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Data Compilation for AGR-1 Variant 2 Coated Particle Composite LEU01-48T

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This document is a compilation of characterization data for the AGR-1 variant 2 coated particle composite LEU01-48T, a composite of three batches of TRISO-coated 350 μm diameter, 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 μm nominal thickness) followed by a dense inner pyrocarbon layer (40 μm nominal thickness) followed by a SiC layer (35 μm nominal thickness) followed by another dense outer pyrocarbon layer (40 μm 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 the fuel shakedown irradiation (AGR-1) experiment. 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 2 coated particles were similar to the AGR-1 baseline coated particles with the exception that the inner pyrocarbon (IPyC) coating was deposited at a coating gas fraction (CGF) of 0.45 propylene/acetylene instead of the baseline CGF of 0.30. 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 LEU01-48T 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 μm diameter 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) 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) 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 LEU01-48T

This section contains all the inspection report forms (IRF) associated with the coated particle composite LEU01-48T. 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. The coated particle composite, LEU01-48T, was found to meet all the requirements in these two sections of EDF-4380, Rev. 8.

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, LEU01-48T. 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 LEU01-48T.

Property	Mean
Average kernel diameter (μm)	349.7
Kernel envelope density (Mg/m^3)	10.924
Average buffer thickness (μm)	102.9
Average IPyC thickness (μm)	40.1
Average SiC thickness (μm)	35.0
Average OPyC thickness (μm)	39.8
Buffer envelope density (Mg/m^3) (interrupted batches)	1.10
IPyC sink/float density (Mg/m^3) (interrupted batches)	1.912
SiC sink/float density (Mg/m^3)	3.2070
OPyC sink/float density (Mg/m^3) (weighted average)	1.901
IPyC anisotropy (BAFo equivalent)	1.023
OPyC anisotropy (BAFo equivalent)	1.018

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, LEU01-48T. 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 LEU01-48T.

Property	Defect Fraction
Particles with SiC gold spot defects	$\leq 6.4 \times 10^{-4}$
Particle aspect ratio	$\leq 1.7 \times 10^{-3}$
Particles with burn-leach defects	$\leq 9.5 \times 10^{-5}$
Particles with missing OPyC	$\leq 9.6 \times 10^{-5}$

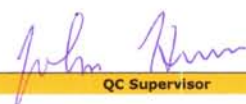
Inspection Report Form IRF-02A: Interrupted Coating Batches - Buffer Density

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 ³)	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 ³)	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 ³)	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 μm based on average envelope volume of 9.25E-5 cc (effective diameter of 561 μm) and average kernel diameter of 345 μm .
 Average thickness of buffer was 108 μm based on average outer diameter of 561 μm obtained per DAM-10 and average kernel diameter of 345 μm .
 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:	LEU01-18I
Batch 1 description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Batch 2 ID:	LEU01-33I
Batch 2 description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Batch 3 ID:	LEU01-39I
Batch 3 description:	Variant 2: 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 ³)	1.9113	0.0165	54	1.674	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85 B = x + ts/√n ≤ 1.95	1.908 1.915	pass pass	DRF-03
				2.831	dispersion ≤ 0.01 ≤ 1.80 ≤ 0.01 ≥ 2.00	C = x - ks > 1.80 D = x + ks < 2.00	1.865 1.958	pass pass	
Batch 2: IPyC sink/float density (Mg/m ³)	1.9089	0.0134	56	1.673	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85 B = x + ts/√n ≤ 1.95	1.906 1.912	pass pass	DRF-03
				2.820	dispersion ≤ 0.01 ≤ 1.80 ≤ 0.01 ≥ 2.00	C = x - ks > 1.80 D = x + ks < 2.00	1.871 1.947	pass pass	
Batch 3: IPyC sink/float density (Mg/m ³)	1.9171	0.0139	42	1.683	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85 B = x + ts/√n ≤ 1.95	1.913 1.921	pass pass	DRF-03
				2.913	dispersion ≤ 0.01 ≤ 1.80 ≤ 0.01 ≥ 2.00	C = x - ks > 1.80 D = x + ks < 2.00	1.877 1.958	pass pass	

Comments

Coating thickness, particle weight, and open porosity of IPyC provided for information only.

QC Supervisor

Date

Accept process for IPyC density (Yes or No):

Yes

QA Reviewer

Date

Inspection Report Form IRF-03: Coated Particle Batches	
Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-22T
Coated particle batch description:	Variant 2: 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)	101.1	7.0	188	1.653	mean 100 ± 15	A = $x - ts/\sqrt{n} \geq 85$	100.3	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 115$	101.9	pass	DRF-11
Average IPyC thickness for each particle (µm)	40.4	2.5	237	1.651	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)	35.0	1.2	237	1.651	mean 35 ± 4	A = $x - ts/\sqrt{n} \geq 31$	34.9	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 39$	35.1	pass	DRF-11
Average OPyC thickness for each particle (µm)	40.6	2.0	237	1.651	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$	40.4	pass	DRF-08
						B = $x + ts/\sqrt{n} \leq 45$	40.8	pass	DRF-11
Particles with missing OPyC			15634		defect fraction $\leq 6.0 \times 10^{-4}$	≤ 4 in 15,500	0	pass	DRF-19

Comments


 QC Supervisor

3-1-06
 Date

Accept Coated particle batch (Yes or No):	Yes
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 QA Reviewer

4/27/06
 Date

Inspection Report Form IRF-03: Coated Particle Batches

Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-42T
Coated particle batch description:	Variant 2: TRISO on BWXT kernel composite 69302

Property	Measured Data				Specification	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	t value (t)	INL EDF-4380 Rev. 6				
Average buffer thickness for each particle (μm)	102.2	7.6	170	1.654	mean 100 ± 15	A = $x - ts/\sqrt{n} \geq 85$ B = $x + ts/\sqrt{n} \leq 115$	101.2 103.2	pass pass	DRF-08 DRF-11
Average IPyC thickness for each particle (μm)	40.3	2.8	233	1.651	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$ B = $x + ts/\sqrt{n} \leq 45$	40.0 40.6	pass pass	DRF-08 DRF-11
Average SiC thickness for each particle (μm)	34.7	1.1	234	1.651	mean 35 ± 4	A = $x - ts/\sqrt{n} \geq 31$ B = $x + ts/\sqrt{n} \leq 39$	34.6 34.8	pass pass	DRF-08 DRF-11
Average OPyC thickness for each particle (μm)	40.2	1.8	234	1.651	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$ B = $x + ts/\sqrt{n} \leq 45$	40.0 40.4	pass pass	DRF-08 DRF-11
Particles with missing OPyC			15643		defect fraction $\leq 6.0 \times 10^{-4}$	≤ 4 in 15,500	0	pass	DRF-19

Comments




QC Supervisor Date

Accept Coated particle batch (Yes or No):	Yes
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QA Reviewer Date

Inspection Report Form IRF-03: Coated Particle Batches	
Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-40T
Coated particle batch description:	Variant 2: 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)	99.5	7.0	199	1.653	mean 100 ± 15	A = $x - ts/\sqrt{n} \geq 85$ B = $x + ts/\sqrt{n} \leq 115$	98.7 100.3	pass pass	DRF-08 DRF-11
Average IPyC thickness for each particle (µm)	40.2	2.5	228	1.652	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$ B = $x + ts/\sqrt{n} \leq 45$	39.9 40.5	pass pass	DRF-08 DRF-11
Average SiC thickness for each particle (µm)	35.0	0.9	229	1.652	mean 35 ± 4	A = $x - ts/\sqrt{n} \geq 31$ B = $x + ts/\sqrt{n} \leq 39$	34.9 35.1	pass pass	DRF-08 DRF-11
Average OPyC thickness for each particle (µm)	38.8	1.8	230	1.652	mean 40 ± 5	A = $x - ts/\sqrt{n} \geq 35$ B = $x + ts/\sqrt{n} \leq 45$	38.6 39.0	pass pass	DRF-08 DRF-11
Particles with missing OPyC			15562		defect fraction $\leq 6.0 \times 10^{-4}$	≤ 4 in 15,500	0	pass	DRF-19

Comments

	
QC Supervisor	Date

Accept Coated particle batch (Yes or No):	Yes
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QA Reviewer	Date

Inspection Report Form IRF-04A: Coated Particle Composites

Procedure:	AGR-CHAR-PIP-04 Rev. 2
Coated particle composite ID:	LEU01-48T
Coated particle composite description:	Variant 2 composite: TRISO on BWXT kernel composite 69302

Property	Measured Data				Specification	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	k or t value	INL EDF-4380 Rev. 8				
Average buffer thickness for each particle (μm)	102.9	7.3	235	1.651	mean 100 ± 15	A = x - ts/√n ≥ 85	102.1	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 115	103.7	pass	
				2.548	dispersion ≤0.01 ≤ 55	C = x - ks > 55	84.3	pass	
Average IPyC thickness for each particle (μm)	40.1	2.8	239	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36	39.8	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 44	40.4	pass	
				2.546	dispersion ≤0.01 ≤ 30 ≤0.01 ≥ 56	C = x - ks > 30	33.0	pass	
						D = x + ks < 56	47.2	pass	
Average SiC thickness for each particle (μm)	35.0	1.0	239	1.651	mean 35 ± 3	A = x - ts/√n ≥ 32	34.9	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 38	35.1	pass	
				2.546	dispersion ≤0.01 ≤ 25	C = x - ks > 25	32.5	pass	
Average OPyC thickness for each particle (μm)	39.8	2.1	239	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36	39.6	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 44	40.0	pass	
				2.546	dispersion ≤0.01 ≤ 20	C = x - ks > 20	34.5	pass	
Buffer envelope density	See IRF-02A							pass	IRF-02A
IPyC sink/float density	See IRF-02B							pass	IRF-02B
SiC sink/float density (Mg/m³)	3.2070	0.0022	41	1.684	mean ≥ 3.19	A = x - ts/√n ≥ 3.19	3.206	pass	DRF-02
				2.922	dispersion ≤0.01 ≤ 3.17	C = x - ks > 3.17	3.201	pass	
OPyC sink/float density	See IRF-04B							pass	IRF-04B
IPyC anisotropy (BAFo equivalent)	1.023	0.002	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.024	pass	DRF-18
				3.981	dispersion ≤0.01 ≥1.06	D = x + ks < 1.06	1.031	pass	
OPyC anisotropy (BAFo equivalent)	1.018	0.001	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.019	pass	DRF-18
				3.981	dispersion ≤0.01 ≥1.06	D = x + ks < 1.06	1.022	pass	
Particles with SiC gold spot defects			12233		defect fraction ≤ 5.0 x 10 ⁻³	≤47 in 12,000 or ≤92 in 22,000	3	pass	DRF-20
Particle aspect ratio			1795		dispersion ≤0.01 ≥1.14	≤1 in 500 or ≤7 in 1420	0	pass	DRF-07 DRF-10
Particles with SiC burn-leach defects			50265		defect fraction ≤ 1.0 x 10 ⁻⁴	≤1 in 50,000 or ≤6 in 120,000	1	pass	DRF-21
Particles with missing OPyC			31306		defect fraction ≤ 3.0 x 10 ⁻⁴	≤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


QC Supervisor

5-1-06
Date

Accept coated particle composite (Yes or No): Yes


QA Reviewer

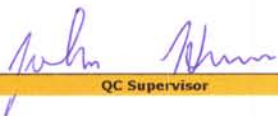
5/1/06
Date

Inspection Report Form IRF-04B: Outer Pyrocarbon Density

Procedure:	AGR-CHAR-PIP-04 Rev. 2
Coated particle composite ID:	LEU01-48T
Coated particle composite description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Batch 1 ID:	LEU01-22T
Batch 1 description:	Variant 2: TRISO on BWXT kernel composite 69302
Batch 2 ID:	LEU01-42T
Batch 2 description:	Variant 2: TRISO on BWXT kernel composite 69302
Batch 3 ID:	LEU01-40T
Batch 3 description:	Variant 2: TRISO on BWXT kernel composite 69302

Property	Measured Data				Specification	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	k or t value	INL EDF-4380 Rev. 6				
Batch 1: OPyC sink/float density (Mg/m ³)	1.8918	0.0078	46	1.679	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.890	pass	DRF-03
				2.882	dispersion ≤ 0.01 ≤ 1.80 ≤ 0.01 ≥ 2.00	B = x + ts/√n ≤ 1.95	1.894	pass	
						C = x - ks > 1.80	1.869	pass	
						D = x + ks < 2.00	1.914	pass	
Batch 2: OPyC sink/float density (Mg/m ³)	1.8998	0.0078	50	1.677	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.898	pass	DRF-03
				2.863	dispersion ≤ 0.01 ≤ 1.80 ≤ 0.01 ≥ 2.00	B = x + ts/√n ≤ 1.95	1.902	pass	
						C = x - ks > 1.80	1.877	pass	
						D = x + ks < 2.00	1.922	pass	
Batch 3: OPyC sink/float density (Mg/m ³)	1.9132	0.0075	51	1.676	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.911	pass	DRF-03
				2.848	dispersion ≤ 0.01 ≤ 1.80 ≤ 0.01 ≥ 2.00	B = x + ts/√n ≤ 1.95	1.915	pass	
						C = x - ks > 1.80	1.892	pass	
						D = x + ks < 2.00	1.935	pass	

Comments


QC Supervisor

3-10-06
Date

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


QA Reviewer

4/27/06
Date

2 Product ID's associated with LEU01-48T

Kernels

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

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

Buffer-only particles

NUCO350-25B (Buffer density qualification batch 1)

NUCO350-36B (Buffer density qualification batch 2)

NUCO350-54B (Buffer density qualification batch 3)

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

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

IPyC/Buffer-only particles

LEU01-18I (IPyC density qualification batch 1)

LEU01-33I (IPyC density qualification batch 2)

LEU01-39I (IPyC density qualification batch 3)

TRISO-coated particles

LEU01-22T (TRISO batch 1)

LEU01-42T (TRISO batch 2)

LEU01-40T (TRISO batch 3)

LEU01-48T (composite of 22T+42T+40T)

3 Coating process conditions

The following pages contain coating process conditions for all coated particle batches associated with the LEU01-48T coated particle composite. The AGR-1 variant 2 fuel particles are similar to the AGR-1 baseline fuel particles with the exception that the inner pyrocarbon (IPyC) coating was deposited at a coating gas fraction (CGF) of 0.45 propylene/acetylene instead of the baseline CGF of 0.30. These particles were coated within the variant 2 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-only interrupted Batches

NUCO350-25B (Buffer density qualification batch 1)
NUCO350-36B (Buffer density qualification batch 2)
NUCO350-54B (Buffer density qualification batch 3)
LEU01-16B (confirmation on LEUCO kernels, for information only)

IPyC/Buffer-only interrupted batches

LEU01-18I (IPyC density qualification batch 1)
LEU01-33I (IPyC density qualification batch 2)
LEU01-39I (IPyC density qualification batch 3)

TRISO Batches

LEU01-22T (TRISO batch 1)
LEU01-42T (TRISO batch 2)
LEU01-40T (TRISO batch 3)

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	
	AGR-1 Parameter	As-Processed
Buffer		
Coating gases	C ₂ H ₂ + Ar	C ₂ H ₂ + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1265 ± 25°C	
Time		
SiC		
Coating gases	H ₂ + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	
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. Lee</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		
	AGR-1 Parameter	As-Processed	
Buffer			
Coating gases	$C_2H_2 + Ar$	$C_2H_2 + Ar$	
TGF		8530 sccm	
CGF	0.60 ± 0.10	0.61	
Temperature	$1450 \pm 25^\circ C$	$1450^\circ C$	
Time		5 min	
IPyC			
Coating gases	$Ar + C_2H_2 + C_3H_8$		
TGF			
CGF	0.30 ± 0.03		
CGR	0.85 ± 0.085		
Temperature	$1265 \pm 25^\circ C$		
Time			
SiC			
Coating gases	$H_2 + MTS$		
TGF			
CGF	0.015 ± 0.005		
Temperature	$1500 \pm 25^\circ C$		
Time			
OPyC			
Coating gases	$Ar + C_2H_2 + C_3H_8$		
TGF			
CGF	0.30 ± 0.03		
CGR	0.85 ± 0.085		
Temperature	$1290 \pm 40^\circ C$		
Time			
Comments/Notes:			
Operator:	<i>Richard A Lowden</i>		Date: <i>6/17/05</i>
QAS:	<i>W.C. Lee</i>		Date: <i>3/30/06</i>

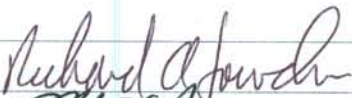

Summary for Baseline Buffer Qualification Run – NUCO350-54B

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		
	AGR-1 Parameter	As-Processed	
Buffer			
Coating gases	C ₂ H ₂ + Ar	C ₂ H ₂ + Ar	
TGF		8530 sccm	
CGF	0.60 ± 0.10	0.61	
Temperature	1450 ± 25°C	1450°C	
Time		5 min	
IPyC			
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆		
TGF			
CGF	0.30 ± 0.03		
CGR	0.85 ± 0.085		
Temperature	1265 ± 25°C		
Time			
SiC			
Coating gases	H ₂ + MTS		
TGF			
CGF	0.015 ± 0.005		
Temperature	1500 ± 25°C		
Time			
OPyC			
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆		
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>MRCP</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	
	AGR-1 Parameter	As-Processed
Buffer		
Coating gases	C ₂ H ₂ + Ar	C ₂ H ₂ + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1265 ± 25°C	
Time		
SiC		
Coating gases	H ₂ + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	
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>MEG</i>	Date: <i>3/30/06</i>

Summary for Variant #2 IPyC Qualification Run – LEU01-18I

Coating Run No.	LEU01-18I	
Description:	Variant #2 processing conditions for IPyC layer	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	LEU01-18K	
Operator:	R. A. Lowden	
Date:	01/13/2006	
Data Location:	B002516, Coating Log, Volume 3, pp. 176 - 185	
Kernel Batch Wt.	63.48 g	
Coated Particle Batch Wt.	107.34 g	
	AGR-1 Parameter	As-Processed
Buffer		
Coating gases	C ₂ H ₂ + Ar	C ₂ H ₂ + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	Ar + C ₂ H ₂ + C ₃ H ₆
TGF		9440 sccm
CGF	0.45 ± 0.03	0.45
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		8.5 min
SiC		
Coating gases	H ₂ + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		
Operator:		Date: 1/13/06
QAS:		Date: 3/28/06

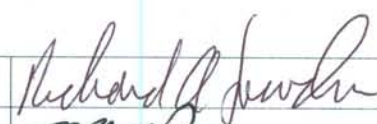
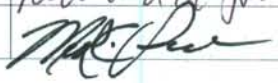
Summary for Variant #2 IPyC Qualification Run – LEU01-33I

Coating Run No.	LEU01-33I	
Description:	Variant #2 processing conditions for IPyC layer	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	LEU01-33K	
Operator:	R. A. Lowden	
Date:	01/23/2006	
Data Location:	B002516, Coating Log, Volume 3, pp. 216 - 223	
Kernel Batch Wt.	63.43 g	
Coated Particle Batch Wt.	108.25 g	
	AGR-1 Parameter	As-Processed
Buffer		
Coating gases	C ₂ H ₂ + Ar	C ₂ H ₂ + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	Ar + C ₂ H ₂ + C ₃ H ₆
TGF		9440 sccm
CGF	0.45 ± 0.03	0.45
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		8.5 min
SiC		
Coating gases	H ₂ + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	
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: 1/23/06
QAS:	<i>Mark G. ...</i>	Date: 3/28/06

Summary for Variant #2 IPyC Qualification Run – LEU01-39I

Coating Run No.	LEU01-39I	
Description:	Variant #2 processing conditions for IPyC layer	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	LEU01-39K	
Operator:	R. A. Lowden	
Date:	01/24/2006	
Data Location:	B002516, Coating Log, Volume 3, pp. 226 - 233	
Kernel Batch Wt.	63.43 g	
Coated Particle Batch Wt.	108.82 g	
	AGR-1 Parameter	As-Processed
Buffer		
Coating gases	C ₂ H ₂ + Ar	C ₂ H ₂ + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	Ar + C ₂ H ₂ + C ₃ H ₆
TGF		9440 sccm
CGF	0.45 ± 0.03	0.45
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		8.5 min
SiC		
Coating gases	H ₂ + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	
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: 1/24/06
QAS:	<i>M.C. Lee</i>	Date: 3/28/06

Summary for Variant #2 Coating Run - LEU01-22T

Coating Run No.	LEU01-22T	
Description:	Variant #2 AGR-1 processing conditions	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	LEU01-22K	
Operator:	R. A. Lowden	
Date:	02/02/2006	
Data Location:	B002516, Coating Log, Volume 3, pp. 254 - 263	
Kernel Batch Wt.	63.26 g	
Coated Particle Batch Wt.	186.87 g	
	AGR-1 Parameter	As-Processed
Buffer		
Coating gases	C ₂ H ₂ + Ar	C ₂ H ₂ + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5.0 min
IPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	Ar + C ₂ H ₂ + C ₃ H ₆
TGF		9440 sccm
CGF	0.45 ± 0.03	0.45
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		8.0 min
SiC		
Coating gases	H ₂ + MTS	H ₂ + MTS
TGF		16,923 sccm
CGF	0.015 ± 0.005	0.0116
Temperature	1500 ± 25°C	1500°C
Time		140 min
OPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	Ar + C ₂ H ₂ + C ₃ H ₆
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:		Date: 2/2/06
QAS:		Date: 3/28/06

Summary for Variant #2 Coating Run - LEU01-42T

Coating Run No.	LEU01-42T		
Description:	Variant #2 AGR-1 processing conditions		
Procedure:	AGR-COAT-SOP-01, Rev. 1		
Kernel Lot No.	LEU01-42K		
Operator:	R. A. Lowden		
Date:	02/08/2006		
Data Location:	B002516, Coating Log, Volume 3, pp. 274 - 283		
Kernel Batch Wt.	63.28 g		
Coated Particle Batch Wt.	186.52 g		
	AGR-1 Parameter	As-Processed	
Buffer			
Coating gases	C ₂ H ₂ + Ar	C ₂ H ₂ + Ar	
TGF		8530 sccm	
CGF	0.60 ± 0.10	0.61	
Temperature	1450 ± 25°C	1450°C	
Time		5.0 min	
IPyC			
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	Ar + C ₂ H ₂ + C ₃ H ₆	
TGF		9440 sccm	
CGF	0.45 ± 0.03	0.45	
CGR	0.85 ± 0.085	0.85	
Temperature	1265 ± 25°C	1265°C	
Time		8.0 min	
SiC			
Coating gases	H ₂ + MTS	H ₂ + MTS	
TGF		16,917 sccm	
CGF	0.015 ± 0.005	0.0113	
Temperature	1500 ± 25°C	1500°C	
Time		140 min	
OPyC			
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	Ar + C ₂ H ₂ + C ₃ H ₆	
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:	<i>2/8/06</i>
QAS:	<i>MC</i>	Date:	<i>3/28/06</i>

Summary for Variant #2 Coating Run - LEU01-40T

Coating Run No.	LEU01-40T	
Description:	Variant #2 AGR-1 processing conditions	
Procedure:	AGR-COAT-SOP-01, Rev. 1	
Kernel Lot No.	LEU01-40K	
Operator:	R. A. Lowden	
Date:	02/10/2006	
Data Location:	B002516, Coating Log, Volume 3, pp. 284 - 295	
Kernel Batch Wt.	63.32 g	
Coated Particle Batch Wt.	183.32 g	
	AGR-1 Parameter	As-Processed
Buffer		
Coating gases	C ₂ H ₂ + Ar	C ₂ H ₂ + Ar
TGF		8530 sccm
CGF	0.60 ± 0.10	0.61
Temperature	1450 ± 25°C	1450°C
Time		5.0 min
IPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	Ar + C ₂ H ₂ + C ₃ H ₆
TGF		9440 sccm
CGF	0.45 ± 0.03	0.45
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		8.0 min
SiC		
Coating gases	H ₂ + MTS	H ₂ + MTS
TGF		16,913 sccm
CGF	0.015 ± 0.005	0.0111
Temperature	1500 ± 25°C	1500°C
Time		140 min
OPyC		
Coating gases	Ar + C ₂ H ₂ + C ₃ H ₆	Ar + C ₂ H ₂ + C ₃ H ₆
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: 2/10/06
QAS:	<i>Mark 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.

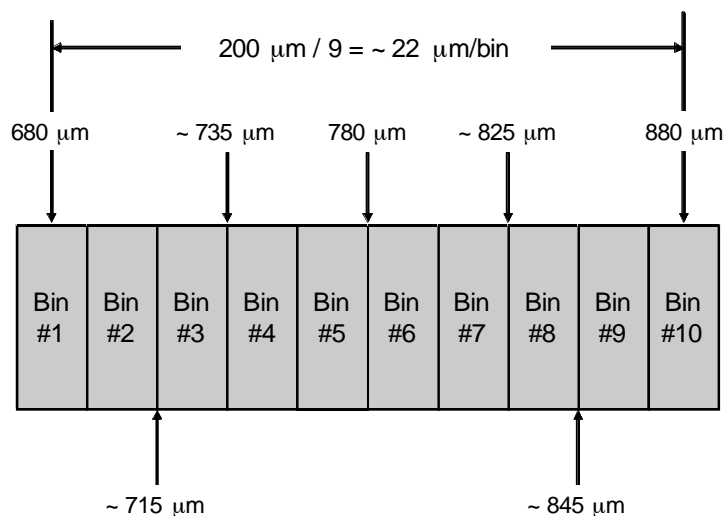


Figure 4-1: Schematic of the collection bins and roller spacing showing relationship between roller gap and particle size.

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 μm 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 μm , respectively, producing the size distribution shown in Figure 4-1. Only particles from Bins #3 - #8, with a particle size range of 715 to 845 μm , were retained with the majority of the particles being from Bins #4 through #7 with a nominal particle size range 735 to 825 μm .

The following pages contain records of the classification performed on the TRISO-coated particle batches associated with the LEU01-48T coated particle composite.

TRISO batches

LEU01-22T (TRISO batch 1)

LEU01-42T (TRISO batch 2)

LEU01-40T (TRISO batch 3)

Sizing & Removal of Aspherical Particles for LEU01-22T**Summary for Sizing of Kernels or Coated Particles**

Procedure:		AGR-ROLLER-SOP-01, Rev. 0		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-22T		
Kernel/Coated Particle Description:		Variant #2, full TRISO on 350 μ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 54		
Date	Batch Weight (g)	Sized Batch Weight (g)	Scrap (g)	Loss (g)
02/02/2006	186.87	179.53	7.37	+0.03
Comments:				
Operator:	<i>Richard A Lowden</i>		Date:	<i>2/6/06</i>
QAS:	<i>MAJ</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:		LEU01-22T		
Kernel/Coated Particle Description:		Variant #2, full TRISO on 350 μ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 55		
Date	Batch Weight (g)	Tabled Batch Weight (g)	Scrap (g)	Loss (g)
02/06/2006	179.53	171.96	7.56	(0.01)
Comments:				
Operator:	<i>Richard A Lowden</i>		Date:	<i>2/6/06</i>
QAS:	<i>MAJ</i>		Date:	<i>3/28/06</i>

Sizing & Removal of Aspherical Particles for LEU01-42T**Summary for Sizing of Kernels or Coated Particles**

Procedure:		AGR-ROLLER-SOP-01, Rev. 0		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-42T		
Kernel/Coated Particle Description:		Variant #2, full TRISO on 350 μ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 56		
Date	Batch Weight (g)	Sized Batch Weight (g)	Scrap (g)	Loss (g)
02/09/2006	186.52	178.70	7.87	+ 0.05
Comments:				
Operator:	<i>Richard A Lowden</i>		Date:	<i>2/14/06</i>
QAS:	<i>Mark G. Jones</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:		LEU01-42T		
Kernel/Coated Particle Description:		Variant #2, full TRISO on 350 μ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 57		
Date	Batch Weight (g)	Tabled Batch Weight (g)	Scrap (g)	Loss (g)
02/14/2006	178.70	167.59	11.04	(0.07)
Comments:				
Operator:	<i>Richard A Lowden</i>		Date:	<i>2/14/06</i>
QAS:	<i>Mark G. Jones</i>		Date:	<i>3/28/06</i>

Sizing & Removal of Aspherical Particles for LEU01-40T

Summary for Sizing of Kernels or Coated Particles

Procedure:		AGR-ROLLER-SOP-01, Rev. 0		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-40T		
Kernel/Coated Particle Description:		Variant #2, full TRISO on 350 μ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 58		
Date	Batch Weight (g)	Sized Batch Weight (g)	Scrap (g)	Loss (g)
02/14/2006	183.32	170.31	13.12	+ 0.11
Comments:				
Operator:	<i>Richard A Lowden</i>		Date:	2/14/06
QAS:	<i>MC</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:		LEU01-40T		
Kernel/Coated Particle Description:		Variant #2, full TRISO on 350 μ m LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 59		
Date	Batch Weight (g)	Tabled Batch Weight (g)	Scrap (g)	Loss (g)
02/15/2006	170.31	160.61	9.66	(0.04)
Comments:				
Operator:	<i>Richard A Lowden</i>		Date:	2/15/06
QAS:	<i>MC</i>		Date:	3/28/06

5 Blend of coated particle composites

Three batches of TRISO-coated particles were blended into composite LEU01-48T. The mass of each batch added to the composite is shown in the following table.

Batch ID	Amount added to LEU01-48T composite (g)
LEU01-22T	153.1337
LEU01-42T	148.8251
LEU01-40T	142.3030
Total	444.2618

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.

Batch ID	Amount added to NUCO350-58B composite (g)
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 LEU01-48T. 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	Acceptance Criteria	Acceptance Test Value	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	k or t value	INL EDF-4380 Rev. 6			
Average kernel diameter (μm)	349.7	9	4304	1.645	mean 350 ± 10	$A = x - ts/\sqrt{n} \geq 340$	349.5	DRF-06 DRF-09
						$B = x + ts/\sqrt{n} \leq 360$	349.9	
				2.38	dispersion $\leq 0.01 < 300$ $\leq 0.01 > 400$	$C = x - ks > 300$	328.3	
						$D = x + ks < 400$	371.1	
Kernel ellipticity (Dmax/Dmin)	1.021		4304		dispersion $\leq 0.10 \geq 1.05$	≤ 1 in 50 or ≤ 7 in 142	94	DRF-06 DRF-09
Kernel envelope density (Mg/m^3)	10.924	0.015	5	2.132	mean ≥ 10.4	$A = x - ts/\sqrt{n} \geq 10.4$	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

Procedure:	AGR-CHAR-DAM-06 Rev. 0
Operator:	Andrew Kercher
Sample ID:	LEUGO350-01B renamed LEU01-01K-B JH 4-17-06
Sample Description:	LEUCO kernel composite 69302
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05051902\

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

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



Operator

05/19/05

Date

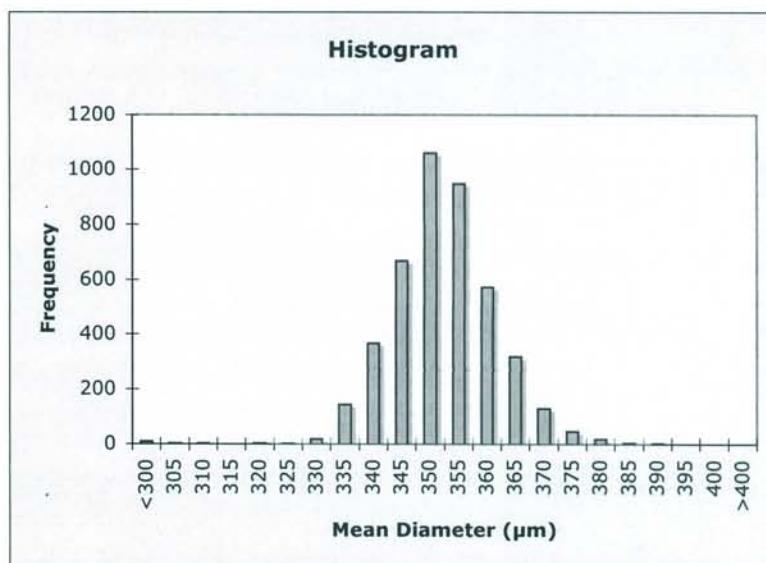
Data Report Form DRF-09A: Measurement of Kernel Diameter

Procedure:	AGR-CHAR-DAM-09 Rev. 0
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05051902
Sample ID:	LEUCO350-01B renamed LEU01-01K-B gm 4-17-06
Sample Description:	BWXT LEUCO kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P05051902_output

Number of kernels analyzed:	4304
Mean of the average diameter of each kernel (μm):	349.7
Standard deviation in the average diameter of each kernel (μm):	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

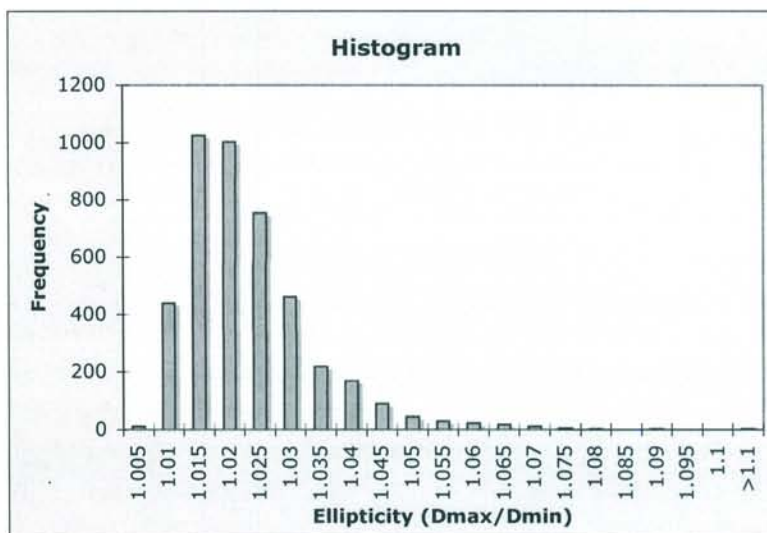
Data Report Form DRF-09B: Measurement of Kernel Ellipticity (Dmax/Dmin)

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

Number of kernels analyzed:	4304
Number of kernels with ellipticity > 1.05:	94
Average kernel ellipticity:	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:	LEUC0350-01 <i>renamed LEJ01-01 K g 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	Acceptance Criteria	Acceptance Test Value	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	k or t value	INL EDF-4380 Rev. 4			
Average kernel diameter (μm)	344.9	15	4202	1.645	mean 350 ± 10	$A = x - ts/\sqrt{n} \geq 340$	344.5	DRF-06 DRF-09
						$B = x + ts/\sqrt{n} \leq 360$	345.3	
				2.38	dispersion $\leq 0.01 < 300$ $\leq 0.01 > 400$	$C = x - ks > 300$	309.2	
						$D = x + ks < 400$	380.6	
Kernel ellipticity (Dmax/Dmin)	1.022		4202		dispersion $\leq 0.10 \geq 1.05$	≤ 1 in 50 or ≤ 7 in 142	186	DRF-06 DRF-09
Kernel envelope density (Mg/m^3)	10.800	0.006	5	2.132	mean ≥ 10.4	$A = x - ts/\sqrt{n} \geq 10.4$	10.79	DRF-15 DRF-22

Comments

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



QC Supervisor

2-20-06

Date



QA Reviewer

2/22/06

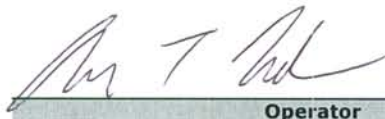
Date

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

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

DMR Calibration Expiration Date:	3/25/06
Stage Micrometer Calibration Expiration Date:	2/17/07
Measured Value for 760 μm in Stage Micrometer Image:	760.6 μ m

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


Operator

5/25/2005
Date

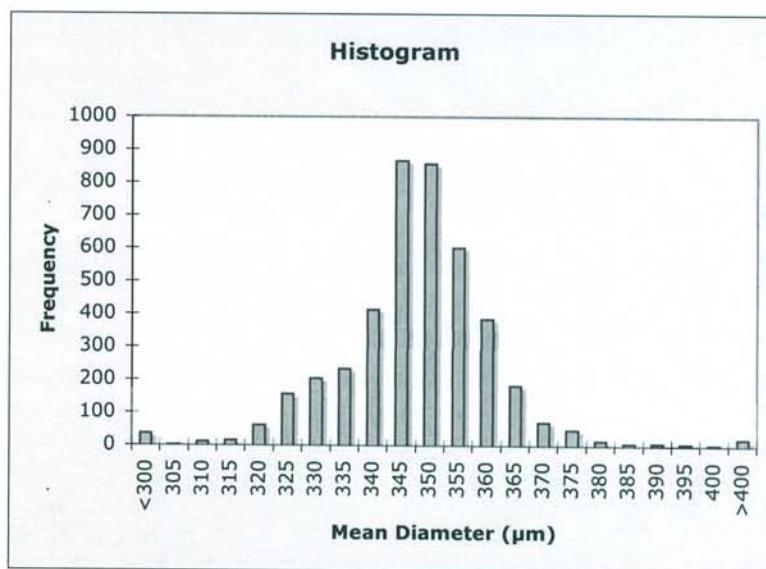
Data Report Form DRF-09A: Measurement of Kernel Diameter

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

Number of kernels analyzed:	4202
Mean of the average diameter of each kernel (μm):	344.9
Standard deviation in the average diameter of each kernel (μm):	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

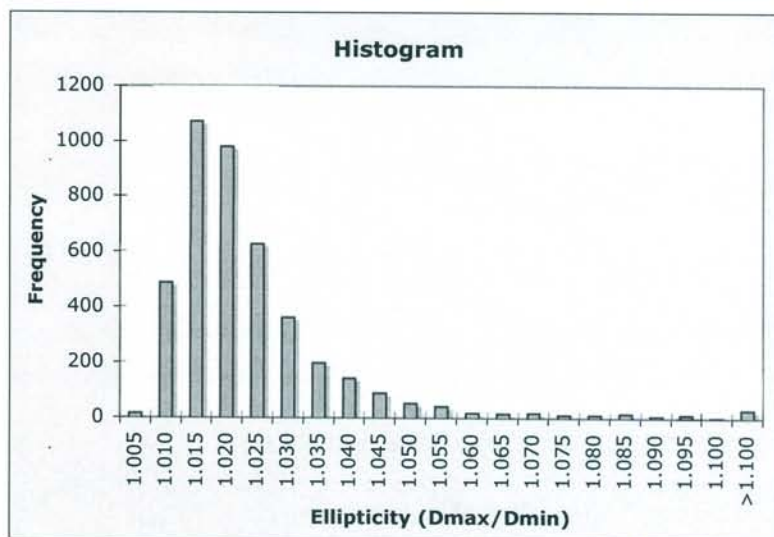
Data Report Form DRF-09B: Measurement of Kernel Ellipticity (Dmax/Dmin)

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

Number of kernels analyzed:	4202
Number of kernels with ellipticity >1.05:	186
Average kernel ellipticity:	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

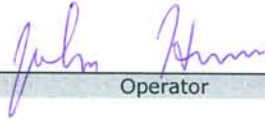
Date

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 LEU01-48T 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 μm diameter 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 sets of results for all buffer interrupted batches were within the density range specified in table 5.2 of 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.

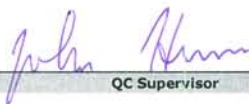
Inspection Report Form IRF-02A: Interrupted Coating Batches - Buffer Density

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	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	t value (t)	INL EDF-4380 Rev. 6				
Batch 1: Buffer envelope density (Mg/m ³)	1.08	0.04	5	2.132	mean 1.03 ± 0.15	A = $x - ts/\sqrt{n} \geq 0.88$	1.04	pass	DRF-16
						B = $x + ts/\sqrt{n} \leq 1.18$	1.12	pass	DRF-22
Batch 2: Buffer envelope density (Mg/m ³)	1.11	0.05	5	2.132	mean 1.03 ± 0.15	A = $x - ts/\sqrt{n} \geq 0.88$	1.06	pass	DRF-16
						B = $x + ts/\sqrt{n} \leq 1.18$	1.16	pass	DRF-22
Batch 3: Buffer envelope density (Mg/m ³)	1.11	0.04	5	2.132	mean 1.03 ± 0.15	A = $x - ts/\sqrt{n} \geq 0.88$	1.07	pass	DRF-16
						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 μm based on average envelope volume of 9.25E-5 cc (effective diameter of 561 μm) and average kernel diameter of 345 μm .
 Average thickness of buffer was 108 μm based on average outer diameter of 561 μm obtained per DAM-10 and average kernel diameter of 345 μm .
 Confirmatory batch on LEUCO kernels, LEU01-163: mean buffer density = 1.10 g/cc.


 QC Supervisor


 Date

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


 QA Reviewer


 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

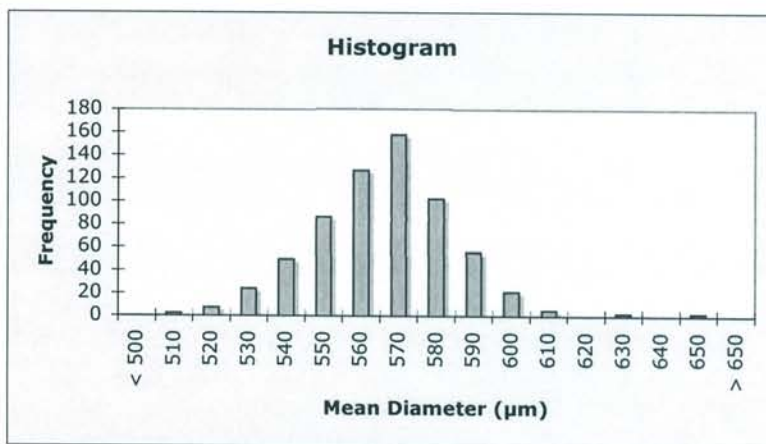
Data Report Form DRF-10A: Measurement of Particle Diameter

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 (μm):	561
Standard deviation in the average diameter of each particle (μm):	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



Operator

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


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 LEU01-48T 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. According to section 5.3 of EDF-4380, Rev. 6, three representative IPyC layers from interrupted batches which meet the specification for IPyC density are sufficient to qualify the process for IPyC density.

The IPyC coatings for variant 2 were deposited at a coating gas fraction (CGF) of 0.45 propylene/acetylene instead of the baseline CGF of 0.30. According to section 3.2 of EDF-4380, the increase in coating gas fraction was not expected to produce a significant increase in IPyC density. The average IPyC density of the baseline IPyC interrupted batches was 1.904 Mg/m³. The average IPyC density of the variant 2 IPyC interrupted batches was 1.912 Mg/m³ and all three were within the density range specified in table 5.2 of EDF-4380, Rev. 6

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-028: Interrupted Coating Batches - IPyC Density

Procedure:	AGR-CHAR-PIP-02 Rev. 4
Batch 1 ID:	LEU01-18I
Batch 1 description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Batch 2 ID:	LEU01-33I
Batch 2 description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Batch 3 ID:	LEU01-39I
Batch 3 description:	Variant 2: 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 (\bar{x})	Std. Dev. (s)	# measured (n)						
Batch 1: IPyC sink/float density (Mg/m ³)	1.9113	0.0165	54	1.674	mean 1.90 ± 0.05	$A = \bar{x} - ts/\sqrt{n} \geq 1.85$	1.908	pass	DRF-03
						$B = \bar{x} + ts/\sqrt{n} \leq 1.95$	1.915	pass	
				2.831	dispersion $\leq 0.01 \leq 1.80$ $\leq 0.01 \geq 2.00$	$C = \bar{x} - ks > 1.80$	1.865	pass	
						$D = \bar{x} + ks < 2.00$	1.958	pass	
Batch 2: IPyC sink/float density (Mg/m ³)	1.9089	0.0134	56	1.673	mean 1.90 ± 0.05	$A = \bar{x} - ts/\sqrt{n} \geq 1.85$	1.906	pass	DRF-03
						$B = \bar{x} + ts/\sqrt{n} \leq 1.95$	1.912	pass	
				2.820	dispersion $\leq 0.01 \leq 1.80$ $\leq 0.01 \geq 2.00$	$C = \bar{x} - ks > 1.80$	1.871	pass	
						$D = \bar{x} + ks < 2.00$	1.947	pass	
Batch 3: IPyC sink/float density (Mg/m ³)	1.9171	0.0139	42	1.683	mean 1.90 ± 0.05	$A = \bar{x} - ts/\sqrt{n} \geq 1.85$	1.913	pass	DRF-03
						$B = \bar{x} + ts/\sqrt{n} \leq 1.95$	1.921	pass	
				2.913	dispersion $\leq 0.01 \leq 1.80$ $\leq 0.01 \geq 2.00$	$C = \bar{x} - ks > 1.80$	1.877	pass	
						$D = \bar{x} + ks < 2.00$	1.958	pass	

Comments

Coating thickness, particle weight, and open porosity of IPyC provided for information only.


QC Supervisor

2-28-06
Date

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


QA Reviewer

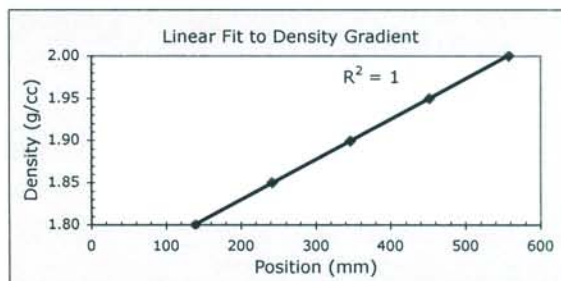
4/27/06
Date

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\D06011901_DRF03R2.xls
Sample ID:	LEU01-181-B01
Sample description:	Variant 2 IPyC/Buffer on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	23.5 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	134.89	143.29	139.09
1.850	237.87	245.82	241.85
1.900	343.13	349.91	346.52
1.950	447.65	455.44	451.55
2.000	554.06	561.21	557.64

Linear Fit			
slope	StDev	intercept	StDev
4.78E-04	2.87E-06	1.73E+00	1.00E-03



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	305.60	1.8801	26	371.90	1.9117	51	414.60	1.9321
2	313.96	1.8841	27	372.32	1.9119	52	419.26	1.9344
3	315.37	1.8847	28	373.51	1.9125	53	426.52	1.9378
4	294.52	1.8748	29	383.89	1.9175	54	435.63	1.9422
5	289.40	1.8723	30	374.77	1.9131	55		
6	293.09	1.8741	31	379.39	1.9153	56		
7	310.32	1.8823	32	380.53	1.9159	57		
8	326.04	1.8898	33	382.22	1.9167	58		
9	340.72	1.8968	34	386.56	1.9187	59		
10	344.78	1.8988	35	387.60	1.9192	60		
11	352.66	1.9025	36	388.82	1.9198	61		
12	352.66	1.9025	37	390.81	1.9208	62		
13	354.53	1.9034	38	391.60	1.9211	63		
14	355.93	1.9041	39	392.52	1.9216	64		
15	356.66	1.9045	40	393.98	1.9223	65		
16	358.14	1.9052	41	394.92	1.9227	66		
17	361.45	1.9067	42	397.51	1.9240	67		
18	362.39	1.9072	43	397.95	1.9242	68		
19	362.92	1.9074	44	399.26	1.9248	69		
20	364.86	1.9084	45	400.71	1.9255	70		
21	366.94	1.9094	46	402.77	1.9265	71		
22	368.20	1.9100	47	403.65	1.9269	72		
23	369.44	1.9106	48	406.52	1.9283	73		
24	371.45	1.9115	49	409.36	1.9296	74		
25	371.45	1.9115	50	413.79	1.9317	75		
Average density of PyC fragments:					1.9113			
Standard deviation in density of PyC fragments:					0.0165			
Uncertainty in calculated density of PyC fragments:					0.0016			

Dixie Barker
Operator

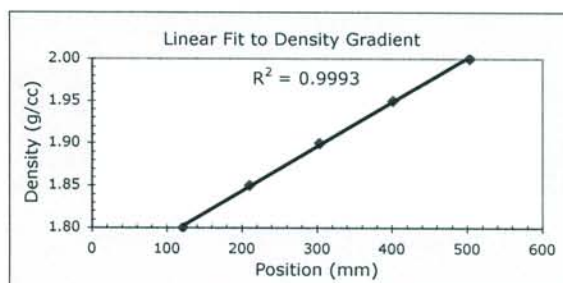
1-19-06
Date

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\D06013101_DRF03R2.xls
Sample ID:	LEU01-331-B01
Sample description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	23.4 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	116.57	126.03	121.30
1.850	206.44	214.80	210.62
1.900	301.14	307.05	304.10
1.950	397.85	405.22	401.54
2.000	499.99	506.96	503.48

Linear Fit			
slope	StDev	intercept	StDev
5.23E-04	3.71E-06	1.74E+00	1.15E-03



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	252.81	1.8710	26	324.14	1.9083	51	355.65	1.9248
2	254.20	1.8718	27	325.10	1.9088	52	356.41	1.9252
3	285.10	1.8879	28	326.48	1.9096	53	359.73	1.9269
4	291.25	1.8911	29	327.13	1.9099	54	361.41	1.9278
5	293.03	1.8921	30	328.24	1.9105	55	362.70	1.9285
6	293.73	1.8924	31	331.49	1.9122	56	375.72	1.9353
7	296.72	1.8940	32	333.89	1.9134	57		
8	296.72	1.8940	33	335.77	1.9144	58		
9	299.29	1.8953	34	336.98	1.9150	59		
10	300.39	1.8959	35	338.22	1.9157	60		
11	301.73	1.8966	36	339.68	1.9165	61		
12	302.44	1.8970	37	340.42	1.9168	62		
13	307.22	1.8995	38	341.77	1.9176	63		
14	308.65	1.9002	39	342.02	1.9177	64		
15	308.34	1.9001	40	343.19	1.9183	65		
16	309.65	1.9008	41	344.59	1.9190	66		
17	310.59	1.9012	42	343.01	1.9182	67		
18	311.48	1.9017	43	344.13	1.9188	68		
19	312.96	1.9025	44	346.30	1.9199	69		
20	313.85	1.9030	45	347.01	1.9203	70		
21	319.05	1.9057	46	347.37	1.9205	71		
22	320.05	1.9062	47	348.05	1.9208	72		
23	322.35	1.9074	48	349.54	1.9216	73		
24	323.15	1.9078	49	350.02	1.9219	74		
25	323.54	1.9080	50	352.10	1.9230	75		
Average density of PyC fragments:					1.9089			
Standard deviation in density of PyC fragments:					0.0134			
Uncertainty in calculated density of PyC fragments:					0.0018			

Dixie Barker
Operator

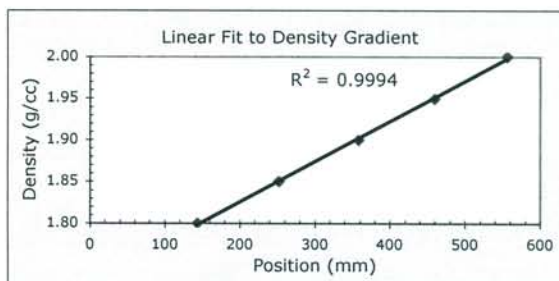
1-31-06
Date

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\D06020101_DRF03R2.xls
Sample ID:	LEU01-39I-B01
Sample description:	Variant 2: IPyC/Buffer 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
1.800	139.34	147.88	143.61
1.850	248.40	256.87	252.64
1.900	356.69	360.66	358.68
1.950	455.78	463.07	459.43
2.000	553.07	559.82	556.45

Linear Fit			
slope	StDev	intercept	StDev
4.84E-04	3.21E-06	1.73E+00	1.14E-03



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	315.65	1.8814	26	403.94	1.9241	51		
2	318.76	1.8829	27	403.94	1.9241	52		
3	328.59	1.8876	28	404.76	1.9245	53		
4	332.02	1.8893	29	405.87	1.9250	54		
5	336.52	1.8915	30	406.98	1.9256	55		
6	341.86	1.8940	31	407.44	1.9258	56		
7	355.18	1.9005	32	408.45	1.9263	57		
8	368.15	1.9068	33	410.00	1.9270	58		
9	378.26	1.9117	34	410.37	1.9272	59		
10	385.69	1.9153	35	410.37	1.9272	60		
11	385.96	1.9154	36	411.99	1.9280	61		
12	390.32	1.9175	37	415.65	1.9298	62		
13	382.69	1.9138	38	417.15	1.9305	63		
14	383.74	1.9143	39	420.98	1.9323	64		
15	387.54	1.9162	40	423.23	1.9334	65		
16	391.94	1.9183	41	413.24	1.9286	66		
17	392.74	1.9187	42	415.29	1.9296	67		
18	392.74	1.9187	43			68		
19	398.10	1.9213	44			69		
20	398.61	1.9215	45			70		
21	398.92	1.9217	46			71		
22	400.21	1.9223	47			72		
23	401.07	1.9227	48			73		
24	401.73	1.9230	49			74		
25	403.25	1.9238	50			75		
Average density of PyC fragments:					1.9171			
Standard deviation in density of PyC fragments:					0.0139			
Uncertainty in calculated density of PyC fragments:					0.0018			

Dixie Barker
Operator

2-01-06
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.

Summary of "info only" measurements

Coating Thickness

		Buffer thickness (μm)	IPyC thickness (μm)
Batch 1	LEU01-18I	107	37.1
Batch 2	LEU01-33I	110	38.0
Batch 3	LEU01-39I	109	38.4
Average		109	37.8

Open Porosity between 250 psi and 10000 psi

		Average particle weight (g)	Open porosity (ml/m^2)
Batch 1	LEU01-18I	4.15E-04	2.03
Batch 2	LEU01-33I	4.22E-04	2.07
Batch 3	LEU01-39I	4.22E-04	2.11
Average		4.20E-04	2.07

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. 8. 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 (ml/m^2)
Batch 1	LEU01-18I	4.15E-04	1.62
Batch 2	LEU01-33I	4.22E-04	1.66
Batch 3	LEU01-39I	4.22E-04	1.73
Average		4.20E-04	1.67

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

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	John Hunn
Sample ID:	LEU01-18I
Sample description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Mount ID number:	M06011902
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06012003

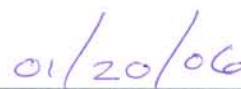
DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 μm in stage micrometer image (μm):	500.4

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
300	297	309	314

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
172	105	40		



Operator



Date

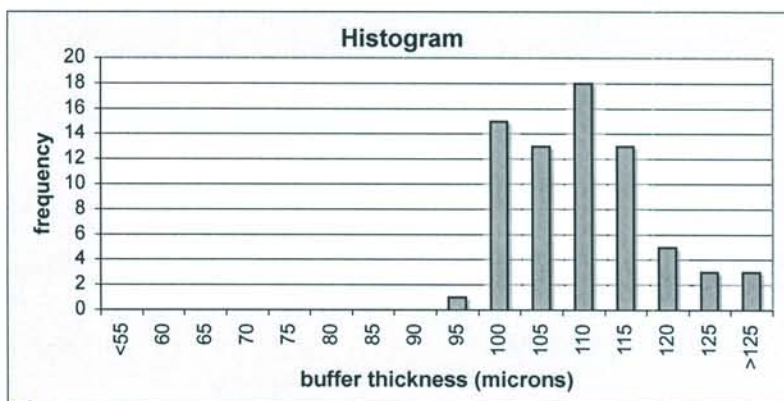
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012003\
Sample ID:	LEU01-18I
Sample Description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012003_output\

Number of buffer layers analyzed:	71
Mean of the average buffer thickness of each particle (μm):	107.3
Standard deviation in the average buffer thickness of each particle (μm):	8.4

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	15
105	13
110	18
115	13
120	5
125	3
>125	3



Andrew K. Kercher
Operator

January 23, 2006
Date

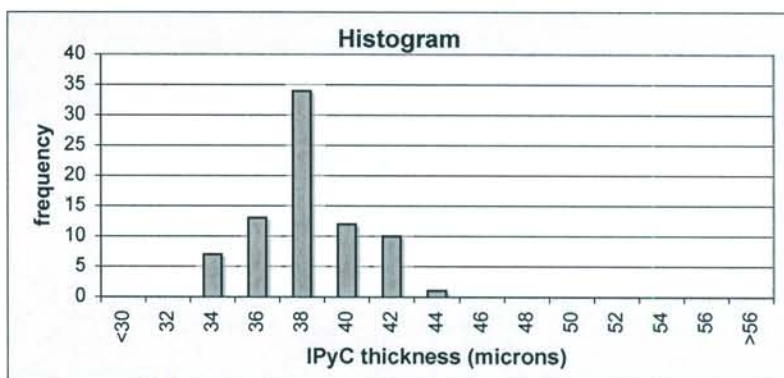
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012003\
Sample ID:	LEU01-18I
Sample Description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06012003_output\

Number of inner pyrocarbon layers analyzed:	77
Mean of the average IPyC thickness of each particle (μm):	37.1
Standard deviation in the average IPyC thickness of each particle (μm):	2.3

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	Frequency
<30	0
32	0
34	7
36	13
38	34
40	12
42	10
44	1
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



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:	LEU01-33I-E01
Sample description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Mount ID number:	M06012702L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06013101\P0601310101\

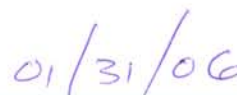
DMR calibration expiration date:	9/8/06
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/07
Measured value for 500 μm in stage micrometer image (μm):	500.4

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
297	301	300	298

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
170	109	40		



Operator



Date

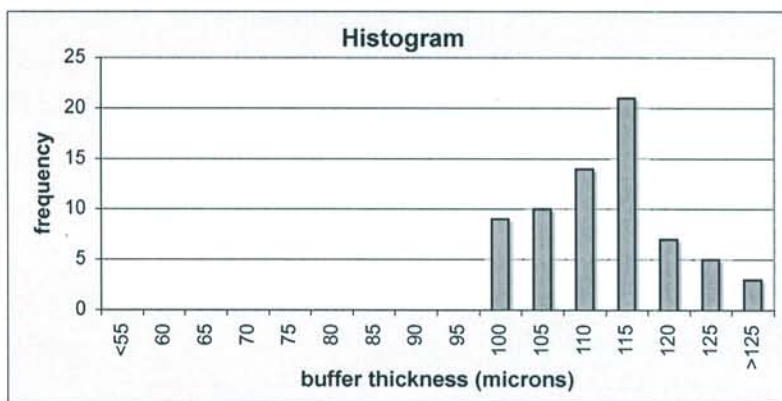
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06013101\
Sample ID:	LEU01-33I-E01
Sample Description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06013101_output\

Number of buffer layers analyzed:	69
Mean of the average buffer thickness of each particle (μm):	109.8
Standard deviation in the average buffer thickness of each particle (μm):	7.7

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	0
100	9
105	10
110	14
115	21
120	7
125	5
>125	3



Andrew K. Kercher
Operator

02/01/06
Date

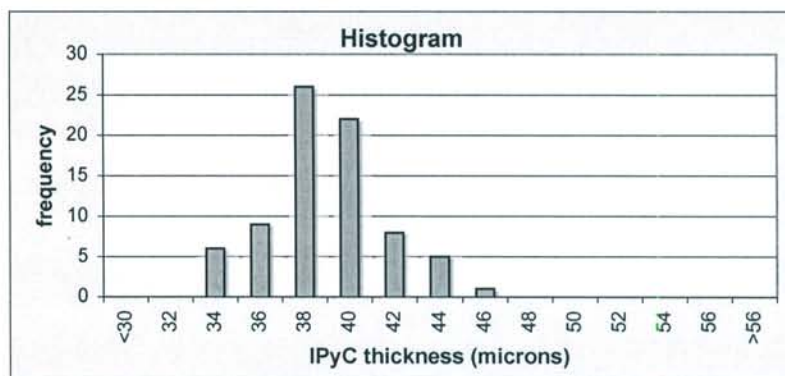
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06013101\
Sample ID:	LEU01-331-E01
Sample Description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06013101_output\

Number of inner pyrocarbon layers analyzed:	77
Mean of the average IPyC thickness of each particle (μm):	38.0
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	0
34	6
36	9
38	26
40	22
42	8
44	5
46	1
48	0
50	0
52	0
54	0
56	0
>56	0



Andrew K. Kercher
Operator

02/01/06
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:	LEU01-39I-E01
Sample description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Mount ID number:	M06013001L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06020101\P0602010101\

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):	500.4

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
327	306	338	310

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
173	115	40		



Operator



Date

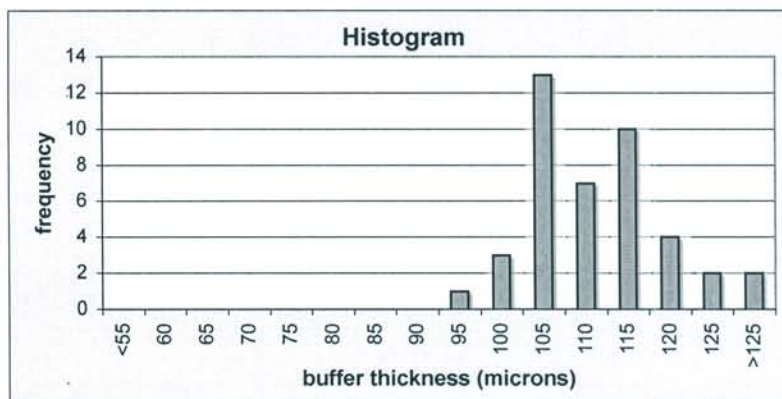
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020101\
Sample ID:	LEU01-391-E01
Sample Description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020101_output\

Number of buffer layers analyzed:	42
Mean of the average buffer thickness of each particle (μm):	108.5
Standard deviation in the average buffer thickness of each particle (μm):	8.1

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	3
105	13
110	7
115	10
120	4
125	2
>125	2



Andrew K. Kercher
Operator

02/02/06
Date

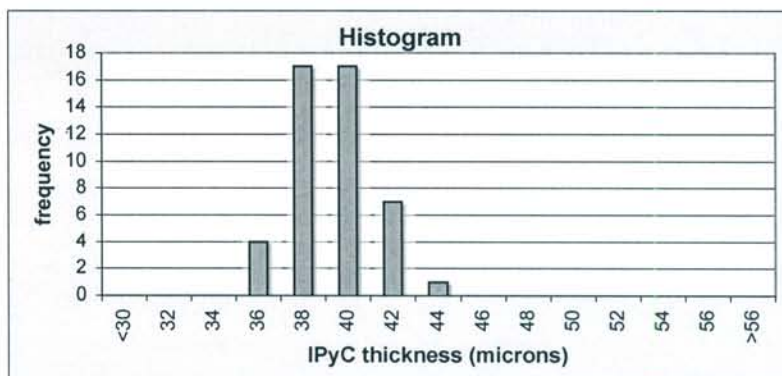
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020101\
Sample ID:	LEU01-391-E01
Sample Description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020101_output\

Number of inner pyrocarbon layers analyzed:	46
Mean of the average IPyC thickness of each particle (μm):	38.4
Standard deviation in the average IPyC thickness of each particle (μm):	1.8

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	Frequency
<30	0
32	0
34	0
36	4
38	17
40	17
42	7
44	1
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



Andrew K. Kercher
Operator

02/02/06
Date

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

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-18I-C01
Particle Lot Description:	Variant 2 IPyC/Buffer on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06011901__DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	6.43E-02	8.26E-02	7.28E-02	8.25E-02	7.45E-02
Number of particles:	154	199	175	200	180
Average weight/particle (g):	4.18E-04	4.15E-04	4.16E-04	4.13E-04	4.14E-04

Mean average weight/particle (g):	4.15E-04
Uncertainty in mean average weight/particle (g):	8.63E-07

Dixie Barker
Operator

1-19-06
Date

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

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-33I-C01
Particle Lot Description:	Variant 2 IPyC/Buffer on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06013001_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	4.62E-02	4.52E-02	6.82E-02	8.19E-02	7.02E-02
Number of particles:	109	107	162	194	167
Average weight/particle (g):	4.24E-04	4.22E-04	4.21E-04	4.22E-04	4.20E-04

Mean average weight/particle (g):	4.22E-04
Uncertainty in mean average weight/particle (g):	6.06E-07

Dixie Barker
Operator

1-30-06
Date

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

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-39I-C01
Particle Lot Description:	Variant 2: IPyC/Buffer on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06013101_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	6.95E-02	6.91E-02	6.77E-02	7.60E-02	6.06E-02
Number of particles:	165	164	160	180	144
Average weight/particle (g):	4.21E-04	4.21E-04	4.23E-04	4.22E-04	4.21E-04

Mean average weight/particle (g):	4.22E-04
Uncertainty in mean average weight/particle (g):	4.13E-07

Dixie Barker
Operator

1-31-06
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:	LEU01-18I-D01
Batch Description:	Variant 2 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\S06012001\S06012001_DRF31R0.xls

Mean average weight/particle (g):	4.15E-04
Uncertainty in mean average weight/particle (g):	8.63E-07

Weight of particles (g):	3.9817
Approximate number of particles:	9594
Uncertainty in number of particles:	20
Total envelope volume of sample (cc):	1.324
Average envelope volume/particle (cc):	1.38E-04
Sample envelope density (g/cc):	3.007

Average particle diameter (microns):	6.41E+02
Average surface area/particle (cm ²):	1.29E-02
Total sample surface area (cm ²):	1.24E+02
Intruded mercury volume from 250-10,000 psia (cc):	2.52E-02
Open porosity (ml/m ²):	2.03E+00

Comments

S.D. Nunn

Operator

1/20/06

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:	LEU01-33I-D01
Batch Description:	Variant 2 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\S06013101\S06013101_DRF31R0.xls

Mean average weight/particle (g):	4.22E-04
Uncertainty in mean average weight/particle (g):	6.06E-07

Weight of particles (g):	3.9130
Approximate number of particles:	9273
Uncertainty in number of particles:	13
Total envelope volume of sample (cc):	1.319
Average envelope volume/particle (cc):	1.42E-04
Sample envelope density (g/cc):	2.967

Average particle diameter (microns):	6.48E+02
Average surface area/particle (cm ²):	1.32E-02
Total sample surface area (cm ²):	1.22E+02
Intruded mercury volume from 250-10,000 psia (cc):	2.53E-02
Open porosity (ml/m ²):	2.07E+00

Comments

S. D. Nunn

Operator

1/31/06

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:	LEU01-39I-D01
Batch Description:	Variant 2 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\S06020101\S06020101_DRF31R0.xls

Mean average weight/particle (g):	4.22E-04
Uncertainty in mean average weight/particle (g):	4.13E-07

Weight of particles (g):	3.9430
Approximate number of particles:	9344
Uncertainty in number of particles:	9
Total envelope volume of sample (cc):	1.316
Average envelope volume/particle (cc):	1.41E-04
Sample envelope density (g/cc):	2.996

Average particle diameter (microns):	6.46E+02
Average surface area/particle (cm ²):	1.31E-02
Total sample surface area (cm ²):	1.22E+02
Intruded mercury volume from 250-10,000 psia (cc):	2.58E-02
Open porosity (ml/m ²):	2.11E+00

Comments

S.D. Nunn

Operator

2/1/06

Date

10 Characterization of first batch of TRISO-coated particles

This section contains data on LEU01-22T, the first batch of TRISO-coated particles used for the LEU01-48T 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 μm 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:	LEU01-22T
Coated particle batch description:	Variant 2: 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)	101.1	7.0	188	1.653	mean 100 ± 15	$A = x - ts/\sqrt{n} \geq 85$ $B = x + ts/\sqrt{n} \leq 115$	100.3 101.9	pass pass	DRF-08 DRF-11
Average IPyC thickness for each particle (μm)	40.4	2.5	237	1.651	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)	35.0	1.2	237	1.651	mean 35 ± 4	$A = x - ts/\sqrt{n} \geq 31$ $B = x + ts/\sqrt{n} \leq 39$	34.9 35.1	pass pass	DRF-08 DRF-11
Average OPyC thickness for each particle (μm)	40.6	2.0	237	1.651	mean 40 ± 5	$A = x - ts/\sqrt{n} \geq 35$ $B = x + ts/\sqrt{n} \leq 45$	40.4 40.8	pass pass	DRF-08 DRF-11
Particles with missing OPyC			15634		defect fraction $\leq 6.0 \times 10^{-4}$	≤ 4 in 15,500	0	pass	DRF-19

Comments


QC Supervisor

3-1-06
Date

Accept Coated particle batch (Yes or No): Yes


QA Reviewer

4/27/06
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:	LEU01-22T-B01
Sample description:	Variant 2: TRISO on BWXT kernel composite 69302
Mount ID number:	M06021501L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06022704\P0602270401\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
Measured value for 500 μm in stage micrometer image (μm):	500.4

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
373	368	370	361

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
174	99	39	38	41

 Operator	February 27, 2006 Date
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Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

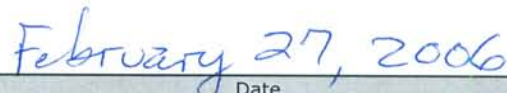
Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-22T-B01
Sample description:	Variant 2: TRISO on BWXT kernel composite 69302
Mount ID number:	M06021502L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06022704\P0602270402\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
Measured value for 500 μm in stage micrometer image (μm):	500.4

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
373	378	371	371

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
176	95	41	37	42


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:	LEU01-22T-B01
Sample description:	Variant 2: TRISO on BWXT kernel composite 69302
Mount ID number:	M06021503L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06022704\P0602270403\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
Measured value for 500 μm in stage micrometer image (μm):	500.4

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
354	367	364	375

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
177	104	39	37	39


Operator

February 27, 2006
Date

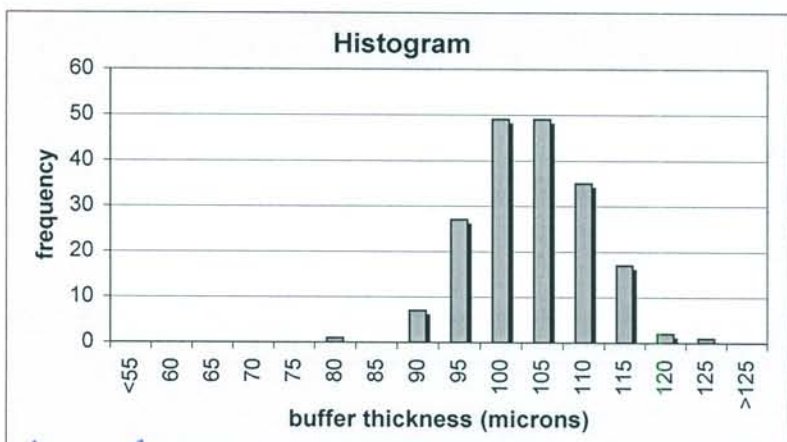
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022704\
Sample ID:	LEU01-22T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel comoposite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022704_output\

Number of buffer layers analyzed:	188
Mean of the average buffer thickness of each particle (μm):	101.1
Standard deviation in the average buffer thickness of each particle (μm):	7.0

Distribution of the average buffer layer thickness (top binned)

Buffer Thickness (μm)	Frequency
<55	0
60	0
65	0
70	0
75	0
80	1
85	0
90	7
95	27
100	49
105	49
110	35
115	17
120	2
125	1
>125	0



Andrew K. Kercher
Operator

February 28, 2006
Date

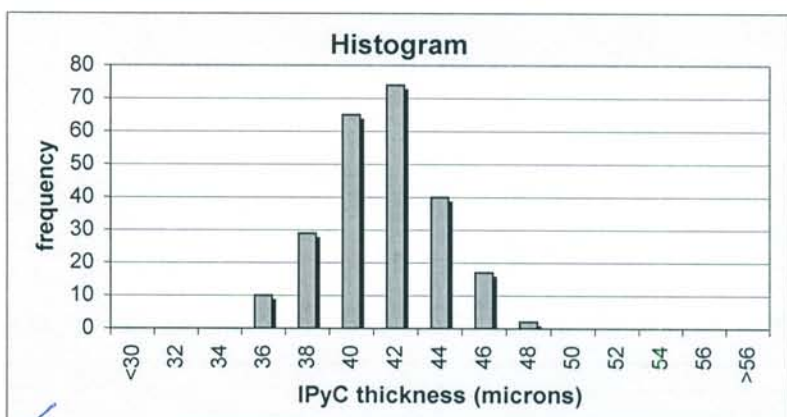
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022704\
Sample ID:	LEU01-22T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022704_output\

Number of inner pyrocarbon layers analyzed:	237
Mean of the average IPyC thickness of each particle (μm):	40.4
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	0
34	0
36	10
38	29
40	65
42	74
44	40
46	17
48	2
50	0
52	0
54	0
56	0
>56	0



Andrew K. Kercher
Operator

February 28, 2006
Date

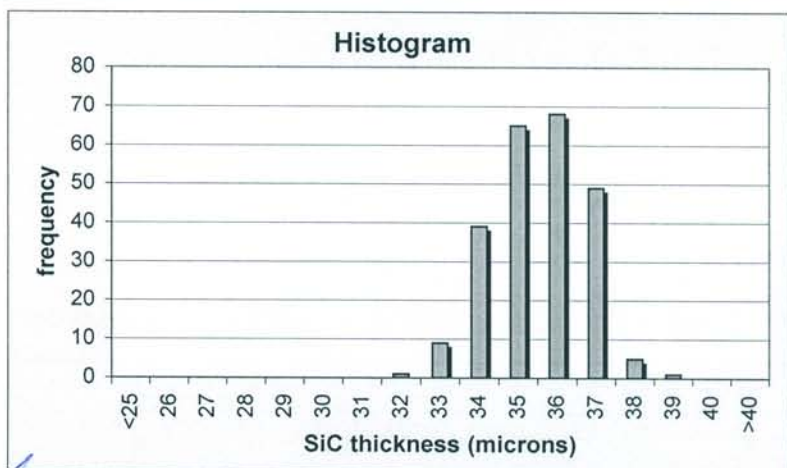
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022704\
Sample ID:	LEU01-22T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel comoposite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022704_output\

Number of silicon carbide layers analyzed:	237
Mean of the average SiC thickness of each particle (μm):	35.0
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	1
33	9
34	39
35	65
36	68
37	49
38	5
39	1
40	0
>40	0



Andrew K. Kercher
Operator

February 28, 2006
Date

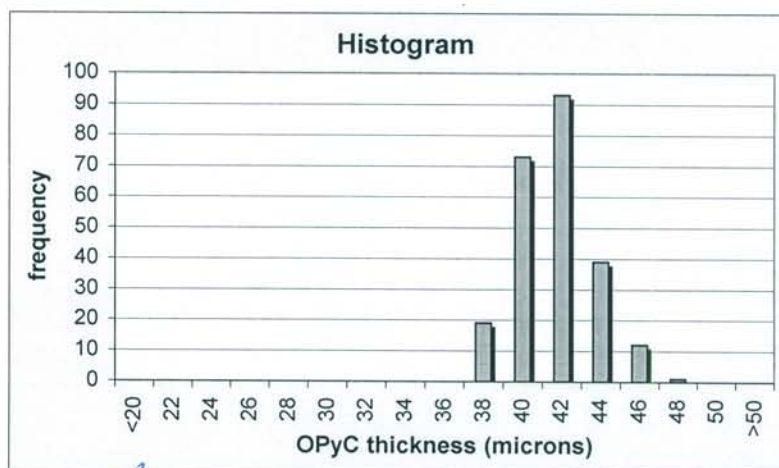
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022704\
Sample ID:	LEU01-22T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022704_output\

Number of outer pyrocarbon layers analyzed:	237
Mean of the average OPyC thickness of each particle (μm):	40.6
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	19
40	73
42	93
44	39
46	12
48	1
50	0
>50	0



Andrew K. Kercher
Operator

February 28, 2006
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:	LEU01-22T-C01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06022201_DRF19R1.xls

Mean average weight/particle (g):	7.31E-04
Uncertainty in average weight/particle (g):	1.00E-06
Weight of sample of particles (g):	11.429
Approximate number of particles in sample:	15634
Uncertainty in number of particles in sample:	21

Number of particles with missing OPyC layer:	0
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Comments on unusual visual characteristics of OPyC

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 Operator	2-22-06 Date
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For Information Only

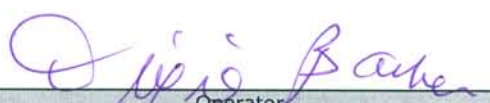
The information in the remainder of this section reports results of measurements not required by the fuel specification and is provided for information only.

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

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEU01-22T-D01
Particle Lot Description:	Variant 2: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06020901_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	8.73E-02	9.39E-02	9.26E-02	9.36E-02	7.83E-02
Number of particles:	119	129	127	128	107
Average weight/particle (g):	7.34E-04	7.28E-04	7.29E-04	7.31E-04	7.32E-04

Mean average weight/particle (g):	7.31E-04
Uncertainty in mean average weight/particle (g):	1.00E-06


Operator


Date

11 Characterization of second batch of TRISO-coated particles

This section contains data on LEU01-42T, the second batch of TRISO-coated particles used for the LEU01-48T 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 μm 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:	LEU01-42T
Coated particle batch description:	Variant 2: 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)	102.2	7.6	170	1.654	mean 100 ± 15	$A = x - ts/\sqrt{n} \geq 85$ $B = x + ts/\sqrt{n} \leq 115$	101.2 103.2	pass pass	DRF-08 DRF-11
Average IPyC thickness for each particle (μm)	40.3	2.8	233	1.651	mean 40 ± 5	$A = x - ts/\sqrt{n} \geq 35$ $B = x + ts/\sqrt{n} \leq 45$	40.0 40.6	pass pass	DRF-08 DRF-11
Average SiC thickness for each particle (μm)	34.7	1.1	234	1.651	mean 35 ± 4	$A = x - ts/\sqrt{n} \geq 31$ $B = x + ts/\sqrt{n} \leq 39$	34.6 34.8	pass pass	DRF-08 DRF-11
Average OPyC thickness for each particle (μm)	40.2	1.8	234	1.651	mean 40 ± 5	$A = x - ts/\sqrt{n} \geq 35$ $B = x + ts/\sqrt{n} \leq 45$	40.0 40.4	pass pass	DRF-08 DRF-11
Particles with missing OPyC			15643		defect fraction $\leq 6.0 \times 10^{-4}$	≤ 4 in 15,500	0	pass	DRF-19

Comments


QC Supervisor

3-10-06
Date

Accept Coated particle batch (Yes or No):	Yes
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QA Reviewer

4/27/06
Date

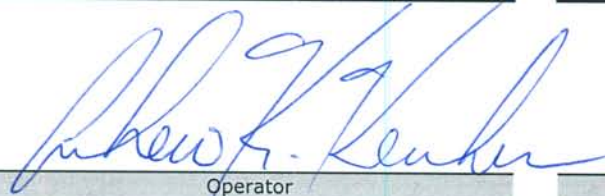

Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-42T-B01
Sample description:	Variant 2: TRISO on BWXT kernel composite 69302
Mount ID number:	M06030101L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06030201\P0603020101\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
Measured value for 500 μm in stage micrometer image (μm):	500.4

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
384	394	401	419

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
180	102	38	37	40

Operator	Date
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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:	LEU01-42T-B01
Sample description:	Variant 2: TRISO on BWXT kernel composite 69302
Mount ID number:	M06030104L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06030201\P0603020102\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
Measured value for 500 μm in stage micrometer image (μm):	500.4

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
405	395	388	382

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
177	105	40	36	40


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:	LEU01-42T-B01
Sample description:	Variant 2: TRISO on BWXT kernel composite 69302
Mount ID number:	M06030105L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06030201\P0603020103\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
Measured value for 500 μm in stage micrometer image (μm):	500.4

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
366	361	371	369

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
174	101	41	36	39

 Operator	March 2, 2006 Date
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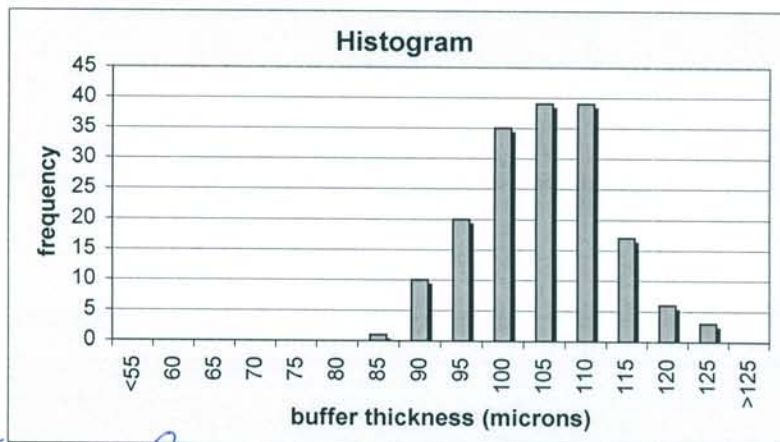
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06030201\
Sample ID:	LEU01-42T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06030201_output\

Number of buffer layers analyzed:	170
Mean of the average buffer thickness of each particle (μm):	102.2
Standard deviation in the average buffer thickness of each particle (μm):	7.6

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	1
90	10
95	20
100	35
105	39
110	39
115	17
120	6
125	3
>125	0



Andrew K. Kercher

Operator

03/02/06

Date

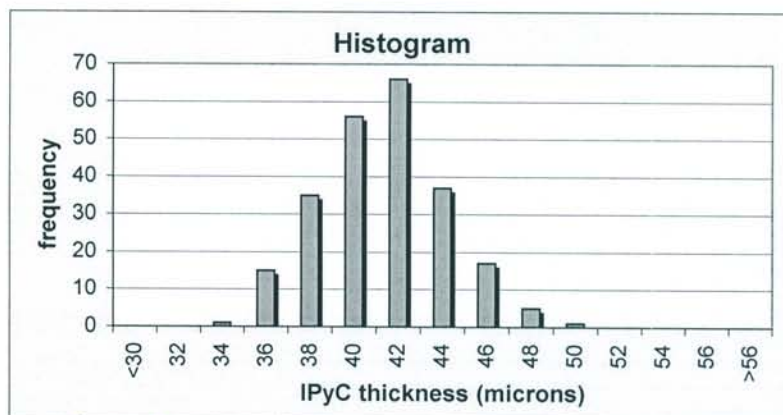
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06030201\
Sample ID:	LEU01-42T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06030201_output\

Number of inner pyrocarbon layers analyzed:	233
Mean of the average IPyC thickness of each particle (μm):	40.3
Standard deviation in the average IPyC thickness of each particle (μm):	2.8

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	Frequency
<30	0
32	0
34	1
36	15
38	35
40	56
42	66
44	37
46	17
48	5
50	1
52	0
54	0
56	0
>56	0



Andrew K. Kercher
Operator

03/02/06
Date

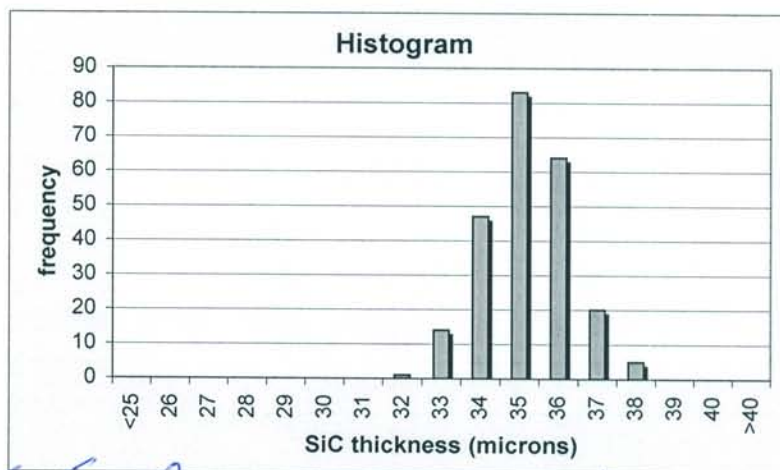
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06030201\
Sample ID:	LEU01-42T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06030201_output\

Number of silicon carbide layers analyzed:	234
Mean of the average SiC thickness of each particle (μm):	34.7
Standard deviation in the average SiC thickness of each particle (μm):	1.1

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	1
33	14
34	47
35	83
36	64
37	20
38	5
39	0
40	0
>40	0



Andrew K. Kercher
Operator

03/02/06
Date

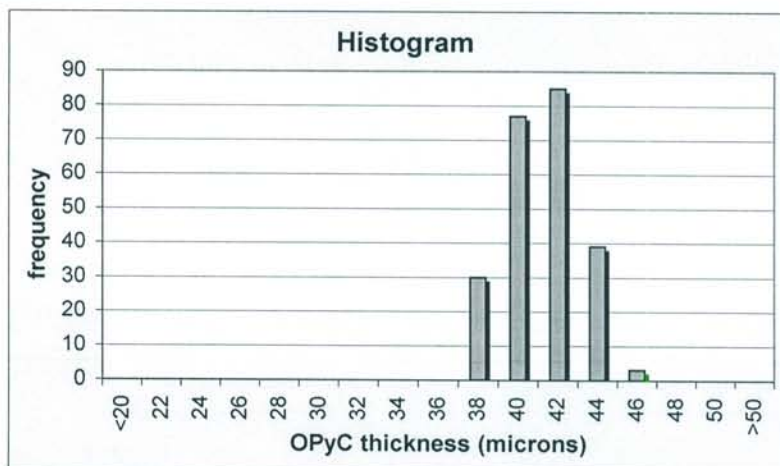
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06030201\
Sample ID:	LEU01-42T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06030201_output\

Number of outer pyrocarbon layers analyzed:	234
Mean of the average OPyC thickness of each particle (μm):	40.2
Standard deviation in the average OPyC thickness of each particle (μm):	1.8

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	30
40	77
42	85
44	39
46	3
48	0
50	0
>50	0



Andrew K. Kercher
Operator

03/02/06
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:	LEU01-42T-C01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06022202_DRF19R1.xls

Mean average weight/particle (g):	7.30E-04
Uncertainty in average weight/particle (g):	1.58E-06
Weight of sample of particles (g):	11.419
Approximate number of particles in sample:	15643
Uncertainty in number of particles in sample:	34

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

Comments on unusual visual characteristics of OPyC

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John Hunn
Operator

2-22-06

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:	LEU01-42T-D01
Particle Lot Description:	Variant 2: TRISO on BWXT kernel Composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06022101_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	9.01E-02	8.43E-02	1.01E-01	7.47E-02	9.21E-02
Number of particles:	123	115	139	103	126
Average weight/particle (g):	7.33E-04	7.33E-04	7.27E-04	7.25E-04	7.31E-04

Mean average weight/particle (g):	7.30E-04
Uncertainty in mean average weight/particle (g):	1.58E-06

Dixie Barker
Operator

2-21-06
Date

12 Characterization of third batch of TRISO-coated particles

This section contains data on LEU01-40T, the third batch of TRISO-coated particles used for the LEU01-48T 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 μm 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:	LEU01-40T
Coated particle batch description:	Variant 2: 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 (μm)	99.5	7.0	199	1.653	mean 100 ± 15	$A = \bar{x} - ts/\sqrt{n} \geq 85$ $B = \bar{x} + ts/\sqrt{n} \leq 115$	98.7 100.3	pass pass	DRF-08 DRF-11
Average IPyC thickness for each particle (μm)	40.2	2.5	228	1.652	mean 40 ± 5	$A = \bar{x} - ts/\sqrt{n} \geq 35$ $B = \bar{x} + ts/\sqrt{n} \leq 45$	39.9 40.5	pass pass	DRF-08 DRF-11
Average SiC thickness for each particle (μm)	35.0	0.9	229	1.652	mean 35 ± 4	$A = \bar{x} - ts/\sqrt{n} \geq 31$ $B = \bar{x} + ts/\sqrt{n} \leq 39$	34.9 35.1	pass pass	DRF-08 DRF-11
Average OPyC thickness for each particle (μm)	38.8	1.8	230	1.652	mean 40 ± 5	$A = \bar{x} - ts/\sqrt{n} \geq 35$ $B = \bar{x} + ts/\sqrt{n} \leq 45$	38.6 39.0	pass pass	DRF-08 DRF-11
Particles with missing OPyC			15562		defect fraction $\leq 6.0 \times 10^{-4}$	≤ 4 in 15,500	0	pass	DRF-19

Comments


 QC Supervisor

3-1-06
 Date

Accept Coated particle batch (Yes or No):	Yes
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 QA Reviewer

4/27/06
 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:	LEU01-40T-B01
Sample description:	Variant 2: TRISO on BWXT kernel composite 69302
Mount ID number:	M06022701L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06022801\P0602280101\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
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
386	389	366	370

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
177	96	42	36	38


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:	LEU01-40T-B01
Sample description:	Variant 2: TRISO on BWXT kernel composite 69302
Mount ID number:	M06022702L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06022801\P0602280102\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
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	387	367	380

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
176	102	39	36	40


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:	LEU01-40T-B01
Sample description:	Variant 2: TRISO on BWXT kernel composite 69302
Mount ID number:	M06022703L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06022801\P0602280103\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
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
378	376	384	381

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
180	95	41	38	41


Operator


Date

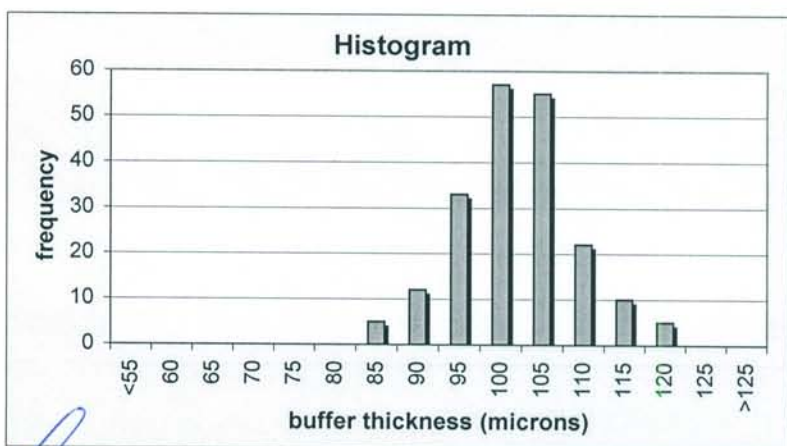
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022801\
Sample ID:	LEU01-40T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022801_output\

Number of buffer layers analyzed:	199
Mean of the average buffer thickness of each particle (μm):	99.5
Standard deviation in the average buffer thickness of each particle (μm):	7.0

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	5
90	12
95	33
100	57
105	55
110	22
115	10
120	5
125	0
>125	0



Andrew K. Kercher
Operator

March 1, 2006
Date

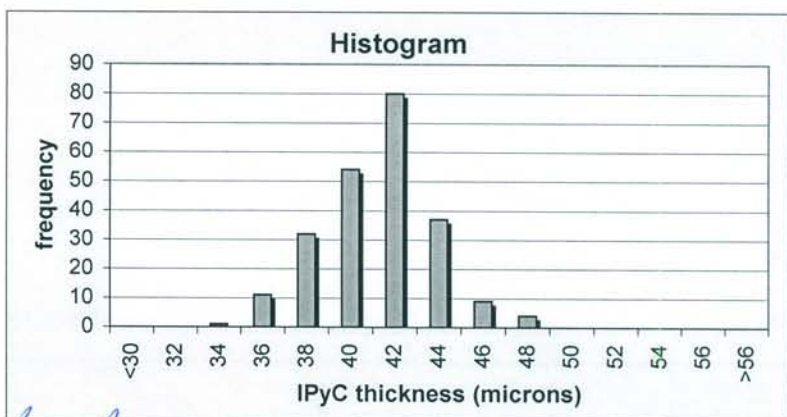
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022801\
Sample ID:	LEU01-40T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022801_output\

Number of inner pyrocarbon layers analyzed:	228
Mean of the average IPyC thickness of each particle (μm):	40.2
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	0
34	1
36	11
38	32
40	54
42	80
44	37
46	9
48	4
50	0
52	0
54	0
56	0
>56	0



Andrew K. Kercher
Operator

March 1, 2006
Date

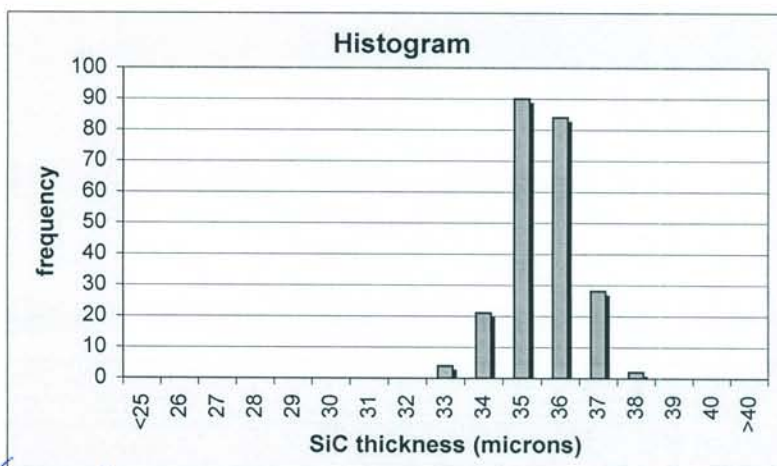
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022801\
Sample ID:	LEU01-40T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022801_output\

Number of silicon carbide layers analyzed:	229
Mean of the average SiC thickness of each particle (μm):	35.0
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	4
34	21
35	90
36	84
37	28
38	2
39	0
40	0
>40	0



Andrew K. Kercher
Operator

March 1, 2006
Date

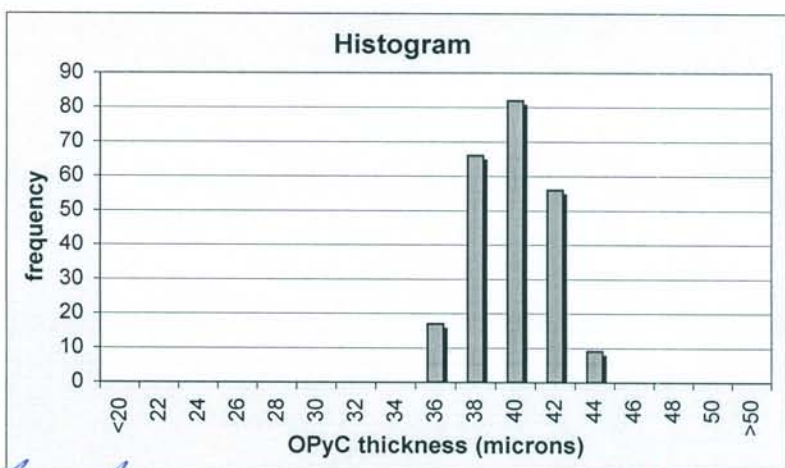
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022801\
Sample ID:	LEU01-40T-B01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06022801_output\

Number of outer pyrocarbon layers analyzed:	230
Mean of the average OPyC thickness of each particle (μm):	38.8
Standard deviation in the average OPyC thickness of each particle (μm):	1.8

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	17
38	66
40	82
42	56
44	9
46	0
48	0
50	0
>50	0



Andrew K. Kercher
Operator

March 1, 2006
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:	LEU01-40T-C01
Sample Description:	Variant 2: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06022203_DRF19R1.xls

Mean average weight/particle (g):	7.12E-04
Uncertainty in average weight/particle (g):	7.58E-07
Weight of sample of particles (g):	11.080
Approximate number of particles in sample:	15562
Uncertainty in number of particles in sample:	17

Number of particles with missing OPyC layer:	0
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Comments on unusual visual characteristics of OPyC

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Operator

2-22-06
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:	LEU01-40T-D01
Particle Lot Description:	Variant 2: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06022201_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	8.77E-02	9.04E-02	1.12E-01	9.93E-02	8.92E-02
Number of particles:	123	127	157	140	125
Average weight/particle (g):	7.13E-04	7.12E-04	7.13E-04	7.09E-04	7.14E-04

Mean average weight/particle (g):	7.12E-04
Uncertainty in mean average weight/particle (g):	7.58E-07

Dixie Barker
Operator

2-22-06
Date

13 Characterization of TRISO-coated particle composite

This section contains data on the TRISO-coated particle composite, LEU01-48T. 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 μm 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 LEU01-48T 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. 8.

Inspection Report Form IRF-04A: Coated Particle Composites

Procedure:	AGR-CHAR-PIP-04 Rev. 2
Coated particle composite ID:	LEU01-48T
Coated particle composite description:	Variant 2 composite: TRISO on BWXT kernel composite 69302

Property	Measured Data				Specification	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	k or t value	INL EDF-4380 Rev. 8				
Average buffer thickness for each particle (μm)	102.9	7.3	235	1.651	mean 100 ± 15	A = x - ts/√n ≥ 85	102.1	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 115	103.7	pass	
				2.548	dispersion ≤0.01 ≤ 55	C = x - ks > 55	84.3	pass	
Average IPyC thickness for each particle (μm)	40.1	2.8	239	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36	39.8	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 44	40.4	pass	
				2.546	dispersion ≤0.01 ≤ 30 ≤0.01 ≥ 56	C = x - ks > 30	33.0	pass	
					D = x + ks < 56	47.2	pass		
Average SiC thickness for each particle (μm)	35.0	1.0	239	1.651	mean 35 ± 3	A = x - ts/√n ≥ 32	34.9	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 38	35.1	pass	
				2.546	dispersion ≤0.01 ≤ 25	C = x - ks > 25	32.5	pass	
Average OPyC thickness for each particle (μm)	39.8	2.1	239	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36	39.6	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 44	40.0	pass	
				2.546	dispersion ≤0.01 ≤ 20	C = x - ks > 20	34.5	pass	
Buffer envelope density	See IRF-02A							pass	IRF-02A
IPyC sink/float density	See IRF-02B							pass	IRF-02B
SiC sink/float density (Mg/m³)	3.2070	0.0022	41	1.684	mean ≥ 3.19	A = x - ts/√n ≥ 3.19	3.206	pass	DRF-02
				2.922	dispersion ≤0.01 ≤ 3.17	C = x - ks > 3.17	3.201	pass	
OPyC sink/float density	See IRF-04B							pass	IRF-04B
IPyC anisotropy (BAFo equivalent)	1.023	0.002	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.024	pass	DRF-18
				3.981	dispersion ≤0.01 ≥1.06	D = x + ks < 1.06	1.031	pass	
OPyC anisotropy (BAFo equivalent)	1.018	0.001	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.019	pass	DRF-18
				3.981	dispersion ≤0.01 ≥1.06	D = x + ks < 1.06	1.022	pass	
Particles with SiC gold spot defects			12233		defect fraction ≤ 5.0 x 10 ⁻³	≤47 in 12,000 or ≤92 in 22,000	3	pass	DRF-20
Particle aspect ratio			1795		dispersion ≤0.01 ≥1.14	≤1 in 500 or ≤7 in 1420	0	pass	DRF-07 DRF-10
Particles with SiC burn-leach defects			50265		defect fraction ≤ 1.0 x 10 ⁻⁴	≤1 in 50,000 or ≤6 in 120,000	1	pass	DRF-21
Particles with missing OPyC			31306		defect fraction ≤ 3.0 x 10 ⁻⁴	≤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

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QC Supervisor

5-1-06
Date

Accept coated particle composite (Yes or No): Yes


QA Reviewer

5/1/06
Date

Inspection Report Form IRF-04B: Outer Pyrocarbon Density

Procedure:	AGR-CHAR-PIP-04 Rev. 2
Coated particle composite ID:	LEU01-48T
Coated particle composite description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Batch 1 ID:	LEU01-22T
Batch 1 description:	Variant 2: TRISO on BWXT kernel composite 69302
Batch 2 ID:	LEU01-42T
Batch 2 description:	Variant 2: TRISO on BWXT kernel composite 69302
Batch 3 ID:	LEU01-40T
Batch 3 description:	Variant 2: TRISO on BWXT kernel composite 69302

Property	Measured Data				Specification	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	k or t value	INL EDF-4380 Rev. 6				
Batch 1: OPyC sink/float density (Mg/m ³)	1.8918	0.0078	46	1.679	mean 1.90 ± 0.05	A = $x - ts/\sqrt{n} \geq 1.85$ B = $x + ts/\sqrt{n} \leq 1.95$	1.890 1.894	pass pass	DRF-03
				2.882	dispersion $\leq 0.01 \leq 1.80$ $\leq 0.01 \geq 2.00$	C = $x - ks > 1.80$ D = $x + ks < 2.00$	1.869 1.914	pass pass	
Batch 2: OPyC sink/float density (Mg/m ³)	1.8998	0.0078	50	1.677	mean 1.90 ± 0.05	A = $x - ts/\sqrt{n} \geq 1.85$ B = $x + ts/\sqrt{n} \leq 1.95$	1.898 1.902	pass pass	DRF-03
				2.863	dispersion $\leq 0.01 \leq 1.80$ $\leq 0.01 \geq 2.00$	C = $x - ks > 1.80$ D = $x + ks < 2.00$	1.877 1.922	pass pass	
Batch 3: OPyC sink/float density (Mg/m ³)	1.9132	0.0075	51	1.676	mean 1.90 ± 0.05	A = $x - ts/\sqrt{n} \geq 1.85$ B = $x + ts/\sqrt{n} \leq 1.95$	1.911 1.915	pass pass	DRF-03
				2.848	dispersion $\leq 0.01 \leq 1.80$ $\leq 0.01 \geq 2.00$	C = $x - ks > 1.80$ D = $x + ks < 2.00$	1.892 1.935	pass pass	

Comments

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QC Supervisor

Date

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

QA Reviewer

Date


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

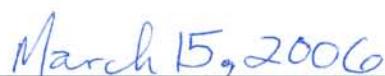
Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-48T-B01
Sample description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Mount ID number:	M06031302L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06031501\P0603150101\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
Measured value for 500 μm in stage micrometer image (μm):	500.7

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
367	381	368	387

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
178	99	41	36	38


Operator


Date

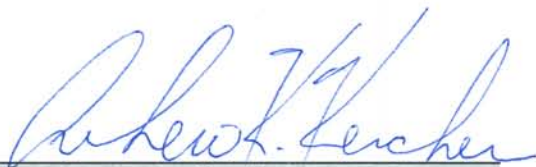
Data Report Form DRF-08: Imaging of Coated Particle Cross-sections Using an Optical Microscope System

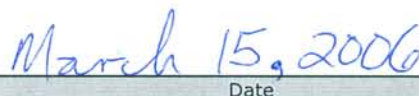
Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-48T-B01
Sample description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Mount ID number:	M06031303L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06031501\P0603150102\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
Measured value for 500 μm in stage micrometer image (μm):	500.7

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
367	381	366	374

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
177	105	42	36	39


Operator


Date

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

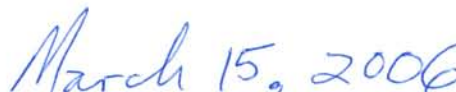
Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-48T-B01
Sample description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Mount ID number:	M06031304L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06031501\P0603150103\

DMR calibration expiration date:	9/8/2006
Calibrated pixels/micron:	2.8260
Stage micrometer calibration expiration date:	2/17/2007
Measured value for 500 μm in stage micrometer image (μm):	500.7

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
367	371	373	380

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
178	102	39	36	37


Operator


Date

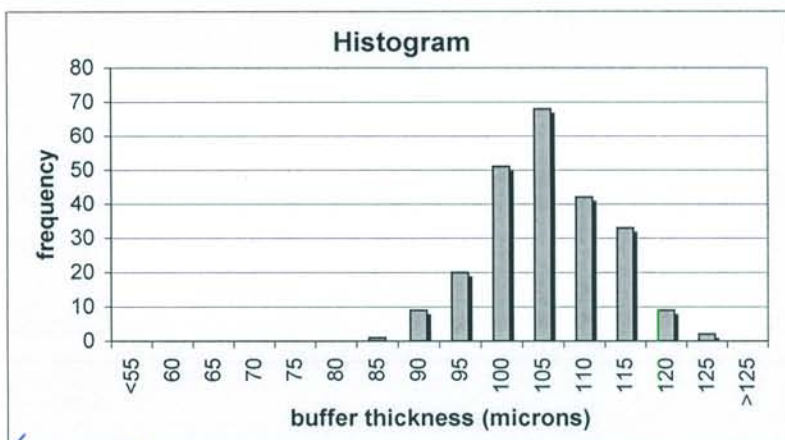
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06031501\
Sample ID:	LEU01-48T-B01
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06031501_output\

Number of buffer layers analyzed:	235
Mean of the average buffer thickness of each particle (μm):	102.9
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	1
90	9
95	20
100	51
105	68
110	42
115	33
120	9
125	2
>125	0



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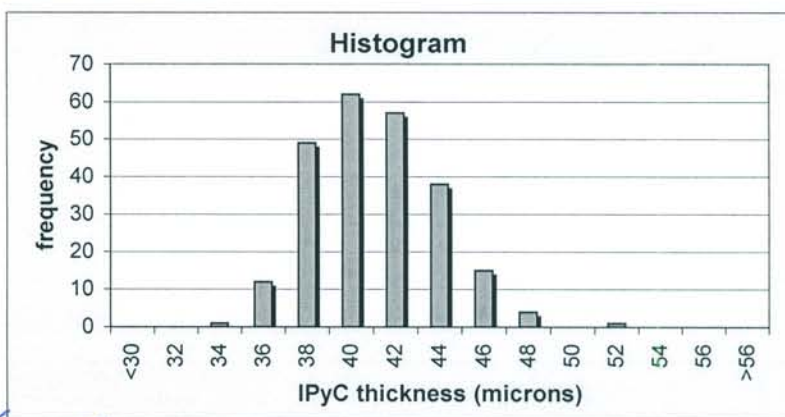
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06031501\
Sample ID:	LEU01-48T-B01
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06031501_output\

Number of inner pyrocarbon layers analyzed:	239
Mean of the average IPyC thickness of each particle (μm):	40.1
Standard deviation in the average IPyC thickness of each particle (μm):	2.8

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	Frequency
<30	0
32	0
34	1
36	12
38	49
40	62
42	57
44	38
46	15
48	4
50	0
52	1
54	0
56	0
>56	0



Andrew K. Kercher
Operator

March 16, 2006
Date

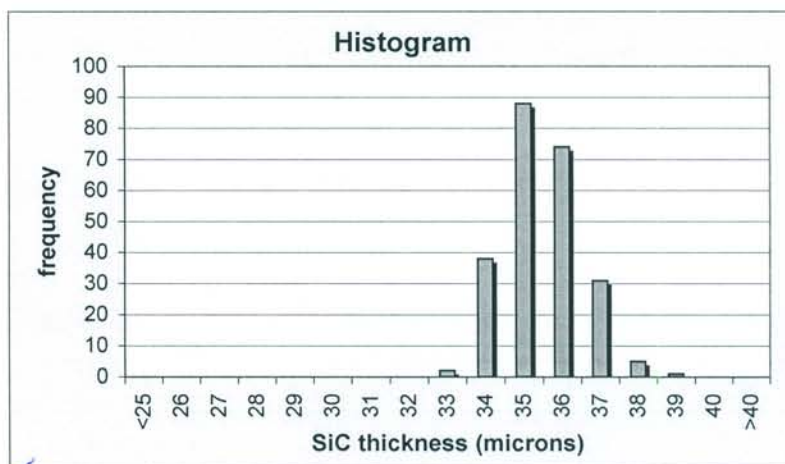
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06031501\
Sample ID:	LEU01-48T-B01
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06031501_output\

Number of silicon carbide layers analyzed:	239
Mean of the average SiC thickness of each particle (μm):	35.0
Standard deviation in the average SiC thickness of each particle (μm):	1.0

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	38
35	88
36	74
37	31
38	5
39	1
40	0
>40	0



Andrew K. Kercher
Operator

March 16, 2006
Date

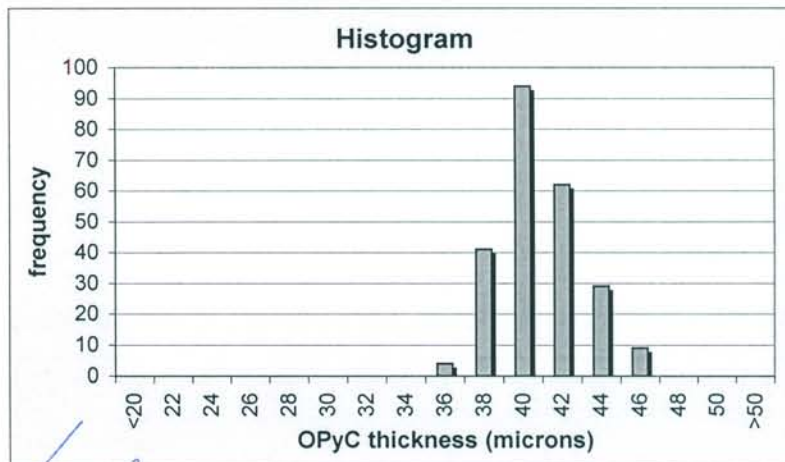
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06031501\
Sample ID:	LEU01-48T-B01
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06031501_output\

Number of outer pyrocarbon layers analyzed:	239
Mean of the average OPyC thickness of each particle (μm):	39.8
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	0
32	0
34	0
36	4
38	41
40	94
42	62
44	29
46	9
48	0
50	0
>50	0



Andrew K. Kercher
Operator

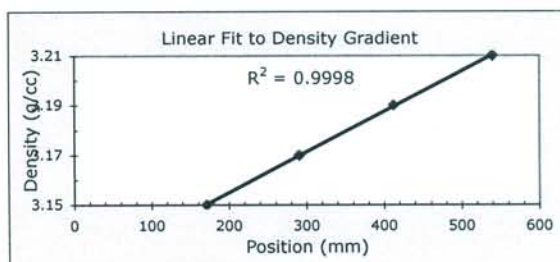
March 16, 2006
Date

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:	\\mc-agr\AGR\DensityColumn\D06030901_DRF02R3.xls
Sample ID:	LEU01-48T-E01
Sample description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	18/2007
Bath temperature:	22.6 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
3.150	157.17	177.83	170.94
3.170	274.76	298.72	290.73
3.190	397.10	419.93	412.32
3.210	523.64	547.48	539.53

Linear Fit			
slope	StDev	intercept	StDev
1.63E-04	3.02E-06	3.12E+00	1.07E-03



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	489.23	3.2021	26	524.73	3.2079	51		
2	490.12	3.2023	27	525.39	3.2080	52		
3	490.92	3.2024	28	526.31	3.2082	53		
4	499.54	3.2038	29	524.86	3.2079	54		
5	500.74	3.2040	30	526.43	3.2082	55		
6	502.04	3.2042	31	527.10	3.2083	56		
7	503.61	3.2045	32	527.90	3.2084	57		
8	506.18	3.2049	33	528.75	3.2086	58		
9	508.35	3.2052	34	537.17	3.2099	59		
10	511.51	3.2058	35	537.87	3.2101	60		
11	513.03	3.2060	36	539.30	3.2103	61		
12	513.90	3.2062	37	545.94	3.2114	62		
13	515.03	3.2063	38	539.17	3.2103	63		
14	517.02	3.2067	39	528.24	3.2085	64		
15	517.02	3.2067	40	525.56	3.2081	65		
16	517.89	3.2068	41	522.50	3.2076	66		
17	518.39	3.2069	42			67		
18	518.37	3.2069	43			68		
19	519.55	3.2071	44			69		
20	520.63	3.2072	45			70		
21	520.99	3.2073	46			71		
22	522.33	3.2075	47			72		
23	523.60	3.2077	48			73		
24	523.60	3.2077	49			74		
25	524.53	3.2079	50			75		
Average density of SiC fragments:					3.2070			
Standard deviation in density of SiC fragments:					0.0022			
Uncertainty in calculated density of SiC fragments:					0.0020			

Dixie Barker
Operator

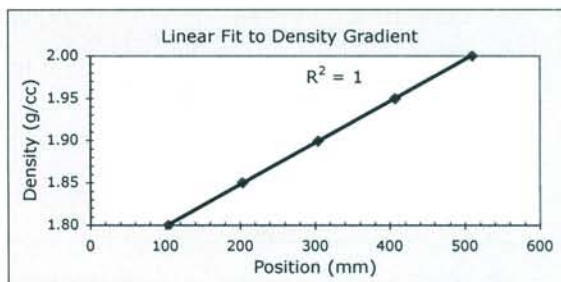
3-9-06
Date

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\D06021301_DRF03R2.xls
Sample ID:	LEU01-22T-E01
Sample description:	OPyC from Variant 2:TRISO on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	23.0 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	99.70	108.45	104.08
1.850	199.88	208.13	204.01
1.900	302.21	307.95	305.08
1.950	404.16	410.46	407.31
2.000	506.77	514.09	510.43

Linear Fit			
slope	StDev	intercept	StDev
4.92E-04	3.04E-06	1.75E+00	9.37E-04



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	261.69	1.8781	26	291.56	1.8928	51		
2	263.23	1.8789	27	293.81	1.8939	52		
3	266.91	1.8807	28	293.81	1.8939	53		
4	267.92	1.8812	29	294.80	1.8944	54		
5	267.92	1.8812	30	295.32	1.8947	55		
6	269.25	1.8818	31	295.65	1.8948	56		
7	271.80	1.8831	32	296.68	1.8953	57		
8	273.78	1.8841	33	294.32	1.8942	58		
9	275.39	1.8848	34	297.16	1.8956	59		
10	275.80	1.8850	35	297.77	1.8959	60		
11	277.60	1.8859	36	299.00	1.8965	61		
12	278.08	1.8862	37	299.44	1.8967	62		
13	280.63	1.8874	38	300.53	1.8972	63		
14	281.51	1.8879	39	301.13	1.8975	64		
15	284.05	1.8891	40	301.59	1.8977	65		
16	284.05	1.8891	41	302.56	1.8982	66		
17	284.91	1.8895	42	306.01	1.8999	67		
18	284.91	1.8895	43	312.65	1.9032	68		
19	284.91	1.8895	44	313.25	1.9035	69		
20	285.16	1.8897	45	324.51	1.9090	70		
21	286.85	1.8905	46	340.84	1.9171	71		
22	288.67	1.8914	47			72		
23	289.68	1.8919	48			73		
24	290.96	1.8925	49			74		
25	291.56	1.8928	50			75		
Average density of PyC fragments:					1.8918			
Standard deviation in density of PyC fragments:					0.0078			
Uncertainty in calculated density of PyC fragments:					0.0014			

Dixie Barker
Operator

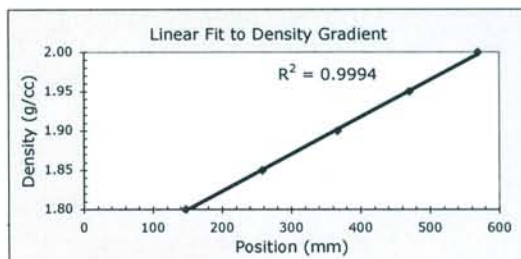
2-13-06
Date

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:	\\unc-agr\AGR\DensityColumn\D06022101_DRF03R2.xls
Sample ID:	LEU01-42T-E01
Sample description:	OPyC from Variant 2: TRISO on BWXT kernel Composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	22.8 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	142.44	151.40	146.92
1.850	253.89	262.62	258.26
1.900	364.27	369.93	367.10
1.950	466.96	474.26	470.61
2.000	565.87	573.05	569.46

Linear Fit			
slope	StDev	Intercept	StDev
4.73E-04	3.09E-06	1.73E+00	1.13E-03



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	323.63	1.8816	26	364.31	1.9009	51		
2	333.05	1.8861	27	364.69	1.9010	52		
3	334.50	1.8868	28	365.70	1.9015	53		
4	336.20	1.8876	29	366.20	1.9018	54		
5	340.09	1.8894	30	367.85	1.9025	55		
6	340.09	1.8894	31	368.48	1.9028	56		
7	344.18	1.8914	32	370.58	1.9038	57		
8	347.10	1.8927	33	371.74	1.9044	58		
9	347.67	1.8930	34	372.83	1.9049	59		
10	348.37	1.8933	35	373.25	1.9051	60		
11	345.92	1.8922	36	373.94	1.9054	61		
12	347.79	1.8931	37	374.53	1.9057	62		
13	350.12	1.8942	38	374.53	1.9057	63		
14	349.20	1.8937	39	374.98	1.9059	64		
15	351.90	1.8950	40	376.57	1.9067	65		
16	352.02	1.8951	41	377.52	1.9071	66		
17	352.16	1.8951	42	377.52	1.9071	67		
18	353.39	1.8957	43	381.69	1.9091	68		
19	354.63	1.8963	44	373.17	1.9051	69		
20	354.63	1.8963	45	383.17	1.9098	70		
21	356.55	1.8972	46	384.03	1.9102	71		
22	359.41	1.8986	47	385.07	1.9107	72		
23	360.90	1.8993	48	385.62	1.9109	73		
24	361.88	1.8997	49	388.33	1.9122	74		
25	363.15	1.9003	50	397.37	1.9165	75		
Average density of PyC fragments:					1.8998			
Standard deviation in density of PyC fragments:					0.0078			
Uncertainty in calculated density of PyC fragments:					0.0017			

Dixie Barker
Operator

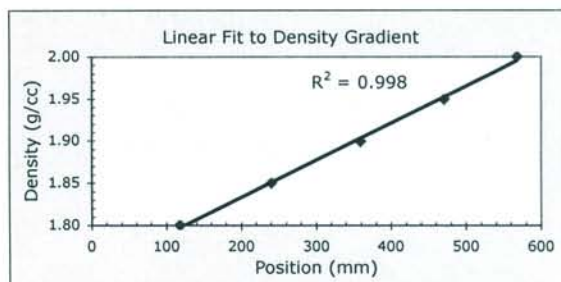
2-21-06
Date

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\D06022201_DRF03R2.xls
Sample ID:	LEU01-40T-E01
Sample description:	OPyC from Variant 2: TRISO on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	22.8 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	113.25	122.55	117.90
1.850	236.39	244.84	240.62
1.900	356.45	362.96	359.71
1.950	467.13	473.89	470.51
2.000	564.89	571.66	568.28

Linear Fit			
slope	StDev	intercept	StDev
4.42E-04	2.35E-06	1.74E+00	9.86E-04



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	338.52	1.8943	26	383.08	1.9140	51	411.72	1.9267
2	343.55	1.8965	27	383.94	1.9144	52		
3	346.94	1.8980	28	384.92	1.9148	53		
4	356.69	1.9023	29	385.70	1.9152	54		
5	360.12	1.9039	30	386.13	1.9154	55		
6	362.03	1.9047	31	385.77	1.9152	56		
7	362.85	1.9051	32	387.99	1.9162	57		
8	364.76	1.9059	33	387.99	1.9162	58		
9	366.37	1.9066	34	389.42	1.9168	59		
10	367.29	1.9070	35	389.76	1.9170	60		
11	367.66	1.9072	36	390.25	1.9172	61		
12	368.17	1.9074	37	391.93	1.9179	62		
13	369.72	1.9081	38	392.68	1.9183	63		
14	370.17	1.9083	39	393.72	1.9187	64		
15	370.80	1.9086	40	394.28	1.9190	65		
16	371.74	1.9090	41	396.62	1.9200	66		
17	372.33	1.9093	42	398.03	1.9206	67		
18	372.33	1.9093	43	398.35	1.9208	68		
19	374.90	1.9104	44	398.47	1.9208	69		
20	376.35	1.9110	45	399.49	1.9213	70		
21	377.11	1.9114	46	403.51	1.9231	71		
22	379.68	1.9125	47	403.51	1.9231	72		
23	380.46	1.9129	48	406.17	1.9242	73		
24	381.05	1.9131	49	406.58	1.9244	74		
25	382.94	1.9140	50	407.32	1.9247	75		
Average density of PyC fragments:					1.9132			
Standard deviation in density of PyC fragments:					0.0075			
Uncertainty in calculated density of PyC fragments:					0.0014			

Dixie Barker
Operator

2-22-06
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:	M06031401L
Sample ID:	LEU01-48T-B01
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Folder containing data:	\\mc-agr\AGR\2-MGEM\R06040601\

Particle #	Grid Position	Diattenuation			Equivalent BAFO		
		Average	St. Dev.	Ave. Error	Average	St. Dev.	Ave. Error
1	3,3	0.0072	0.0029	0.0013	1.0216	0.0087	0.0039
2	3,4	0.0085	0.0030	0.0013	1.0255	0.0090	0.0039
3	3,6	0.0067	0.0024	0.0013	1.0201	0.0072	0.0039
4	4,3	0.0063	0.0028	0.0013	1.0189	0.0084	0.0039
5	4,4	0.0078	0.0027	0.0013	1.0234	0.0081	0.0039
6	4,5	0.0078	0.0027	0.0013	1.0234	0.0081	0.0039
7	5,3	0.0079	0.0029	0.0013	1.0237	0.0087	0.0039
8	5,4	0.0079	0.0025	0.0013	1.0237	0.0075	0.0039
9	5,5	0.0072	0.0027	0.0013	1.0216	0.0081	0.0039
10	3,6	0.0077	0.0025	0.0013	1.0231	0.0075	0.0039
Average		0.0075	0.0027	0.0013	1.0225	0.0081	0.0039

Mean of average BAFO per particle:	1.0225
Standard deviation of average BAFO per particle:	0.0019

Comments

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G. E. Jellison
Operator

4/07/2006
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:	M06031401L
Sample ID:	LEU01-48T-B01
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Folder containing data:	\\mc-agr\AGR\2-MGEM\R06040601\

Particle #	Grid Position	Diattenuation			Equivalent BAFO		
		Average	St. Dev.	Ave. Error	Average	St. Dev.	Ave. Error
1	3,3	0.0051	0.0026	0.0013	1.0153	0.0078	0.0039
2	3,4	0.0062	0.0030	0.0013	1.0186	0.0090	0.0039
3	3,6	0.0061	0.0029	0.0012	1.0183	0.0087	0.0036
4	4,3	0.0060	0.0031	0.0013	1.0180	0.0093	0.0039
5	4,4	0.0060	0.0029	0.0013	1.0180	0.0087	0.0039
6	4,5	0.0055	0.0027	0.0012	1.0165	0.0081	0.0036
7	5,3	0.0060	0.0024	0.0012	1.0180	0.0072	0.0036
8	5,4	0.0060	0.0028	0.0012	1.0180	0.0084	0.0036
9	5,5	0.0061	0.0029	0.0012	1.0183	0.0087	0.0036
10	3,6	0.0055	0.0030	0.0012	1.0165	0.0090	0.0036
Average		0.0059	0.0028	0.0012	1.0176	0.0085	0.0037

Mean of average BAFO per particle:	1.0176
Standard deviation of average BAFO per particle:	0.0011

Comments

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G. E. Jellison

Operator

4/07/2006

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:	LEU01-48T-D02
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\GoldSpots\G06031401_DRF20R1.xls

Mean average weight/particle (g):	7.24E-04
Uncertainty in average weight/particle (g):	1.03E-06
Weight of sample of particles (g):	8.857
Approximate number of particles in sample:	12233
Uncertainty in number of particles in sample:	17

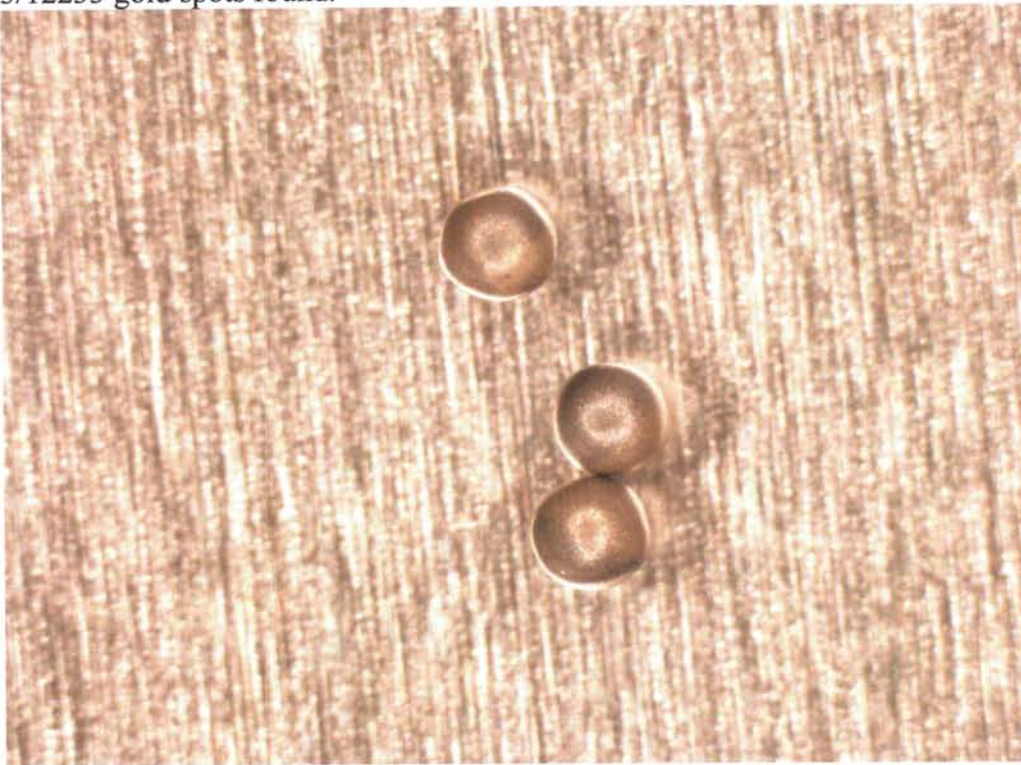
Number of particles with gold spot defects:	3
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Comments on unusual visual characteristics of SiC

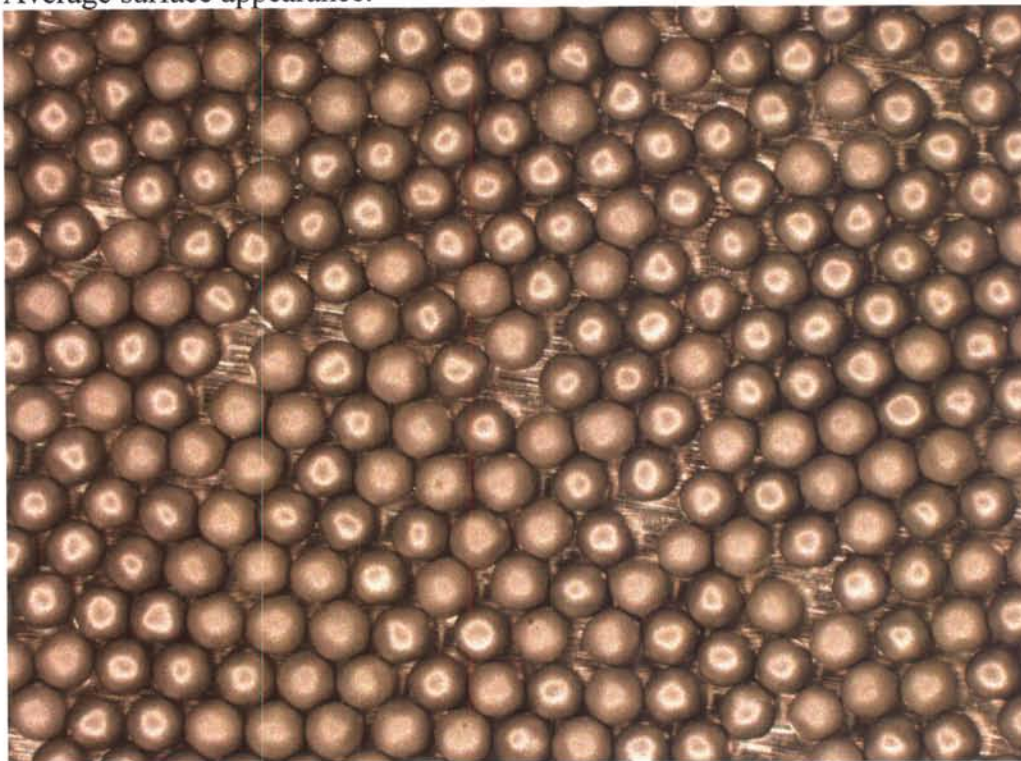
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 Operator	3-14-06 Date
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3/12233 gold spots found.



Average surface appearance.



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:	LEU01-48T-C01
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06031301\

DMR Calibration Expiration Date:	9/8/2006
Stage Micrometer Calibration Expiration Date:	2/17/2007
Measured Value for 1200 μm in Stage Micrometer Image:	1199.1 μm



Operator



Date

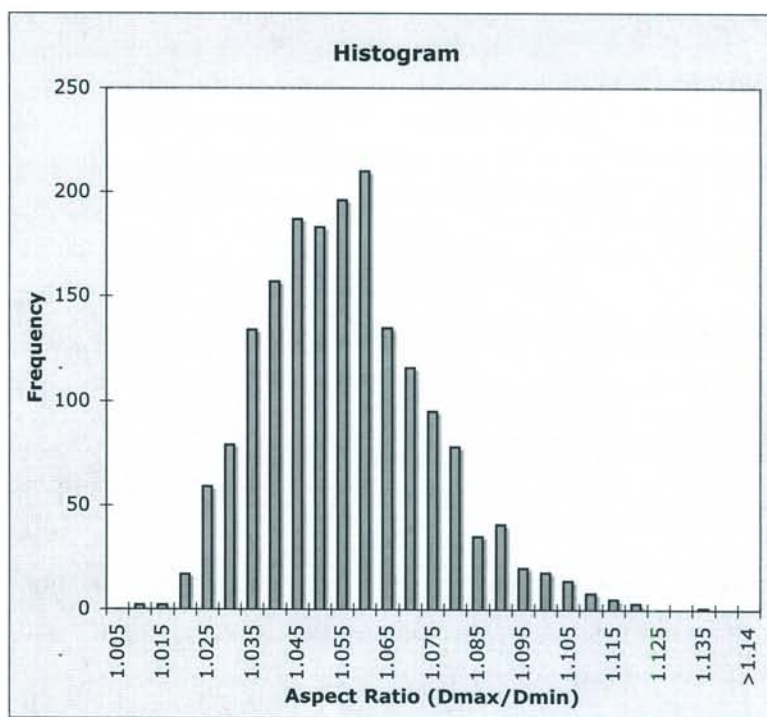
Data Report Form DRF-10B: Measurement of Particle Aspect Ratio (Dmax/Dmin)

Procedure:	AGR-CHAR-DAM-10 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06031301\
Sample ID:	LEU01-48T-C01
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06031301_output\

Number of particles analyzed:	1795
Number of particles with aspect ratio ≥ 1.14	0
Average particle aspect ratio:	1.053

Distribution of the aspect ratio (top binned)

Aspect Ratio (D)	Frequency
1.005	0
1.010	2
1.015	2
1.020	17
1.025	59
1.030	79
1.035	134
1.040	157
1.045	187
1.050	183
1.055	196
1.060	210
1.065	135
1.070	116
1.075	95
1.080	78
1.085	35
1.090	41
1.095	20
1.100	18
1.105	14
1.110	8
1.115	5
1.120	3
1.125	0
1.130	0
1.135	1
1.140	0
>1.14	0



Andrew K. Kercher
Operator

March 15, 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:	LEU01-48T-F01
Sample Description:	Variant 2 Composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\BurnLeach\QCData\B06032201_DRF21R1.xls

Mean average weight/particle (g):	7.24E-04
Uncertainty in mean average weight/particle (g):	1.03E-06
Weight of sample of particles (g):	36.3915
Approximate number of particles in sample:	50265
Uncertainty in number of particles in sample:	72

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	B0604030101	B0604040102	B0603310401	
Volume of solution (ml):				
Measured β activity of 0.1ml aliquot (dpm):				
Estimated weight of U in solution (mg):	0	0	0	
Radiochemical laboratory analysis number	060406-011	060406-016	060406-010	
Weight uranium leached (g):	2.14E-04	3.26E-06	2.16E-05	2.39E-04
Uncertainty in weight uranium leached (g):	2.10E-05	3.30E-07	2.20E-06	2.11E-05
Calculated number of particles with SiC defects:	1	0	0	1
Uncertainty in number of particles with SiC defects:	9.65E-02	1.52E-03	1.01E-02	9.70E-02

Comments

Leach #3 was excess acid from leach #1, removed before starting the reflux and analyzed separately.
Data checked against official results 5/01/06

Fred C. Montgomery
Operator

5/02/06
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:	LEU01-48T-D01
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06031301_DRF19R1.xls

Mean average weight/particle (g):	7.24E-04
Uncertainty in average weight/particle (g):	1.03E-06
Weight of sample of particles (g):	22.666
Approximate number of particles in sample:	31306
Uncertainty in number of particles in sample:	45

Number of particles with missing OPyC layer:	0
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Comments on unusual visual characteristics of OPyC

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Operator

3-13-06

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\E06032301_DRF23R0.xls
Sample ID:	LEU01-48T-B01
Sample Description:	LEU01-48T-B01
Mount Number(s):	M06031301L
Folder name containing images:	\\mc-agr\AGR\SEM\

Images of SiC grain structure			
	particle 1	particle 2	particle 3
1000x image filename	58853	58855	58857
2500x image filename	58854	58856	58858
grain structure acceptable	yes	yes	yes

Comments


Operator

3-23-06
Date


QC Supervisor

3-23-06
Date


QA Reviewer

4/28/06
Date

ORNL/TM-2006/021, Rev. 1

141

Acc.V Spot Magn
10.0 kV 5.0 1000x

Det WD Exp
BSE 6.3 58853

20 μ m

ORNL/TM-2006/021, Rev. 1

142

Acc.V Spot Magn
10.0 kV 5.0 2500x

Det WD Exp
BSE 6.3 58854

10 μ m

ORNL/TM-2006/021, Rev 1

143

Acc.V Spot Magn
10.0 kV 5.0 1000x

Det WD Exp
BSE 6.3 58855

20 μ m

ORNL/TM-2006/021, Rev. 1

144

Acc.V	Spot	Magn	Det	WD	Exp
10.0 kV	5.0	2500x	BSE	6.3	58856

10 μ m

ORNL/TM-2006/021, Rev. 1

145

Acc.V Spot Magn
10.0 kV 5.0 1000x

Det WD Exp
BSE 6.3 58857

20 μ m

ORNL/TM-2006/021, Rev. 1

146

Acc.V	Spot	Magn	Det	WD	Exp	10 μ m
10.0 kV	5.0	2500x	BSE	6.3	58858	

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:	LEU01-48T-H01
Particle Lot Description:	Variant 2 composite: TRISO on BWXT kernel 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06030701_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	7.07E-02	9.64E-02	8.13E-02	8.92E-02	7.93E-02
Number of particles:	98	133	112	123	110
Average weight/particle (g):	7.21E-04	7.25E-04	7.26E-04	7.25E-04	7.21E-04

Mean average weight/particle (g):	7.24E-04
Standard error in mean average weight/particle (g):	1.03E-06

Dixie Barker
Operator

3-7-06
Date

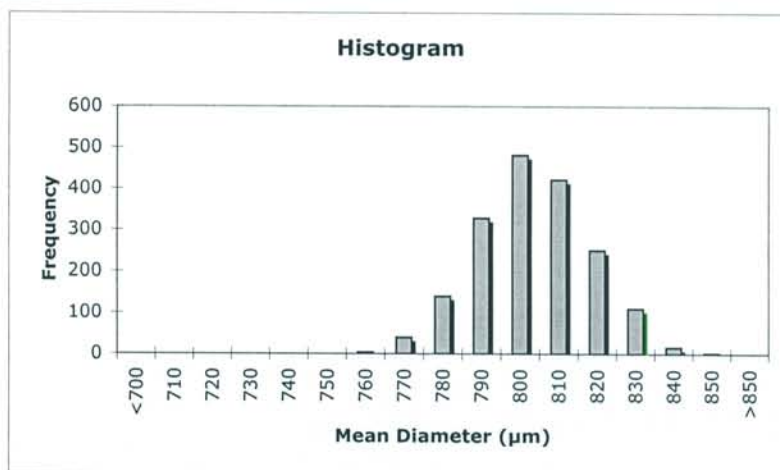
Data Report Form DRF-10A: Measurement of Particle Diameter

Procedure:	AGR-CHAR-DAM-10 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06031301\
Sample ID:	LEU01-48T-C01
Sample Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06031301_output\

Number of particles analyzed:	1795
Mean of the average diameter of each particle (μm):	798.3
Standard deviation in the average diameter of each particle (μm):	14

Distribution of the average particle diameter (top binned)

Mean Diameter (μm)	Frequency
<700	0
710	0
720	0
730	0
740	0
750	0
760	4
770	40
780	140
790	328
800	482
810	422
820	251
830	110
840	16
850	2
>850	0



Andrew K. Kercher
Operator

March 15, 2006
Date

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

Procedure:	AGR-CHAR-DAM-31 Rev. 1
Operator:	S. D. Nunn
Coated particle batch ID:	LEU01-48T-I01
Batch Description:	Variant 2 composite: TRISO on BWXT kernel composite 69302
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S06030801\S06030801_DRF31R1.xls

Mean average weight/particle (g):	7.24E-04
Standard error in mean average weight/particle (g):	1.03E-06

Weight of particles (g):	3.4842
Approximate number of particles:	4812
Uncertainty in number of particles:	7
Total envelope volume of sample (cc):	1.258
Average envelope volume/particle (cc):	2.61E-04
Sample envelope density (g/cc):	2.769

Average particle diameter (microns):	7.93E+02
Average surface area/particle (cm ²):	1.98E-02
Total sample surface area (cm ²):	9.52E+01
Intruded mercury volume from 250-10,000 psia (cc):	9.00E-03
Open porosity (ml/m ²):	9.46E-01

Comments

S. D. Nunn
Operator

3/8/06
Date

Supplement to DRF-21: Impurity Analysis Data

Procedure:	AGR-CHAR-DAM-21 Rev. 1
Operator:	Montgomery
Sample ID:	LEU01-48T-F01
Sample Description:	Variant 2 Composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-aqr\AGR\BurnLeach\OCData\B06032201 DRF21R1.xls

	Leach 1	Leach 2	Leach 3	Total µg
Sample number:	B0604030101	B0604040102	B0603310401	
RMAL Analysis Number:	060406-011	060406-016	060406-010	
Fe content of leach solution (µg)	2.77	0.82	< 0.26	< 3.85
Uncertainty in measured Fe content (µg)	0.28	0.16		0.32
Cr content of leach solution (µg)	< 0.71	< 0.71	< 0.71	< 2.12
Uncertainty in measured Cr content (µg)				
Mn content of leach solution (µg)	< 0.10	< 0.10	< 0.10	< 0.30
Uncertainty in measured Mn content (µg)				
Co content of leach solution (µg)	< 0.28	< 0.28	< 0.28	< 0.85
Uncertainty in measured Co content (µg)				
Ni content of leach solution (µg)	1.35	< 0.50	< 0.50	< 2.35
Uncertainty in measured Ni content (µg)	0.27			0.27
Cr + Mn + Co + Ni (µg)	< 2.44	< 1.59	< 1.59	< 5.62
Uncertainty in Cr + Mn + Co + Ni (µg)	0.27			0.27
Ca content of leach solution (µg)	6.53	2.75	1.31	10.59
Uncertainty in measured Ca content (µg)	0.65	0.55	0.26	0.89
Al content of leach solution (µg)	10.20	< 2.73	< 2.73	<15.66
Uncertainty in measured Al content (µg)	2.00			2.00
Ti content of leach solution (µg)	< 0.86	1.12	< 0.86	< 2.84
Uncertainty in measured Ti content (µg)		0.22		0.22
V content of leach solution (µg)	< 0.39	< 0.39	< 0.39	< 1.18
Uncertainty in measured V content (µg)				
Ti + V content of leach solution (µg)	< 1.25	< 1.51	< 1.25	< 4.02
Uncertainty in measured Ti + V content (µg)		0.22		0.22

Comments

Leach #3 was excess acid from leach #1, removed before starting the reflux and analyzed separately.
Data check against official results 5/01/06

Fred C. Montgomery
Operator

5/02/06

Date

14 Superceded data

This section contains data related to the LEU01-48T TRISO-coated particle composite that has been superceded 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 sets of results for all buffer interrupted batches were within the density range specified in table 5.2 of EDF-4380, Rev. 6.

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

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

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

Mean average weight/particle (g):	2.47E-04
Uncertainty in mean average weight/particle (g):	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

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

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

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

Dixie Barker
Operator

5-24-05
Date

Superseded 2-3-06 .JH

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	S0502602L	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	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
	Mean (x)	Std. Dev. (s)	# measured (n)	t value (t)	INL EDF-4380				
Batch 1: Buffer envelope density	0.97	0.09	5	2.132	mean	$A = x - ts/\sqrt{n} \geq 0.80$	0.89	pass	DRF-16
					0.95 ± 0.15	$B = x + ts/\sqrt{n} \leq 1.10$	1.05	pass	DRF-22
Batch 2: Buffer envelope density	1.01	0.09	5	2.132	mean	$A = x - ts/\sqrt{n} \geq 0.80$	0.93	pass	DRF-16
					0.95 ± 0.15	$B = x + ts/\sqrt{n} \leq 1.10$	1.09	pass	DRF-22
Batch 3: Buffer envelope density	1.01	0.09	5	2.132	mean	$A = x - ts/\sqrt{n} \geq 0.80$	0.93	pass	DRF-16
					0.95 ± 0.15	$B = x + ts/\sqrt{n} \leq 1.10$	1.09	pass	DRF-22
Composite buffer envelope density	0.99	0.08	5	2.132	mean	$A = x - ts/\sqrt{n} \geq 0.80$	0.92	pass	DRF-16
					0.95 ± 0.15	$B = x + ts/\sqrt{n} \leq 1.10$	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 μm based on average envelope volume of 9.25E-5 cc (effective diameter of 561 μm) and average kernel diameter of 345 μm .
 Average thickness of buffer was 108 μm based on average outer diameter of 561 μm obtained per DAM-10 and average kernel diameter of 345 μm .


 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-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:	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

6/30/06
Date

superseded 2-14-06 GH

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:	\\mc-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

6/32/05
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

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:	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