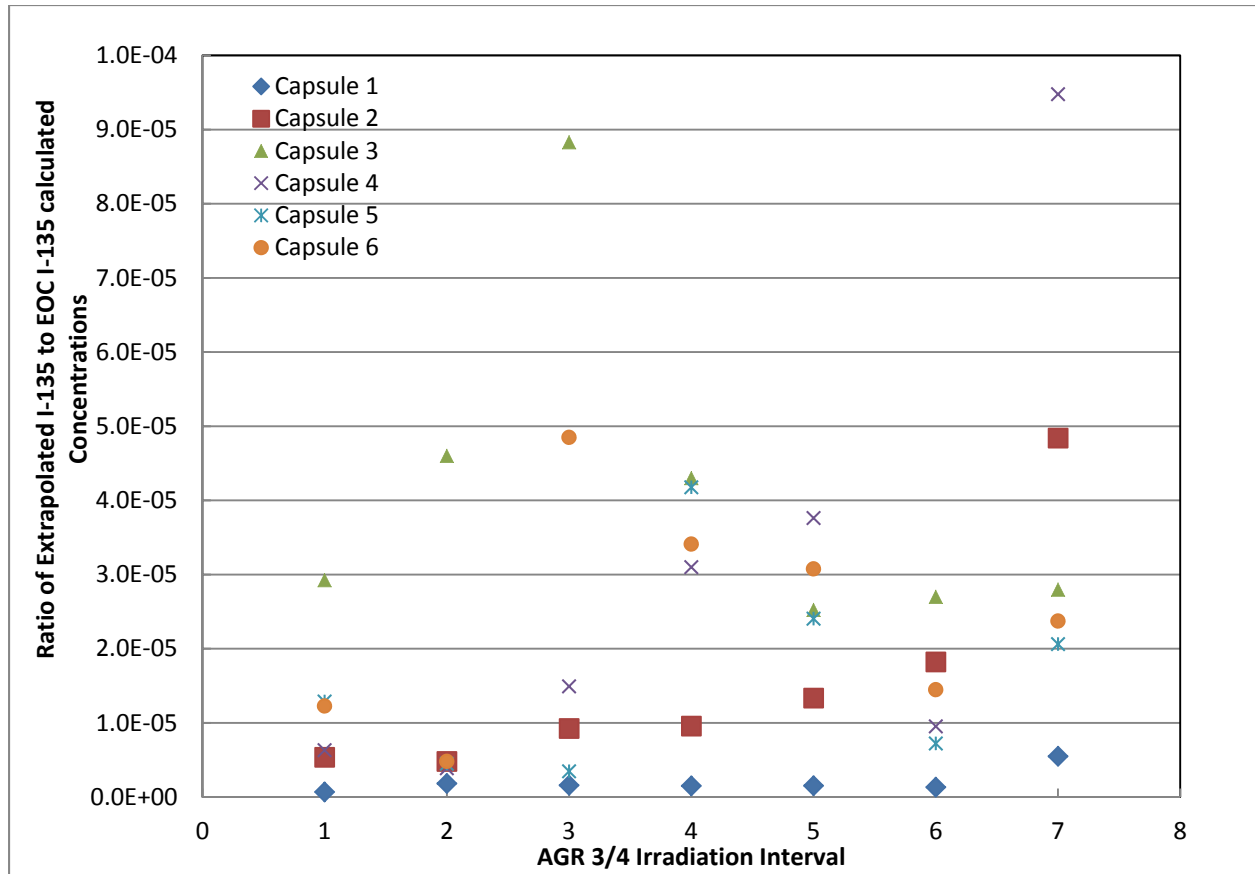
Table C. 2: Release fractions for AGR-2 for irradiation intervals 1 -12. Only data from cycles 147A,148A and 148B are considered qualified. All data after cycle 149A contain possible capsule-to-capsule crosstalk events and the data is used just to trend performance. Capsules 1 and 4 data are protected by CRADA restrictions, and can't be included.



C. 2: ^{135}I release fractions versus operating intervals for experiment AGR-2. Only data from the first three operating intervals (cycles 147A, 148A and 148B) are considered qualified. All data after cycle 149A contain possible capsule-to-capsule crosstalk events and the data is used just to trend performance.

		Release Fraction of Extrapolated ^{135}I to EOC ^{135}I Calculated Concentrations					
Cycle	Interval	Capsule 1	Capsule 2	Capsule 3	Capsule 4	Capsule 5	Capsule 6
151A	1	6.76716E-07	5.37224E-06	2.92508E-05	6.32218E-06	1.28854E-05	1.22783E-05
151B	2	1.82987E-06	4.81106E-06	4.60056E-05	3.87407E-06	4.48751E-06	4.80839E-06
152B	3	1.59765E-06	9.24576E-06	8.82963E-05	1.49254E-05	3.47601E-06	4.85005E-05
154A	4	1.50979E-06	9.56824E-06	4.30127E-05	3.10046E-05	4.17733E-05	3.41008E-05
154B	5	1.52407E-06	1.33496E-05	2.52380E-05	3.76181E-05	2.40499E-05	3.07582E-05
155A	6	1.33029E-06	1.82184E-05	2.70062E-05	9.52626E-06	7.21544E-06	1.44653E-05
155B	7	5.50377E-06	4.84168E-05	2.79755E-05	9.47770E-05	2.06217E-05	2.37379E-05

Table C. 3: Release fractions for AGR-3/4, capsules 1-6 for irradiation intervals 1 -7. The higher release fraction is an effect of the designed to fail fuel that was incorporated within the test train.



C. 3: ^{135}I release fraction versus operating intervals for experiment AGR-3/4, capsules 1-6. The high release fraction directly correlates to the designed to fail fuel within the experiment.

Cycle	Interval	Release Fraction of Extrapolated ^{135}I to EOC ^{135}I Calculated Concentrations					
		Capsule 7	Capsule 8	Capsule 9	Capsule 10	Capsule 11	Capsule 12
151A	1	1.09778E-04	1.06539E-04	7.27816E-06	1.06188E-04	5.41265E-05	1.14613E-06
151B	2	8.92819E-05	1.09495E-04	5.54730E-06	7.63804E-05	5.32945E-05	3.17078E-06
152B	3	9.77853E-05	8.50023E-05	3.54789E-05	1.10508E-04	7.07223E-05	2.82649E-06
154A	4	5.72385E-05	9.93549E-05	2.53407E-05	6.68706E-05	6.7163E-05	1.70805E-05
154B	5	2.17861E-05	9.84303E-05	1.41906E-05	1.27401E-04	6.17891E-05	4.65186E-06
155A	6	1.67590E-05	1.45321E-05	2.45940E-05	6.45731E-05	3.57567E-05	4.75439E-06
155B	7	1.33552E-05	8.70155E-06	5.28269E-06	1.34726E-05	3.65067E-05	2.23515E-06

Table C. 4: Release fractions for AGR-3/4, capsules 7-12 for irradiation intervals 1-7. The higher release fraction is an effect of the designed to fail fuel that was incorporated within the test train.

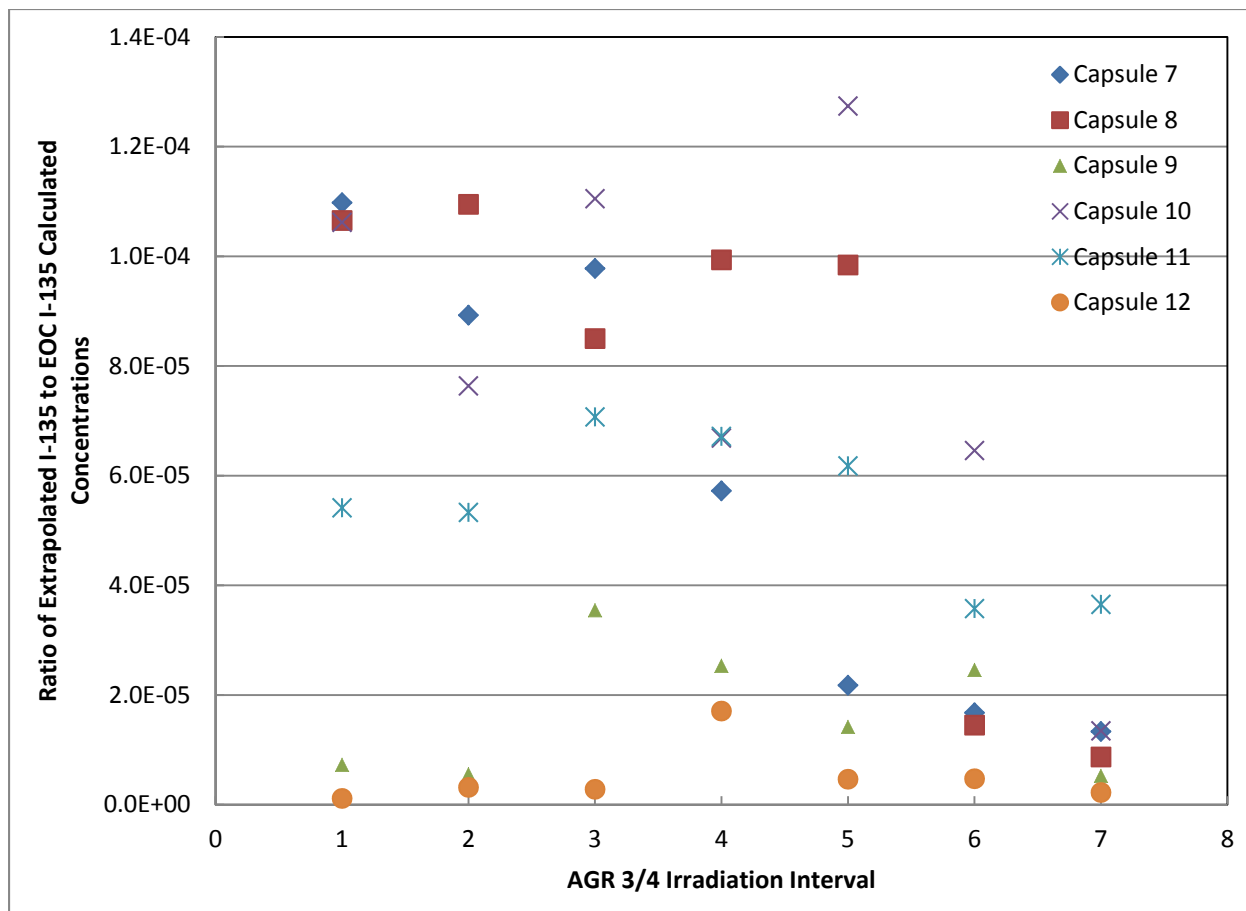


Table C. 5: ^{135}I release fraction versus operating intervals for experiment AGR-3/4, capsules 7-12. The high release fraction directly correlates to the designed to fail fuel within the experiment.