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ORNL-27 (4-00)

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## Data Compilation for AGR-1 Variant 1 Coated Particle Composite LEU01-47T

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Oak Ridge National Laboratory

This document is a compilation of characterization data for the AGR-1 variant 1 coated particle composite LEU01-47T, a composite of three batches of TRISO-coated 350  $\mu\text{m}$  19.7% low enrichment uranium oxide/uranium carbide kernels (LEUCO). The AGR-1 TRISO-coated particles consist of a spherical kernel coated with a  $\sim 50\%$  dense carbon buffer layer (100  $\mu\text{m}$  nominal thickness) followed by a dense inner pyrocarbon layer (40  $\mu\text{m}$  nominal thickness) followed by a SiC layer (35  $\mu\text{m}$  nominal thickness) followed by another dense outer pyrocarbon layer (40  $\mu\text{m}$  nominal thickness). The coated particles were produced by ORNL for the Advanced Gas Reactor Fuel Development and Qualification (AGR) program to be put into compacts for insertion in the first irradiation test capsule, AGR-1. The kernels were obtained from BWXT and identified as composite G73D-20-69302. The BWXT kernel lot G73D-20-69302 was riffled into sublots for characterization and coating by ORNL and identified as LEU01-## (where ## is a series of integers beginning with 01).

The AGR-1 variant 1 coated particles were similar to the AGR-1 baseline coated particles with the exception that the inner pyrocarbon (IPyC) coating was deposited at  $\sim 25^\circ\text{C}$  higher temperature. A data compilation for the AGR-1 baseline coated particle composite LEU01-46T can be found in ORNL/TM-2006/019.

Additional particle batches were coated with only buffer or buffer plus inner pyrocarbon (IPyC) layers using similar process conditions as used for the full TRISO batches comprising the LEU01-47T composite. These batches were fabricated in order to qualify that the process conditions used for buffer would produce acceptable densities as described in sections 8 and to measure the IPyC density as described in section 9. The buffer qualification batches were the same as used to qualify the baseline buffer conditions and used 350  $\mu\text{m}$  natural uranium oxide/uranium carbide kernels (NUCO). The NUCO kernels were obtained from BWXT and were identified as composite G73B-NU-69300. The use of NUCO surrogate kernels is not expected to significantly effect the density of the buffer coating. A confirmatory buffer-only batch using LEUCO kernels from G73D-20-69302 was coated and characterized to verify this assumption. The IPyC qualification batches used LEUCO kernels from G73D-20-69302.

The AGR-1 Fuel Product Specification and Characterization Guidance (INL EDF-4380, Rev. 6) provides the requirements necessary for acceptance of the fuel manufactured for the AGR-1 irradiation test. Sections 5.2 and 5.3 of EDF-4380 provide the property requirements for the coated particle batches and coated particle composite. The Statistical Sampling Plan for AGR Fuel Materials (INL EDF-4542, Rev. 6) provides additional guidance regarding statistical methods for product acceptance and recommended sample sizes. The procedures for characterizing and qualifying the particles are outlined in ORNL product inspection plans: AGR-CHAR-PIP-01, AGR-CHAR-PIP-02, AGR-CHAR-PIP-03, and AGR-CHAR-PIP-04. The inspection report forms generated by these product inspection plans document the product acceptance for the property requirements listed in sections 5.2 and 5.3 of EDF-4380.

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**1 Summary of acceptance test results for LEU01-47T**

This section contains all the inspection report forms (IRF) associated with the coated particle composite LEU01-47T. These inspection report forms summarize the acceptance testing performed according to the product inspection plans: AGR-CHAR-PIP-02, AGR-CHAR-PIP-03, and AGR-CHAR-PIP-04. The information in these forms covers all the property specifications listed in sections 5.2 and 5.3 of the AGR-1 Fuel Product Specification and Characterization Guidance document INL EDF-4380, Rev. 6. The coated particle composite, LEU01-47T, was found to meet all the requirements in these two sections of EDF-4380 with the exception of the IPyC density. The IPyC coatings for variant 1 were deposited at ~25°C higher temperature than was used to deposit the IPyC coatings for the baseline fuel particles, and are not required to meet the baseline IPyC density specification in section 5.3 of EDF-4380. The expected IPyC density according to section 3.2 of EDF-4380 was ~1.85 g/cc.

These inspection report forms also appear in later sections of this compilation, accompanied by the associated data report forms showing the results of each individual measurement.

Table 1-1 is provided for quick reference. It gives the mean values of key properties of the coated particle composite, LEU01-47T. For standard deviations of the distribution of the measured values see the appropriate IRF. For discussions on the uncertainty in these values, see the associated data acquisition methods and data report forms. The kernel diameter and density values are from ORNL measurements made for information only. The buffer and IPyC densities in the table are averages of the means for the individual interrupted batches (including buffer confirmation batch on LEUCO), rather than direct measurements on the composite. The OPyC density in the table is an average of the mean OPyC density for each batch weighted by the fraction of each batch in the composite.

**Table 1-1:** Quick reference table for key variable properties of LEU01-47T.

<b>Property</b>	<b>Mean</b>
Average kernel diameter ( $\mu\text{m}$ )	349.7
Kernel envelope density ( $\text{Mg}/\text{m}^3$ )	10.924
Average buffer thickness ( $\mu\text{m}$ )	102.5
Average IPyC thickness ( $\mu\text{m}$ )	40.5
Average SiC thickness ( $\mu\text{m}$ )	35.7
Average OPyC thickness ( $\mu\text{m}$ )	41.1
Buffer envelope density ( $\text{Mg}/\text{m}^3$ ) (interrupted batches)	1.10
IPyC sink/float density ( $\text{Mg}/\text{m}^3$ ) (interrupted batches)	1.853
SiC sink/float density ( $\text{Mg}/\text{m}^3$ )	3.2060
OPyC sink/float density ( $\text{Mg}/\text{m}^3$ ) (weighted average)	1.898
IPyC anisotropy (BAFo equivalent)	1.014
OPyC anisotropy (BAFo equivalent)	1.013

Table 1-2 is also provided for quick reference. It gives the upper limit of the 95% confidence interval of the defect fraction for key attribute properties of the coated particle composite, LEU01-47T. In other words, these values are the lowest tolerance limits for which the composite would be deemed acceptable at 95% confidence based on the particular sample that was measured. For the actual number of trials and number of failures observed, see the inspection report form for the coated particle composite.

**Table 1-2:** Quick reference table for key attribute properties of LEU01-47T.

<b>Property</b>	<b>Defect Fraction</b>
Particles with SiC gold spot defects	$\leq 8.2 \times 10^{-4}$
Particle aspect ratio	$\leq 1.7 \times 10^{-3}$
Particles with burn-leach defects	$\leq 4.0 \times 10^{-5}$
Particles with missing OPyC	$\leq 9.7 \times 10^{-5}$

**Inspection Report Form IRF-02A: Interrupted Coating Batches - Buffer Density**

<b>Procedure:</b>	AGR-CHAR-PIP-02 Rev. 4
<b>Batch 1 ID:</b>	NUCO350-25B
<b>Batch 1 description:</b>	Buffer-coated BWXT kernel composite 69300
<b>Batch 2 ID:</b>	NUCO350-36B
<b>Batch 2 description:</b>	Buffer-coated BWXT kernel composite 69300
<b>Batch 3 ID:</b>	NUCO350-54B
<b>Batch 3 description:</b>	Buffer-coated BWXT kernel composite 69300

Property	Measured Data				Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	t value (t)					
Batch 1: Buffer envelope density (Mg/m <sup>3</sup> )	1.08	0.04	5	2.132	mean	A = $x - ts/\sqrt{n} \geq 0.88$	1.04	pass	DRF-16
					$1.03 \pm 0.15$	B = $x + ts/\sqrt{n} \leq 1.18$	1.12	pass	DRF-22
Batch 2: Buffer envelope density (Mg/m <sup>3</sup> )	1.11	0.05	5	2.132	mean	A = $x - ts/\sqrt{n} \geq 0.88$	1.06	pass	DRF-16
					$1.03 \pm 0.15$	B = $x + ts/\sqrt{n} \leq 1.18$	1.16	pass	DRF-22
Batch 3: Buffer envelope density (Mg/m <sup>3</sup> )	1.11	0.04	5	2.132	mean	A = $x - ts/\sqrt{n} \geq 0.88$	1.07	pass	DRF-16
					$1.03 \pm 0.15$	B = $x + ts/\sqrt{n} \leq 1.18$	1.15	pass	DRF-22

**Comments**

Standard deviations are  $\sqrt{5}$  times the uncertainties in buffer density (standard errors) reported on DRF-16.  
 Average thickness of buffer was 108  $\mu\text{m}$  based on average envelope volume of  $9.25\text{E-}5$  cc (effective diameter of 561  $\mu\text{m}$ ) and average kernel diameter of 345  $\mu\text{m}$ .  
 Average thickness of buffer was 108  $\mu\text{m}$  based on average outer diameter of 561  $\mu\text{m}$  obtained per DAM-10 and average kernel diameter of 345  $\mu\text{m}$ .  
 Confirmatory batch on LEUCO kernels, LEU01-16E: mean buffer density = 1.10 g/cc.

**QC Supervisor**

3-10-06  
**Date**

Accept process for buffer density (Yes or No):  Yes

**QA Reviewer**

3/29/06  
**Date**

Inspection Report Form IRF-02B: Interrupted Coating Batches - IPyC Density

Procedure:	AGR-CHAR-PIP-02 Rev. 4
Batch 1 ID:	LEU01-381
Batch 1 description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Batch 2 ID:	LEU01-301
Batch 2 description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Batch 3 ID:	LEU01-341
Batch 3 description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302

Property	Measured Data				Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	k or t value					
Batch 1: IPyC sink/float density (Mg/m <sup>3</sup> )	1.8430	0.0123	46	1.679	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.840	Note 1	DRF-03
				2.882	dispersion ≤ 0.01 ≤ 1.80 ≤ 0.01 ≥ 2.00	B = x + ts/√n ≤ 1.95	1.846	Note 1	
						C = x - ks > 1.80	1.808	Note 1	
						D = x + ks < 2.00	1.878	Note 1	
Batch 2: IPyC sink/float density (Mg/m <sup>3</sup> )	1.8588	0.0118	40	1.685	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.856	Note 1	DRF-03
				2.941	dispersion ≤ 0.01 ≤ 1.80 ≤ 0.01 ≥ 2.00	B = x + ts/√n ≤ 1.95	1.862	Note 1	
						C = x - ks > 1.80	1.824	Note 1	
						D = x + ks < 2.00	1.894	Note 1	
Batch 3: IPyC sink/float density (Mg/m <sup>3</sup> )	1.8578	0.0103	50	1.677	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.855	Note 1	DRF-03
				2.863	dispersion ≤ 0.01 ≤ 1.80 ≤ 0.01 ≥ 2.00	B = x + ts/√n ≤ 1.95	1.860	Note 1	
						C = x - ks > 1.80	1.828	Note 1	
						D = x + ks < 2.00	1.887	Note 1	

Comments
Note 1: Variant 1 is designed to have a density of around 1.85 g/cc and is not required to meet the density specification.

*[Signature]*  
QC Supervisor

3-22-06  
Date

Accept process for IPyC density (Yes or No): Not Applicable

*[Signature]*  
QA Reviewer

3/22/06  
Date

Inspection Report Form IRF-03: Coated Particle Batches

<b>Procedure:</b>	AGR-CHAR-PIP-03 Rev. 2
<b>Coated particle batch ID:</b>	LEUD1-43T
<b>Coated particle batch description:</b>	Variant 1: TRISO on BWXT kernel composite 69302

Property	Measured Data				Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean ( $\bar{x}$ )	Std. Dev. (s)	# measured (n)	t value (t)					
Average buffer thickness for each particle ( $\mu\text{m}$ )	107.6	8.5	174	1.654	mean $100 \pm 15$	$A = \bar{x} - ts/\sqrt{n} \geq 85$ $B = \bar{x} + ts/\sqrt{n} \leq 115$	106.5 108.7	pass pass	DRF-08 DRF-11
Average IPyC thickness for each particle ( $\mu\text{m}$ )	42.0	2.3	224	1.652	mean $40 \pm 5$	$A = \bar{x} - ts/\sqrt{n} \geq 35$ $B = \bar{x} + ts/\sqrt{n} \leq 45$	41.7 42.3	pass pass	DRF-08 DRF-11
Average SiC thickness for each particle ( $\mu\text{m}$ )	35.3	1.0	223	1.652	mean $35 \pm 4$	$A = \bar{x} - ts/\sqrt{n} \geq 31$ $B = \bar{x} + ts/\sqrt{n} \leq 39$	35.2 35.4	pass pass	DRF-08 DRF-11
Average OPyC thickness for each particle ( $\mu\text{m}$ )	40.7	2.2	223	1.652	mean $40 \pm 5$	$A = \bar{x} - ts/\sqrt{n} \geq 35$ $B = \bar{x} + ts/\sqrt{n} \leq 45$	40.5 40.9	pass pass	DRF-08 DRF-11
Particles with missing OPyC			16957		defect fraction $\leq 6.0 \times 10^{-4}$	$\leq 4$ in 15,500	0	pass	DRF-19

Comments
Goldspot analysis performed on missing OPyC sample for information only. 7 out of 16957 gold spots observed.

*John K...*

QC Supervisor

3-21-06

Date

Accept Coated particle batch (Yes or No):

Yes

*M. J. ...*

QA Reviewer

3/22/06

Date



Inspection Report Form IRE-03: Coated Particle Batches

<b>Procedure:</b>	AGR-CHAR-PIP-03 Rev. 2
<b>Coated particle batch ID:</b>	LEU01-44T
<b>Coated particle batch description:</b>	Variant 1: TRISO on BWXT kernel composite 69302

Property	Measured Data			t value (t)	Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)						
Average buffer thickness for each particle (µm)	103.4	6.6	176	1.654	mean 100 ± 15	A = $x - ts/\sqrt{n} \geq 85$	102.6	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 115$	104.2	pass	DRF-11
Average IPyC thickness for each particle (µm)	39.7	2.4	220	1.652	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$	39.4	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 45$	40.0	pass	DRF-11
Average SiC thickness for each particle (µm)	36.2	0.9	220	1.652	mean 35 ± 4	A = $x - ts/\sqrt{n} \geq 31$	36.1	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 39$	36.3	pass	DRF-11
Average OPyC thickness for each particle (µm)	42.8	2.1	220	1.652	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$	42.6	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 45$	43.0	pass	DRF-11
Particles with missing OPyC			15637		defect fraction $\leq 6.0 \times 10^{-4}$	$\leq 4$ in 15,500	0	pass	DRF-19

Comments
Goldspot analysis performed on missing OPyC sample for information only. 13 out of 15637 gold spots observed.

  
 QC Supervisor

3-21-06  
 Date

Accept Coated particle batch (Yes or No): Yes

  
 QA Reviewer

3/22/06  
 Date

Inspection Report Form IRF-03: Coated Particle Batches

Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-29T
Coated particle batch description:	Variant 1: TRISO on BWXT kernel composite 69302

Property	Measured Data				Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	t value (t)					
Average buffer thickness for each particle (µm)	103.1	7.3	209	1.652	mean 100 ± 15	A = $x - ts/\sqrt{n} \geq 85$ B = $x + ts/\sqrt{n} \leq 115$	102.3 103.9	pass pass	DRF-08 DRF-11
Average IPyC thickness for each particle (µm)	40.4	2.4	229	1.652	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$ B = $x + ts/\sqrt{n} \leq 45$	40.1 40.7	pass pass	DRF-08 DRF-11
Average SIC thickness for each particle (µm)	36.6	0.9	230	1.652	mean 35 ± 4	A = $x - ts/\sqrt{n} \geq 31$ B = $x + ts/\sqrt{n} \leq 39$	36.5 36.7	pass pass	DRF-08 DRF-11
Average OPyC thickness for each particle (µm)	41.1	2.0	230	1.652	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$ B = $x + ts/\sqrt{n} \leq 45$	40.9 41.3	pass pass	DRF-08 DRF-11
Particles with missing OPyC			15565		defect fraction $\leq 6.0 \times 10^{-4}$	$\leq 4$ in 15,500	0	pass	DRF-19

Comments
Goldspot analysis performed on missing OPyC sample for information only. 15 out of 15565 gold spots observed.

*John R. ...*

QC Supervisor

3-21-06

Date

Accept Coated particle batch (Yes or No): Yes

*M. C. ...*

QA Reviewer

3/22/06

Date

Inspection Report Form IRF-04A: Coated Particle Composites

Procedure:	AGR-CHAR-PIP-04 Rev. 2
Coated particle composite ID:	LEU01-47T
Coated particle composite description:	Variant 1: TRISO on BWXT kernel composite 69302

Property	Measured Data			k or t value	Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)						
Average buffer thickness for each particle (µm)	102.5	7.1	177	1.654	mean 100 ± 15	A = x - ts/√n ≥ 85 B = x + ts/√n ≤ 115	101.6 103.4	pass pass	DRF-08 DRF-11
				2.584	dispersion ≤0.01 ≤ 55	C = x - ks > 55	84.2	pass	
Average IPyC thickness for each particle (µm)	40.5	2.4	232	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36 B = x + ts/√n ≤ 44	40.2 40.8	pass pass	DRF-08 DRF-11
				2.549	dispersion ≤0.01 ≤ 30 ≤0.01 ≥ 56	C = x - ks > 30 D = x + ks < 56	34.4 46.6	pass pass	
Average SiC thickness for each particle (µm)	35.7	1.2	233	1.651	mean 35 ± 3	A = x - ts/√n ≥ 32 B = x + ts/√n ≤ 38	35.6 35.8	pass pass	DRF-08 DRF-11
				2.549	dispersion ≤0.01 ≤ 25	C = x - ks > 25	32.6	pass	
Average OPyC thickness for each particle (µm)	41.1	2.4	233	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36 B = x + ts/√n ≤ 44	40.8 41.4	pass pass	DRF-08 DRF-11
				2.549	dispersion ≤0.01 ≤ 20	C = x - ks > 20	35.0	pass	
Buffer envelope density	See IRF-02A							pass	IRF-02A
IPyC sink/float density	See IRF-02B							Note 1	IRF-02B
SiC sink/float density (Mg/m³)	3.2060	0.0021	42	1.683	mean ≥ 3.19	A = x - ts/√n ≥ 3.19	3.205	pass	DRF-02
				2.913	dispersion ≤0.01 ≤ 3.17	C = x - ks > 3.17	3.200	pass	
OPyC sink/float density	See IRF-04B							pass	IRF-04B
IPyC anisotropy (BAFo equivalent)	1.0140	0.0014	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.015	pass	DRF-18
				3.981	dispersion ≤0.01 ≥ 1.06	D = x + ks < 1.06	1.020	pass	
OPyC anisotropy (BAFo equivalent)	1.0132	0.0017	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.014	pass	DRF-18
				3.981	dispersion ≤0.01 ≥ 1.06	D = x + ks < 1.06	1.020	pass	
Particles with SiC gold spot defects			22461		defect fraction ≤ 1.0 × 10 <sup>-3</sup>	≤ 6 in 12,000 or ≤ 14 in 22,000	11	pass	DRF-20
Particle aspect ratio			1808		dispersion ≤0.01 ≥ 1.14	≤ 1 in 500 or ≤ 7 in 1420	0	pass	DRF-07 DRF-10
Particles with SiC burn-leach defects			121117		defect fraction ≤ 1.0 × 10 <sup>-4</sup>	≤ 1 in 50,000 or ≤ 6 in 120,000	1	pass	DRF-21
Particles with missing OPyC			31191		defect fraction ≤ 3.0 × 10 <sup>-4</sup>	≤ 4 in 31,000	0	pass	DRF-19
SiC microstructure			3		comparison to visual standard	all imaged pass visual standard comparison	3	pass	DRF-23

Comments
Note 1: Variant 1 is designed to have a density around 1.85 g/cc and is not required to meet the IPyC density specification.

  
QC Supervisor

3-21-06  
Date

Accept coated particle composite (Yes or No):

  
QA Reviewer

3/21/06  
Date



**Inspection Report Form IRF-04B: Outer Pyrocarbon Density**

<b>Procedure:</b>	AGR-CHAR-PIP-04 Rev. 2
<b>Coated particle composite ID:</b>	LEU01-47T
<b>Coated particle composite description:</b>	Variant 1: TRISO on BWXT kernel composite 69302
<b>Batch 1 ID:</b>	LEU01-43T
<b>Batch 1 description:</b>	Variant 1: TRISO on BWXT kernel composite 69302
<b>Batch 2 ID:</b>	LEU01-44T
<b>Batch 2 description:</b>	Variant 1: TRISO on BWXT kernel composite 69302
<b>Batch 3 ID:</b>	LEU01-29T
<b>Batch 3 description:</b>	Variant 1: TRISO on BWXT kernel composite 69302

Property	Measured Data				Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	k or t value					
Batch 1: OPyC sink/float density (Mg/m <sup>3</sup> )	1.9012	0.0077	51	1.676	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.899	pass	DRF-03
				2.848	dispersion ≤0.01 ≤ 1.80	B = x + ts/√n ≤ 1.95	1.903	pass	
					≤0.01 ≥ 2.00	C = x - ks > 1.80	1.879	pass	
D = x + ks < 2.00	1.923	pass							
Batch 2: OPyC sink/float density (Mg/m <sup>3</sup> )	1.8815	0.0111	54	1.674	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.879	pass	DRF-03
				2.831	dispersion ≤0.01 ≤ 1.80	B = x + ts/√n ≤ 1.95	1.884	pass	
					≤0.01 ≥ 2.00	C = x - ks > 1.80	1.850	pass	
D = x + ks < 2.00	1.913	pass							
Batch 3: OPyC sink/float density (Mg/m <sup>3</sup> )	1.9085	0.0085	45	1.680	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.906	pass	DRF-03
				2.897	dispersion ≤0.01 ≤ 1.80	B = x + ts/√n ≤ 1.95	1.911	pass	
					≤0.01 ≥ 2.00	C = x - ks > 1.80	1.884	pass	
D = x + ks < 2.00	1.933	pass							

Comments	

  
 QC Supervisor

3-21-06  
 Date

Accept composite for OPyC density (Yes or No): Yes

  
 QA Reviewer

3/22/06  
 Date

## 2 Product ID's associated with LEU01-47T

### Kernels

LEU01-## (from BWXT G73D-20-69302)

NUCO350-## (from BWXT G73B-NU-69300)

### Buffer-only particles

NUCO350-25B

NUCO350-36B

NUCO350-54B

NUCO350-58B (composite of 25B+36B+54B, for information only)

LEU01-16B (confirmation on LEUCO kernels, for information only)

### IPyC coating process qualification

LEU01-38I

LEU01-30I

LEU01-34I

### TRISO-coated particles

LEU01-43T

LEU01-44T

LEU01-29T

LEU01-47T (composite of 43T+44T+29T)

### **3 Coating process conditions**

The following pages contain coating process conditions for all coated particle batches associated with the LEU01-47T coated particle composite. The AGR-1 variant 1 fuel particles are similar to the AGR-1 baseline fuel particles with the exception that the inner pyrocarbon (IPyC) coating was deposited at ~25°C higher temperature. These particles were coated within the variant 1 process conditions listed in sections 3.1 and 3.2 of the AGR-1 Fuel Product Specification and Characterization Guidance document INL EDF-4380, Rev. 6.

#### **Buffer Qualification Batches**

NUCO350-25B  
NUCO350-36B  
NUCO350-54B  
LEU01-16B

#### **IPyC Qualification Batches**

LEU01-38I  
LEU01-30I  
LEU01-34I

#### **TRISO Batches**

LEU01-43T  
LEU01-44T  
LEU01-29T

**Summary for Baseline Buffer Qualification Run – NUCO350-25B**

Coating Run No.	NUCO350-25B	
Description:	Baseline processing conditions for Buffer layer	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	NUCO350-25	
Operator:	R. A. Lowden	
Date:	06/17/2005	
Data Location:	B002249, Coating Log, Volume 1, pp. 202 - 212	
Kernel Batch Wt.	62.11 g	
Coated Particle Batch Wt.	81.33 g	
	<b>AGR-1 Parameter</b>	<b>As-Processed</b>
<b>Buffer</b>		
Coating gases	C <sub>2</sub> H <sub>2</sub> + Ar	C <sub>2</sub> H <sub>2</sub> + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
<b>IPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1265 ± 25°C	
Time		
<b>SiC</b>		
Coating gases	H <sub>2</sub> + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
<b>OPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		
Operator:	<i>Richard A. Lowden</i>	Date: 6/17/05
QAS:	<i>M.C. Jones</i>	Date: 3/30/06

**Summary for Baseline Buffer Qualification Run – NUCO350-36B**

Coating Run No.	NUCO350-36B	
Description:	Baseline processing conditions for Buffer layer	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	NUCO350-36	
Operator:	R. A. Lowden	
Date:	06/17/2005	
Data Location:	B002249, Coating Log, Volume 1, pp. 214 - 223	
Kernel Batch Wt.	61.97 g	
Coated Particle Batch Wt.	81.50 g	
	<b>AGR-1 Parameter</b>	<b>As-Processed</b>
<b>Buffer</b>		
Coating gases	C <sub>2</sub> H <sub>2</sub> + Ar	C <sub>2</sub> H <sub>2</sub> + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
<b>IPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1265 ± 25°C	
Time		
<b>SiC</b>		
Coating gases	H <sub>2</sub> + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
<b>OPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		
Operator:	<i>Richard A Lowden</i>	Date: <i>6/17/05</i>
QAS:	<i>M.C. Dean</i>	Date: <i>3/30/06</i>



**Summary for Baseline Buffer Qualification Run – NUCO350-54B**

Coating Run No.	NUCO350-54B	
Description:	Baseline processing conditions for Buffer layer	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	NUCO350-54	
Operator:	R. A. Lowden	
Date:	06/20/2005	
Data Location:	B002249, Coating Log, Volume 1, pp. 224 - 233	
Kernel Batch Wt.	62.08 g	
Coated Particle Batch Wt.	81.47 g	
	<b>AGR-1 Parameter</b>	<b>As-Processed</b>
<b>Buffer</b>		
Coating gases	C <sub>2</sub> H <sub>2</sub> + Ar	C <sub>2</sub> H <sub>2</sub> + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
<b>IPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1265 ± 25°C	
Time		
<b>SiC</b>		
Coating gases	H <sub>2</sub> + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
<b>OPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		
Operator:	<i>Richard A. Lowden</i>	Date: <i>6/20/05</i>
QAS:	<i>MAE</i>	Date: <i>3/30/06</i>

**Summary for Baseline Buffer Qualification Run – LEU01-16B**

Coating Run No.	LEU01-16B		
Description:	Baseline processing conditions for Buffer layer		
Procedure:	AGR-COAT-SOP-01, Rev. 1		
Kernel Lot No.	LEU01-16K		
Operator:	R. A. Lowden		
Date:	11/03/2005		
Data Location:	B002516, Coating Log, Volume 3, pp. 2 – 10		
Kernel Batch Wt.	63.30 g		
Coated Particle Batch Wt.	82.57 g		
	<b>AGR-1 Parameter</b>	<b>As-Processed</b>	
<b>Buffer</b>			
Coating gases	C <sub>2</sub> H <sub>2</sub> + Ar	C <sub>2</sub> H <sub>2</sub> + Ar	
TGF		8530 sccm	
CGF	0.60 ± 0.10	0.61	
Temperature	1450 ± 25°C	1450°C	
Time		5 min	
<b>IPyC</b>			
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>		
TGF			
CGF	0.30 ± 0.03		
CGR	0.85 ± 0.085		
Temperature	1265 ± 25°C		
Time			
<b>SiC</b>			
Coating gases	H <sub>2</sub> + MTS		
TGF			
CGF	0.015 ± 0.005		
Temperature	1500 ± 25°C		
Time			
<b>OPyC</b>			
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>		
TGF			
CGF	0.30 ± 0.03		
CGR	0.85 ± 0.085		
Temperature	1290 ± 40°C		
Time			
Comments/Notes:			
Operator:	<i>Richard A Lowden</i>	Date:	<i>11/3/05</i>
QAS:	<i>MCC</i>	Date:	<i>3/30/06</i>

**Summary for Variant #1 IPyC Qualification Run – LEU01-38I**

Coating Run No.	LEU01-38I		
Description:	Variant #1 processing conditions for IPyC layer		
Procedure:	AGR-COAT-SOP-01, Rev. 1		
Kernel Lot No.	LEU01-38K		
Operator:	R. A. Lowden		
Date:	12/02/2005		
Data Location:	B002516, Coating Log, Volume 3, pp. 64 - 73		
Kernel Batch Wt.	63.37 g		
Coated Particle Batch Wt.	107.39 g		
	<b>AGR-1 Parameter</b>	<b>As-Processed</b>	
<b>Buffer</b>			
Coating gases	C <sub>2</sub> H <sub>2</sub> + Ar	C <sub>2</sub> H <sub>2</sub> + Ar	
TGF		8530 sccm	
CGF	0.60 ± 0.10	0.61	
Temperature	1450 ± 25°C	1450°C	
Time		5 min	
<b>IPyC</b>			
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	
TGF		9430 sccm	
CGF	0.30 ± 0.03	0.30	
CGR	0.85 ± 0.085	0.85	
Temperature	1290 ± 25°C	1290°C	
Time		12.33 min	
<b>SiC</b>			
Coating gases	H <sub>2</sub> + MTS		
TGF			
CGF	0.015 ± 0.005		
Temperature	1500 ± 25°C		
Time			
<b>OPyC</b>			
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>		
TGF			
CGF	0.30 ± 0.03		
CGR	0.85 ± 0.085		
Temperature	1290 ± 40°C		
Time			
Comments/Notes:			
Operator:	<i>Richard A Lowden</i>	Date:	<i>12/2/05</i>
QAS:	<i>M.C. Pen</i>	Date:	<i>3/28/06</i>



**Summary for Variant #1 IPyC Qualification Run – LEU01-30I**

Coating Run No.	LEU01-30I		
Description:	Variant #1 processing conditions for IPyC layer		
Procedure:	AGR-COAT-SOP-01, Rev. 1		
Kernel Lot No.	LEU01-30K		
Operator:	R. A. Lowden		
Date:	12/01/2005		
Data Location:	B002516, Coating Log, Volume 3, pp. 54 - 63		
Kernel Batch Wt.	63.29 g		
Coated Particle Batch Wt.	104.81 g		
	<b>AGR-1 Parameter</b>	<b>As-Processed</b>	
<b>Buffer</b>			
Coating gases	C <sub>2</sub> H <sub>2</sub> + Ar	C <sub>2</sub> H <sub>2</sub> + Ar	
TGF		8530 sccm	
CGF	0.60 ± 0.10	0.61	
Temperature	1450 ± 25°C	1450°C	
Time		5 min	
<b>IPyC</b>			
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	
TGF		9430 sccm	
CGF	0.30 ± 0.03	0.30	
CGR	0.85 ± 0.085	0.85	
Temperature	1290 ± 25°C	1290°C	
Time		12.33 min	
<b>SiC</b>			
Coating gases	H <sub>2</sub> + MTS		
TGF			
CGF	0.015 ± 0.005		
Temperature	1500 ± 25°C		
Time			
<b>OPyC</b>			
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>		
TGF			
CGF	0.30 ± 0.03		
CGR	0.85 ± 0.085		
Temperature	1290 ± 40°C		
Time			
Comments/Notes:			
Operator:	<i>Richard A. Lowden</i>	Date:	<i>12/01/05</i>
QAS:	<i>M.A.C.</i>	Date:	<i>3/28/06</i>

**Summary for Variant #1 IPyC Qualification Run – LEU01-34I**

Coating Run No.	LEU01-34I		
Description:	Variant #1 processing conditions for IPyC layer		
Procedure:	AGR-COAT-SOP-01, Rev. 1		
Kernel Lot No.	LEU01-34K		
Operator:	R. A. Lowden		
Date:	12/02/2005		
Data Location:	B002516, Coating Log, Volume 3, pp. 74 - 83		
Kernel Batch Wt.	63.27 g		
Coated Particle Batch Wt.	107.31 g		
	<b>AGR-1 Parameter</b>	<b>As-Processed</b>	
<b>Buffer</b>			
Coating gases	C <sub>2</sub> H <sub>2</sub> + Ar	C <sub>2</sub> H <sub>2</sub> + Ar	
TGF		8530 sccm	
CGF	0.60 ± 0.10	0.61	
Temperature	1450 ± 25°C	1450°C	
Time		5 min	
<b>IPyC</b>			
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	
TGF		9430 sccm	
CGF	0.30 ± 0.03	0.30	
CGR	0.85 ± 0.085	0.85	
Temperature	1290 ± 25°C	1290°C	
Time		12.33 min	
<b>SiC</b>			
Coating gases	H <sub>2</sub> + MTS		
TGF			
CGF	0.015 ± 0.005		
Temperature	1500 ± 25°C		
Time			
<b>OPyC</b>			
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>		
TGF			
CGF	0.30 ± 0.03		
CGR	0.85 ± 0.085		
Temperature	1290 ± 40°C		
Time			
Comments/Notes:			
Operator:	<i>Richard A Lowden</i>	Date:	<i>12/2/05</i>
QAS:	<i>M.C. [Signature]</i>	Date:	<i>3/28/06</i>

**Summary for Variant #1 Coating Run - LEU01-43T**

Coating Run No.	LEU01-43T	
Description:	Variant #1 AGR-1 processing conditions	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	LEU01-43K	
Operator:	R. A. Lowden	
Date:	12/20/2005	
Data Location:	B002516, Coating Log, Volume 3, pp. 146 -154	
Kernel Batch Wt.	63.40 g	
Coated Particle Batch Wt.	187.27 g	
	<b>AGR-1 Parameter</b>	<b>As-Processed</b>
<b>Buffer</b>		
Coating gases	C <sub>2</sub> H <sub>2</sub> + Ar	C <sub>2</sub> H <sub>2</sub> + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
<b>IPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>
TGF		9435 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1290 ± 25°C	1290°C
Time		12.33 min
<b>SiC</b>		
Coating gases	H <sub>2</sub> + MTS	H <sub>2</sub> + MTS
TGF		16,923 sccm
CGF	0.015 ± 0.005	0.0117
Temperature	1500 ± 25°C	1500°C
Time		140 min
<b>OPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>
TGF		16,215 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1290 ± 40°C	1290°C
Time		10 min
Comments/Notes:		
Operator:	<i>Richard A. Lowden</i>	Date: 12/20/05
QAS:	<i>M.C. Jones</i>	Date: 3/28/06



**Summary for Variant #1 Coating Run - LEU01-44T**

Coating Run No.	LEU01-44T	
Description:	Variant #1 AGR-1 processing conditions	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	LEU01-44K	
Operator:	R. A. Lowden	
Date:	01/09/2006	
Data Location:	B002516, Coating Log, Volume 3, pp. 156 -164	
Kernel Batch Wt.	63.27 g	
Coated Particle Batch Wt.	187.11 g	
	<b>AGR-1 Parameter</b>	<b>As-Processed</b>
<b>Buffer</b>		
Coating gases	C <sub>2</sub> H <sub>2</sub> + Ar	C <sub>2</sub> H <sub>2</sub> + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
<b>IPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>
TGF		9435 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1290 ± 25°C	1290°C
Time		12 min
<b>SiC</b>		
Coating gases	H <sub>2</sub> + MTS	H <sub>2</sub> + MTS
TGF		16,923 sccm
CGF	0.015 ± 0.005	0.0116
Temperature	1500 ± 25°C	1500°C
Time		140 min
<b>OPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>
TGF		16,215 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1290 ± 40°C	1290°C
Time		10.33 min
Comments/Notes:		
Operator:	<i>Richard A. Lowden</i>	Date: <i>1/9/06</i>
QAS:	<i>M.C. Fisher</i>	Date: <i>3/28/06</i>

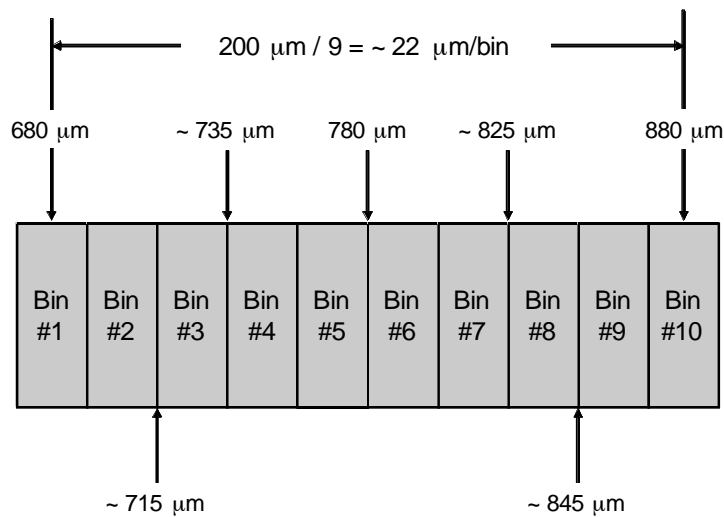
**Summary for Variant #1 Coating Run - LEU01-29T**

Coating Run No.	LEU01-29T	
Description:	Variant #1 AGR-1 processing conditions	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	LEU01-29K	
Operator:	R. A. Lowden	
Date:	01/10/2006	
Data Location:	B002516, Coating Log, Volume 3, pp. 166 -174	
Kernel Batch Wt.	63.50 g	
Coated Particle Batch Wt.	188.89 g	
	<b>AGR-1 Parameter</b>	<b>As-Processed</b>
<b>Buffer</b>		
Coating gases	C <sub>2</sub> H <sub>2</sub> + Ar	C <sub>2</sub> H <sub>2</sub> + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
<b>IPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>
TGF		9435 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1290 ± 25°C	1290°C
Time		12 min
<b>SiC</b>		
Coating gases	H <sub>2</sub> + MTS	H <sub>2</sub> + MTS
TGF		16,925 sccm
CGF	0.015 ± 0.005	0.0117
Temperature	1500 ± 25°C	1500°C
Time		140 min
<b>OPyC</b>		
Coating gases	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>	Ar + C <sub>2</sub> H <sub>2</sub> + C <sub>3</sub> H <sub>6</sub>
TGF		16,215 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1290 ± 40°C	1290°C
Time		10.33 min
Comments/Notes:		
Operator:	<i>Richard A. Lowden</i>	Date: 1/10/06
QAS:	<i>M.C. Jones</i>	Date: 3/28/06

#### 4 Classification of coated particles

Fully-coated batches of particles were sorted employing a sizing technique described in AGR-ROLLER-SOP-1, Rev. 0 and a tabling method described in AGR-TABLER-SOP-1, Rev. 1 as required in section 5.1 of the AGR-1 Fuel Product Specification and Characterization Guidance document INL EDF-4380, Rev. 6. The purpose of this classification is to remove aspherical particles and particles outside a specified diameter range. Details regarding the application of the procedures to the classification of coated particle batches can be found in the logbooks referenced on the summary sheets.

Particles can be sized using a set of sieves, with diameter ranges and limits determined by the selected mesh openings. As an alternative to sieving, the roller technique uses rotating sloped rollers with a diverging gap to size classify particles. Particles are fed onto the gap between the rollers. The rollers are tilted or angled downward away from the feed point to create an inclined track. The rollers rotate with an upward and outward motion. A particle travels down the gradually widening gap until it reaches a point equal to its diameter upon which it drops through the gap into a collection bin. The gap between the rollers is adjusted to separate different sizes of particles or to classify particles within a specific range of diameters. A schematic illustrating the relationship between roller gap and particle size is shown in Figure 4.1.



**Figure 4.1.** Schematic of the collection bins and roller spacing showing relationship between roller gap and particle size.

From EDF-4380, Rev 6, section 5.1.1, Sieving or Rolling to Remove Undersize and Oversize Particles, “Each batch of coated particles shall be double-sieved with electroformed sieves to remove all particles that pass through a 700 μm sieve and all particles that do not pass through an

850  $\mu\text{m}$  sieve. . . . Alternately, the particles can be size-classified using a roller micrometer that achieves results equivalent to or better than sieving." To size separate the batches of coated particles, the gaps between the rollers above bins #1 and #10 were set at 680 and 880  $\mu\text{m}$ , respectively, producing the size distribution shown in the figure. Only particles from Bins #3 - #8, with a particle size range of 715 to 845  $\mu\text{m}$ , were retained with the majority of the particles being from Bins #4 through #7 with a nominal particle size range 735 to 825  $\mu\text{m}$ .

The following pages contain records of the classification performed on the TRISO-coated particle batches associated with the LEU01-47T coated particle composite.

TRISO batches

LEU01-43T  
LEU01-44T  
LEU01-29T



### Sizing & Removal of Aspherical Particles for LEU01-43T

#### Summary for Sizing of Kernels or Coated Particles

Procedure:		AGR-ROLLER-SOP-01, Rev. 0		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-43T		
Kernel/Coated Particle Description:		Variant #1, full TRISO on 350 $\mu$ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 44		
Date	Batch Weight (g)	Sized Batch Weight (g)	Scrap (g)	Loss (g)
12/21/2005	188.27	180.08	8.21	+ 0.02
Comments:				
Operator:		<i>Richard A Lowden</i>		Date: 12/22/05
QAS:		<i>M.C. Jones</i>		Date: 3/28/06

#### Summary for Tabling of Kernels or Coated Particles

Procedure:		AGR-TABLE-SOP-01, Rev. 1		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-43T		
Kernel/Coated Particle Description:		Variant #1, full TRISO on 350 $\mu$ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 45		
Date	Batch Weight (g)	Tabled Batch Weight (g)	Scrap (g)	Loss (g)
12/22/2005	180.08	173.06	6.93	(0.09)
Comments:				
Operator:		<i>Richard A Lowden</i>		Date: 12/22/05
QAS:		<i>M.C. Jones</i>		Date: 3/28/06



### Sizing & Removal of Aspherical Particles for LEU01-44T

#### Summary for Sizing of Kernels or Coated Particles

Procedure:		AGR-ROLLER-SOP-01, Rev. 0		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-44T		
Kernel/Coated Particle Description:		Variant #1, full TRISO on 350 $\mu$ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 46		
Date	Batch Weight (g)	Sized Batch Weight (g)	Scrap (g)	Loss (g)
01/10/2006	183.42	176.17	7.18	(0.07)
Comments:				
Operator:	<i>Richard A. Lowden</i>		Date:	<i>1/11/06</i>
QAS:	<i>M.C.P.</i>		Date:	<i>3/28/06</i>

#### Summary for Tabling of Kernels or Coated Particles

Procedure:		AGR-TABLE-SOP-01, Rev. 1		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-44T		
Kernel/Coated Particle Description:		Variant #1, full TRISO on 350 $\mu$ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 47		
Date	Batch Weight (g)	Tabled Batch Weight (g)	Scrap (g)	Loss (g)
01/11/2006	176.19	168.25	7.91	(0.03)
Comments:				
Operator:	<i>Richard A. Lowden</i>		Date:	<i>1/11/06</i>
QAS:	<i>M.C.P.</i>		Date:	<i>3/28/06</i>

### Sizing & Removal of Aspherical Particles for LEU01-29T

#### Summary for Sizing of Kernels or Coated Particles

Procedure:		AGR-ROLLER-SOP-01, Rev. 0		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-29T		
Kernel/Coated Particle Description:		Variant #1, full TRISO on 350 $\mu$ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 48		
Date	Batch Weight (g)	Sized Batch Weight (g)	Scrap (g)	Loss (g)
01/11/2006	188.89	183.23	5.61	(0.05)
Comments:				
Operator:	<i>Richard A Lowden</i>		Date:	1/12/06
QAS:	<i>M.C.P.</i>		Date:	3/28/06

#### Summary for Tabling of Kernels or Coated Particles

Procedure:		AGR-TABLE-SOP-01, Rev. 1		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-29T		
Kernel/Coated Particle Description:		Variant #1, full TRISO on 350 $\mu$ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 49		
Date	Batch Weight (g)	Tabled Batch Weight (g)	Scrap (g)	Loss (g)
01/12/2006	183.23	172.90	10.35	+0.02
Comments:				
Operator:	<i>Richard A Lowden</i>		Date:	1/12/06
QAS:	<i>M.C.P.</i>		Date:	3/28/06

### 5 Blend of coated particle composites

Three batches of TRISO-coated particles were blended into composite LEU01-47T. The mass of each batch added to the composite is shown in the following table.

<b>Batch ID</b>	<b>Amount added to LEU01-47T composite (g)</b>
LEU01-43T	153.1087
LEU01-44T	149.2793
LEU01-29T	153.6930
Total	456.0810

Three batches of buffer-coated particles were blended into composite NUCO350-58B. The mass of each batch added to the composite is shown in the following table.

<b>Batch ID</b>	<b>Amount added to NUCO350-58B composite (g)</b>
NUCO350-25B	54.4356
NUCO350-36B	55.8622
NUCO350-54B	56.0934
Total	166.3912

## 6 Characterization of LEUCO kernel composite

This section contains data on the kernel composite used for LEU01-47T. The data was obtained according to product inspection plan AGR-CHAR-PIP-01R1. Some of the kernel data in this section was used as input for subsequent measurements of coating properties (e.g., buffer density and burn-leach defects). This is only a partial analysis of the kernel composite and was not used for product acceptance. Characterization of the kernel composite for acceptance according to the specific requirements listed in section 4 of INL EDF-4380 is documented in the BWXT data package for G73D-20-69302. The BWXT kernel lot G73D-20-69302 was riffled into sublots for characterization and coating by ORNL and identified as LEU01-## (where ## is a series of integers beginning with 01).

Note that the average kernel weights were remeasured using a revised procedure which improved the accuracy of the reported value by improving the randomness of the measured samples. The measured value of the LEUCO average kernel weight changed from  $(2.47 \pm 0.01) \cdot 10^{-4}$  grams per kernel to  $(2.418 \pm 0.006) \cdot 10^{-4}$  grams per kernel. On data report form DRF-15 for the measurement of average kernel envelope density, the average kernel weight is used to approximate the number of kernels in a sample from the weight of the sample. The approximate number of kernels in a sample is divided into the sample envelope volume to determine the average kernel envelope volume. The change in average kernel weight resulted in a significant change in the calculated average kernel envelope volume. The data in this section shows the new average kernel weight and average kernel envelope volume. Records showing the original values are included in section 14.

The following pages shows the inspection report form (IRF-01). Following IRF-01 are the individual data report forms for the measurements that were performed.

Inspection Report Form IRF-01: BWXT LEUCO Kernel Composite 69302

Procedure: AGR-CHAR-PIP-01 Rev. 1

Property	Measured Data				Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	k or t value				
Average kernel diameter (µm)	349.7	9	4304	1.645	mean 350 ± 10	A = x - ts/√n ≥ 340	349.5	DRF-06 DRF-09
						B = x + ts/√n ≤ 360	349.9	
				2.38	dispersion ≤0.01 < 300 ≤0.01 > 400	C = x - ks > 300	328.3	
						D = x + ks < 400	371.1	
Kernel ellipticity (Dmax/Dmin)	1.021		4304		dispersion ≤0.10 ≥1.05	≤1 in 50 or ≤7 in 142	94	DRF-06 DRF-09
Kernel envelope density (Mg/m³)	10.924	0.015	5	2.132	mean ≥10.4	A = x - ts/√n ≥ 10.4	10.91	DRF-15 DRF-22

Comments

94 kernels with ellipticity ≥1.05 out of 4304 kernels measured passes the dispersion specification acceptance criteria of ≤397 in 4304.  
 This composite would pass a control limit of ≥1.035 at 10% tolerance limit with 95% confidence level.  
 This composite would pass a control limit of ≥1.05 at 2.6% tolerance limit with 95% confidence level.

  
 QC Supervisor

2-16-06  
 Date

  
 QA Reviewer

3/29/06  
 Date



**Data Report Form DRF-06: Imaging of Kernel Diameter and Ellipticity Using an Optical Microscope System**

<b>Procedure:</b>	AGR-CHAR-DAM-06 Rev. 0
<b>Operator:</b>	Andrew Kercher
<b>Sample ID:</b>	LEUCO350-01B renamed LEU01-01K-B gH 4-17-06
<b>Sample Description:</b>	LEUCO kernel composite 69302
<b>Folder name containing images:</b>	\\mc-agr\AGR\ImageProcessing\P05051902\

<b>DMR Calibration Expiration Date:</b>	3/24/06
<b>Stage Micrometer Calibration Expiration Date:</b>	2/17/07
<b>Measured Value for 760 µm in Stage Micrometer Image:</b>	760. µm

<b>Mean average weight/particle (g):</b>	<del>2.47E-04</del> 2.42E-04 gH 3-22-06
<b>Weight of sample of particles (g):</b>	1.519
<b>Approximate number of particles in sample:</b>	<del>6150</del> 6277 gH 3-22-06

*Andrew Kercher*

Operator

05/19/05

Date

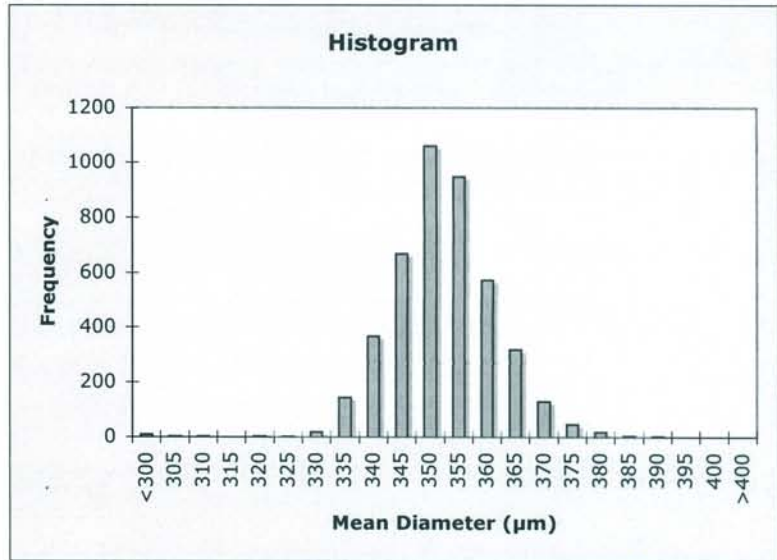
**Data Report Form DRF-09A: Measurement of Kernel Diameter**

<b>Procedure:</b>	AGR-CHAR-DAM-09 Rev. 0
<b>Operator:</b>	Andrew K. Kercher
<b>Folder name containing images:</b>	\\mc-agr\AGR\ImageProcessing\P05051902
<b>Sample ID:</b>	LEUC0350-01B renamed LEU01-01K-B pt 4-17-06
<b>Sample Description:</b>	BWXT LEUCO kernel composite 69302
<b>Folder name containing processed data:</b>	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P05051902_output

<b>Number of kernels analyzed:</b>	4304
<b>Mean of the average diameter of each kernel (<math>\mu\text{m}</math>):</b>	349.7
<b>Standard deviation in the average diameter of each kernel (<math>\mu\text{m}</math>):</b>	9

**Distribution of the average kernel diameter (top binned)**

Mean Diameter	Frequency
<300	9
305	2
310	2
315	1
320	2
325	2
330	18
335	143
340	366
345	666
350	1060
355	946
360	572
365	317
370	128
375	45
380	18
385	4
390	3
395	0
400	0
>400	0



*Andrew K. Kercher*  
 Operator

*May 23, 2005*  
 Date

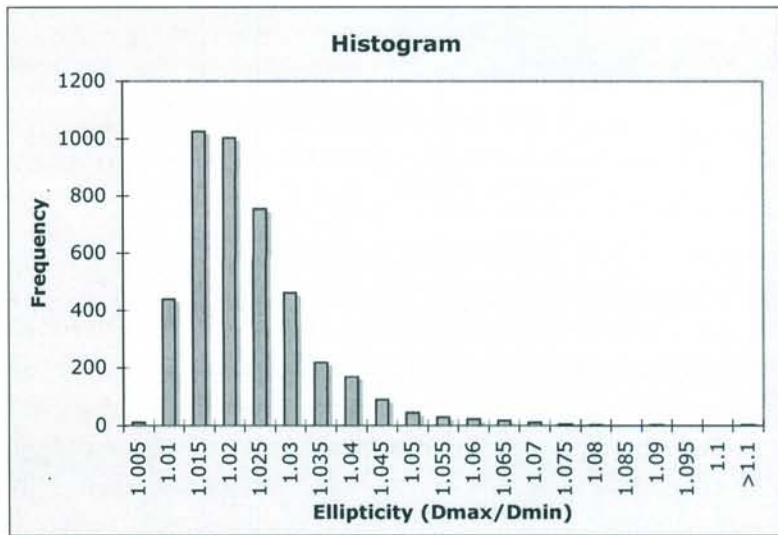
**Data Report Form DRF-09B: Measurement of Kernel Ellipticity (Dmax/Dmin)**

<b>Procedure:</b>	AGR-CHAR-DAM-09 Rev. 0
<b>Operator:</b>	Andrew K. Kercher
<b>Folder name containing images:</b>	\\mc-agr\AGR\ImageProcessing\P05051902
<b>Sample ID:</b>	LEUCO350-010 <i>renamed LEJ01-01K-B # 4-17-06</i>
<b>Sample Description:</b>	BWXT LEUCO kernel composite 69302
<b>Folder name containing processed data:</b>	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P05051902_output

<b>Number of kernels analyzed:</b>	4304
<b>Number of kernels with ellipticity &gt;1.05:</b>	94
<b>Average kernel ellipticity:</b>	1.021

**Distribution of the ellipticity (top binned)**

Ellipticity (D)	Frequency
1.005	10
1.01	439
1.015	1025
1.02	1003
1.025	754
1.03	462
1.035	218
1.04	166
1.045	89
1.05	44
1.055	29
1.06	21
1.065	17
1.07	12
1.075	5
1.08	3
1.085	1
1.09	2
1.095	0
1.1	1
>1.1	3



*Andrew K. Kercher*  
**Operator**

*May 23, 2005*  
**Date**



Data Report Form DRF-15: Measurement of Average Kernel Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-15 Rev. 2
Operator:	S. D. NUNN
Kernel Lot ID:	LEUCO350-01 <i>renamed LEJ01-01 K of 4-17-06</i>
Kernel Lot Description:	BWXT LEUCO KERNEL COMPOSITE 69302
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05052701\S05052701R1_DRF15R2

Mean average weight/kernel (g):	2.42E-04
Uncertainty in mean average weight/kernel (g):	5.96E-07

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05052701L	S05052702L	S05052703L	S05052704L	S05052705L
Weight of kernels (g):	12.5822	12.5075	12.8773	12.6448	12.6895
Approximate number of kernels:	52036	51727	53256	52294	52479
Uncertainty in number of kernels:	128	128	131	129	129
Envelope volume of sample (cc):	1.150	1.145	1.180	1.157	1.164
Average envelope volume/kernel (cc):	2.21E-05	2.21E-05	2.22E-05	2.21E-05	2.22E-05
Sample envelope density (g/cc):	10.943	10.925	10.912	10.932	10.906

Mean average envelope volume/kernel (cc):	2.214E-05
Uncertainty in mean envelope volume/kernel (cc):	1.34E-08
Mean sample envelope density (g/cc):	10.924
Standard deviation in sample envelope density (g/cc):	0.015

*S.D. Nunn*

Operator

*2/14/06*

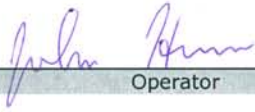
Date

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	John Hunn
Particle Lot ID:	LEU01-32K-A
Particle Lot Description:	BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06020601_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	5.76E-02	5.33E-02	5.20E-02	4.90E-02	4.85E-02
Number of particles:	239	220	215	204	199
Average weight/particle (g):	2.41E-04	2.42E-04	2.42E-04	2.40E-04	2.44E-04

Mean average weight/particle (g):	2.418E-04
Uncertainty in mean average weight/particle (g):	5.96E-07

  
Operator

2-6-06

Date

## 7 Characterization of NUCO kernel composite

This section contains data on the kernel composite used for buffer process qualification batches. The data was obtained according to product inspection plan AGR-CHAR-PIP-01R1. Some of the kernel data in this section was used as input for subsequent measurements of coating properties (e.g., buffer density). This is only a partial analysis of the kernel composite and was not used for product acceptance. Characterization of the kernel composite for acceptance according to the specific requirements listed in section 4 of INL EDF-4380, is documented in the BWXT data package for G73B-NU-69300. The BWXT kernel lot G73B-NU-69300 was riffled into sublots for characterization and coating. The ORNL identification for these kernels was NUCO350-## (where ## were a series of integers beginning with 01).

Note that the average kernel weights were remeasured using a revised procedure which improved the accuracy of the reported value by improving the randomness of the measured samples. The NUCO average kernel weight changed from  $(2.39 \pm 0.03) \cdot 10^{-4}$  grams per kernel to  $(2.308 \pm 0.009) \cdot 10^{-4}$  grams per kernel. On data report form DRF-15 for the measurement of average kernel envelope density, the average kernel weight is used to approximate the number of kernels in a sample from the weight of the sample. The approximate number of kernels in a sample is divided into the sample envelope volume to determine the average kernel envelope volume. The change in average kernel weight resulted in a significant change in the calculated average kernel envelope volume. The data in this section shows the new average kernel weight and average kernel envelope volume. Records showing the original values are included in section 14.

The following pages shows the inspection report form (IRF-01). Following IRF-01 are the individual data report forms for the measurements that were performed.

**Inspection Report Form IRF-01: BWXT NUCO Kernel Composite 69300**

**Procedure:** AGR-CHAR-PIP-01 Rev. 1

Property	Measured Data				Specification INL EDF-4380 Rev. 4	Acceptance Criteria	Acceptance Test Value	Data Records
	Mean ( $\bar{x}$ )	Std. Dev. ( $s$ )	# measured ( $n$ )	k or t value				
Average kernel diameter ( $\mu\text{m}$ )	344.9	15	4202	1.645	mean $350 \pm 10$	$A = \bar{x} - ts/\sqrt{n} \geq 340$	344.5	DRF-06 DRF-09
						$B = \bar{x} + ts/\sqrt{n} \leq 360$	345.3	
				2.38	dispersion $\leq 0.01 < 300$ $\leq 0.01 > 400$	$C = \bar{x} - ks > 300$	309.2	
						$D = \bar{x} + ks < 400$	380.6	
Kernel ellipticity ( $D_{\text{max}}/D_{\text{min}}$ )	1.022		4202		dispersion $\leq 0.10 \geq 1.05$	$\leq 1$ in 50 or $\leq 7$ in 142	186	DRF-06 DRF-09
Kernel envelope density ( $\text{Mg}/\text{m}^3$ )	10.800	0.006	5	2.132	mean $\geq 10.4$	$A = \bar{x} - ts/\sqrt{n} \geq 10.4$	10.79	DRF-15 DRF-22

**Comments**

186 kernels with ellipticity  $\geq 1.05$  out of 4202 kernels measured passes the dispersion specification acceptance criteria of  $\leq 387$  in 4202.  
 This composite would pass an ellipticity control limit of  $\geq 1.038$  at 10% tolerance limit with 95% confidence level.  
 This composite would pass an ellipticity control limit of  $\geq 1.05$  at 5% tolerance limit with 95% confidence level.

  
 QC Supervisor

2-20-06  
 Date

  
 QA Reviewer

2/22/06  
 Date

**Data Report Form DRF-06: Imaging of Kernel Diameter and Ellipticity Using an Optical Microscope System**

<b>Procedure:</b>	AGR-CHAR-DAM-06 Rev. 0
<b>Operator:</b>	Andrew Nelson
<b>Sample ID:</b>	NUCO350-26B
<b>Sample Description:</b>	350 $\mu$ m NUCO kernels from BWXT 69300 Composite
<b>Folder name containing images:</b>	\\mc-agr\AGR\ImageProcessing\P05052501

<b>DMR Calibration Expiration Date:</b>	3/25/06
<b>Stage Micrometer Calibration Expiration Date:</b>	2/17/07
<b>Measured Value for 760 <math>\mu</math>m in Stage Micrometer Image:</b>	760.6 $\mu$ m

<b>Mean average weight/particle (g):</b>	<del>2.39E-04</del> 2.31E-04 JH 4-17-06
<b>Weight of sample of particles (g):</b>	1.408
<b>Approximate number of particles in sample:</b>	<del>5891</del> 6095 JH 4-17-06

  
 Operator

5/25/2005  
 Date



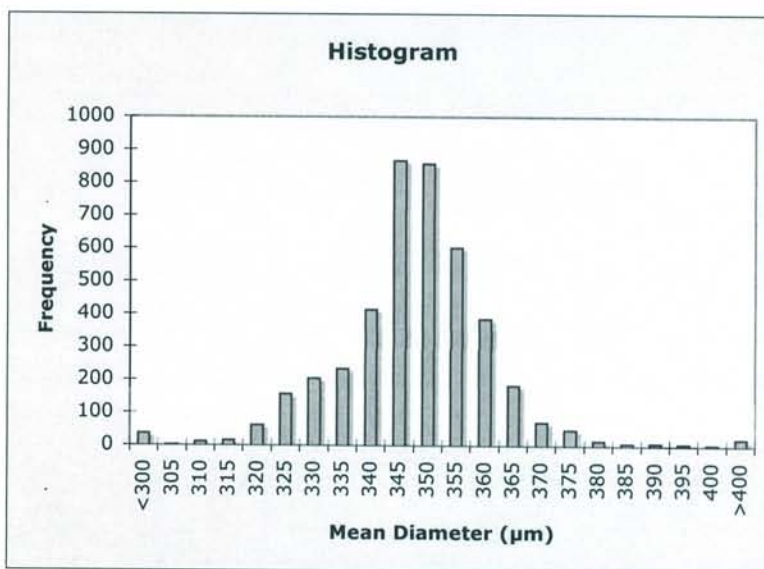
**Data Report Form DRF-09A: Measurement of Kernel Diameter**

<b>Procedure:</b>	AGR-CHAR-DAM-09 Rev. 0
<b>Operator:</b>	Andrew K. Kercher
<b>Folder name containing images:</b>	\\mc-agr\AGR\ImageProcessing\P05052501
<b>Sample ID:</b>	NUCO350-26B NUCO kernels
<b>Sample Description:</b>	350 um NUCO kernels from BWXT 69300 Composite
<b>Folder name containing processed data:</b>	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P05052501_output

<b>Number of kernels analyzed:</b>	4202
<b>Mean of the average diameter of each kernel (μm):</b>	344.9
<b>Standard deviation in the average diameter of each kernel (μm):</b>	15

**Distribution of the average kernel diameter (top binned)**

Mean Diameter	Frequency
<300	36
305	1
310	11
315	15
320	61
325	156
330	204
335	233
340	412
345	867
350	858
355	603
360	383
365	182
370	71
375	48
380	16
385	8
390	7
395	5
400	3
>400	22



*Andrew K. Kercher*

Operator

*May 31, 2005*

Date

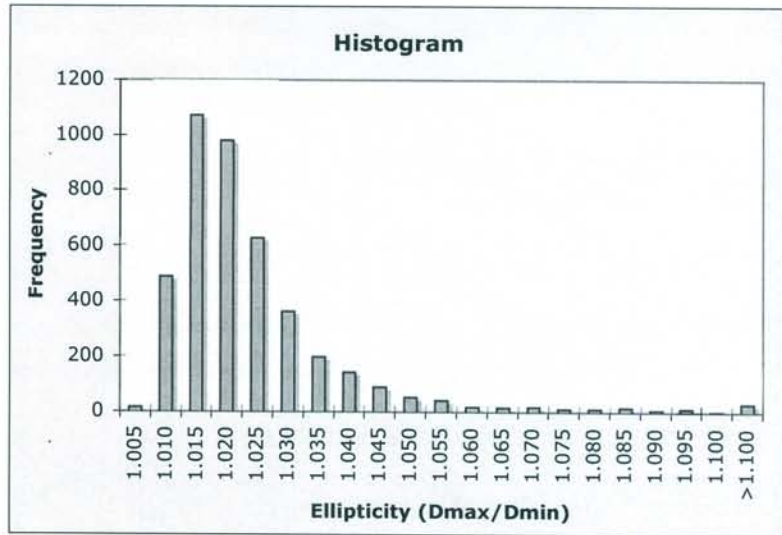
**Data Report Form DRF-09B: Measurement of Kernel Ellipticity (Dmax/Dmin)**

<b>Procedure:</b>	AGR-CHAR-DAM-09 Rev. 0
<b>Operator:</b>	Andrew K. Kercher
<b>Folder name containing images:</b>	\\mc-agr\AGR\ImageProcessing\P05052501
<b>Sample ID:</b>	NUCO350-26B NUCO kernels
<b>Sample Description:</b>	350 um NUCO kernels from BWXT 69300 Composite
<b>Folder name containing processed data:</b>	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P05052501_output

<b>Number of kernels analyzed:</b>	4202
<b>Number of kernels with ellipticity &gt;1.05:</b>	186
<b>Average kernel ellipticity:</b>	1.022

**Distribution of the ellipticity (top binned)**

Ellipticity (D)	Frequency
1.005	15
1.010	486
1.015	1069
1.020	979
1.025	627
1.030	361
1.035	197
1.040	141
1.045	89
1.050	52
1.055	42
1.060	19
1.065	17
1.070	19
1.075	11
1.080	12
1.085	15
1.090	8
1.095	11
1.100	2
>1.100	30



*Andrew K. Kercher*  
 Operator

*May 31, 2005*  
 Date

Data Report Form DRF-15: Measurement of Average Kernel Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-15 Rev. 2
Operator:	S. D. NUNN
Kernel Lot ID:	NUCO350-26
Kernel Lot Description:	NUCO KERNEL COMPOSITE 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05052601\S05052601R1_DRF15R2

Mean average weight/kernel (g):	2.31E-04
Uncertainty in mean average weight/kernel (g):	8.69E-07

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05052601L	S0502602L	S05052603L	S05052604L	S05052605L
Weight of kernels (g):	12.8272	12.9542	12.9410	12.9793	12.9624
Approximate number of kernels:	55577	56127	56070	56236	56163
Uncertainty in number of kernels:	209	211	211	212	211
Envelope volume of sample (cc):	1.187	1.200	1.199	1.202	1.199
Average envelope volume/kernel (cc):	2.14E-05	2.14E-05	2.14E-05	2.14E-05	2.14E-05
Sample envelope density (g/cc):	10.805	10.792	10.797	10.799	10.807

Mean average envelope volume/kernel (cc):	2.137E-05
Uncertainty in mean envelope volume/kernel (cc):	5.47E-09
Mean sample envelope density (g/cc):	10.800
Standard deviation in sample envelope density (g/cc):	0.006

*S. D. Nunn*

Operator

*2/14/06*

Date

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	John Hunn
Particle Lot ID:	NUCO350-42-A
Particle Lot Description:	BWXT kernel composite 69300
Filename:	\\mc-agr\AGR\ParticleWeight\W06020302_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	3.13E-02	2.84E-02	3.40E-02	3.48E-02	3.40E-02
Number of particles:	136	123	149	149	147
Average weight/particle (g):	2.30E-04	2.31E-04	2.28E-04	2.34E-04	2.31E-04

Mean average weight/particle (g):	2.308E-04
Uncertainty in mean average weight/particle (g):	8.69E-07

  
Operator

2-3-06  
Date

## **8 Characterization of buffer on interrupted batches**

This section contains data on the buffer coating density and other buffer properties for particles removed from the coater after deposition of only the buffer layer. The data was obtained according to product inspection plan AGR-CHAR-PIP-02R4. The buffer on these particles was deposited under similar conditions as the buffer on the particles in composite LEU01-47T and should therefore be representative of the buffer on the particles in that composite. Density measurements were made on these interrupted batches because it was not feasible to measure the buffer density after all coating layers were applied. According to section 5.3 of EDF-4380, Rev. 6, three representative buffer layers from interrupted batches which meet the specification for buffer density are sufficient to qualify the process for buffer density. The qualifying batches used 350  $\mu\text{m}$  natural uranium oxide/uranium carbide kernels (NUCO). The kernels were obtained from BWXT and were identified as composite G73B-NU-69300. The use of NUCO surrogate kernels was not expected to significantly effect the density of the buffer. A confirmatory batch using LEUCO kernels from G73D-20-69302 was coated and characterized to verify this assumption.

Note that the average kernel weights and volumes for both the LEUCO and NUCO kernel composites were remeasured after coated particle composite characterization was underway in order to improve the accuracy of the reported value, as discussed in sections 6 and 7. On data report form DRF-16 for the buffer envelope density, the average kernel weight and volume are used to calculate the buffer density. The change in average kernel weight and volume resulted in a significant change in the calculated buffer densities previously used to determine acceptability of the buffer deposition conditions. The data in this section shows the new average kernel weight, average kernel volume, and buffer densities. Records showing the original values are included in section 14. The new values for buffer density were about 10% higher than the originally reported values, but both were within the range specified in INL EDF-4380, Rev. 6.

The following page shows the inspection report form (IRF-02A). Following IRF-02A are the individual data report forms for the measurements that were performed. Additional data at the end of this section is provided for information only.



**Inspection Report Form IRF-02A: Interrupted Coating Batches - Buffer Density**

Procedure:	AGR-CHAR-PIP-02 Rev. 4
Batch 1 ID:	NUCO350-25B
Batch 1 description:	Buffer-coated BWXT kernel composite 69300
Batch 2 ID:	NUCO350-36B
Batch 2 description:	Buffer-coated BWXT kernel composite 69300
Batch 3 ID:	NUCO350-54B
Batch 3 description:	Buffer-coated BWXT kernel composite 69300

Property	Measured Data				Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	t value (t)					
Batch 1: Buffer envelope density (Mg/m <sup>3</sup> )	1.08	0.04	5	2.132	mean	A = $x - ts/\sqrt{n} \geq 0.88$	1.04	pass	DRF-16
					1.03 ± 0.15	B = $x + ts/\sqrt{n} \leq 1.18$	1.12	pass	DRF-22
Batch 2: Buffer envelope density (Mg/m <sup>3</sup> )	1.11	0.05	5	2.132	mean	A = $x - ts/\sqrt{n} \geq 0.88$	1.06	pass	DRF-16
					1.03 ± 0.15	B = $x + ts/\sqrt{n} \leq 1.18$	1.16	pass	DRF-22
Batch 3: Buffer envelope density (Mg/m <sup>3</sup> )	1.11	0.04	5	2.132	mean	A = $x - ts/\sqrt{n} \geq 0.88$	1.07	pass	DRF-16
					1.03 ± 0.15	B = $x + ts/\sqrt{n} \leq 1.18$	1.15	pass	DRF-22

**Comments**

Standard deviations are  $\sqrt{5}$  times the uncertainties in buffer density (standard errors) reported on DRF-16.  
 Average thickness of buffer was 108  $\mu\text{m}$  based on average envelope volume of 9.25E-5 cc (effective diameter of 561  $\mu\text{m}$ ) and average kernel diameter of 345  $\mu\text{m}$ .  
 Average thickness of buffer was 108  $\mu\text{m}$  based on average outer diameter of 561  $\mu\text{m}$  obtained per DAM-10 and average kernel diameter of 345  $\mu\text{m}$ .  
 Confirmatory batch on LEUCO kernels, LEU01-163: mean buffer density = 1.10 g/cc.

QC Supervisor

3-10-06

Date

Accept process for buffer density (Yes or No):  Yes

QA Reviewer

3/29/06

Date

Data Report Form DRF-16: Measurement of Buffer Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D. NUNN
Buffer-coated kernel batch ID:	NUCO350-25B
Batch Description:	Buffer Coated BWXT Kernel Composite 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05062001\S05062001R1_DRF16R2.xls

Mean average weight/buffer-coated kernel (g):	3.07E-04
Uncertainty in mean average weight/b-c kernel (g):	1.00E-06
Mean average weight/bare kernel (g):	2.31E-04
Uncertainty in mean average weight/bare kernel (g):	8.69E-07
Mean average envelope volume/bare kernel (cc):	2.14E-05
Uncertainty in envelope volume/bare kernel (cc):	5.47E-09

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05062001L	S05062002L	S05062003L	S05062004L	S05062005L
Weight of buffer-coated kernels (g):	4.1223	4.2165	4.4333	4.4104	4.0445
Approximate number of b-c kernels:	13428	13735	14441	14366	13174
Uncertainty in number of b-c kernels:	44	45	47	47	43
Total envelope volume of sample (cc):	1.235	1.268	1.335	1.321	1.212
Av. envelope volume/b-c kernels (cc):	9.19E-05	9.23E-05	9.24E-05	9.19E-05	9.20E-05
Sample envelope density (g/cc):	3.339	3.326	3.321	3.340	3.338

Mean average envelope volume/b-c kernel (cc):	9.21E-05
Uncertainty in envelope volume/b-c kernel (cc):	1.1E-07

Buffer density:	1.08E+00
Uncertainty in buffer density:	1.88E-02

*S. D. Nunn*

Operator

*2/14/06*

Date

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	NUC0350-25B
Particle Lot Description:	Buffer Coated NUCO
Filename:	\\mc-agr\AGR\ParticleWeight\W05062001_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	3.28E-02	2.73E-02	3.08E-02	3.46E-02	3.99E-02
Number of particles:	107	90	100	113	129
Average weight/particle (g):	3.07E-04	3.03E-04	3.08E-04	3.06E-04	3.09E-04

Mean average weight/particle (g):	3.07E-04
Uncertainty in mean average weight/particle (g):	1.00E-06

*Dixie Barker*  
Operator

6-20-05  
Date

Data Report Form DRF-16: Measurement of Buffer Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D. NUNN
Buffer-coated kernel batch ID:	NUCO350-36B
Batch Description:	Buffer Coated BWXT Kernel Composite 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05062006\S05062006R1_DRF16R2.xls

Mean average weight/buffer-coated kernel (g):	3.11E-04
Uncertainty in mean average weight/b-c kernel (g):	1.20E-06
Mean average weight/bare kernel (g):	2.31E-04
Uncertainty in mean average weight/bare kernel (g):	8.69E-07
Mean average envelope volume/bare kernel (cc):	2.14E-05
Uncertainty in envelope volume/bare kernel (cc):	5.47E-09

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05062006L	S05062007L	S05062008L	S05062101L	S05062102L
Weight of buffer-coated kernels (g):	4.0723	4.0655	4.0860	4.0696	4.0514
Approximate number of b-c kernels:	13094	13072	13138	13086	13027
Uncertainty in number of b-c kernels:	51	50	51	50	50
Total envelope volume of sample (cc):	1.226	1.227	1.232	1.226	1.217
Av. envelope volume/b-c kernels (cc):	9.37E-05	9.38E-05	9.38E-05	9.37E-05	9.34E-05
Sample envelope density (g/cc):	3.321	3.315	3.317	3.319	3.328

Mean average envelope volume/b-c kernel (cc):	9.37E-05
Uncertainty in envelope volume/b-c kernel (cc):	6.7E-08

Buffer density:	1.11E+00
Uncertainty in buffer density:	2.05E-02

*S. D. Nunn*

Operator

*2/14/06*

Date



Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	NUCO350-36B
Particle Lot Description:	Buffer Coated NUCO
Filename:	\\mc-agr\AGR\ParticleWeight\W05062002_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	3.45E-02	3.26E-02	3.54E-02	3.58E-02	3.42E-02
Number of particles:	110	104	115	116	110
Average weight/particle (g):	3.14E-04	3.13E-04	3.08E-04	3.09E-04	3.11E-04

Mean average weight/particle (g):	3.11E-04
Uncertainty in mean average weight/particle (g):	1.20E-06

*Dixie Barker*  
Operator

6-20-05  
Date



Data Report Form DRF-16: Measurement of Buffer Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D. NUNN
Buffer-coated kernel batch ID:	NUCO350-54B
Batch Description:	Buffer Coated BWXT Kernel Composite 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05062201\S05062201R1_DRF16R2.xls

Mean average weight/buffer-coated kernel (g):	3.11E-04
Uncertainty in mean average weight/b-c kernel (g):	1.09E-06
Mean average weight/bare kernel (g):	2.31E-04
Uncertainty in mean average weight/bare kernel (g):	8.69E-07
Mean average envelope volume/bare kernel (cc):	2.14E-05
Uncertainty in envelope volume/bare kernel (cc):	5.47E-09

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05062201L	S05062202L	S05062203L	S05062204L	S05062205L
Weight of buffer-coated kernels (g):	4.1223	4.0694	4.0160	4.0391	4.0471
Approximate number of b-c kernels:	13255	13085	12913	12987	13013
Uncertainty in number of b-c kernels:	46	46	45	46	46
Total envelope volume of sample (cc):	1.233	1.225	1.209	1.215	1.215
Av. envelope volume/b-c kernels (cc):	9.30E-05	9.36E-05	9.36E-05	9.35E-05	9.34E-05
Sample envelope density (g/cc):	3.344	3.323	3.323	3.326	3.331

Mean average envelope volume/b-c kernel (cc):	9.34E-05
Uncertainty in envelope volume/b-c kernel (cc):	1.1E-07

Buffer density:	1.11E+00
Uncertainty in buffer density:	1.94E-02

*S. D. Nunn*

Operator

*2/14/06*

Date

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	NUCO350-54B
Particle Lot Description:	Buffer Coated NUCO
Filename:	\\mc-agr\AGR\ParticleWeight\W05062101_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	3.66E-02	4.39E-02	3.80E-02	4.22E-02	3.97E-02
Number of particles:	118	140	123	135	129
Average weight/particle (g):	3.10E-04	3.14E-04	3.09E-04	3.13E-04	3.08E-04

Mean average weight/particle (g):	3.11E-04
Uncertainty in mean average weight/particle (g):	1.09E-06

*Dixie Barker*  
Operator

6-21-05  
Date

**For Information Only**

The information in the remainder of this section reports results of measurements not required by the fuel specification and is provided for information only.

Data Report Form DRF-16: Measurement of Buffer Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D. NUNN
Buffer-coated kernel batch ID:	NUCO350-58B
Batch Description:	Composite of Buffer Coated BWXT Kernel Composite 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05062206\S05062206R1_DRF16R2.xls

Mean average weight/buffer-coated kernel (g):	3.09E-04
Uncertainty in mean average weight/b-c kernel (g):	4.99E-07
Mean average weight/bare kernel (g):	2.31E-04
Uncertainty in mean average weight/bare kernel (g):	8.69E-07
Mean average envelope volume/bare kernel (cc):	2.14E-05
Uncertainty in envelope volume/bare kernel (cc):	5.47E-09

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05062206L	S05062207L	S05062301L	S05062302L	S05062303L
Weight of buffer-coated kernels (g):	4.3399	4.3264	4.3459	4.4478	4.3485
Approximate number of b-c kernels:	14045	14001	14064	14394	14073
Uncertainty in number of b-c kernels:	23	23	23	23	23
Total envelope volume of sample (cc):	1.300	1.296	1.300	1.333	1.303
Av. envelope volume/b-c kernels (cc):	9.25E-05	9.26E-05	9.24E-05	9.26E-05	9.26E-05
Sample envelope density (g/cc):	3.340	3.338	3.344	3.337	3.338

Mean average envelope volume/b-c kernel (cc):	9.25E-05
Uncertainty in envelope volume/b-c kernel (cc):	3.8E-08

Buffer density:	1.10E+00
Uncertainty in buffer density:	1.41E-02

*S. D. Nunn*

Operator

*2/14/06*

Date

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	NUCO350-58B
Particle Lot Description:	Composite of Buffer Coated BWXT Kernel Composite 69300
Filename:	\\mc-agr\AGR\ParticleWeight\W05062201_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	3.35E-02	3.07E-02	4.09E-02	3.50E-02	4.08E-02
Number of particles:	109	99	132	113	132
Average weight/particle (g):	3.07E-04	3.10E-04	3.10E-04	3.10E-04	3.09E-04

Mean average weight/particle (g):	3.09E-04
Uncertainty in mean average weight/particle (g):	4.99E-07

*Dixie Barker*  
Operator

6-22-05  
Date



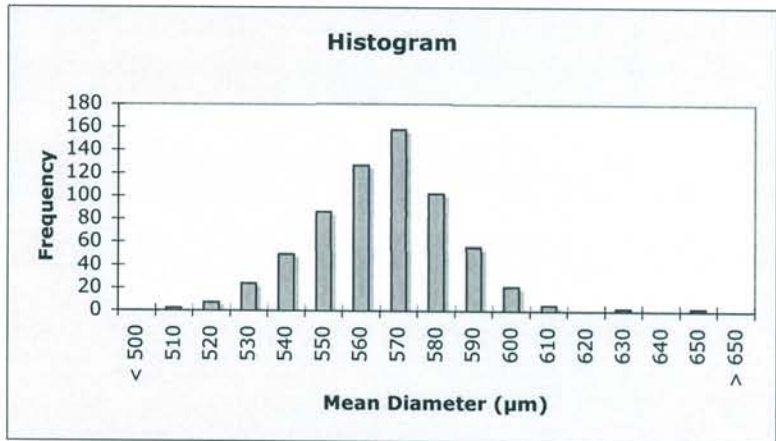
Data Report Form DRF-10A: Measurement of Particle Diameter

Procedure:	AGR-CHAR-DAM-10 Rev. 0
Operator:	Andy Nelson
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05062401
Sample ID:	NUCO350-58B
Sample Description:	Composite of Buffer-coated BWXT Kernel Composite 69300
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P05062401_output

Number of particles analyzed:	640
Mean of the average diameter of each particle ( $\mu\text{m}$ ):	561
Standard deviation in the average diameter of each particle ( $\mu\text{m}$ ):	18

Distribution of the average particle diameter (top binned)

Mean Diameter	Frequency
< 500	0
510	2
520	7
530	24
540	49
550	86
560	127
570	158
580	102
590	55
600	21
610	5
620	0
630	2
640	0
650	2
> 650	0



*Andy Nelson*

Operator

6/27/2005

Date

Data Report Form DRF-16: Measurement of Buffer Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D. NUNN
Buffer-coated kernel batch ID:	LEU01-16B
Batch Description:	Buffer on BWXT LEUCO kernel composite 69302
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05110701\S05110701R1_DRF16R2.xls

Mean average weight/buffer-coated kernel (g):	3.20E-04
Uncertainty in mean average weight/b-c kernel (g):	8.22E-07
Mean average weight/bare kernel (g):	2.42E-04
Uncertainty in mean average weight/bare kernel (g):	5.96E-07
Mean average envelope volume/bare kernel (cc):	2.21E-05
Uncertainty in envelope volume/bare kernel (cc):	1.34E-08

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05110701L	S05110702L	S05110703L	S05110704L	S05110705L
Weight of buffer-coated kernels (g):	4.0951	4.1007	4.2203	4.2527	4.3448
Approximate number of b-c kernels:	12797	12815	13188	13290	13578
Uncertainty in number of b-c kernels:	33	33	34	34	35
Total envelope volume of sample (cc):	1.192	1.193	1.234	1.229	1.267
Av. envelope volume/b-c kernels (cc):	9.32E-05	9.31E-05	9.36E-05	9.25E-05	9.33E-05
Sample envelope density (g/cc):	3.435	3.438	3.421	3.460	3.430

Mean average envelope volume/b-c kernel (cc):	9.31E-05
Uncertainty in envelope volume/b-c kernel (cc):	1.8E-07

Buffer density:	1.10E+00
Uncertainty in buffer density:	1.46E-02

*S. D. Nunn*

Operator

*2/14/06*

Date

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-16B
Particle Lot Description:	Buffer on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W05110701_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	6.21E-02	6.72E-02	5.58E-02	5.12E-02	6.32E-02
Number of particles:	194	209	175	159	199
Average weight/particle (g):	3.20E-04	3.22E-04	3.19E-04	3.22E-04	3.18E-04

Mean average weight/particle (g):	3.20E-04
Uncertainty in mean average weight/particle (g):	8.22E-07

  
Operator

11-7-05  
Date

## **9 Characterization of IPyC on interrupted batches**

This section contains data on the inner pyrocarbon (IPyC) coating density and other properties for particles removed from the coater after deposition of only the buffer and IPyC layers. The data was obtained according to product inspection plan AGR-CHAR-PIP-02R4. The IPyC on these particles was deposited under similar conditions as the IPyC on the particles in composite LEU01-47T and should therefore be representative of the IPyC on the particles in that composite. Density measurements were made on these interrupted batches because it was not feasible to measure the IPyC density after all coating layers were applied.

The IPyC coatings for variant 1 were deposited at  $\sim 25^{\circ}\text{C}$  higher temperature than the baseline IPyC coatings. The variant 1 IPyC coatings are not required to meet the IPyC density specification in section 5.3 of EDF-4380, Rev. 6. However, the expected mean IPyC density according to section 3.2 of EDF-4380 is  $\sim 1.85$  g/cc. The observed mean IPyC densities for the three interrupted batches were in good agreement with the expected value.

The following page shows the inspection report form (IRF-02B). Following IRF-02B are the individual data report forms for the measurements that were performed. Additional data at the end of this section is provided for information only.

Inspection Report Form IRF-02B: Interrupted Coating Batches - IPyC Density

<b>Procedure:</b>	AGR-CHAR-PIP-02 Rev. 4
<b>Batch 1 ID:</b>	LEU01-381
<b>Batch 1 description:</b>	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
<b>Batch 2 ID:</b>	LEU01-301
<b>Batch 2 description:</b>	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
<b>Batch 3 ID:</b>	LEU01-341
<b>Batch 3 description:</b>	Variant 1: IPyC/Buffer on BWXT kernel composite 69302

Property	Measured Data			k or t value	Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)						
Batch 1: IPyC sink/float density (Mg/m <sup>3</sup> )	1.8430	0.0123	46	1.679	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.840	Note 1	DRF-03
				2.882	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	B = x + ts/√n ≤ 1.95	1.846	Note 1	
						C = x - ks > 1.80	1.808	Note 1	
D = x + ks < 2.00	1.878	Note 1							
Batch 2: IPyC sink/float density (Mg/m <sup>3</sup> )	1.8588	0.0118	40	1.685	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.856	Note 1	DRF-03
				2.941	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	B = x + ts/√n ≤ 1.95	1.862	Note 1	
						C = x - ks > 1.80	1.824	Note 1	
D = x + ks < 2.00	1.894	Note 1							
Batch 3: IPyC sink/float density (Mg/m <sup>3</sup> )	1.8578	0.0103	50	1.677	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.855	Note 1	DRF-03
				2.863	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	B = x + ts/√n ≤ 1.95	1.860	Note 1	
						C = x - ks > 1.80	1.828	Note 1	
D = x + ks < 2.00	1.887	Note 1							

**Comments**  
 Note 1: Variant 1 is designed to have a density of around 1.85 g/cc and is not required to meet the density specification.

  
 QC Supervisor

3-22-06  
 Date

Accept process for IPyC density (Yes or No): Not Applicable

  
 QA Reviewer

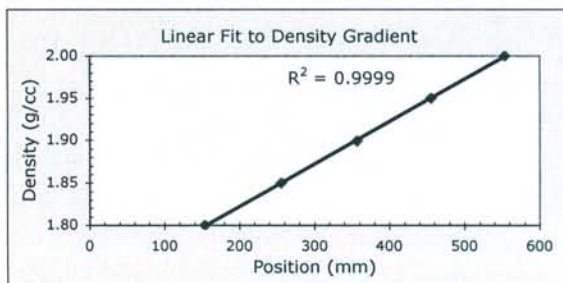
3/28/06  
 Date



Data Report Form DRF-03: Measurement of PyC Density using a Density Gradient Column

Procedure:	AGR-CHAR-DAM-03 Rev. 2
Operator:	Dixie Barker
Filename:	\\mc-agr\AGR\DensityColumn\D05120502_DRF03R2.xls
Sample ID:	LEU01-381-B01
Sample description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2006
Bath temperature:	22.9 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	149.95	158.89	154.42
1.850	251.72	260.12	255.92
1.900	353.85	359.38	356.62
1.950	452.01	459.33	455.67
2.000	549.91	556.80	553.36



Linear Fit			
slope	StDev	intercept	StDev
5.01E-04	3.14E-06	1.72E+00	1.12E-03

Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	170.57	1.8075	26	247.57	1.8461	51		
2	174.32	1.8094	27	249.59	1.8471	52		
3	193.79	1.8191	28	250.22	1.8474	53		
4	211.10	1.8278	29	252.90	1.8487	54		
5	213.72	1.8291	30	255.12	1.8498	55		
6	216.51	1.8305	31	258.75	1.8517	56		
7	217.76	1.8311	32	259.01	1.8518	57		
8	219.24	1.8319	33	259.56	1.8521	58		
9	219.94	1.8322	34	260.92	1.8528	59		
10	223.03	1.8338	35	262.24	1.8534	60		
11	223.64	1.8341	36	262.24	1.8534	61		
12	226.71	1.8356	37	262.64	1.8536	62		
13	228.29	1.8364	38	265.07	1.8548	63		
14	230.89	1.8377	39	265.87	1.8552	64		
15	231.79	1.8382	40	265.87	1.8552	65		
16	232.87	1.8387	41	266.29	1.8554	66		
17	235.90	1.8402	42	269.68	1.8571	67		
18	237.13	1.8408	43	270.19	1.8574	68		
19	238.34	1.8414	44	271.16	1.8579	69		
20	241.60	1.8431	45	274.77	1.8597	70		
21	242.25	1.8434	46	268.94	1.8568	71		
22	242.55	1.8435	47			72		
23	243.36	1.8440	48			73		
24	243.98	1.8443	49			74		
25	245.71	1.8451	50			75		
Average density of PyC fragments:						1.8430		
Standard deviation in density of PyC fragments:						0.0123		
Uncertainty in calculated density of PyC fragments:						0.0014		

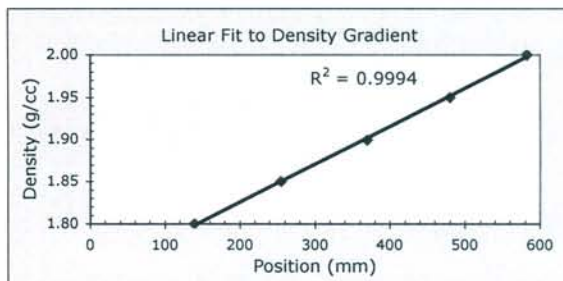
*Dixie Barker*  
Operator

12-5-05  
Date

Data Report Form DRF-03: Measurement of PyC Density using a Density Gradient Column

Procedure:	AGR-CHAR-DAM-03 Rev. 2
Operator:	Dixie Barker
Filename:	\\mc-agr\AGR\DensityColumn\D05120601_DRF03R2.xls
Sample ID:	LEU01-30I-B01
Sample description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2006
Bath temperature:	22.9 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	135.10	144.19	139.65
1.850	250.48	258.95	254.72
1.900	366.91	373.04	369.98
1.950	477.16	484.02	480.59
2.000	580.05	586.34	583.20



Linear Fit			
slope	StDev	intercept	StDev
4.49E-04	2.67E-06	1.74E+00	1.05E-03

Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	214.66	1.8322	26	285.34	1.8640	51		
2	229.86	1.8390	27	287.20	1.8648	52		
3	230.44	1.8393	28	289.59	1.8659	53		
4	231.29	1.8397	29	290.37	1.8662	54		
5	236.81	1.8422	30	291.81	1.8669	55		
6	243.34	1.8451	31	292.18	1.8670	56		
7	246.12	1.8463	32	300.65	1.8708	57		
8	247.09	1.8468	33	301.80	1.8713	58		
9	248.19	1.8473	34	302.69	1.8717	59		
10	250.33	1.8482	35	304.68	1.8726	60		
11	254.09	1.8499	36	306.54	1.8735	61		
12	259.93	1.8525	37	307.38	1.8738	62		
13	262.96	1.8539	38	311.36	1.8756	63		
14	264.11	1.8544	39	317.99	1.8786	64		
15	265.97	1.8553	40	306.82	1.8736	65		
16	265.20	1.8549	41			66		
17	267.42	1.8559	42			67		
18	271.65	1.8578	43			68		
19	276.33	1.8599	44			69		
20	276.62	1.8600	45			70		
21	282.53	1.8627	46			71		
22	282.67	1.8628	47			72		
23	283.78	1.8633	48			73		
24	284.55	1.8636	49			74		
25	284.99	1.8638	50			75		
Average density of PyC fragments:						1.8588		
Standard deviation in density of PyC fragments:						0.0118		
Uncertainty in calculated density of PyC fragments:						0.0014		

*Dixie Barker*  
Operator

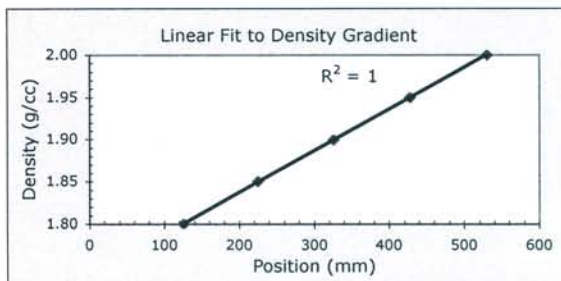
12-6-05  
Date



Data Report Form DRF-03: Measurement of PyC Density using a Density Gradient Column

Procedure:	AGR-CHAR-DAM-03 Rev. 2
Operator:	Dixie Barker
Filename:	\\mc-agr\AGR\DensityColumn\D05120701_DRF03R2.xls
Sample ID:	LEU01-34I-B01
Sample description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2006
Bath temperature:	22.9 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	120.86	130.25	125.56
1.850	221.39	229.38	225.39
1.900	323.49	329.36	326.43
1.950	424.49	431.57	428.03
2.000	527.25	534.16	530.71



Linear Fit			
slope	StDev	intercept	StDev
4.94E-04	3.06E-06	1.74E+00	1.01E-03

Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	204.28	1.8393	26	240.62	1.8573	51		
2	207.45	1.8409	27	241.65	1.8578	52		
3	213.45	1.8438	28	242.13	1.8580	53		
4	213.87	1.8440	29	242.66	1.8583	54		
5	215.61	1.8449	30	245.49	1.8597	55		
6	215.92	1.8451	31	247.12	1.8605	56		
7	217.00	1.8456	32	251.01	1.8624	57		
8	218.00	1.8461	33	251.37	1.8626	58		
9	219.65	1.8469	34	253.09	1.8634	59		
10	219.31	1.8467	35	255.84	1.8648	60		
11	219.73	1.8469	36	257.37	1.8655	61		
12	223.66	1.8489	37	257.77	1.8657	62		
13	226.13	1.8501	38	258.58	1.8661	63		
14	226.46	1.8503	39	258.58	1.8661	64		
15	227.21	1.8506	40	258.06	1.8659	65		
16	229.17	1.8516	41	260.63	1.8671	66		
17	230.62	1.8523	42	264.67	1.8691	67		
18	231.54	1.8528	43	265.91	1.8697	68		
19	231.54	1.8528	44	269.73	1.8716	69		
20	232.04	1.8530	45	270.02	1.8718	70		
21	234.73	1.8543	46	271.20	1.8723	71		
22	235.41	1.8547	47	278.21	1.8758	72		
23	236.51	1.8552	48	278.93	1.8762	73		
24	239.41	1.8567	49	280.19	1.8768	74		
25	239.96	1.8569	50	281.80	1.8776	75		
Average density of PyC fragments:						1.8578		
Standard deviation in density of PyC fragments:						0.0103		
Uncertainty in calculated density of PyC fragments:						0.0013		

*Dixie Barker*  
Operator

12-7-05  
Date

**For Information Only**

The information in the remainder of this section reports results of measurements not required by the fuel specification and is provided for information only.

## Summary of "info only" measurements

## Coating Thickness

		Buffer thickness ( $\mu\text{m}$ )	IPyC thickness ( $\mu\text{m}$ )
Batch 1	LEU01-38I	110	37.2
Batch 2	LEU01-30I	104	36.5
Batch 3	LEU01-34I	111	37.5
Average		108	37.1

## Open Porosity between 250 psi and 10000 psi

		Average particle weight (g)	Open porosity ( $\text{ml}/\text{m}^2$ )
Batch 1	LEU01-38I	4.16E-04	1.88
Batch 2	LEU01-30I	4.09E-04	1.53
Batch 3	LEU01-34I	4.19E-04	1.86
Average		4.15E-04	1.76

Note: The open porosity measurement on the IPyC was calculated from the mercury intrusion between 250 psi and 10000 psi per table 5.3 in EDF-4380, Rev. 6. In the upper half of this pressure range, there is some compression of the buffer layer that results in a value for open porosity that is higher than the actual value. The open porosity of the IPyC, calculated from the mercury intrusion between 250 psi and 5000 psi, is shown in the table below. Studies have shown that the open porosity measurement for this pressure range is less affected by buffer compression and more appropriate for measurements on IPyC.

## Open Porosity between 250 psi and 5000 psi

		Average particle weight (g)	Open porosity ( $\text{ml}/\text{m}^2$ )
Batch 1	LEU01-38I	4.16E-04	1.47
Batch 2	LEU01-30I	4.09E-04	1.15
Batch 3	LEU01-34I	4.19E-04	1.44
Average		4.15E-04	1.35



Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 0
Operator:	Andrew K. Kercher
Sample ID:	LEU01-38I-A01
Sample Description:	Buffer/IPyC on BWXT kernel composite 69302
Mount Number(s):	M05120601L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05120802\

DMR Calibration Expiration Date:	9/8/06
Stage Micrometer Calibration Expiration Date:	2/17/07
Measured Value for 500 $\mu\text{m}$ in Stage Micrometer Image:	500. $\mu\text{m}$

Operator

12/8/05

Date

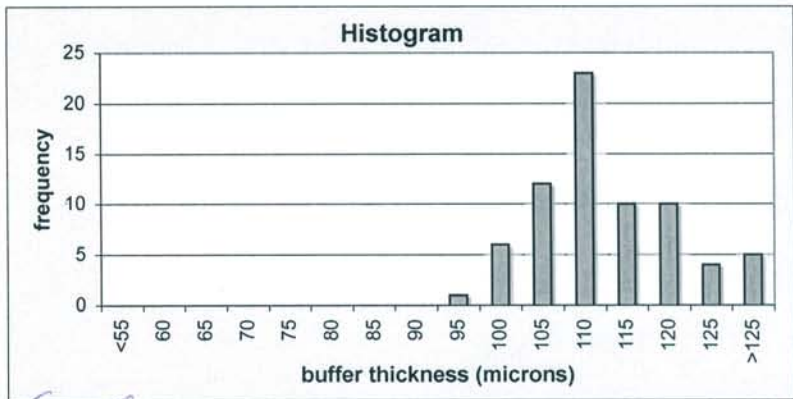
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120802\
Sample ID:	LEU01-38I-A01
Sample Description:	Variant 1: Buffer/IPyC on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120802_output\

Number of buffer layers analyzed:	71
Mean of the average buffer thickness of each particle (μm):	110.2
Standard deviation in the average buffer thickness of each particle (μm):	8.5

Distribution of the average buffer layer thickness (top binned)

Buffer Thickness (μm)	Frequency
<55	0
60	0
65	0
70	0
75	0
80	0
85	0
90	0
95	1
100	6
105	12
110	23
115	10
120	10
125	4
>125	5



*Andrew K. Kercher*  
Operator

12/12/05  
Date

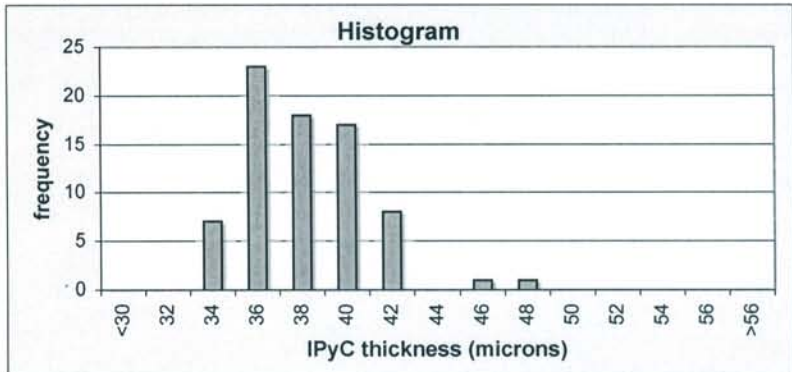
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120802\
Sample ID:	LEU01-38I-A01
Sample Description:	Variation 1: Buffer/IPyC on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120802_output\

Number of inner pyrocarbon layers analyzed:	75
Mean of the average IPyC thickness of each particle ( $\mu\text{m}$ ):	37.2
Standard deviation in the average IPyC thickness of each particle ( $\mu\text{m}$ ):	2.7

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness ( $\mu\text{m}$ )	Frequency
<30	0
32	0
34	7
36	23
38	18
40	17
42	8
44	0
46	1
48	1
50	0
52	0
54	0
56	0
>56	0



*Andrew K. Kercher*  
Operator

12/12/05  
Date

Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 0
Operator:	Andrew K. Kercher
Sample ID:	LEU01-30I-A01
Sample Description:	Buffer/IPyC on BWXT kernel composite 69302
Mount Number(s):	M05120502L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05120801\

DMR Calibration Expiration Date:	9/8/06
Stage Micrometer Calibration Expiration Date:	2/17/07
Measured Value for 500 µm in Stage Micrometer Image:	500. µm

  
 Operator

12/8/05  
 Date

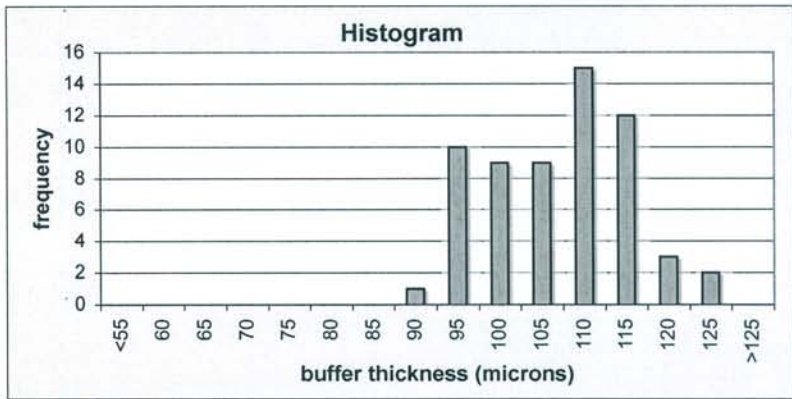
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120801\
Sample ID:	LEU01-30I-A01
Sample Description:	Variant 1: Buffer/IPyC on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120801_output\

Number of buffer layers analyzed:	61
Mean of the average buffer thickness of each particle (μm):	104.1
Standard deviation in the average buffer thickness of each particle (μm):	8.5

Distribution of the average buffer layer thickness (top binned)

Buffer Thickness (μm)	Frequency
<55	0
60	0
65	0
70	0
75	0
80	0
85	0
90	1
95	10
100	9
105	9
110	15
115	12
120	3
125	2
>125	0



*Andrew K. Kercher*  
Operator

12/12/05  
Date



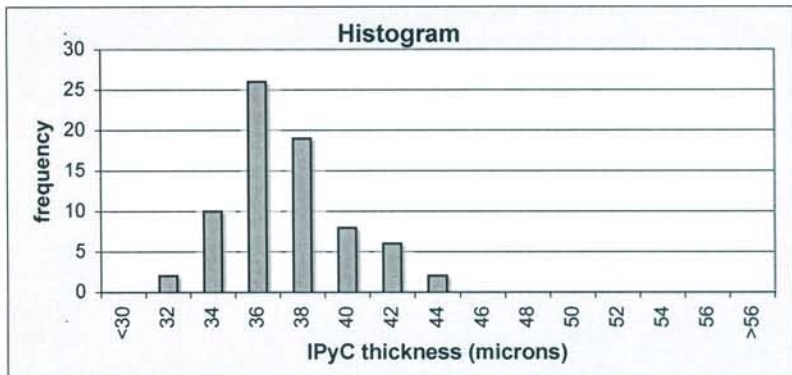
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120801\
Sample ID:	LEU01-30I-A01
Sample Description:	Variant 1: Buffer/IPyC on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120801_output\

Number of inner pyrocarbon layers analyzed:	73
Mean of the average IPyC thickness of each particle (μm):	36.5
Standard deviation in the average IPyC thickness of each particle (μm):	2.5

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	Frequency
<30	0
32	2
34	10
36	26
38	19
40	8
42	6
44	2
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



*Andrew K. Kercher*  
Operator

12/12/05  
Date

Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 0
Operator:	Andrew K. Kercher
Sample ID:	LEU01-34I-A01
Sample Description:	Buffer/IPyC on BWXT kernel composite 69302
Mount Number(s):	M05120701L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05120803\

DMR Calibration Expiration Date:	9/8/06
Stage Micrometer Calibration Expiration Date:	2/17/07
Measured Value for 500 µm in Stage Micrometer Image:	500. µm

*Andrew K. Kercher*

Operator

12/8/05

Date

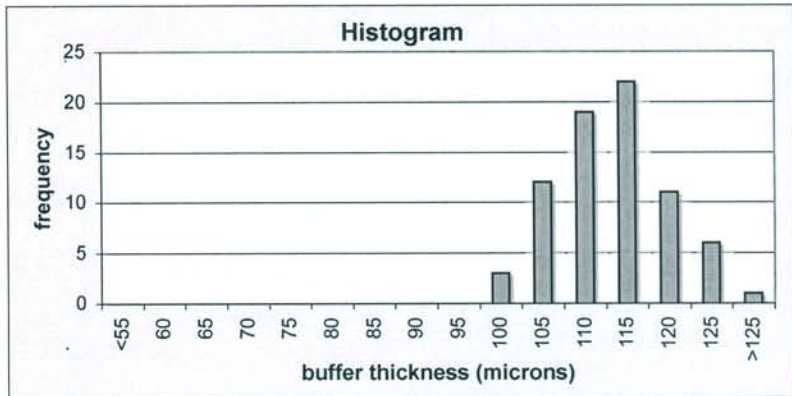
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120803\
Sample ID:	LEU01-34I-A01
Sample Description:	Variants 1: Buffer/IPyC on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120803_output\

Number of buffer layers analyzed:	74
Mean of the average buffer thickness of each particle ( $\mu\text{m}$ ):	110.8
Standard deviation in the average buffer thickness of each particle ( $\mu\text{m}$ ):	6.7

Distribution of the average buffer layer thickness (top binned)

Buffer Thickness ( $\mu\text{m}$ )	Frequency
<55	0
60	0
65	0
70	0
75	0
80	0
85	0
90	0
95	0
100	3
105	12
110	19
115	22
120	11
125	6
>125	1



*Andrew K. Kercher*  
Operator

12/12/05  
Date

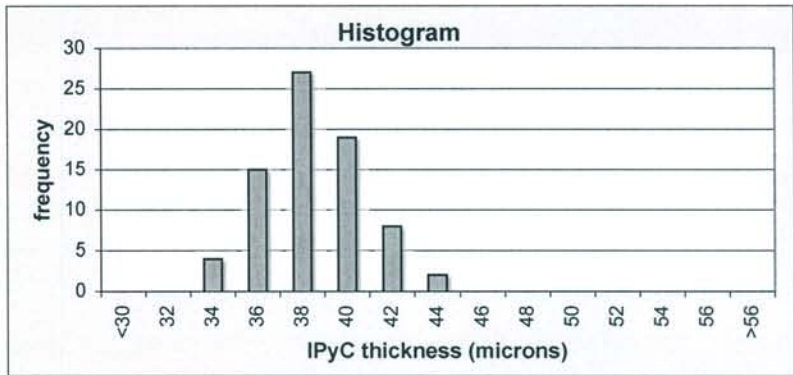
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120803\
Sample ID:	LEU01-34I-A01
Sample Description:	Variat 1: Buffer/IPyC on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05120803_output\

Number of inner pyrocarbon layers analyzed:	75
Mean of the average IPyC thickness of each particle (μm):	37.5
Standard deviation in the average IPyC thickness of each particle (μm):	2.2

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	Frequency
<30	0
32	0
34	4
36	15
38	27
40	19
42	8
44	2
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



*Andrew K. Kercher*  
Operator

12/12/05  
Date

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-38I-C01
Particle Lot Description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W05120702_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	5.55E-02	6.72E-02	6.50E-02	7.08E-02	6.25E-02
Number of particles:	133	161	156	170	151
Average weight/particle (g):	4.17E-04	4.17E-04	4.17E-04	4.16E-04	4.14E-04

Mean average weight/particle (g):	4.16E-04
Uncertainty in mean average weight/particle (g):	6.35E-07

*Dixie Barker*  
Operator

*12-7-05*  
Date



Data Report Form DRF-31: Measurement of Open Porosity using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-31 Rev. 0
Operator:	S. D. Nunn
Coated particle batch ID:	LEU01-381-D01
Batch Description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\vmc-agr\AGR\Porosimeter\S05120801\S05120801_DRF31R0.xls

Mean average weight/particle (g):	4.16E-04
Uncertainty in mean average weight/particle (g):	6.35E-07

Weight of particles (g):	4.0531
Approximate number of particles:	9743
Uncertainty in number of particles:	15
Total envelope volume of sample (cc):	1.368
Average envelope volume/particle (cc):	1.40E-04
Sample envelope density (g/cc):	2.962

Average particle diameter (microns):	6.45E+02
Average surface area/particle (cm <sup>2</sup> ):	1.31E-02
Total sample surface area (cm <sup>2</sup> ):	1.27E+02
Intruded mercury volume from 250-10,000 psia (cc):	2.39E-02
Open porosity (ml/m <sup>2</sup> ):	1.88E+00

*S. D. Nunn*

Operator

*12/8/05*

Date

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-30I-C01
Particle Lot Description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W05120601_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	4.03E-02	5.53E-02	8.18E-02	7.78E-02	5.32E-02
Number of particles:	98	135	200	191	131
Average weight/particle (g):	4.11E-04	4.10E-04	4.09E-04	4.07E-04	4.06E-04

Mean average weight/particle (g):	4.09E-04
Uncertainty in mean average weight/particle (g):	8.92E-07

*Dixie Barker*

Operator

*12-6-05*

Date

Data Report Form DRF-31: Measurement of Open Porosity using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-31 Rev. 0
Operator:	S. D. Nunn
Coated particle batch ID:	LEU01-30I-D02
Batch Description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05120802\S05120802_DRF31R0.xls

Mean average weight/particle (g):	4.09E-04
Uncertainty in mean average weight/particle (g):	8.92E-07

Weight of particles (g):	3.9560
Approximate number of particles:	9672
Uncertainty in number of particles:	21
Total envelope volume of sample (cc):	1.298
Average envelope volume/particle (cc):	1.34E-04
Sample envelope density (g/cc):	3.049

Average particle diameter (microns):	6.35E+02
Average surface area/particle (cm <sup>2</sup> ):	1.27E-02
Total sample surface area (cm <sup>2</sup> ):	1.23E+02
Intruded mercury volume from 250-10,000 psia (cc):	1.87E-02
Open porosity (ml/m <sup>2</sup> ):	1.53E+00

*S.D. Nunn*

Operator

*12/8/05*

Date

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-34I-C01
Particle Lot Description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W05120701_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	5.36E-02	5.75E-02	5.50E-02	7.28E-02	5.88E-02
Number of particles:	127	136	132	175	141
Average weight/particle (g):	4.22E-04	4.23E-04	4.17E-04	4.16E-04	4.17E-04

Mean average weight/particle (g):	4.19E-04
Uncertainty in mean average weight/particle (g):	1.45E-06

*Dixie Barker*  
Operator

12-7-05  
Date

Data Report Form DRF-31: Measurement of Open Porosity using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-31 Rev. 0
Operator:	S. D. Nunn
Coated particle batch ID:	LEU01-34I-D01
Batch Description:	Variant 1: IPyC/Buffer on BWXT kernel composite 69302
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05120702\S05120702_DRF31R0.xls

Mean average weight/particle (g):	4.19E-04
Uncertainty in mean average weight/particle (g):	1.45E-06

Weight of particles (g):	4.1166
Approximate number of particles:	9825
Uncertainty in number of particles:	34
Total envelope volume of sample (cc):	1.399
Average envelope volume/particle (cc):	1.42E-04
Sample envelope density (g/cc):	2.942

Average particle diameter (microns):	6.48E+02
Average surface area/particle (cm <sup>2</sup> ):	1.32E-02
Total sample surface area (cm <sup>2</sup> ):	1.30E+02
Intruded mercury volume from 250-10,000 psia (cc):	2.41E-02
Open porosity (ml/m <sup>2</sup> ):	1.86E+00

*S. D. Nunn*

Operator

*12/7/05*

Date



## **10 Characterization of first batch of TRISO-coated particles**

This section contains data on LEU01-43T, the first batch of TRISO-coated particles used for the LEU01-47T particle composite. The data was obtained according to product inspection plan AGR-CHAR-PIP-03R2.

Note that some of the carbon deposited for the buffer layer reacted with the kernel to form a uranium carbide layer between the kernel and the buffer. The uranium carbide layer was not included in the measurement of the buffer thickness. The thickness of this carbide layer varied, but was typically around 6  $\mu\text{m}$  thick and effectively increased the kernel radius by that amount.

The following pages show the inspection report form (IRF-03). Following IRF-03 are the individual data report forms for the measurements that were performed. Additional data at the end of this section is provided for information only. This batch was determined to satisfy the specifications in section 5.2 of EDF 4380, Rev. 6.

Inspection Report Form IRF-03: Coated Particle Batches

<b>Procedure:</b>	AGR-CHAR-PIP-03 Rev. 2
<b>Coated particle batch ID:</b>	LEU01-43T
<b>Coated particle batch description:</b>	Variant 1: TRISO on BWXT kernel composite 69302

Property	Measured Data			t value (t)	Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)						
Average buffer thickness for each particle (µm)	107.6	8.5	174	1.654	mean 100 ± 15	A = x - ts/√n ≥ 85	106.5	pass	DRF-08
						B = x + ts/√n ≤ 115	108.7	pass	DRF-11
Average IPyC thickness for each particle (µm)	42.0	2.3	224	1.652	mean 40 ± 5	A = x - ts/√n ≥ 35	41.7	pass	DRF-08
						B = x + ts/√n ≤ 45	42.3	pass	DRF-11
Average SiC thickness for each particle (µm)	35.3	1.0	223	1.652	mean 35 ± 4	A = x - ts/√n ≥ 31	35.2	pass	DRF-08
						B = x + ts/√n ≤ 39	35.4	pass	DRF-11
Average OPyC thickness for each particle (µm)	40.7	2.2	223	1.652	mean 40 ± 5	A = x - ts/√n ≥ 35	40.5	pass	DRF-08
						B = x + ts/√n ≤ 45	40.9	pass	DRF-11
Particles with missing OPyC			16957		defect fraction ≤ 6.0 x 10 <sup>-4</sup>	≤ 4 in 15,500	0	pass	DRF-19

**Comments**  
 Goldspot analysis performed on missing OPyC sample for information only. 7 out of 16957 gold spots observed.

  
 QC Supervisor

3-21-06  
 Date

Accept Coated particle batch (Yes or No):	Yes
---	-----

  
 QA Reviewer

3/22/06  
 Date

Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-43T-B01
Sample description:	TRISO on BWXT kernel composite 69302
Mount ID number:	M06010301L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06010401\P0601040101\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 $\mu\text{m}$ in stage micrometer image ( $\mu\text{m}$ ):	500.0

Polish-down distance n,m ( $\mu\text{m}$ )			
2,2	2,8	8,2	8,8
369	374	354	360

Approximate layer width in polish plane ( $\mu\text{m}$ )				
Kernel radius	Buffer	IPyC	SiC	OPyC
162	124	42	36	44

*Andrew K. Kercher*      *January 4, 2006*

---

Operator      Date

Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-43T-B01
Sample description:	TRISO on BWXT kernel composite 69302
Mount ID number:	M06010302L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06010401\P0601040102\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 $\mu\text{m}$ in stage micrometer image ( $\mu\text{m}$ ):	500.0

Polish-down distance n,m ( $\mu\text{m}$ )			
2,2	2,8	8,2	8,8
366	378	377	377

Approximate layer width in polish plane ( $\mu\text{m}$ )				
Kernel radius	Buffer	IPyC	SiC	OPyC
167	114	41	38	39

*Andrew K. Kercher* January 4, 2006  
 Operator Date

Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-43T-B01
Sample description:	TRISO on BWXT kernel composite 69302
Mount ID number:	M06010303L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06010401\P0601040103\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 $\mu\text{m}$ in stage micrometer image ( $\mu\text{m}$ ):	500.0

Polish-down distance n,m ( $\mu\text{m}$ )			
2,2	2,8	8,2	8,8
367	378	355	363

Approximate layer width in polish plane ( $\mu\text{m}$ )				
Kernel radius	Buffer	IPyC	SiC	OPyC
169	109	39	38	44

*Andrew K. Kercher*      *January 4, 2006*

Operator      Date



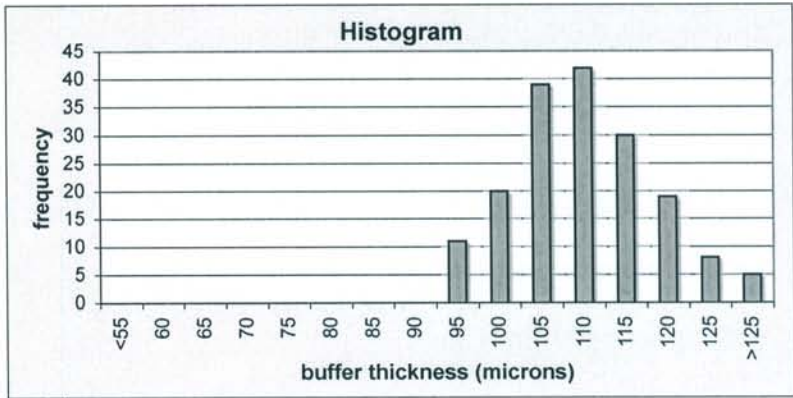
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06010401\
Sample ID:	LEU01-43T-B01
Sample Description:	Variants 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06010401_output\

Number of buffer layers analyzed:	174
Mean of the average buffer thickness of each particle (μm):	107.6
Standard deviation in the average buffer thickness of each particle (μm):	8.5

Distribution of the average buffer layer thickness (top binned)

Buffer Thickness (μm)	Frequency
<55	0
60	0
65	0
70	0
75	0
80	0
85	0
90	0
95	11
100	20
105	39
110	42
115	30
120	19
125	8
>125	5



*Andrew K. Kercher*  
Operator

01/27/06  
Date

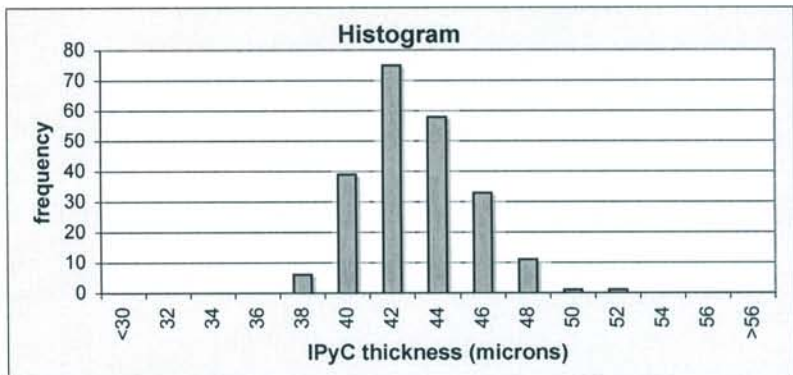
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06010401\
Sample ID:	LEU01-43T-B01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06010401_output\

Number of inner pyrocarbon layers analyzed:	224
Mean of the average IPyC thickness of each particle ( $\mu\text{m}$ ):	42.0
Standard deviation in the average IPyC thickness of each particle ( $\mu\text{m}$ ):	2.3

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness ( $\mu\text{m}$ )	Frequency
<30	0
32	0
34	0
36	0
38	6
40	39
42	75
44	58
46	33
48	11
50	1
52	1
54	0
56	0
>56	0



*Andrew K. Kercher*  
Operator

01/27/06  
Date

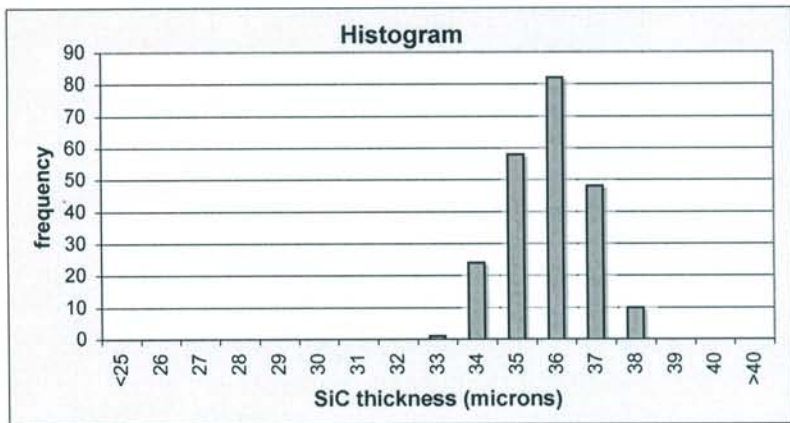
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06010401\
Sample ID:	LEU01-43T-B01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06010401_output\

Number of silicon carbide layers analyzed:	223
Mean of the average SiC thickness of each particle ( $\mu\text{m}$ ):	35.3
Standard deviation in the average SiC thickness of each particle ( $\mu\text{m}$ ):	1.0

Distribution of the average SiC layer thickness (top binned)

SiC Thickness ( $\mu\text{m}$ )	Frequency
<25	0
26	0
27	0
28	0
29	0
30	0
31	0
32	0
33	1
34	24
35	58
36	82
37	48
38	10
39	0
40	0
>40	0



*Andrew K. Kercher*  
Operator

01/27/06  
Date

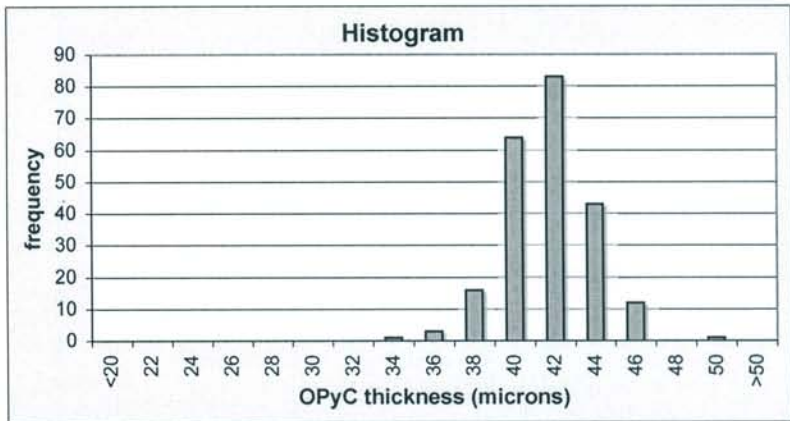
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder Name:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06010401\
Sample ID:	LEU01-43T-B01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06010401_output\

Number of outer pyrocarbon layers analyzed:	223
Mean of the average OPyC thickness of each particle (μm):	40.7
Standard deviation in the average OPyC thickness of each particle (μm):	2.2

Distribution of the average OPyC layer thickness (top binned)

OPyC Thickness (μm)	Frequency
<20	0
22	0
24	0
26	0
28	0
30	0
32	0
34	1
36	3
38	16
40	64
42	83
44	43
46	12
48	0
50	1
>50	0



*Andrew K. Kercher*  
Operator

01/27/06  
Date



Data Report Form DRF-19: Counting of Particles with Missing OPyC Layer by Visual Inspection

Procedure:	AGR-CHAR-DAM-19 Rev. 1
Operator:	John Hunn
Sample ID:	LEU01-43T-C01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06011101_DRF19R1.xls

Mean average weight/particle (g):	7.32E-04
Uncertainty in average weight/particle (g):	2.19E-06
Weight of sample of particles (g):	12.412
Approximate number of particles in sample:	16957
Uncertainty in number of particles in sample:	51

Number of particles with missing OPyC layer:	0
--	---

Comments on unusual visual characteristics of OPyC

13 particles had a mottled gray surface appearance. SEM EDS analysis on 2 particles showed no SiC at surface (the OPyC layer was not partially missing). 11 particles were polished to midplane, 1 had a thin OPyC layer (~20 um thick) but no other unusual features were observed.



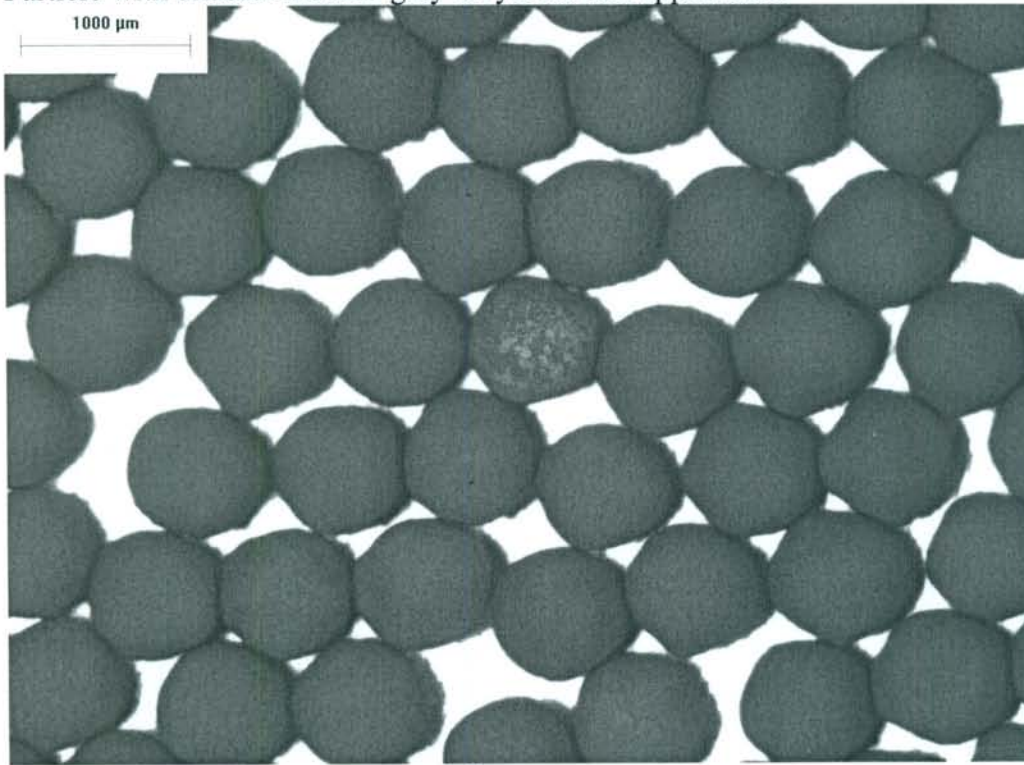
Operator

1-11-06

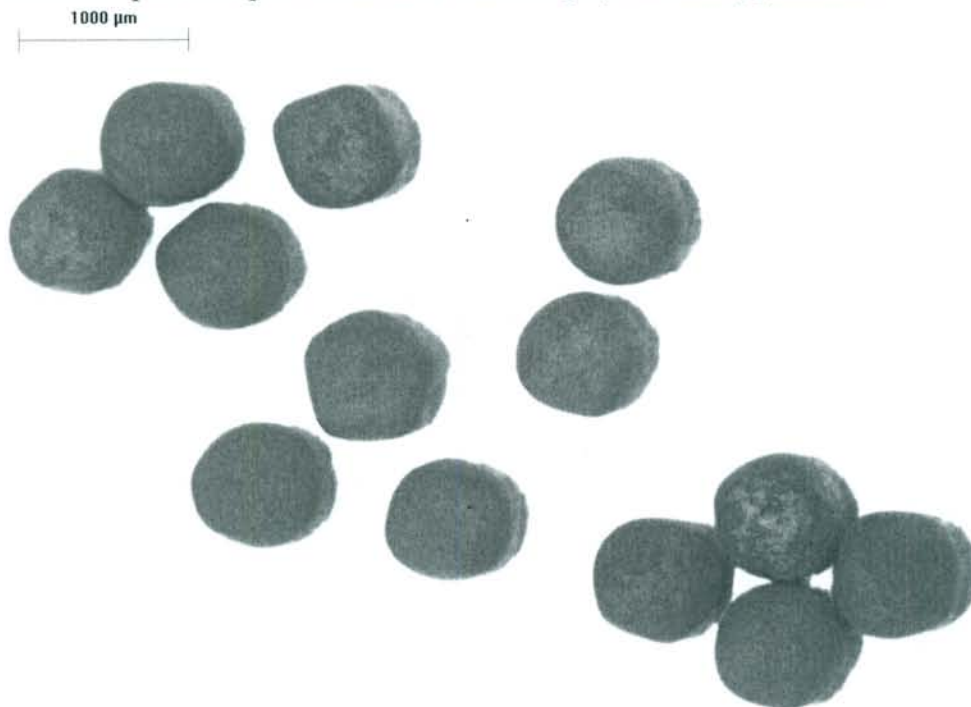
Date



Particle with unusual mottled gray OPyC surface appearance.



13/16957 particles picked out with mottled gray surface appearance.



**For Information Only**

The information in the remainder of this section reports results of measurements not required by the fuel specification and is provided for information only.

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-43T-D01
Particle Lot Description:	Variant 1 TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06010301_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	8.47E-02	8.75E-02	1.01E-01	8.61E-02	7.70E-02
Number of particles:	116	120	138	118	104
Average weight/particle (g):	7.30E-04	7.29E-04	7.29E-04	7.30E-04	7.40E-04

Mean average weight/particle (g):	7.32E-04
Uncertainty in mean average weight/particle (g):	2.19E-06

*Dixie Barker*  
Operator

1-3-06  
Date

Data Report Form DRF-20: Counting of Particles with SiC Gold Spot Defects by Visual Inspection

Procedure:	AGR-CHAR-DAM-20 Rev. 1
Operator:	John Hunn
Sample ID:	LEU01-43T-C01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\GoldSpots\G06011801_DRF20R1.xls

Mean average weight/particle (g):	7.32E-04
Uncertainty in average weight/particle (g):	2.19E-06
Weight of sample of particles (g):	12.412
Approximate number of particles in sample:	16957
Uncertainty in number of particles in sample:	51

Number of particles with gold spot defects:	7
---	---

Comments on unusual visual characteristics of SiC

One particle had several clumps of SiC protruding from surface. Goldspots were not obvious. Prepared polished cross sections of 7 particles picked out for goldspots. Only 3 showed visible SiC defects.



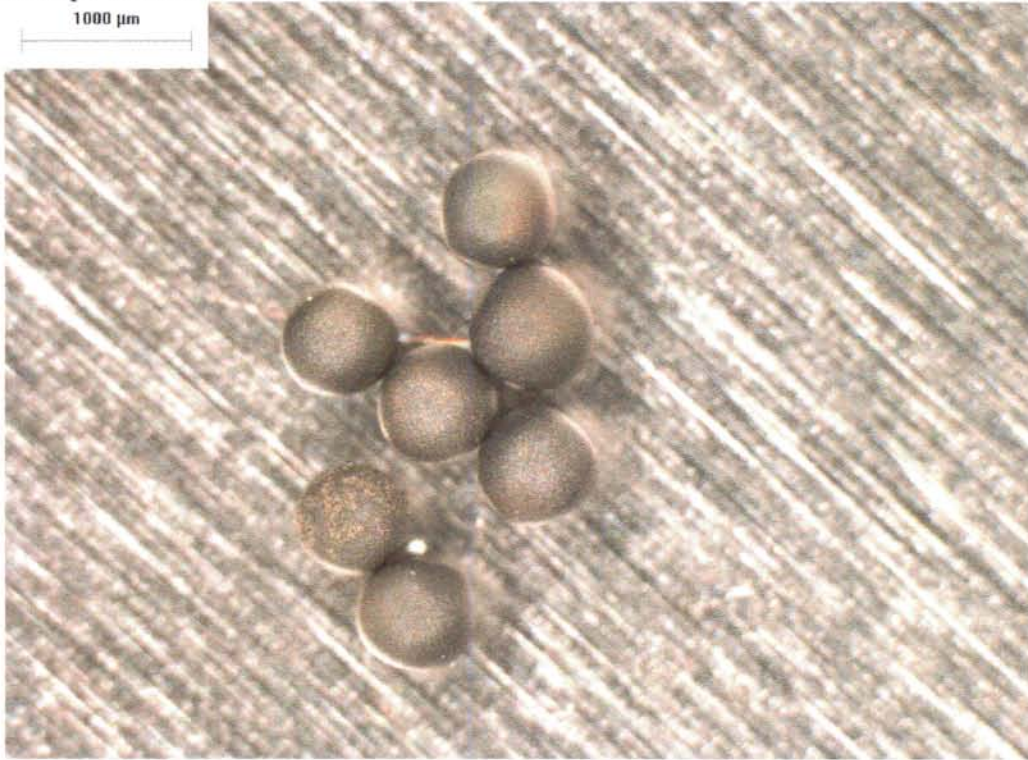
Operator

1-18-06

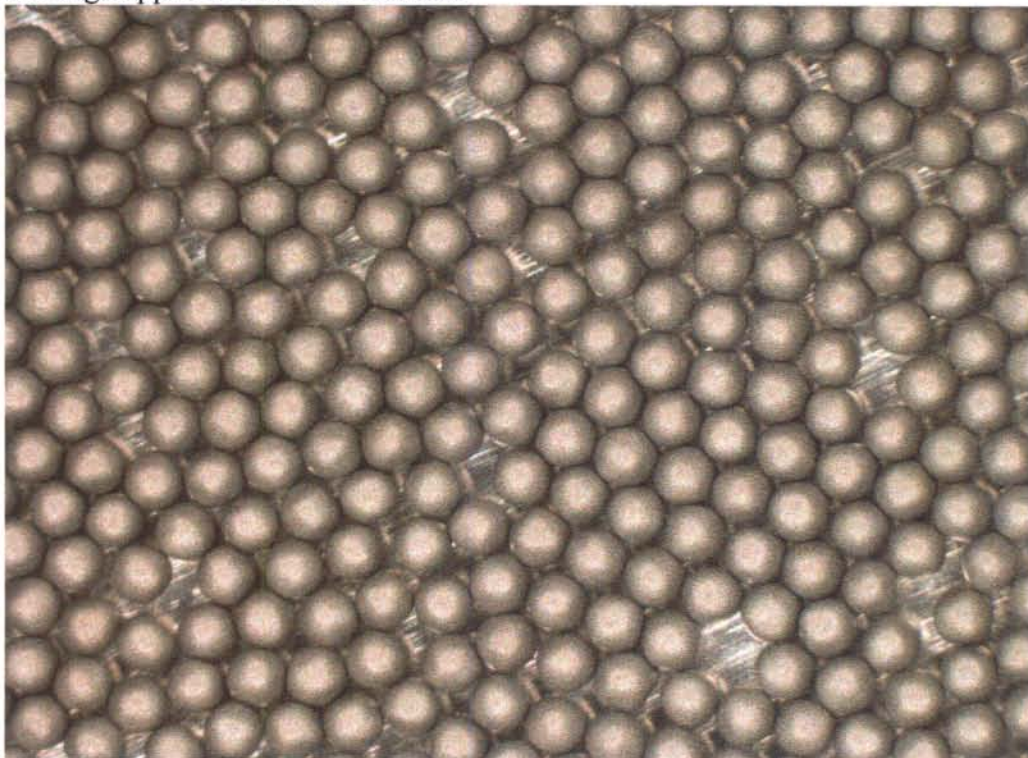
Date



7/16957 gold spots found (1 not shown). Also 1 particle with what appeared to be SiC clumps on surface.



Average appearance of SiC surface.





Data Report Form DRF-23: Imaging of SiC Grain Structure

Procedure:	AGR-CHAR-DAM-23 Rev. 0
Operator:	Paul Menchhofer
Filename:	\\mc-agr\AGR\SEM\E06022304_DRF23R0.xls
Sample ID:	LEU01-43T-BO1
Sample Description:	LEU01-43T-BO1
Mount Number(s):	M06021303L
Folder name containing images:	\\mc-agr\AGR\SEM\

Images of SiC grain structure			
	particle 1	particle 2	particle 3
1000x image filename	58293	58297	58299
2500x image filename	58292	58296	58298
grain structure acceptable	yes	yes	yes

Comments

*PA Menchhofer*  
Operator

*2-23-06*  
Date

*John Hume*  
QC Supervisor

*3-21-06*  
Date

*M.C. Jones*  
QA Reviewer

*3/22/06*  
Date

ORNL/TM-2006/020, Rev. 1

98

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 5.4 58293

20  $\mu$ m

ORNL/TM-2006/020, Rev. 1

99

Acc.V	Spot	Magn	Det	WD	Exp
10.0 kV	5.0	2500x	BSE	5.4	58292

10  $\mu$ m

ORNL/TM-2006/020, Rev. 1

100

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 5.4 58297

20  $\mu$ m

ORNL/TM-2006/020, Rev. 1

101

Acc.V	Spot	Magn	Det	WD	Exp
10.0 kV	5.0	2500x	BSE	5.4	58296

10 μm



ORNL/TM-2006/020, Rev. 1

102

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 5.3 58299

20  $\mu$ m

ORNL/TM-2006/020, Rev. 1

103

Acc.V	Spot	Magn	Det	WD	Exp
10.0 kV	5.0	2500x	BSE	5.3	58298

10 μm

## **11 Characterization of second batch of TRISO-coated particles**

This section contains data on LEU01-44T, the second batch of TRISO-coated particles used for the LEU01-47T particle composite. The data was obtained according to product inspection plan AGR-CHAR-PIP-03R2.

Note that some of the carbon deposited for the buffer layer reacted with the kernel to form a uranium carbide layer between the kernel and the buffer. The uranium carbide layer was not included in the measurement of the buffer thickness. The thickness of this carbide layer varied, but was typically around 6  $\mu\text{m}$  thick and effectively increased the kernel radius by that amount.

The following pages show the inspection report form (IRF-03). Following IRF-03 are the individual data report forms for the measurements that were performed. Additional data at the end of this section is provided for information only. This batch was determined to satisfy the specifications in section 5.2 of EDF 4380, Rev. 6.

Inspection Report Form IRF-03: Coated Particle Batches

Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-44T
Coated particle batch description:	Variant 1: TRISO on BWXT kernel composite 69302

Property	Measured Data				Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	t value (t)					
Average buffer thickness for each particle (µm)	103.4	6.6	176	1.654	mean 100 ± 15	A = $x - ts/\sqrt{n} \geq 85$	102.6	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 115$	104.2	pass	DRF-11
Average IPyC thickness for each particle (µm)	39.7	2.4	220	1.652	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$	39.4	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 45$	40.0	pass	DRF-11
Average SiC thickness for each particle (µm)	36.2	0.9	220	1.652	mean 35 ± 4	A = $x - ts/\sqrt{n} \geq 31$	36.1	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 39$	36.3	pass	DRF-11
Average OPyC thickness for each particle (µm)	42.8	2.1	220	1.652	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$	42.6	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 45$	43.0	pass	DRF-11
Particles with missing OPyC			15637		defect fraction $\leq 6.0 \times 10^{-4}$	$\leq 4$ in 15,500	0	pass	DRF-19

**Comments**  
 Goldspot analysis performed on missing OPyC sample for information only. 13 out of 15637 gold spots observed.

  
 QC Supervisor

3-21-06  
 Date

Accept Coated particle batch (Yes or No): Yes

  
 QA Reviewer

3/22/06  
 Date

Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-44T-B01
Sample description:	Variation 1 TRISO on BWXT kernel composite 69302
Mount ID number:	M06011301L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06012301\P0601230101\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 $\mu\text{m}$ in stage micrometer image ( $\mu\text{m}$ ):	500.4

Polish-down distance n,m ( $\mu\text{m}$ )			
2,2	2,8	8,2	8,8
379	381	366	363

Approximate layer width in polish plane ( $\mu\text{m}$ )				
Kernel radius	Buffer	IPyC	SiC	OPyC
171	107	39	38	43

*Andrew K. Kercher*      *January 23, 2006*

Operator      Date



Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-44T-B01
Sample description:	Variant 1 TRISO on BWXT kernel composite 69302
Mount ID number:	M06011302L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06012301\P0601230102\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 $\mu\text{m}$ in stage micrometer image ( $\mu\text{m}$ ):	500.4

Polish-down distance n,m ( $\mu\text{m}$ )			
2,2	2,8	8,2	8,8
382	364	373	351

Approximate layer width in polish plane ( $\mu\text{m}$ )				
Kernel radius	Buffer	IPyC	SiC	OPyC
171	105	40	39	40

*Andrew K. Kercher*  
Operator

*January 23, 2006*  
Date

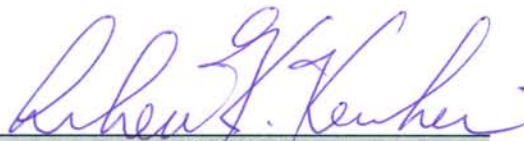

Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-44T-B01
Sample description:	Variant 1 TRISO on BWXT kernel composite 69302
Mount ID number:	M06011901L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06012301\P0601230103\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 $\mu\text{m}$ in stage micrometer image ( $\mu\text{m}$ ):	500.4

Polish-down distance n,m ( $\mu\text{m}$ )			
2,2	2,8	8,2	8,8
378	374	376	387

Approximate layer width in polish plane ( $\mu\text{m}$ )				
Kernel radius	Buffer	IPyC	SiC	OPyC
179	105	41	39	43

Operator
Date

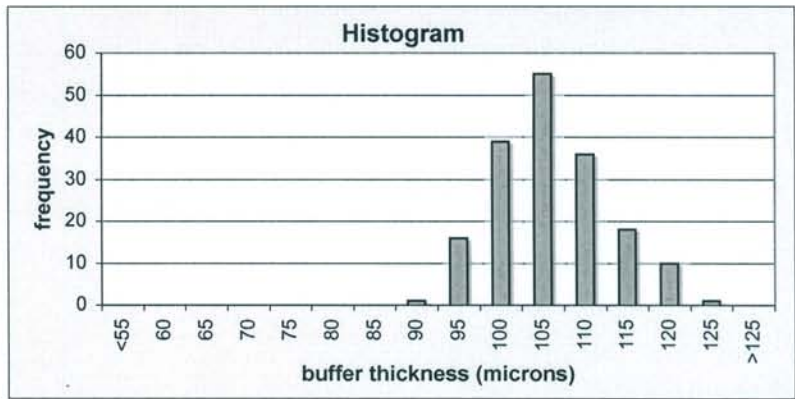
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012301\
Sample ID:	LEU01-44T-B01
Sample Description:	VARIANT 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012301_output\

Number of buffer layers analyzed:	176
Mean of the average buffer thickness of each particle (µm):	103.4
Standard deviation in the average buffer thickness of each particle (µm):	6.6

Distribution of the average buffer layer thickness (top binned)

Buffer Thickness (µm)	Frequency
<55	0
60	0
65	0
70	0
75	0
80	0
85	0
90	1
95	16
100	39
105	55
110	36
115	18
120	10
125	1
>125	0



*Andrew K. Kercher*

Operator

01/26/06

Date

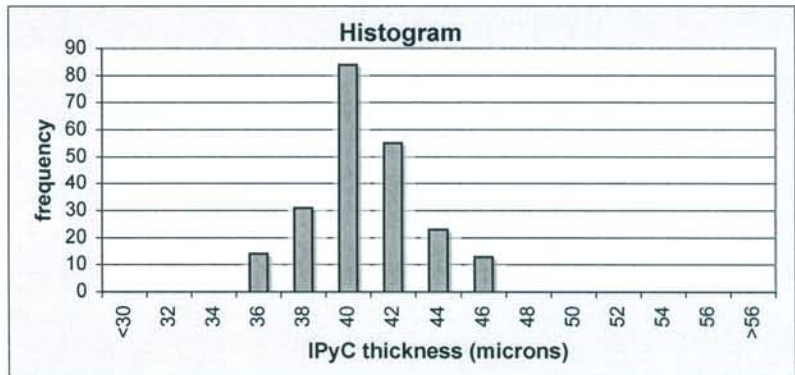
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012301\
Sample ID:	LEU01-44T-B01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012301_output\

Number of inner pyrocarbon layers analyzed:	220
Mean of the average IPyC thickness of each particle ( $\mu\text{m}$ ):	39.7
Standard deviation in the average IPyC thickness of each particle ( $\mu\text{m}$ ):	2.4

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness ( $\mu\text{m}$ )	Frequency
<30	0
32	0
34	0
36	14
38	31
40	84
42	55
44	23
46	13
48	0
50	0
52	0
54	0
56	0
>56	0



*Andrew K. Kercher*

Operator

01/26/06

Date



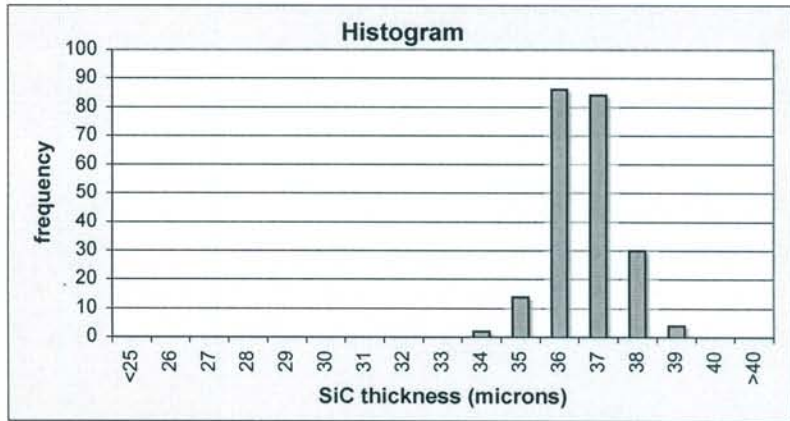
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012301\
Sample ID:	LEU01-44T-B01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012301_output\

Number of silicon carbide layers analyzed:	220
Mean of the average SiC thickness of each particle (μm):	36.2
Standard deviation in the average SiC thickness of each particle (μm):	0.9

Distribution of the average SiC layer thickness (top binned)

SiC Thickness (μm)	Frequency
<25	0
26	0
27	0
28	0
29	0
30	0
31	0
32	0
33	0
34	2
35	14
36	86
37	84
38	30
39	4
40	0
>40	0



*Andrew K. Kercher*  
Operator

01/26/06  
Date



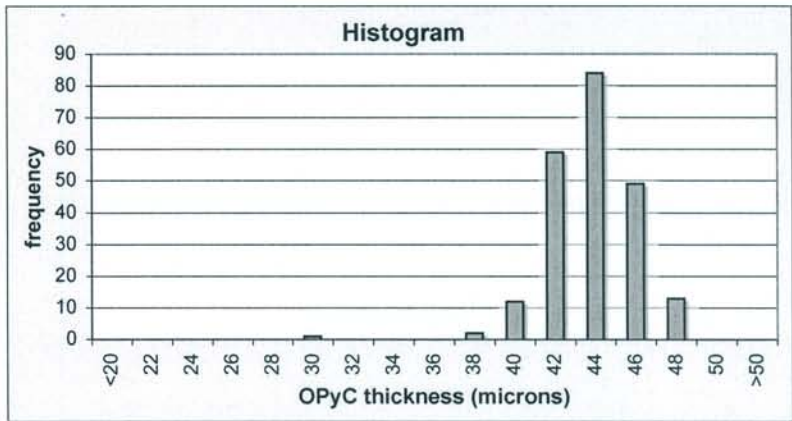
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder Name:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012301\
Sample ID:	LEU01-44T-B01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012301_output\

Number of outer pyrocarbon layers analyzed:	220
Mean of the average OPyC thickness of each particle (μm):	42.8
Standard deviation in the average OPyC thickness of each particle (μm):	2.1

Distribution of the average OPyC layer thickness (top binned)

OPyC Thickness (μm)	Frequency
<20	0
22	0
24	0
26	0
28	0
30	1
32	0
34	0
36	0
38	2
40	12
42	59
44	84
46	49
48	13
50	0
>50	0



*Andrew K. Kercher*  
Operator

*01/26/06*  
Date

Data Report Form DRF-19: Counting of Particles with Missing OPyC Layer by Visual Inspection

Procedure:	AGR-CHAR-DAM-19 Rev. 1
Operator:	John Hunn
Sample ID:	LEU01-44T-C01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06011901_DRF19R1.xls

Mean average weight/particle (g):	7.33E-04
Uncertainty in average weight/particle (g):	6.69E-07
Weight of sample of particles (g):	11.462
Approximate number of particles in sample:	15637
Uncertainty in number of particles in sample:	14

Number of particles with missing OPyC layer:	0
--	---

Comments on unusual visual characteristics of OPyC

  
Operator

1-19-06

Date

**For Information Only**

The information in the remainder of this section reports results of measurements not required by the fuel specification and is provided for information only.

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Andrew K. Kercher
Particle Lot ID:	LEU01-44T-D01
Particle Lot Description:	Variant 1 TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06011301_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	1.09E-01	9.10E-02	1.02E-01	9.99E-02	8.88E-02
Number of particles:	148	124	140	136	121
Average weight/particle (g):	7.33E-04	7.34E-04	7.31E-04	7.35E-04	7.34E-04

Mean average weight/particle (g):	7.33E-04
Uncertainty in mean average weight/particle (g):	6.69E-07

*Andrew K. Kercher*

Operator

1-13-06

Date

Data Report Form DRF-20: Counting of Particles with SIC Gold Spot Defects by Visual Inspection

Procedure:	AGR-CHAR-DAM-20 Rev. 1
Operator:	John Hunn
Sample ID:	LEU01-44T-C01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\GoldSpots\G06012001_DRF20R1.xls

Mean average weight/particle (g):	7.33E-04
Uncertainty in average weight/particle (g):	6.69E-07
Weight of sample of particles (g):	11.462
Approximate number of particles in sample:	15637
Uncertainty in number of particles in sample:	14

Number of particles with gold spot defects:	13
---	----

Comments on unusual visual characteristics of SIC

Two particles had "shiny" surface.

  
Operator

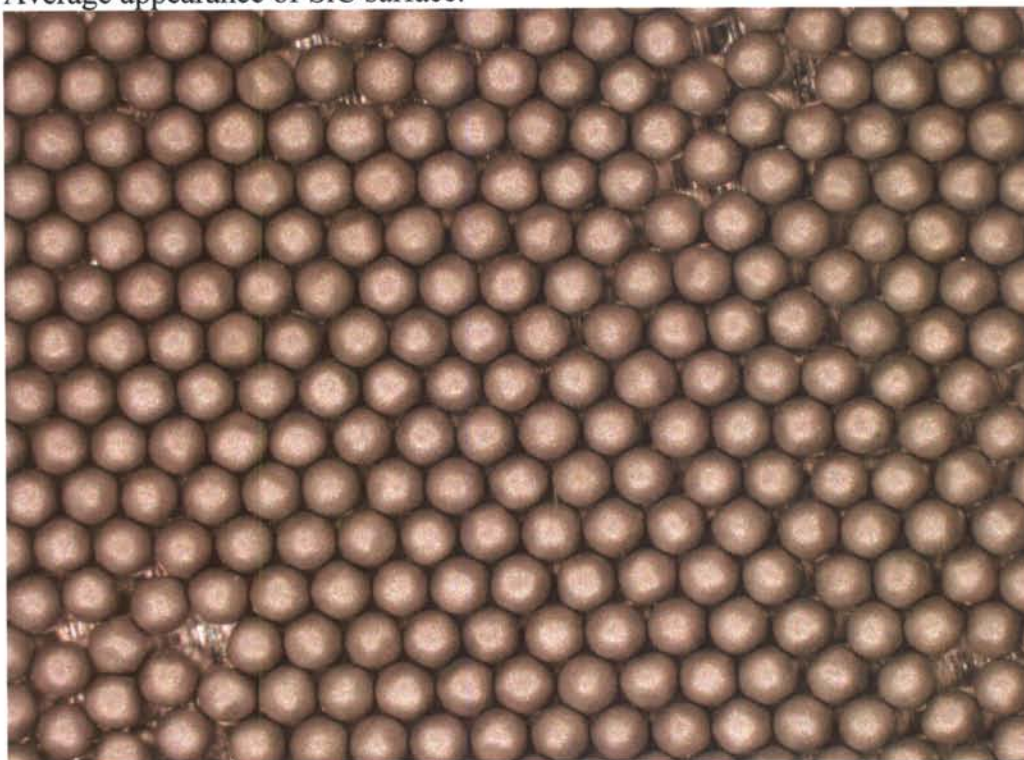
1-20-06  
Date



13/15637 gold spots found. Also 2 shiny particles (appearance caused by surface anomaly).



Average appearance of SiC surface.



Data Report Form DRF-23: Imaging of SiC Grain Structure

Procedure:	AGR-CHAR-DAM-23 Rev. 0
Operator:	Paul Menchhofer
Filename:	\\mc-agr\AGR\SEM\E06022303_DRF23R0.xls
Sample ID:	LEU01-44T-BO1
Sample Description:	LEU01-44T-BO1
Mount Number(s):	M06021401L
Folder name containing images:	\\mc-agr\AGR\SEM\

Images of SiC grain structure			
	particle 1	particle 2	particle 3
1000x image filename	58282	58285	58289
2500x image filename	58281	58283	58288
grain structure acceptable	yes	yes	yes

Comments

*PA Menchhofer*  
Operator

*2.23.06*  
Date

*John K...*  
QC Supervisor

*3-21-06*  
Date

*M.C.J.*  
QA Reviewer

*3/22/06*  
Date

ORNL/TM-2006/020, Rev. 1

119

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 5.6 58282

20  $\mu$ m

ORNL/TM-2006/020, Rev. 1

120

Acc.V Spot Magn  
10.0 kV 5.0 2500x

Det WD Exp  
BSE 5.6 58281

10  $\mu$ m

ORNL/TM-2006/020, Rev. 1

121

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 5.6 58285

20  $\mu$ m



ORNL/TM-2006/020, Rev. 1

122

Acc.V	Spot	Magn	Det	WD	Exp	10 μm
10.0 kV	5.0	2500x	BSE	5.6	58283	

ORNL/TM-2006/020, Rev. 1

123

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 5.5 58289

20  $\mu$ m

ORNL/TM-2006/020, Rev. 1

124

Acc.V	Spot	Magn	Det	WD	Exp	10 μm
10.0 kV	5.0	2500x	BSE	5.5	58288	

## **12 Characterization of third batch of TRISO-coated particles**

This section contains data on LEU01-29T, the third batch of TRISO-coated particles used for the LEU01-47T particle composite. The data was obtained according to product inspection plan AGR-CHAR-PIP-03R2.

Note that some of the carbon deposited for the buffer layer reacted with the kernel to form a uranium carbide layer between the kernel and the buffer. The uranium carbide layer was not included in the measurement of the buffer thickness. The thickness of this carbide layer varied, but was typically around 6  $\mu\text{m}$  thick and effectively increased the kernel radius by that amount.

The following pages show the inspection report form (IRF-03). Following IRF-03 are the individual data report forms for the measurements that were performed. Additional data at the end of this section is provided for information only. This batch was determined to satisfy the specifications in section 5.2 of EDF 4380, Rev. 6.

Inspection Report Form IRF-03: Coated Particle Batches

Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-29T
Coated particle batch description:	Variant 1: TRISO on BWXT kernel composite 69302

Property	Measured Data				Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	t value (t)					
Average buffer thickness for each particle (µm)	103.1	7.3	209	1.652	mean 100 ± 15	A = $x - ts/\sqrt{n} \geq 85$	102.3	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 115$	103.9	pass	DRF-11
Average IPyC thickness for each particle (µm)	40.4	2.4	229	1.652	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$	40.1	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 45$	40.7	pass	DRF-11
Average SiC thickness for each particle (µm)	36.6	0.9	230	1.652	mean 35 ± 4	A = $x - ts/\sqrt{n} \geq 31$	36.5	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 39$	36.7	pass	DRF-11
Average OPyC thickness for each particle (µm)	41.1	2.0	230	1.652	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$	40.9	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 45$	41.3	pass	DRF-11
Particles with missing OPyC			15565		defect fraction $\leq 6.0 \times 10^{-4}$	$\leq 4$ in 15,500	0	pass	DRF-19

Comments
Goldspot analysis performed on missing OPyC sample for information only. 15 out of 15565 gold spots observed.

  
 QC Supervisor

3-21-06  
 Date

Accept Coated particle batch (Yes or No):	Yes
---	-----

  
 QA Reviewer

3/22/06  
 Date



Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-29T-B01
Sample description:	Variant 1 TRISO on BWXT kernel composite 69302
Mount ID number:	M06012301L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06012501\P0601250101\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 $\mu\text{m}$ in stage micrometer image ( $\mu\text{m}$ ):	500.0

Polish-down distance n,m ( $\mu\text{m}$ )			
2,2	2,8	8,2	8,8
367	372	360	375

Approximate layer width in polish plane ( $\mu\text{m}$ )				
Kernel radius	Buffer	IPyC	SiC	OPyC
173	108	40	39	40

*Andrew K. Kercher*

Operator

*January 25, 2006*

Date

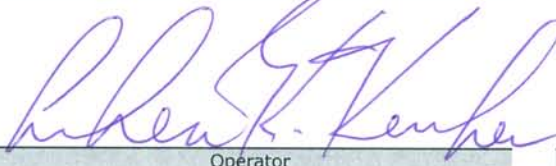
Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-29T-B01
Sample description:	Variant 1 TRISO on BWXT kernel composite 69302
Mount ID number:	M06012302L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06012501\P0601250102\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 $\mu\text{m}$ in stage micrometer image ( $\mu\text{m}$ ):	500.0

Polish-down distance n,m ( $\mu\text{m}$ )			
2,2	2,8	8,2	8,8
411	406	354	357

Approximate layer width in polish plane ( $\mu\text{m}$ )				
Kernel radius	Buffer	IPyC	SiC	OPyC
169	103	42	38	41

  
Operator

  
Date

Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-29T-B01
Sample description:	Variant 1 TRISO on BWXT kernel composite 69302
Mount ID number:	M06012303L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06012501\P0601250103\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 $\mu\text{m}$ in stage micrometer image ( $\mu\text{m}$ ):	500.0

Polish-down distance n,m ( $\mu\text{m}$ )			
2,2	2,8	8,2	8,8
369	366	356	351

Approximate layer width in polish plane ( $\mu\text{m}$ )				
Kernel radius	Buffer	IPyC	SiC	OPyC
175	104	39	38	43

  
Operator

January 25, 2006  
Date

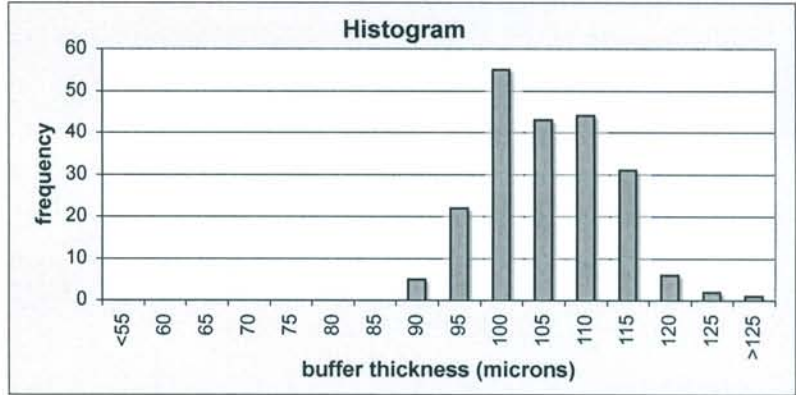
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012501\
Sample ID:	LEU01-29T-B01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012501_output\

Number of buffer layers analyzed:	209
Mean of the average buffer thickness of each particle (μm):	103.1
Standard deviation in the average buffer thickness of each particle (μm):	7.3

Distribution of the average buffer layer thickness (top binned)

Buffer Thickness (μm)	Frequency
<55	0
60	0
65	0
70	0
75	0
80	0
85	0
90	5
95	22
100	55
105	43
110	44
115	31
120	6
125	2
>125	1



*Andrew K. Kercher*

Operator

01/26/06

Date

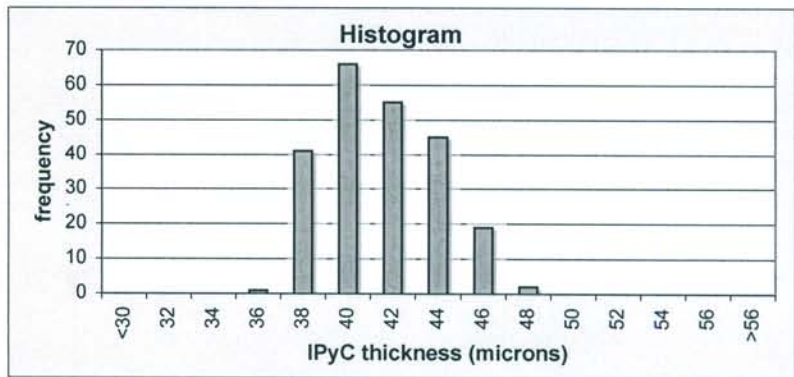
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012501\
Sample ID:	LEU01-29T-B01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012501_output\

Number of inner pyrocarbon layers analyzed:	229
Mean of the average IPyC thickness of each particle (μm):	40.4
Standard deviation in the average IPyC thickness of each particle (μm):	2.4

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	Frequency
<30	0
32	0
34	0
36	1
38	41
40	66
42	55
44	45
46	19
48	2
50	0
52	0
54	0
56	0
>56	0



*Andrew K. Kercher*  
Operator

01/26/06  
Date



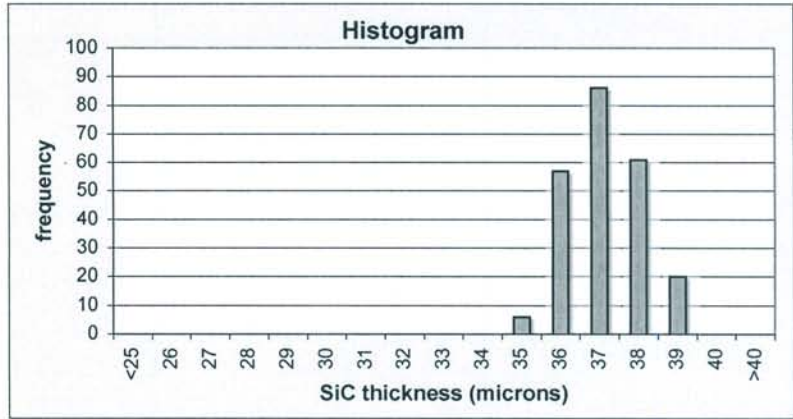
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012501\
Sample ID:	LEU01-29T-B01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012501_output\

Number of silicon carbide layers analyzed:	230
Mean of the average SiC thickness of each particle (μm):	36.6
Standard deviation in the average SiC thickness of each particle (μm):	0.9

Distribution of the average SiC layer thickness (top binned)

SiC Thickness (μm)	Frequency
<25	0
26	0
27	0
28	0
29	0
30	0
31	0
32	0
33	0
34	0
35	6
36	57
37	86
38	61
39	20
40	0
>40	0



*Andrew K. Kercher*  
Operator

*01/26/06*  
Date

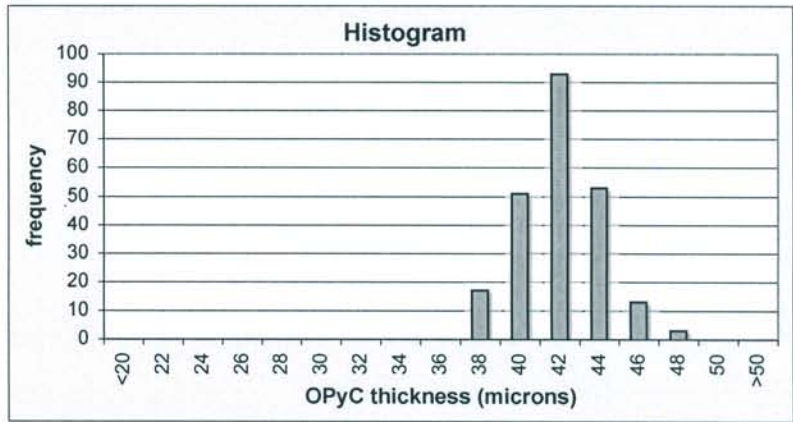
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder Name:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012501\
Sample ID:	LEU01-29T-B01
Sample Description:	Variant 1 TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012501_output\

Number of outer pyrocarbon layers analyzed:	230
Mean of the average OPyC thickness of each particle (μm):	41.1
Standard deviation in the average OPyC thickness of each particle (μm):	2.0

Distribution of the average OPyC layer thickness (top binned)

OPyC Thickness (μm)	Frequency
<20	0
22	0
24	0
26	0
28	0
30	0
32	0
34	0
36	0
38	17
40	51
42	93
44	53
46	13
48	3
50	0
>50	0



*Andrew K. Kercher*  
Operator

*01/26/06*  
Date

Data Report Form DRF-19: Counting of Particles with Missing OPyC Layer by Visual Inspection

Procedure:	AGR-CHAR-DAM-19 Rev. 1
Operator:	John Hunn
Sample ID:	LEU01-29T-C01
Sample Description:	Variant 1: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06012401_DRF19R1.xls

Mean average weight/particle (g):	7.35E-04
Uncertainty in average weight/particle (g):	1.28E-06
Weight of sample of particles (g):	11.440
Approximate number of particles in sample:	15565
Uncertainty in number of particles in sample:	27

Number of particles with missing OPyC layer:	0
--	---

Comments on unusual visual characteristics of OPyC

*John Hunn*

Operator

1-24-06

Date

**For Information Only**

The information in the remainder of this section reports results of measurements not required by the fuel specification and is provided for information only.

Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-29T-D01
Particle Lot Description:	Variant 1 TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06012301__DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	1.04E-01	8.46E-02	8.90E-02	9.22E-02	8.74E-02
Number of particles:	141	115	121	126	119
Average weight/particle (g):	7.40E-04	7.36E-04	7.36E-04	7.32E-04	7.34E-04

Mean average weight/particle (g):	7.35E-04
Uncertainty in mean average weight/particle (g):	1.28E-06

*Dixie Barker*  
Operator

1-23-06  
Date



Data Report Form DRF-20: Counting of Particles with SIC Gold Spot Defects by Visual Inspection

Procedure:	AGR-CHAR-DAM-20 Rev. 1
Operator:	John Hunn
Sample ID:	LEU01-29T-C01
Sample Description:	Variant 1: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\GoldSpots\G06012401_DRF20R1.xls

Mean average weight/particle (g):	7.35E-04
Uncertainty in average weight/particle (g):	1.28E-06
Weight of sample of particles (g):	11.440
Approximate number of particles in sample:	15565
Uncertainty in number of particles in sample:	27

Number of particles with gold spot defects:	15
---	----

Comments on unusual visual characteristics of SIC

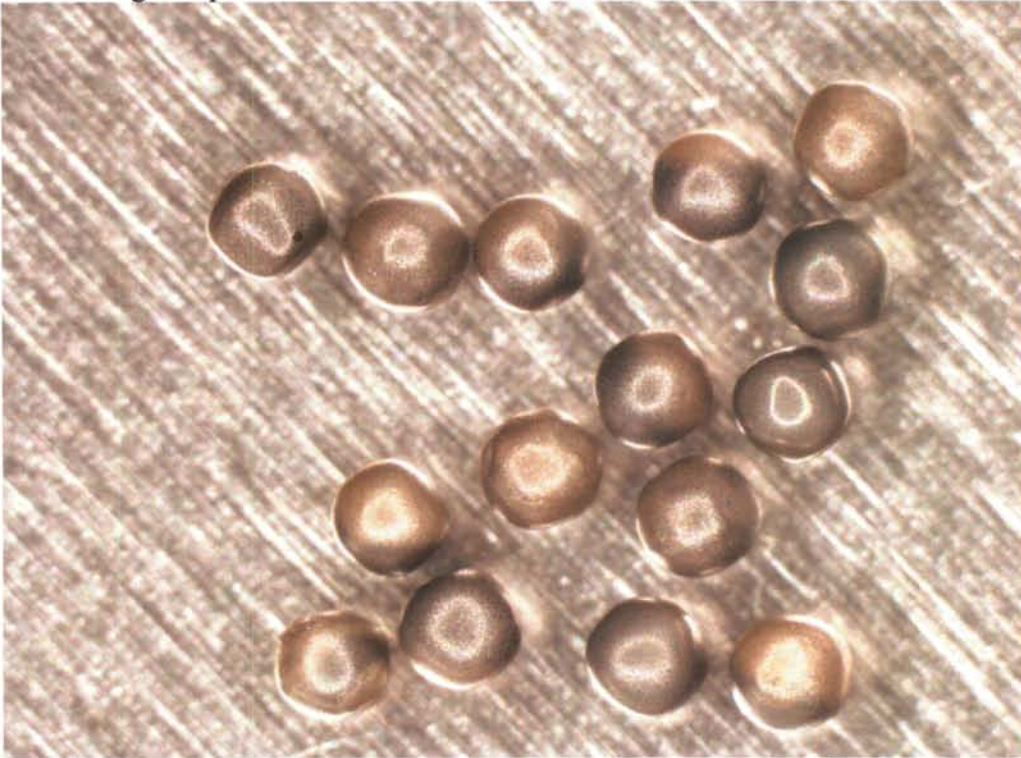
--

*John Hunn*  
Operator

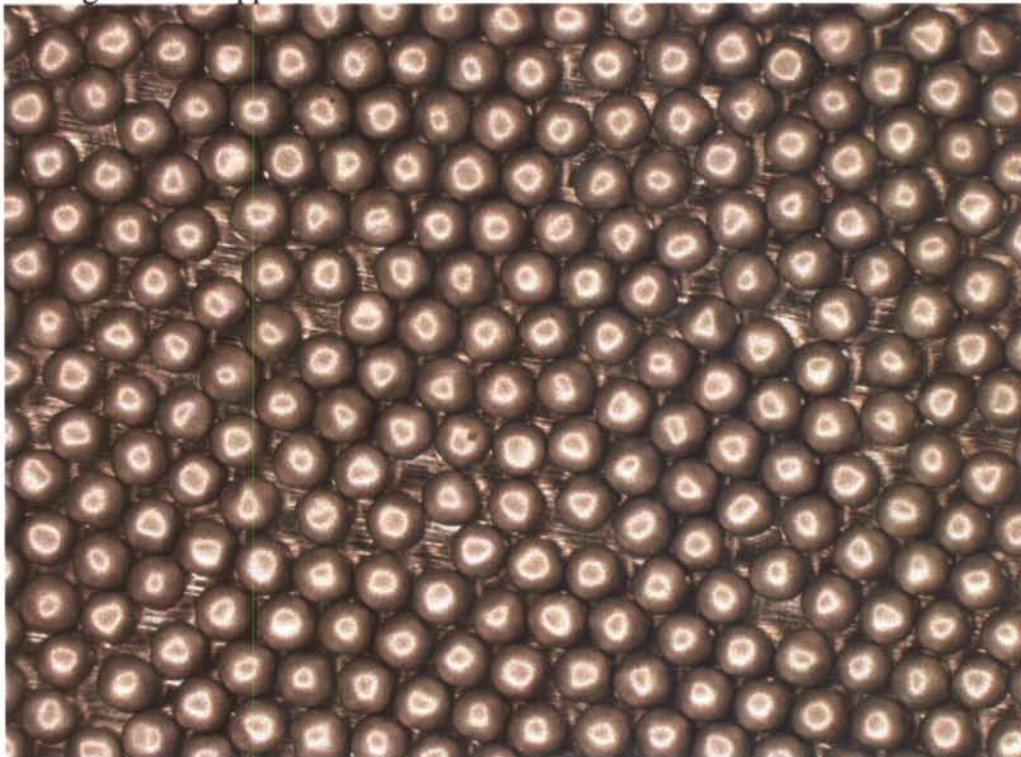
1-24-06

Date

15/15565 gold spots found.



Average surface appearance.



Data Report Form DRF-23: Imaging of SiC Grain Structure

Procedure:	AGR-CHAR-DAM-23 Rev. 0
Operator:	Paul Menchhofer
Filename:	\\mc-agr\AGR\SEM\E06022302_DRF23R0.xls
Sample ID:	LEU01-29T-BO1
Sample Description:	LEU01-29T-BO1
Mount Number(s):	M06021302L
Folder name containing images:	\\mc-agr\AGR\SEM\

Images of SiC grain structure			
	particle 1	particle 2	particle 3
1000x image filename	58276	58278	58280
2500x image filename	58275	58277	58279
grain structure acceptable	yes	yes	yes

Comments

*PA Menchhofer*  
Operator

*2-23-06*  
Date

*John [Signature]*  
QC Supervisor

*3-21-06*  
Date

*M.C.P.*  
QA Reviewer

*3/22/06*  
Date

ORNL/TM-2006/020, Rev. 1

140

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 5.8 58276

20  $\mu$ m



ORNL/TM-2006/020, Rev. 1

141

Acc.V	Spot	Magn	Det	WD	Exp	10 μm
10.0 kV	5.0	2500x	BSE	5.8	58275	



ORNL/TM-2006/020, Rev. 1

142

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 5.8 58278

20  $\mu$ m

ORNL/TM-2006/020, Rev. 1

143

Acc.V Spot Magn  
10.0 kV 5.0 2500x

Det WD Exp  
BSE 5.8 58277

10  $\mu$ m

ORNL/TM-2006/020, Rev. 1

144

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 5.8 58280

20  $\mu$ m

ORNL/TM-2006/020, Rev. 1

145

Acc.V

Spot

Magn

Det

WD

Exp

10.0 kV

5.0

2500x

BSE

5.8

58279

10  $\mu$ m

### **13 Characterization of TRISO-coated particle composite**

This section contains data on the TRISO-coated particle composite, LEU01-47T. The data was obtained according to product inspection plan AGR-CHAR-PIP-04R2.

Note that some of the carbon deposited for the buffer layer reacted with the kernel to form a uranium carbide layer between the kernel and the buffer. The uranium carbide layer was not included in the measurement of the buffer thickness. The thickness of this carbide layer varied, but was typically around 6  $\mu\text{m}$  thick and effectively increased the kernel radius by that amount.

The following pages shows the inspection report forms (IRF-04A and IRF-04B) for the LEU01-47T composite. Following IRF-04A and IRF-04B are the individual data report forms for the measurements that were performed. Additional data at the end of this section is provided for information only. This composite was determined to satisfy the specifications in section 5.3 of EDF 4380, Rev. 6.



Inspection Report Form IRF-04A: Coated Particle Composites

Procedure:	AGR-CHAR-PIP-04 Rev. 2
Coated particle composite ID:	LEU01-47T
Coated particle composite description:	Variant 1: TRISO on BWXT kernel composite 69302

Property	Measured Data			k or t value	Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)						
Average buffer thickness for each particle (µm)	102.5	7.1	177	1.654	mean 100 ± 15	A = x - ts/√n ≥ 85	101.6	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 115	103.4	pass	
				2.584	dispersion ≤0.01 ≤ 55	C = x - ks > 55	84.2	pass	
Average IPyC thickness for each particle (µm)	40.5	2.4	232	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36	40.2	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 44	40.8	pass	
				2.549	dispersion ≤0.01 ≤ 30 ≤0.01 ≥ 56	C = x - ks > 30	34.4	pass	
						D = x + ks < 56	46.6	pass	
Average SiC thickness for each particle (µm)	35.7	1.2	233	1.651	mean 35 ± 3	A = x - ts/√n ≥ 32	35.6	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 38	35.8	pass	
				2.549	dispersion ≤0.01 ≤ 25	C = x - ks > 25	32.6	pass	
Average OPyC thickness for each particle (µm)	41.1	2.4	233	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36	40.8	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 44	41.4	pass	
				2.549	dispersion ≤0.01 ≤ 20	C = x - ks > 20	35.0	pass	
Buffer envelope density	See IRF-02A							pass	IRF-02A
IPyC sink/float density	See IRF-02B							Note 1	IRF-02B
SiC sink/float density (Mg/m³)	3.2060	0.0021	42	1.683	mean ≥ 3.19	A = x - ts/√n ≥ 3.19	3.205	pass	DRF-02
						C = x - ks > 3.17	3.200	pass	
				2.913	dispersion ≤0.01 ≤ 3.17				
OPyC sink/float density	See IRF-04B							pass	IRF-04B
IPyC anisotropy (BAFo equivalent)	1.0140	0.0014	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.015	pass	DRF-18
				3.981	dispersion ≤0.01 ≥ 1.06	D = x + ks < 1.06	1.020	pass	
OPyC anisotropy (BAFo equivalent)	1.0132	0.0017	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.014	pass	DRF-18
				3.981	dispersion ≤0.01 ≥ 1.06	D = x + ks < 1.06	1.020	pass	
Particles with SiC gold spot defects			22461		defect fraction ≤ 1.0 × 10 <sup>-3</sup>	≤ 6 in 12,000 or ≤ 14 in 22,000	11	pass	DRF-20
Particle aspect ratio			1808		dispersion ≤0.01 ≥ 1.14	≤ 1 in 500 or ≤ 7 in 1420	0	pass	DRF-07 DRF-10
Particles with SiC burn-leach defects			121117		defect fraction ≤ 1.0 × 10 <sup>-4</sup>	≤ 1 in 50,000 or ≤ 6 in 120,000	1	pass	DRF-21
Particles with missing OPyC			31191		defect fraction ≤ 3.0 × 10 <sup>-4</sup>	≤ 4 in 31,000	0	pass	DRF-19
SiC microstructure			3		comparison to visual standard	all imaged pass visual standard comparison	3	pass	DRF-23

**Comments**  
 Note 1: Variant 1 is designed to have a density around 1.85 g/cc and is not required to meet the IPyC density specification.

  
 QC Supervisor

3-21-06  
 Date

Accept coated particle composite (Yes or No):

  
 QA Reviewer

3/22/06  
 Date

Inspection Report Form IRF-04B: Outer Pyrocarbon Density

<b>Procedure:</b>	AGR-CHAR-PIP-04 Rev. 2
<b>Coated particle composite ID:</b>	LEU01-47T
<b>Coated particle composite description:</b>	Variation 1: TRISO on BWXT kernel composite 69302
<b>Batch 1 ID:</b>	LEU01-43T
<b>Batch 1 description:</b>	Variation 1: TRISO on BWXT kernel composite 69302
<b>Batch 2 ID:</b>	LEU01-44T
<b>Batch 2 description:</b>	Variation 1: TRISO on BWXT kernel composite 69302
<b>Batch 3 ID:</b>	LEU01-29T
<b>Batch 3 description:</b>	Variation 1: TRISO on BWXT kernel composite 69302

Property	Measured Data			k or t value	Specification INL EDF-4380 Rev. 6	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records	
	Mean (x)	Std. Dev. (s)	# measured (n)							
Batch 1: OPyC sink/float density (Mg/m <sup>3</sup> )	1.9012	0.0077	51	1.676	mean 1.90 ± 0.05	A = $x - ts/\sqrt{n} \geq 1.85$	1.899	pass	DRF-03	
							B = $x + ts/\sqrt{n} \leq 1.95$	1.903		pass
				2.848	dispersion $\leq 0.01 \leq 1.80$ $\leq 0.01 \geq 2.00$	C = $x - ks > 1.80$	1.879	pass		
						D = $x + ks < 2.00$	1.923	pass		
Batch 2: OPyC sink/float density (Mg/m <sup>3</sup> )	1.8815	0.0111	54	1.674	mean 1.90 ± 0.05	A = $x - ts/\sqrt{n} \geq 1.85$	1.879	pass	DRF-03	
						B = $x + ts/\sqrt{n} \leq 1.95$	1.884	pass		
				2.831	dispersion $\leq 0.01 \leq 1.80$ $\leq 0.01 \geq 2.00$	C = $x - ks > 1.80$	1.850	pass		
						D = $x + ks < 2.00$	1.913	pass		
Batch 3: OPyC sink/float density (Mg/m <sup>3</sup> )	1.9085	0.0085	45	1.680	mean 1.90 ± 0.05	A = $x - ts/\sqrt{n} \geq 1.85$	1.906	pass	DRF-03	
						B = $x + ts/\sqrt{n} \leq 1.95$	1.911	pass		
				2.897	dispersion $\leq 0.01 \leq 1.80$ $\leq 0.01 \geq 2.00$	C = $x - ks > 1.80$	1.884	pass		
						D = $x + ks < 2.00$	1.933	pass		

**Comments**

---

  
 QC Supervisor

3-21-06  
 Date

Accept composite for OPyC density (Yes or No): Yes

  
 QA Reviewer

3/22/06  
 Date


Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-47T-B01
Sample description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Mount ID number:	M06020101L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06020901\P0602090101\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 µm in stage micrometer image (µm):	500.0

Polish-down distance n,m (µm)			
2,2	2,8	8,2	8,8
360	369	359	370

Approximate layer width in polish plane (µm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
177	101	38	37	39

  
Operator

02/09/06  
Date



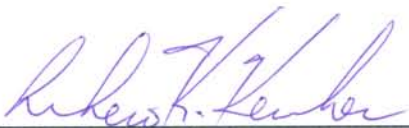
Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-47T-B01
Sample description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Mount ID number:	M06020102L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06020901\P0602090102\

DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 $\mu\text{m}$ in stage micrometer image ( $\mu\text{m}$ ):	500.0

Polish-down distance n,m ( $\mu\text{m}$ )			
2,2	2,8	8,2	8,8
377	372	389	381

Approximate layer width in polish plane ( $\mu\text{m}$ )				
Kernel radius	Buffer	IPyC	SiC	OPyC
180	102	39	36	40

  
Operator

02/09/06  
Date

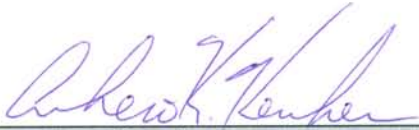
Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-47T-B01
Sample description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Mount ID number:	M06020103L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06020901\P0602090103\

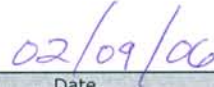
DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 µm in stage micrometer image (µm):	500.0

Polish-down distance n,m (µm)			
2,2	2,8	8,2	8,8
376	362	373	357

Approximate layer width in polish plane (µm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
178	104	37	37	40



Operator



Date



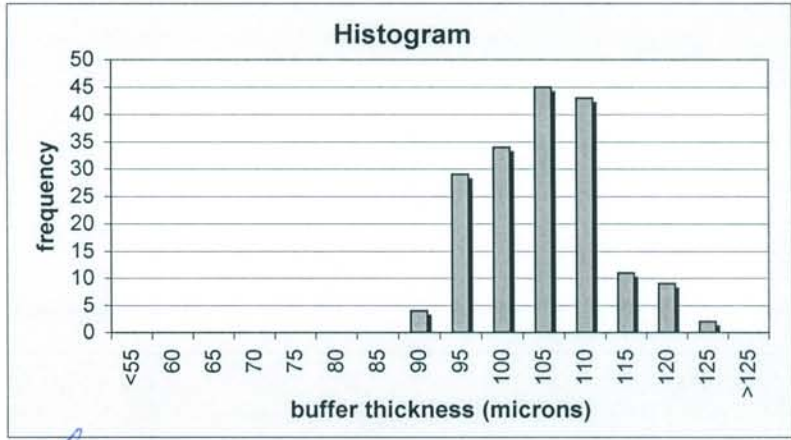
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020901\
Sample ID:	LEU01-47T-B01
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020901_output\

Number of buffer layers analyzed:	177
Mean of the average buffer thickness of each particle ( $\mu\text{m}$ ):	102.5
Standard deviation in the average buffer thickness of each particle ( $\mu\text{m}$ ):	7.1

Distribution of the average buffer layer thickness (top binned)

Buffer Thickness ( $\mu\text{m}$ )	Frequency
<55	0
60	0
65	0
70	0
75	0
80	0
85	0
90	4
95	29
100	34
105	45
110	43
115	11
120	9
125	2
>125	0



*Andrew K. Kercher*  
Operator

February 21, 2006  
Date

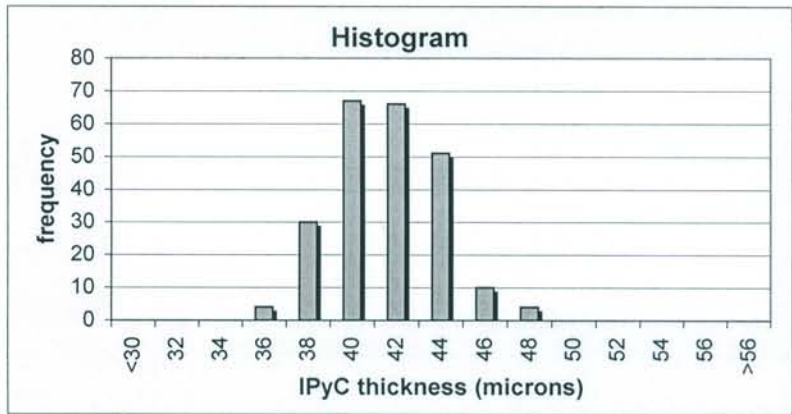
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020901\
Sample ID:	LEU01-47T-B01
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020901_output\

Number of inner pyrocarbon layers analyzed:	232
Mean of the average IPyC thickness of each particle ( $\mu\text{m}$ ):	40.5
Standard deviation in the average IPyC thickness of each particle ( $\mu\text{m}$ ):	2.4

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness ( $\mu\text{m}$ )	Frequency
<30	0
32	0
34	0
36	4
38	30
40	67
42	66
44	51
46	10
48	4
50	0
52	0
54	0
56	0
>56	0



*Andrew K. Kercher*  
Operator

*February 21, 2006*  
Date

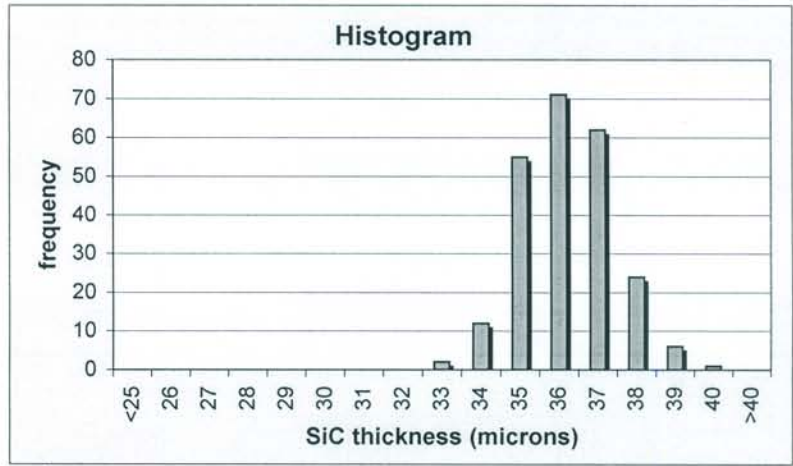
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020901\
Sample ID:	LEU01-47T-B01
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020901_output\

Number of silicon carbide layers analyzed:	233
Mean of the average SiC thickness of each particle (μm):	35.7
Standard deviation in the average SiC thickness of each particle (μm):	1.2

Distribution of the average SiC layer thickness (top binned)

SiC Thickness (μm)	Frequency
<25	0
26	0
27	0
28	0
29	0
30	0
31	0
32	0
33	2
34	12
35	55
36	71
37	62
38	24
39	6
40	1
>40	0



*Andrew K. Kercher*  
Operator

*February 21, 2006*  
Date

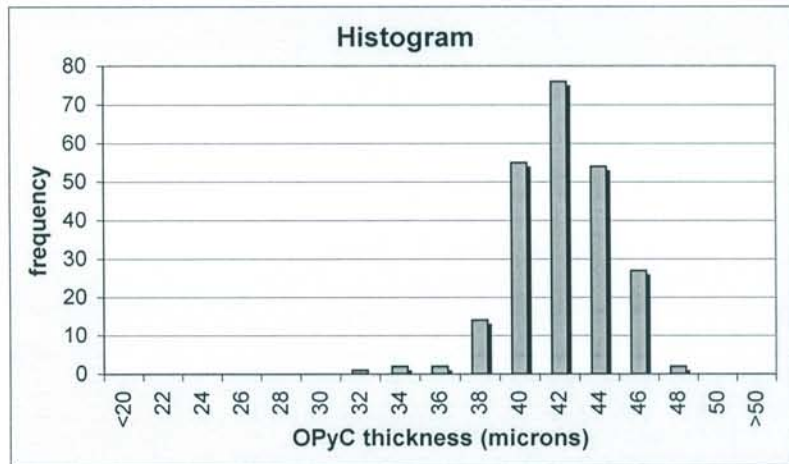
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020901\
Sample ID:	LEU01-47T-B01
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020901_output\

Number of outer pyrocarbon layers analyzed:	233
Mean of the average OPyC thickness of each particle ( $\mu\text{m}$ ):	41.1
Standard deviation in the average OPyC thickness of each particle ( $\mu\text{m}$ ):	2.4

Distribution of the average OPyC layer thickness (top binned)

OPyC Thickness ( $\mu\text{m}$ )	Frequency
<20	0
22	0
24	0
26	0
28	0
30	0
32	1
34	2
36	2
38	14
40	55
42	76
44	54
46	27
48	2
50	0
>50	0



*Andrew K. Kercher*  
Operator

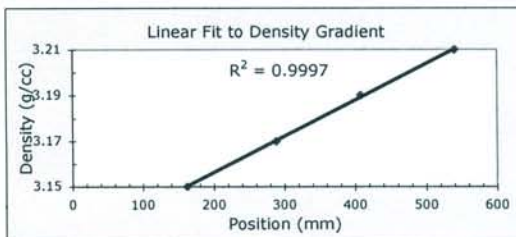
*February 21, 2006*  
Date



Data Report Form DRF-02: Measurement of SIC Density using a Density Gradient Column

Procedure:	AGR-CHAR-DAM-02 Rev. 3
Operator:	Dixie Barker
Filename:	\\vmc-agr\AGR\DensityColumn\D06020301_DRF02R3.xls
Sample ID:	LEU01-47T-E01
Sample description:	Variant 1: Triso on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	23.2 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
3.150	148.71	169.54	162.60
3.170	271.92	295.73	287.79
3.190	392.97	415.24	407.82
3.210	523.71	548.02	539.92



Linear Fit			
slope	StDev	intercept	StDev
1.60E-04	2.88E-06	3.12E+00	1.03E-03

Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	487.50	3.2020	26	515.11	3.2064	51		
2	488.33	3.2022	27	516.87	3.2067	52		
3	493.75	3.2030	28	517.84	3.2069	53		
4	494.89	3.2032	29	518.62	3.2070	54		
5	497.37	3.2036	30	519.28	3.2071	55		
6	495.88	3.2034	31	520.08	3.2072	56		
7	499.57	3.2040	32	522.67	3.2076	57		
8	499.57	3.2040	33	524.06	3.2079	58		
9	500.61	3.2041	34	524.69	3.2080	59		
10	501.89	3.2043	35	524.78	3.2080	60		
11	501.89	3.2043	36	527.39	3.2084	61		
12	501.89	3.2043	37	527.77	3.2085	62		
13	502.63	3.2044	38	534.50	3.2095	63		
14	503.46	3.2046	39	534.50	3.2095	64		
15	504.56	3.2048	40	534.50	3.2095	65		
16	506.85	3.2051	41	536.15	3.2098	66		
17	507.95	3.2053	42	537.58	3.2100	67		
18	508.69	3.2054	43			68		
19	509.75	3.2056	44			69		
20	510.48	3.2057	45			70		
21	510.94	3.2058	46			71		
22	512.63	3.2060	47			72		
23	512.63	3.2060	48			73		
24	512.63	3.2060	49			74		
25	513.64	3.2062	50			75		
Average density of SIC fragments:						3.2060		
Standard deviation in density of SIC fragments:						0.0021		
Uncertainty in calculated density of SIC fragments:						0.0019		

*Dixie Barker*  
Operator

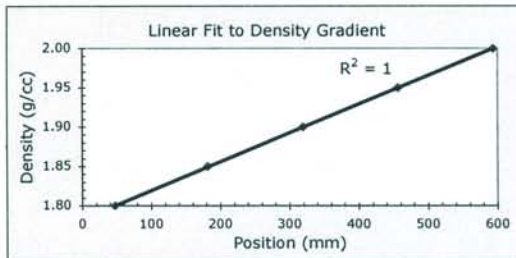
2-03-06  
Date



Data Report Form DRF-03: Measurement of PyC Density using a Density Gradient Column

Procedure:	AGR-CHAR-DAM-03 Rev. 2
Operator:	Dixie Barker
Filename:	\\vmc-agr\AGR\DensityColumn\D05122701_DRF03R2.xls
Sample ID:	LEU01-43T-E01
Sample description:	OPyC from Variant 1: TRISO on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	24.3 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	42.21	51.56	46.89
1.850	177.40	185.95	181.68
1.900	317.04	322.77	319.91
1.950	453.04	459.86	456.45
2.000	590.31	597.59	593.95



Linear Fit			
slope	StDev	Intercept	StDev
3.65E-04	1.83E-06	1.78E+00	5.91E-04

Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	269.61	1.8817	26	326.19	1.9023	51	365.00	1.9165
2	285.01	1.8873	27	326.19	1.9023	52		
3	288.36	1.8885	28	323.95	1.9015	53		
4	292.60	1.8901	29	324.54	1.9017	54		
5	293.42	1.8904	30	327.75	1.9029	55		
6	296.70	1.8916	31	328.26	1.9031	56		
7	297.48	1.8919	32	329.19	1.9034	57		
8	299.16	1.8925	33	330.65	1.9040	58		
9	300.67	1.8930	34	330.65	1.9040	59		
10	301.44	1.8933	35	332.49	1.9046	60		
11	303.13	1.8939	36	334.48	1.9054	61		
12	306.62	1.8952	37	336.09	1.9060	62		
13	307.01	1.8953	38	336.87	1.9062	63		
14	309.88	1.8964	39	337.72	1.9066	64		
15	311.74	1.8971	40	337.73	1.9066	65		
16	314.26	1.8980	41	339.53	1.9072	66		
17	315.22	1.8983	42	340.23	1.9075	67		
18	316.79	1.8989	43	344.16	1.9089	68		
19	316.79	1.8989	44	349.64	1.9109	69		
20	317.58	1.8992	45	351.99	1.9118	70		
21	320.49	1.9003	46	351.99	1.9118	71		
22	321.49	1.9006	47	353.43	1.9123	72		
23	323.36	1.9013	48	355.60	1.9131	73		
24	323.98	1.9015	49	354.25	1.9126	74		
25	325.16	1.9020	50	355.36	1.9130	75		
Average density of PyC fragments:					1.9012			
Standard deviation in density of PyC fragments:					0.0077			
Uncertainty in calculated density of PyC fragments:					0.0009			

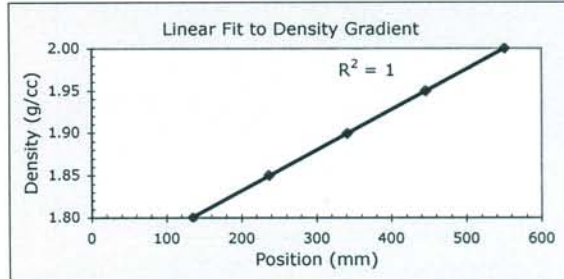
*Dixie Barker*  
Operator

*12-20-05*  
Date

Data Report Form DRF-03: Measurement of PyC Density using a Density Gradient Column

Procedure:	AGR-CHAR-DAM-03 Rev. 2
Operator:	Dixie Barker
Filename:	\\mc-agr\AGR\DensityColumn\D06011701_DRF03R2.xls
Sample ID:	LEU01-44T-E01
Sample description:	OPyC from Variant 1: TRISO on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	23.8 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	130.42	139.77	135.10
1.850	232.88	241.20	237.04
1.900	339.13	344.61	341.87
1.950	442.45	450.20	446.33
2.000	547.93	555.20	551.57



Linear Fit			
slope	StDev	intercept	StDev
4.80E-04	2.89E-06	1.74E+00	9.97E-04

Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	261.55	1.8612	26	300.76	1.8800	51	346.82	1.9021
2	269.90	1.8652	27	302.38	1.8808	52	352.43	1.9048
3	272.68	1.8666	28	302.89	1.8811	53	356.45	1.9067
4	261.99	1.8614	29	303.97	1.8816	54	359.18	1.9081
5	266.69	1.8637	30	303.68	1.8814	55		
6	271.37	1.8659	31	303.68	1.8814	56		
7	280.35	1.8702	32	305.82	1.8825	57		
8	281.48	1.8708	33	306.42	1.8827	58		
9	281.97	1.8710	34	307.21	1.8831	59		
10	282.45	1.8712	35	308.04	1.8835	60		
11	285.05	1.8725	36	308.82	1.8839	61		
12	286.30	1.8731	37	309.54	1.8842	62		
13	287.82	1.8738	38	312.26	1.8855	63		
14	288.86	1.8743	39	312.26	1.8855	64		
15	289.40	1.8746	40	313.99	1.8864	65		
16	291.89	1.8758	41	318.59	1.8886	66		
17	292.89	1.8763	42	319.73	1.8891	67		
18	292.89	1.8763	43	320.68	1.8896	68		
19	294.11	1.8768	44	322.83	1.8906	69		
20	294.64	1.8771	45	324.26	1.8913	70		
21	296.09	1.8778	46	324.26	1.8913	71		
22	291.74	1.8757	47	326.44	1.8924	72		
23	298.60	1.8790	48	328.56	1.8934	73		
24	299.13	1.8793	49	341.26	1.8995	74		
25	300.76	1.8800	50	342.12	1.8999	75		
Average density of PyC fragments:					1.8815			
Standard deviation in density of PyC fragments:					0.0111			
Uncertainty in calculated density of PyC fragments:					0.0014			

*Dixie Barker*  
Operator

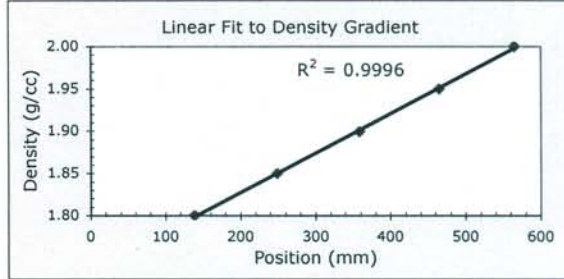
1-17-06  
Date



Data Report Form DRF-03: Measurement of PyC Density using a Density Gradient Column

Procedure:	AGR-CHAR-DAM-03 Rev. 2
Operator:	Dixie Barker
Filename:	\\mc-agr\AGR\DensityColumn\D06012301_DRF03R2.xls
Sample ID:	LEU01-29T-E01
Sample description:	OPyC from Variant 1: TRISO on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	22.6 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	134.23	143.47	138.85
1.850	244.74	253.37	249.06
1.900	356.07	361.94	359.01
1.950	461.04	468.47	464.76
2.000	560.89	568.22	564.56



Linear Fit			
slope	StDev	intercept	StDev
4.68E-04	2.80E-06	1.73E+00	1.09E-03

Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	320.13	1.8836	26	377.86	1.9106	51		
2	331.07	1.8887	27	378.71	1.9110	52		
3	342.16	1.8939	28	379.21	1.9112	53		
4	342.16	1.8939	29	381.50	1.9123	54		
5	351.97	1.8985	30	382.09	1.9126	55		
6	354.39	1.8996	31	382.09	1.9126	56		
7	360.09	1.9023	32	382.46	1.9127	57		
8	361.94	1.9031	33	384.28	1.9136	58		
9	361.94	1.9031	34	384.28	1.9136	59		
10	362.49	1.9034	35	385.41	1.9141	60		
11	362.97	1.9036	36	386.42	1.9146	61		
12	364.33	1.9043	37	388.50	1.9156	62		
13	365.23	1.9047	38	389.50	1.9160	63		
14	366.60	1.9053	39	390.41	1.9165	64		
15	366.86	1.9054	40	391.54	1.9170	65		
16	367.28	1.9056	41	392.63	1.9175	66		
17	367.80	1.9059	42	398.53	1.9203	67		
18	368.55	1.9062	43	399.97	1.9209	68		
19	369.16	1.9065	44	402.08	1.9219	69		
20	371.55	1.9076	45	410.35	1.9258	70		
21	372.60	1.9081	46			71		
22	373.06	1.9083	47			72		
23	375.67	1.9096	48			73		
24	376.54	1.9100	49			74		
25	377.31	1.9103	50			75		
Average density of PyC fragments:					1.9085			
Standard deviation in density of PyC fragments:					0.0085			
Uncertainty in calculated density of PyC fragments:					0.0016			

*Dixie Barker*  
Operator

1-23-06  
Date

Data Report Form DRF-18A: Measurement of Pyrocarbon Anisotropy using the 2-MGEM - IPyC

Procedure:	AGR-CHAR-DAM-18 Rev. 1
Operator:	G. E. Jellison
Mount ID:	M06020701L
Sample ID:	LEU01-47T-B01
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Folder containing data:	\\mc-agr\AGR\2-MGEM\R06030101\

Particle #	Grid Position	Diattenuation			Equivalent BAFO		
		Average	St. Dev.	Ave. Error	Average	St. Dev.	Ave. Error
1	4,4	0.0046	0.0014	0.0015	1.0138	0.0042	0.0045
2	4,5	0.0048	0.0012	0.0013	1.0144	0.0036	0.0039
3	4,6	0.0046	0.0013	0.0011	1.0138	0.0039	0.0033
4	5,4	0.0051	0.0011	0.0011	1.0153	0.0033	0.0033
5	5,5	0.0048	0.0012	0.0012	1.0144	0.0036	0.0036
6	5,6	0.0049	0.0015	0.0013	1.0147	0.0045	0.0039
7	6,4	0.0042	0.0013	0.0014	1.0126	0.0039	0.0042
8	6,5	0.0039	0.0011	0.0013	1.0117	0.0033	0.0039
9	6,6	0.0044	0.0011	0.0013	1.0132	0.0033	0.0039
10	5,7	0.0055	0.0014	0.0014	1.0165	0.0042	0.0042
Average		0.0047	0.0013	0.0013	1.0140	0.0038	0.0039

Mean of average BAFO per particle:	1.0140
Standard deviation of average BAFO per particle:	0.0014

Comments

*G. E. Jellison*

Operator

3/1/06

Date



Data Report Form DRF-18B: Measurement of Pyrocarbon Anisotropy using the 2-MGEM - OPyC

Procedure:	AGR-CHAR-DAM-18 Rev. 1
Operator:	G. E. Jellison
Mount ID:	M06020701L
Sample ID:	LEU01-47T-B01
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Folder containing data:	\\mc-agr\AGR\2-MGEM\R06030101\

Particle #	Grid Position	Diattenuation			Equivalent BAFO		
		Average	St. Dev.	Ave. Error	Average	St. Dev.	Ave. Error
1	4,4	0.0035	0.0017	0.0020	1.0105	0.0051	0.0060
2	4,5	0.0048	0.0021	0.0017	1.0144	0.0063	0.0051
3	4,6	0.0041	0.0018	0.0017	1.0123	0.0054	0.0051
4	5,4	0.0043	0.0019	0.0017	1.0129	0.0057	0.0051
5	5,5	0.0042	0.0017	0.0019	1.0126	0.0051	0.0057
6	5,6	0.0051	0.0016	0.0016	1.0153	0.0048	0.0048
7	6,4	0.0044	0.0019	0.0024	1.0132	0.0057	0.0072
8	6,5	0.0038	0.0016	0.0018	1.0114	0.0048	0.0054
9	6,6	0.0054	0.0016	0.0018	1.0162	0.0048	0.0054
10	5,7	0.0043	0.0018	0.0017	1.0129	0.0054	0.0051
Average		0.0044	0.0018	0.0018	1.0132	0.0053	0.0055

Mean of average BAFO per particle:	1.0132
Standard deviation of average BAFO per particle:	0.0017

Comments

*A. E. Jellison*  
Operator

3/1/06  
Date



Data Report Form DRF-20: Counting of Particles with SiC Gold Spot Defects by Visual Inspection

Procedure:	AGR-CHAR-DAM-20 Rev. 1
Operator:	John Hunn
Sample ID:	LEU01-47T-D02
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\GoldSpots\G06030101_DRF20R1.xls

Mean average weight/particle (g):	7.33E-04
Uncertainty in average weight/particle (g):	1.52E-06
Weight of sample of particles (g):	8.964
Approximate number of particles in sample:	12230
Uncertainty in number of particles in sample:	25

Number of particles with gold spot defects:	8
---	---

Comments on unusual visual characteristics of SiC

  
Operator

3-1-06

Date

Data Report Form DRF-20: Counting of Particles with SiC Gold Spot Defects by Visual Inspection

Procedure:	AGR-CHAR-DAM-20 Rev. 1
Operator:	John Hunn
Sample ID:	LEU01-47T-D03
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\GoldSpots\G06030102_DRF20R1.xls

Mean average weight/particle (g):	7.33E-04
Uncertainty in average weight/particle (g):	1.52E-06
Weight of sample of particles (g):	7.499
Approximate number of particles in sample:	10231
Uncertainty in number of particles in sample:	21

Number of particles with gold spot defects:	3
---	---

Comments on unusual visual characteristics of SiC

  
Operator

3-1-06

Date

Data Report Form DRF-07: Imaging of Particle Diameter and Aspect Ratio Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-07 Rev. 1
Operator:	Andrew K. Kercher
Sample ID:	LEU01-47T-C01
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06022301\

DMR Calibration Expiration Date:	9/8/2006
Stage Micrometer Calibration Expiration Date:	2/17/2007
Measured Value for 1200 $\mu\text{m}$ in Stage Micrometer Image:	1200. $\mu\text{m}$


February 23, 2006  
Date

Operator

Date

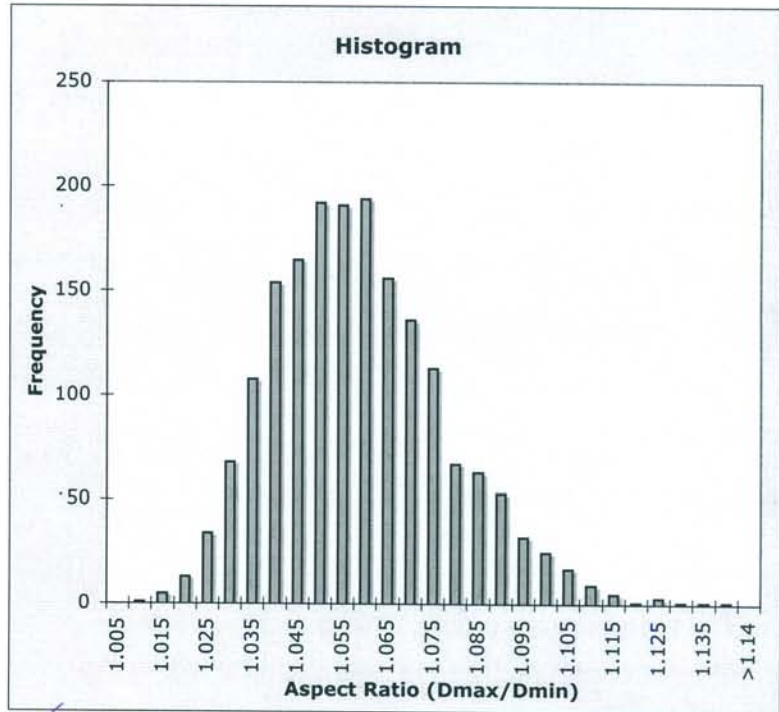
Data Report Form DRF-10B: Measurement of Particle Aspect Ratio (Dmax/Dmin)

Procedure:	AGR-CHAR-DAM-10 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06022301\
Sample ID:	LEU01-47T-C01
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06022301_output\

Number of particles analyzed:	1808
Number of particles with aspect ratio $\geq 1.14$ :	0
Average particle aspect ratio:	1.056

Distribution of the aspect ratio (top binned)

Aspect Ratio (D)	Frequency
1.005	0
1.010	1
1.015	5
1.020	13
1.025	34
1.030	68
1.035	108
1.040	154
1.045	165
1.050	192
1.055	191
1.060	194
1.065	156
1.070	136
1.075	113
1.080	67
1.085	63
1.090	53
1.095	32
1.100	25
1.105	17
1.110	9
1.115	5
1.120	1
1.125	3
1.130	1
1.135	1
1.140	1
>1.14	0



*Andrew K. Kercher*  
Operator

*February 24, 2006*  
Date



Data Report Form DRF-21: Measurement of Number of Particles with SiC Burn-Leach Defects

Procedure:	AGR-CHAR-DAM-21 Rev. 1
Operator:	Montgomery
Sample ID:	LEU01-47T-F01
Sample Description:	Variant 1 Composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\BurnLeach\QCData\B06020201_DRF21R1.xls

Mean average weight/particle (g):	7.33E-04
Uncertainty in mean average weight/particle (g):	1.52E-06
Weight of sample of particles (g):	36.8796
Approximate number of particles in sample:	50313
Uncertainty in number of particles in sample:	104

Mean average weight/kernel (g):	2.42E-04
Uncertainty in mean average weight/kernel (g):	5.96E-07
Mean weight % uranium/kernel:	90.06
Standard deviation in weight % uranium/kernel:	0.09
Approximate weight uranium/kernel (g):	2.18E-04
Uncertainty in approximate weight uranium/kernel (g):	5.76E-07

	Leach 1	Leach 2	Leach 3	Total
Sample ID	B0602020101	B0602020102		
Volume of solution (ml):	40.0	45.0		
Measured $\beta$ activity of 0.1ml aliquot (dpm):	0.0	0.0		
Estimated weight of U in solution (mg):	0	0	0	
Radiochemical laboratory analysis number	060223-027	060223-028		
Weight uranium leached (g):	1.53E-04	4.30E-06		1.57E-04
Uncertainty in weight uranium leached (g):	1.50E-05	4.30E-07		1.50E-05
Calculated number of particles with SiC defects:	1	0		1
Uncertainty in number of particles with SiC defects:	6.89E-02	1.98E-03		6.89E-02

Comments

fcm data checked 3/01/06

*Fred C. Montgomery*  
Operator

*3/20/06*  
Date



Data Report Form DRF-21: Measurement of Number of Particles with SiC Burn-Leach Defects

Procedure:	AGR-CHAR-DAM-21 Rev. 1
Operator:	Montgomery
Sample ID:	LEU01-47T-G01
Sample Description:	Variant 1 Composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\BurnLeach\QCData\B06020202_DRF21R1.xls

Mean average weight/particle (g):	7.33E-04
Uncertainty in mean average weight/particle (g):	1.52E-06
Weight of sample of particles (g):	51.8993
Approximate number of particles in sample:	70804
Uncertainty in number of particles in sample:	147

Mean average weight/kernel (g):	2.42E-04
Uncertainty in mean average weight/kernel (g):	5.96E-07
Mean weight % uranium/kernel:	90.06
Standard deviation in weight % uranium/kernel:	0.09
Approximate weight uranium/kernel (g):	2.18E-04
Uncertainty in approximate weight uranium/kernel (g):	5.76E-07

	Leach 1	Leach 2	Leach 3	Total
Sample ID	B0602020201	B0602020202		
Volume of solution (ml):	37.5	47.5		
Measured $\beta$ activity of 0.1ml aliquot (dpm):	0.0	0.0		
Estimated weight of U in solution (mg):	0	0	0	
Radiochemical laboratory analysis number	060223-029	060223-030		
Weight uranium leached (g):	1.42E-07	7.20E-08		2.14E-07
Uncertainty in weight uranium leached (g):	1.40E-08	7.20E-09		1.57E-08
Calculated number of particles with SiC defects:	0	0		0
Uncertainty in number of particles with SiC defects:	6.43E-05	3.31E-05		7.23E-05

Comments

fcm checked data 3/01/06

*Fred C. Montgomery*  
Operator

*3/20/06*  
Date

Data Report Form DRF-19: Counting of Particles with Missing OPyC Layer by Visual Inspection

Procedure:	AGR-CHAR-DAM-19 Rev. 1
Operator:	John Hunn
Sample ID:	LEU01-47T-D01
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06020601_DRF19R1.xls

Mean average weight/particle (g):	7.33E-04
Uncertainty in average weight/particle (g):	1.52E-06
Weight of sample of particles (g):	22.863
Approximate number of particles in sample:	31191
Uncertainty in number of particles in sample:	65

Number of particles with missing OPyC layer:	0
--	---

Comments on unusual visual characteristics of OPyC

*John Hunn*  
Operator

2-6-06

Date

Data Report Form DRF-23: Imaging of SiC Grain Structure

Procedure:	AGR-CHAR-DAM-23 Rev. 0
Operator:	Paul Menchhofer
Filename:	\\mc-agr\AGR\SEM\E06020801_DRF23R0.xls
Sample ID:	LEU01-47T-BO1
Sample Description:	LEU01-47T-BO1
Mount Number(s):	M06020602L
Folder name containing images:	\\mc-agr\AGR\SEM\

Images of SiC grain structure			
	particle 1	particle 2	particle 3
1000x image filename	58046	58050	58055
2500x image filename	58047	58051	58056
grain structure acceptable	Yes	Yes	Yes

Comments

Some large columnar grains were observed. The largest extended through half the layer thickness.

  
Operator

*2.8.06*  
Date

  
QC Supervisor

*2-20-06*  
Date

  
QA Reviewer

*3/22/06*  
Date

ORNL/TM-2006/020, Rev. 1

170

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 6.8 58046

20  $\mu$ m

ORNL/TM-2006/020, Rev. 1

171

Acc.V	Spot	Magn	Det	WD	Exp	10 μm
10.0 kV	5.0	2500x	BSE	6.8	58047	



ORNL/TM-2006/020, Rev. 1

172

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 6.7 58050

20  $\mu$ m

ORNL/TM-2006/020, Rev. 1.

173

Acc.V	Spot	Magn	Det	WD	Exp	10 μm
10.0 kV	5.0	2500x	BSE	6.7	58051	

ORNL/TM-2006/020, Rev. 1

174

Acc.V Spot Magn  
10.0 kV 5.0 1000x

Det WD Exp  
BSE 6.6 58055

20  $\mu$ m

ORNL/TM-2006/020, Rev. 1

175

Acc.V	Spot	Magn	Det	WD	Exp
10.0 kV	5.0	2500x	BSE	6.6	58056

10  $\mu$ m

**For Information Only**

The information in the remainder of this section reports results of measurements not required by the fuel specification and is provided for information only.



Data Report Form DRF-22: Estimation of Average Particle Weight

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-47T-H01
Particle Lot Description:	Variant 1 composite:TRISO on BWXT kernel 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06020101_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	8.54E-02	8.82E-02	1.00E-01	8.59E-02	8.45E-02
Number of particles:	117	120	136	118	115
Average weight/particle (g):	7.30E-04	7.35E-04	7.35E-04	7.28E-04	7.35E-04

Mean average weight/particle (g):	7.33E-04
Uncertainty in mean average weight/particle (g):	1.52E-06

*Dixie Barker*  
Operator

*2-1-06*  
Date

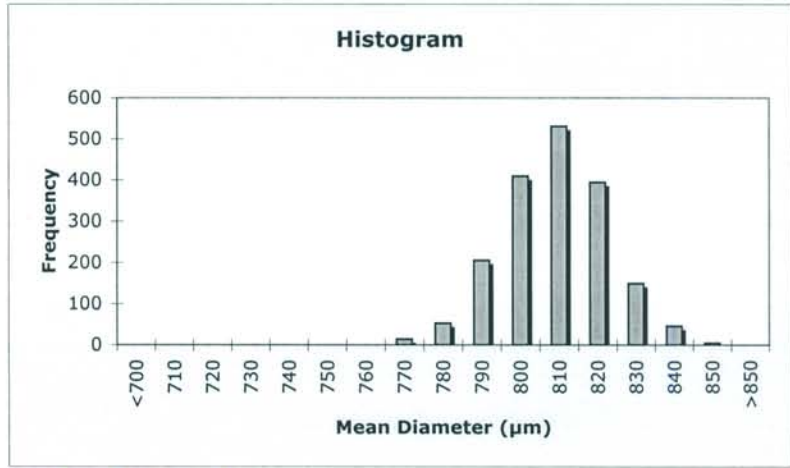
Data Report Form DRF-10A: Measurement of Particle Diameter

Procedure:	AGR-CHAR-DAM-10 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06022301\
Sample ID:	LEU01-47T-C01
Sample Description:	Variant 1 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06022301_output\

Number of particles analyzed:	1808
Mean of the average diameter of each particle ( $\mu\text{m}$ ):	804.0
Standard deviation in the average diameter of each particle ( $\mu\text{m}$ ):	13

Distribution of the average particle diameter (top binned)

Mean Diameter ( $\mu\text{m}$ )	Frequency
<700	0
710	0
720	0
730	0
740	0
750	0
760	0
770	14
780	53
790	206
800	409
810	531
820	394
830	150
840	46
850	5
>850	0



*Andrew K. Kercher*  
Operator

*February 24, 2006*  
Date

Data Report Form DRF-31: Measurement of Open Porosity using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-31 Rev. 0
Operator:	S. D. Nunn
Coated particle batch ID:	LEU01-47T-I01
Batch Description:	Variant 1 Composite: TRISO on BWXT kernel composite 69302
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\unc-agr\AGR\Porosimeter\S06020201\S06020201_DRF31R0.xls

Mean average weight/particle (g):	7.33E-04
Uncertainty in mean average weight/particle (g):	1.52E-06

Weight of particles (g):	3.5480
Approximate number of particles:	4840
Uncertainty in number of particles:	10
Total envelope volume of sample (cc):	1.304
Average envelope volume/particle (cc):	2.69E-04
Sample envelope density (g/cc):	2.720

Average particle diameter (microns):	8.01E+02
Average surface area/particle (cm <sup>2</sup> ):	2.02E-02
Total sample surface area (cm <sup>2</sup> ):	9.77E+01
Intruded mercury volume from 250-10,000 psia (cc):	1.14E-02
Open porosity (ml/m <sup>2</sup> ):	1.17E+00

Comments

*S. D. Nunn*  
Operator

*2/3/06*  
Date

Supplement to DRF-21: Impurity Analysis Data

Procedure:	AGR-CHAR-DAM-21 Rev. 1
Operator:	Montgomery
Sample ID:	LEU01-47T-F01
Sample Description:	Variant 1 Composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\BurnLeach\OCData\B06020201 DRF21R1.xls

	Leach 1	Leach 2	Leach 3	Total µg
Sample number:	B0602020101	B0602020102		
RMAL Analysis Number:	060223-027	060223-028		
Fe content of leach solution (µg)	4.23	2.63		6.86
Uncertainty in measured Fe content (µg)	0.42	0.53		0.68
Cr content of leach solution (µg)	0.50	< 0.45		< 0.95
Uncertainty in measured Cr content (µg)	0.10			0.10
Mn content of leach solution (µg)	0.21	0.15		0.36
Uncertainty in measured Mn content (µg)	0.04	0.03		0.05
Co content of leach solution (µg)	0.56	0.68		1.24
Uncertainty in measured Co content (µg)	0.11	0.14		0.18
Ni content of leach solution (µg)	1.30	< 0.77		< 2.07
Uncertainty in measured Ni content (µg)	0.26			0.26
Cr + Mn + Co + Ni (µg)	2.57	< 2.05		< 4.62
Uncertainty in Cr + Mn + Co + Ni (µg)	0.30	0.14		0.33
Ca content of leach solution (µg)	6.88	6.12		13.00
Uncertainty in measured Ca content (µg)	0.69	0.61		0.92
Al content of leach solution (µg)	5.61	2.46		8.07
Uncertainty in measured Al content (µg)	1.10	0.49		1.20
Ti content of leach solution (µg)	< 0.50	< 0.50		< 1.00
Uncertainty in measured Ti content (µg)				
V content of leach solution (µg)	< 0.65	< 0.65		< 1.30
Uncertainty in measured V content (µg)				
Ti + V content of leach solution (µg)	< 1.15	< 1.15		< 2.30
Uncertainty in measured Ti + V content (µg)				

Comments

*Yuel C. Montgomery*

Operator

*3/20/06*

Date



Supplement to DRF-21: Impurity Analysis Data

Procedure:	AGR-CHAR-DAM-21 Rev. 1
Operator:	Montgomery
Sample ID:	LEU01-47T-G01
Sample Description:	Variant 1 Composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\BurnLeach\OCData\B06020202 DRF21R1.xls

	Leach 1	Leach 2	Leach 3	Total µg
Sample number:	B0602020201	B0602020202		
RMAL Analysis Number:	060223-029	060223-030		
Fe content of leach solution (µg)	2.05	1.35		3.40
Uncertainty in measured Fe content (µg)	0.41	0.27		0.49
Cr content of leach solution (µg)	< 0.45	< 0.45		< 0.90
Uncertainty in measured Cr content (µg)				
Mn content of leach solution (µg)	0.15	0.13		0.28
Uncertainty in measured Mn content (µg)	0.03	0.03		0.04
Co content of leach solution (µg)	0.56	0.61		1.17
Uncertainty in measured Co content (µg)	0.11	0.12		0.16
Ni content of leach solution (µg)	< 0.77	< 0.77		< 1.54
Uncertainty in measured Ni content (µg)				
Cr + Mn + Co + Ni (µg)	< 1.93	< 1.96		< 3.89
Uncertainty in Cr + Mn + Co + Ni (µg)	0.11	0.12		0.17
Ca content of leach solution (µg)	4.63	3.43		8.06
Uncertainty in measured Ca content (µg)	0.93	0.69		1.16
Al content of leach solution (µg)	4.38	< 2.11		< 6.49
Uncertainty in measured Al content (µg)	0.88			0.88
Ti content of leach solution (µg)	< 0.50	< 0.50		< 1.00
Uncertainty in measured Ti content (µg)				
V content of leach solution (µg)	< 0.65	< 0.65		< 1.30
Uncertainty in measured V content (µg)				
Ti + V content of leach solution (µg)	< 1.15	< 1.15		< 2.30
Uncertainty in measured Ti + V content (µg)				

Comments

*Fred C. Montgomery*

Operator

*3/20/06*

Date



## 14 Superseded data

This section contains data related to the LEU01-47T TRISO-coated particle composite that has been superseded by more recent analysis.

It was determined that the average kernel weight as measured using procedure AGR-CHAR-DAM-22 Rev. 0 was of insufficient accuracy. The average kernel weight was remeasured to improve the accuracy of the reported value according to AGR-CHAR-DAM-22 Rev. 1. The measured value of the LEUCO average kernel weight changed from  $(2.47 \pm 0.01) \cdot 10^{-4}$  grams per kernel to  $(2.418 \pm 0.006) \cdot 10^{-4}$  grams per kernel. The measured value of the NUCO average kernel weight changed from  $(2.39 \pm 0.03) \cdot 10^{-4}$  grams per kernel to  $(2.308 \pm 0.009) \cdot 10^{-4}$  grams per kernel. On data report form DRF-15 for the measurement of average kernel envelope density, the average kernel weight is used to approximate the number of kernels in a sample from the weight of the sample. The approximate number of kernels in a sample is divided into the sample envelope volume to determine the average kernel envelope volume. The change in average kernel weight resulted in a significant change in the calculated average kernel envelope volume. On data report form DRF-16 for the buffer envelope density, the average kernel weight and volume are used to calculate the buffer density. The change in average kernel weight and volume resulted in a significant change in the calculated buffer densities previously used to determine acceptability of the buffer deposition conditions. The data in this compilation shows the new average kernel weights and average kernel volumes in sections 6 and 7, and the new buffer densities in section 8. Records showing the original values are included in this section. The new values for buffer density were about 10% higher than the originally reported values, but both were within the range specified in INL EDF-4380, Rev. 6.

**Data Report Form DRF-22: Estimation of Average Particle Weight**

<b>Procedure:</b>	AGR-CHAR-DAM-22 Rev. 0
<b>Operator:</b>	Dixie Barker
<b>Particle Lot ID:</b>	LEUCO350-01H
<b>Particle Lot Description:</b>	BWXT LEUCO KERNELS COMPOSITE 69302
<b>Filename:</b>	\\mc-agr\AGR\ParticleWeight\W5051701_DRF22.xls

	1st Measurement	2nd Measurement	3rd Measurement	4th Measurement	5th Measurement
<b>Weight of 100 particles (g):</b>	2.48E-02	2.50E-02	2.45E-02	2.49E-02	2.45E-02
<b>Average weight/particle (g):</b>	2.48E-04	2.50E-04	2.45E-04	2.49E-04	2.45E-04

<b>Mean average weight/particle (g):</b>	2.47E-04
<b>Uncertainty in mean average weight/particle (g):</b>	1.03E-06

*Dixie Barker*  
Operator

5-17-05  
Date

superseded 2-6-06 *gh*

Data Report Form DRF-15: Measurement of Average Kernel Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-15 Rev. 2
Operator:	S. D. NUNN
Kernel Lot ID:	LEUCO350-01
Kernel Lot Description:	BWXT LEUCO KERNEL COMPOSITE 69302
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05052701\S05052701_DRF15R2

Mean average weight/kernel (g):	2.47E-04
Uncertainty in mean average weight/kernel (g):	1.03E-06

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05052701L	S05052702L	S05052703L	S05052704L	S05052705L
Weight of kernels (g):	12.5822	12.5075	12.8773	12.6448	12.6895
Approximate number of kernels:	50940	50638	52135	51194	51374
Uncertainty in number of kernels:	212	211	217	213	214
Envelope volume of sample (cc):	1.150	1.145	1.180	1.157	1.164
Average envelope volume/kernel (cc):	2.26E-05	2.26E-05	2.26E-05	2.26E-05	2.26E-05
Sample envelope density (g/cc):	10.943	10.925	10.912	10.932	10.906

Mean average envelope volume/kernel (cc):	2.261E-05
Uncertainty in mean envelope volume/kernel (cc):	1.4E-08
Mean sample envelope density (g/cc):	10.924
Standard deviation in sample envelope density (g/cc):	0.015

*S.D. Nunn*  
Operator

*5/27/05*  
Date

*Superseded 2-14-06 JH*

**Data Report Form DRF-22: Estimation of Average Particle Weight**

<b>Procedure:</b>	AGR-CHAR-DAM-22 Rev. 0
<b>Operator:</b>	Dixie Barker
<b>Particle Lot ID:</b>	NUC0350-26-H
<b>Particle Lot Description:</b>	BWXT NUCO Batch 69300
<b>Filename:</b>	\\mc-agr\AGR\ParticleWeight\W05052401_DRF22.xls

	1st Measurement	2nd Measurement	3rd Measurement	4th Measurement	5th Measurement
<b>Weight of 100 particles (g):</b>	2.31E-02	2.38E-02	2.44E-02	2.45E-02	2.38E-02
<b>Average weight/particle (g):</b>	2.31E-04	2.38E-04	2.44E-04	2.45E-04	2.38E-04

<b>Mean average weight/particle (g):</b>	2.39E-04
<b>Uncertainty in mean average weight/particle (g):</b>	2.52E-06

*Dixie Barker*  
Operator

5-24-05  
Date

Superseded 2-3-06 .GH

Data Report Form DRF-15: Measurement of Average Kernel Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-15 Rev. 2
Operator:	S. D. NUNN
Kernel Lot ID:	NUCO350-26
Kernel Lot Description:	NUCO KERNEL COMPOSITE 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05052601\S05052601_DRF15R2

Mean average weight/kernel (g):	2.39E-04
Uncertainty in mean average weight/kernel (g):	2.52E-06

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05052601L	S05052602L	S05052603L	S05052604L	S05052605L
Weight of kernels (g):	12.8272	12.9542	12.9410	12.9793	12.9624
Approximate number of kernels:	53670	54202	54146	54307	54236
Uncertainty in number of kernels:	566	571	571	573	572
Envelope volume of sample (cc):	1.187	1.200	1.199	1.202	1.199
Average envelope volume/kernel (cc):	2.21E-05	2.21E-05	2.21E-05	2.21E-05	2.21E-05
Sample envelope density (g/cc):	10.805	10.792	10.797	10.799	10.807

Mean average envelope volume/kernel (cc):	2.213E-05
Uncertainty in mean envelope volume/kernel (cc):	5.7E-09
Mean sample envelope density (g/cc):	10.800
Standard deviation in sample envelope density (g/cc):	0.006

*S.D. Nunn*  
Operator

*5/26/05*  
Date

*Superseded 2-3-06 JH*



Inspection Report Form IRF-02A: Interrupted Coating Batches - Buffer Density

Procedure:	AGR-CHAR-PIP-02 Rev. 2
Batch 1 ID:	NUCO350-25B
Batch 1 description:	Buffer-coated BWXT kernel composite 69300
Batch 2 ID:	NUCO350-36B
Batch 2 description:	Buffer-coated BWXT kernel composite 69300
Batch 3 ID:	NUCO350-54B
Batch 3 description:	Buffer-coated BWXT kernel composite 69300
Composite ID:	NUCO350-58B
Composite description:	Composite (25B+36B+54B) Buffer-coated BWXT kernel composite 69300

Property	Measured Data				Specification INL EDF-4380	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	t value (t)					
Batch 1: Buffer envelope density	0.97	0.09	5	2.132	mean 0.95 ± 0.15	A = $x - ts/\sqrt{n} \geq 0.80$	0.89	pass	DRF-16
						B = $x + ts/\sqrt{n} \leq 1.10$	1.05	pass	DRF-22
Batch 2: Buffer envelope density	1.01	0.09	5	2.132	mean 0.95 ± 0.15	A = $x - ts/\sqrt{n} \geq 0.80$	0.93	pass	DRF-16
						B = $x + ts/\sqrt{n} \leq 1.10$	1.09	pass	DRF-22
Batch 3: Buffer envelope density	1.01	0.09	5	2.132	mean 0.95 ± 0.15	A = $x - ts/\sqrt{n} \geq 0.80$	0.93	pass	DRF-16
						B = $x + ts/\sqrt{n} \leq 1.10$	1.09	pass	DRF-22
Composite buffer envelope density	0.99	0.08	5	2.132	mean 0.95 ± 0.15	A = $x - ts/\sqrt{n} \geq 0.80$	0.92	pass	DRF-16
						B = $x + ts/\sqrt{n} \leq 1.10$	1.07	pass	DRF-22


Comments

Standard deviations are  $\sqrt{5}$  times the uncertainties in buffer density (standard errors) reported on DRF-16.  
 Average thickness of buffer was 108  $\mu\text{m}$  based on average envelope volume of 9.25E-5 cc (effective diameter of 561  $\mu\text{m}$ ) and average kernel diameter of 345  $\mu\text{m}$ .  
 Average thickness of buffer was 108  $\mu\text{m}$  based on average outer diameter of 561  $\mu\text{m}$  obtained per DAM-10 and average kernel diameter of 345  $\mu\text{m}$ .

  
 QC Supervisor

6-28-05  
 Date

Accept for buffer density (Yes or No): Yes

  
 QA Reviewer

8/2/05  
 Date

Superseded 3-10-06 JH

Data Report Form DRF-16: Measurement of Buffer Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D. NUNN
Buffer-coated kernel batch ID:	NUCO350-25B
Batch Description:	Buffer Coated BWXT Kernel Composite 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05062001\S05062001_DRF16R2.xls

Mean average weight/buffer-coated kernel (g):	3.07E-04
Uncertainty in mean average weight/b-c kernel (g):	1.00E-06
Mean average weight/bare kernel (g):	2.39E-04
Uncertainty in mean average weight/bare kernel (g):	2.52E-05
Mean average envelope volume/bare kernel (cc):	2.21E-05
Uncertainty in envelope volume/bare kernel (cc):	5.70E-09

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05062001L	S05062002L	S05062003L	S05062004L	S05062005L
Weight of buffer-coated kernels (g):	4.1223	4.2165	4.4333	4.4104	4.0445
Approximate number of b-c kernels:	13428	13735	14441	14366	13174
Uncertainty in number of b-c kernels:	44	45	47	47	43
Total envelope volume of sample (cc):	1.235	1.268	1.335	1.321	1.212
Av. envelope volume/b-c kernels (cc):	9.19E-05	9.23E-05	9.24E-05	9.19E-05	9.20E-05
Sample envelope density (g/cc):	3.339	3.326	3.321	3.340	3.338

Mean average envelope volume/b-c kernel (cc):	9.21E-05
Uncertainty in envelope volume/b-c kernel (cc):	1.1E-07

Buffer density:	9.71E-01
Uncertainty in buffer density:	3.88E-02

*S.D. Nunn*  
Operator

*6/30/05*  
Date

*superceded 2-14-06 JH*

Data Report Form DRF-16: Measurement of Buffer Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D. NUNN
Buffer-coated kernel batch ID:	NUCO350-36B
Batch Description:	Buffer Coated BWXT Kernel Composite 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05062006\S05062006_DRF16R2.xls

Mean average weight/buffer-coated kernel (g):	3.11E-04
Uncertainty in mean average weight/b-c kernel (g):	1.20E-06
Mean average weight/bare kernel (g):	2.39E-04
Uncertainty in mean average weight/bare kernel (g):	2.52E-06
Mean average envelope volume/bare kernel (cc):	2.21E-05
Uncertainty in envelope volume/bare kernel (cc):	5.70E-09

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05062006L	S05062007L	S05062008L	S05062101L	S05062102L
Weight of buffer-coated kernels (g):	4.0723	4.0655	4.0860	4.0696	4.0514
Approximate number of b-c kernels:	13094	13072	13138	13086	13027
Uncertainty in number of b-c kernels:	51	50	51	50	50
Total envelope volume of sample (cc):	1.226	1.227	1.232	1.226	1.217
Av. envelope volume/b-c kernels (cc):	9.37E-05	9.38E-05	9.38E-05	9.37E-05	9.34E-05
Sample envelope density (g/cc):	3.321	3.315	3.317	3.319	3.328

Mean average envelope volume/b-c kernel (cc):	9.37E-05
Uncertainty in envelope volume/b-c kernel (cc):	6.7E-08

Buffer density:	1.01E+00
Uncertainty in buffer density:	3.90E-02

*S. D. Nunn*  
Operator

*6/21/05*  
Date

*superseded 2-14-06 JH*



Data Report Form DRF-16: Measurement of Buffer Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D. NUNN
Buffer-coated kernel batch ID:	NUCO350-54B
Batch Description:	Buffer Coated BWXT Kernel Composite 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\vmc-agr\AGR\Porosimeter\S05062201\S05062201_DRF16R2.xls

Mean average weight/buffer-coated kernel (g):	3.11E-04
Uncertainty in mean average weight/b-c kernel (g):	1.09E-06
Mean average weight/bare kernel (g):	2.39E-04
Uncertainty in mean average weight/bare kernel (g):	2.52E-06
Mean average envelope volume/bare kernel (cc):	2.21E-05
Uncertainty in envelope volume/bare kernel (cc):	5.70E-09

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05062201L	S05062202L	S05062203L	S05062204L	S05062205L
Weight of buffer-coated kernels (g):	4.1223	4.0694	4.0160	4.0391	4.0471
Approximate number of b-c kernels:	13255	13085	12913	12987	13013
Uncertainty in number of b-c kernels:	46	46	45	46	46
Total envelope volume of sample (cc):	1.233	1.225	1.209	1.215	1.215
Av. envelope volume/b-c kernels (cc):	9.30E-05	9.36E-05	9.36E-05	9.35E-05	9.34E-05
Sample envelope density (g/cc):	3.344	3.323	3.323	3.326	3.331

Mean average envelope volume/b-c kernel (cc):	9.34E-05
Uncertainty in envelope volume/b-c kernel (cc):	1.1E-07

Buffer density:	1.01E+00
Uncertainty in buffer density:	3.85E-02

*S.D. Nunn*  
Operator

*6/22/05*  
Date

*superseded 2-14-06 JH*

Data Report Form DRF-16: Measurement of Buffer Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D. NUNN
Buffer-coated kernel batch ID:	NUCO350-58B
Batch Description:	Composite of Buffer Coated BWXT Kernel Composite 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05062206\S05062206_DRF16R2.xls

Mean average weight/buffer-coated kernel (g):	3.09E-04
Uncertainty in mean average weight/b-c kernel (g):	4.99E-07
Mean average weight/bare kernel (g):	2.39E-04
Uncertainty in mean average weight/bare kernel (g):	2.52E-06
Mean average envelope volume/bare kernel (cc):	2.21E-05
Uncertainty in envelope volume/bare kernel (cc):	5.70E-09

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05062206L	S05062207L	S05062301L	S05062302L	S05062303L
Weight of buffer-coated kernels (g):	4.3399	4.3264	4.3459	4.4478	4.3485
Approximate number of b-c kernels:	14045	14001	14064	14394	14073
Uncertainty in number of b-c kernels:	23	23	23	23	23
Total envelope volume of sample (cc):	1.300	1.296	1.300	1.333	1.303
Av. envelope volume/b-c kernels (cc):	9.25E-05	9.26E-05	9.24E-05	9.26E-05	9.26E-05
Sample envelope density (g/cc):	3.340	3.338	3.344	3.337	3.338

Mean average envelope volume/b-c kernel (cc):	9.25E-05
Uncertainty in envelope volume/b-c kernel (cc):	3.8E-08

Buffer density:	9.94E-01
Uncertainty in buffer density:	3.65E-02

*S. D. Nunn*  
Operator

*6/23/05*  
Date

*suporced 2-14-06 JH*



Data Report Form DRF-16: Measurement of Buffer Envelope Density using a Mercury Porosimeter

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D. NUNN
Buffer-coated kernel batch ID:	LEU01-16B
Batch Description:	Buffer on BWXT LEUCO kernel composite 69302
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\vmc-agr\AGR\Porosimeter\S05110701\S05110701_DRF16R2.xls

Mean average weight/buffer-coated kernel (g):	3.20E-04
Uncertainty in mean average weight/b-c kernel (g):	8.22E-07
Mean average weight/bare kernel (g):	2.47E-04
Uncertainty in mean average weight/bare kernel (g):	1.03E-06
Mean average envelope volume/bare kernel (cc):	2.26E-05
Uncertainty in envelope volume/bare kernel (cc):	1.40E-08

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Porosimeter data file number:	S05110701L	S05110702L	S05110703L	S05110704L	S05110705L
Weight of buffer-coated kernels (g):	4.0951	4.1007	4.2203	4.2527	4.3448
Approximate number of b-c kernels:	12797	12815	13188	13290	13578
Uncertainty in number of b-c kernels:	33	33	34	34	35
Total envelope volume of sample (cc):	1.192	1.193	1.234	1.229	1.267
Av. envelope volume/b-c kernels (cc):	9.32E-05	9.31E-05	9.36E-05	9.25E-05	9.33E-05
Sample envelope density (g/cc):	3.435	3.438	3.421	3.460	3.430

Mean average envelope volume/b-c kernel (cc):	9.31E-05
Uncertainty in envelope volume/b-c kernel (cc):	1.8E-07

Buffer density:	1.04E+00
Uncertainty in buffer density:	1.89E-02

*S.D. Nunn*

Operator

*11/7/05*

Date

*Superseded 2-14-06*