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ORNL/TM-2006/022

Data Compilation for AGR-1 Variant 3 Coated Particle Composite LEU01-49T

Revision 0

John D. Hunn and Richard A. Lowden

May 2006

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Data Compilation for AGR-1 Variant 3 Coated Particle Composite LEU01-49T

J. D. Hunn and R. A. Lowden
Oak Ridge National Laboratory

This document is a compilation of characterization data for the AGR-1 variant 3 coated particle composite LEU01-49T, 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 ~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 3 coated particles are similar to the AGR-1 baseline coated particles with the exception that the silicon carbide coating was deposited at a lower temperature (1425°C versus 1500°C) using argon and hydrogen gas for fluidization in the coater as opposed to just hydrogen. 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 LEU01-49T composite. These batches were fabricated in order to qualify that the process conditions used for buffer and IPyC would produce acceptable densities as described in sections 8 and 9. The buffer and IPyC qualification batches were the same as used to qualify the baseline buffer and IPyC 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 densities of the buffer and IPyC coatings. Confirmatory batches using LEUCO kernels from G73D-20-69302 were coated and characterized to verify this assumption.

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.

Table of Contents

1 Summary of acceptance test results for LEU01-49T *5*
2 Product ID's associated with LEU01-49T *14*
3 Coating process conditions *15*
4 Classification of coated particles *30*
5 Blend of coated particle composites *35*
6 Characterization of LEUCO kernel composite *36*
7 Characterization of NUCO kernel composite *43*
8 Characterization of buffer on interrupted batches *50*
9 Characterization of IPyC on interrupted batches *64*
10 Characterization of IPyC on additional interrupted batches *88*
11 Characterization of first batch of TRISO-coated particles *103*
12 Characterization of second batch of TRISO-coated particles *115*
13 Characterization of third batch of TRISO-coated particles *127*
14 Characterization of TRISO-coated particle composite *139*
15 Superceded data *176*

1 Summary of acceptance test results for LEU01-49T

This section contains all the inspection report forms (IRF) associated with the coated particle composite LEU01-49T. 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, LEU01-49T, 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, LEU01-49T. 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 confirmation batches 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 LEU01-49T.

Property	Mean
Average kernel diameter (μm)	349.7
Kernel envelope density (Mg/m^3)	10.924
Average buffer thickness (μm)	104.2
Average IPyC thickness (μm)	38.8
Average SiC thickness (μm)	35.9
Average OPyC thickness (μm)	39.3
Buffer envelope density (Mg/m^3) (interrupted batches)	1.10
IPyC sink/float density (Mg/m^3) (interrupted batches)	1.904
SiC sink/float density (Mg/m^3)	3.2046
OPyC sink/float density (Mg/m^3) (weighted average)	1.911
IPyC anisotropy (BAFo equivalent)	1.029
OPyC anisotropy (BAFo equivalent)	1.021

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, LEU01-49T. 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 LEU01-49T.

Property	Defect Fraction
Particles with SiC gold spot defects	$\leq 2.5 \times 10^{-4}$
Particle aspect ratio	$\leq 2.8 \times 10^{-3}$
Particles with burn-leach defects	$\leq 4.0 \times 10^{-5}$
Particles with missing OPyC	$\leq 9.7 \times 10^{-5}$

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

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 √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:	NUCO350-30BI
Batch 1 description:	IPyC/Buffer on BWXT kernel composite 69300
Batch 2 ID:	NUCO350-37BI
Batch 2 description:	IPyC/Buffer on BWXT kernel composite 69300
Batch 3 ID:	NUCO350-29BI
Batch 3 description:	IPyC/Buffer on 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)	k or t value	INL EDF-4380 Rev. 6				
Batch 1: IPyC sink/float density (Mg/m³)	1.8917	0.0113	25	1.711	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.888	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.896	pass	
				3.158	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.856	pass	
						D = x + ks < 2.00	1.927	pass	
Batch 2: IPyC sink/float density (Mg/m³)	1.9038	0.0153	21	1.725	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.898	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.910	pass	
				3.262	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.854	pass	
						D = x + ks < 2.00	1.954	pass	
Batch 3: IPyC sink/float density (Mg/m³)	1.9112	0.0142	20	1.729	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.906	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.917	pass	
				3.295	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.864	pass	
						D = x + ks < 2.00	1.958	pass	

Comments

95% confidence interval for Buffer thickness in composite = (104μm, 106μm) with <1% ≤55μm.
95% confidence interval for IPyC thickness in composite = (34.2μm, 34.9μm) with >1% ≤30μm and <1% ≥56μm.
Confirmatory batch on LEUCO kernels, LEU01-151: mean IPyC density = 1.9074 g/cc.

QC Supervisor — Date: 3-10-06

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

QA Reviewer — Date: 3/29/06

Inspection Report Form IRF-03: Coated Particle Batches

Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-24T
Coated particle batch description:	Variant 3: 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. 7				
Average buffer thickness for each particle (μm)	102.6	7.8	228	1.652	mean 100 ± 15	A = x - ts/√n ≥ 85	101.7	pass	DRF-08
						B = x + ts/√n ≤ 115	103.5	pass	DRF-11
Average IPyC thickness for each particle (μm)	38.2	2.0	238	1.651	mean 40 ± 5	A = x - ts/√n ≥ 35	38.0	pass	DRF-08
						B = x + ts/√n ≤ 45	38.4	pass	DRF-11
Average SiC thickness for each particle (μm)	36.3	0.9	238	1.651	mean 35 ± 4	A = x - ts/√n ≥ 31	36.2	pass	DRF-08
						B = x + ts/√n ≤ 39	36.4	pass	DRF-11
Average OPyC thickness for each particle (μm)	38.7	1.8	238	1.651	mean 40 ± 5	A = x - ts/√n ≥ 35	38.5	pass	DRF-08
						B = x + ts/√n ≤ 45	38.9	pass	DRF-11
Particles with missing OPyC			15566		defect fraction $\leq 6.0 \times 10^{-4}$	≤4 in 15,500	0	pass	DRF-19

Comments

QC Supervisor — **Date** 4-19-06

Accept Coated particle batch (Yes or No):	Yes

QA Reviewer — **Date** 4/20/06

Inspection Report Form IRF-03: Coated Particle Batches

Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-25T
Coated particle batch description:	Variant 3: 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. 7				
Average buffer thickness for each particle (μm)	103.6	7.4	222	1.652	mean 100 ± 15	$A = x - ts/\sqrt{n} \geq 85$	102.8	pass	DRF-08
						$B = x + ts/\sqrt{n} \leq 115$	104.4	pass	DRF-11
Average IPyC thickness for each particle (μm)	39.2	1.9	236	1.651	mean 40 ± 5	$A = x - ts/\sqrt{n} \geq 35$	39.0	pass	DRF-08
						$B = x + ts/\sqrt{n} \leq 45$	39.4	pass	DRF-11
Average SiC thickness for each particle (μm)	38.1	1.0	236	1.651	mean 35 ± 4	$A = x - ts/\sqrt{n} \geq 31$	38.0	pass	DRF-08
						$B = x + ts/\sqrt{n} \leq 39$	38.2	pass	DRF-11
Average OPyC thickness for each particle (μm)	40.5	1.9	236	1.651	mean 40 ± 5	$A = x - ts/\sqrt{n} \geq 35$	40.3	pass	DRF-08
						$B = x + ts/\sqrt{n} \leq 45$	40.7	pass	DRF-11
Particles with missing OPyC			15636		defect fraction $\leq 6.0 \times 10^{-4}$	≤4 in 15,500	0	pass	DRF-19

Comments

QC Supervisor

4-19-06
Date

Accept Coated particle batch (Yes or No):	Yes

QA Reviewer

4/20/06
Date

Inspection Report Form IRF-03: Coated Particle Batches

Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-37T
Coated particle batch description:	Variant 3: 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. 7				
Average buffer thickness for each particle (μm)	101.7	6.9	195	1.653	mean 100 ± 15	$A = x - ts/\sqrt{n} \geq 85$	100.9	pass	DRF-08
						$B = x + ts/\sqrt{n} \leq 115$	102.5	pass	DRF-11
Average IPyC thickness for each particle (μm)	38.5	2.0	215	1.652	mean 40 ± 5	$A = x - ts/\sqrt{n} \geq 35$	38.3	pass	DRF-08
						$B = x + ts/\sqrt{n} \leq 45$	38.7	pass	DRF-11
Average SiC thickness for each particle (μm)	33.2	1.0	217	1.652	mean 35 ± 4	$A = x - ts/\sqrt{n} \geq 31$	33.1	pass	DRF-08
						$B = x + ts/\sqrt{n} \leq 39$	33.3	pass	DRF-11
Average OPyC thickness for each particle (μm)	39.0	1.9	218	1.652	mean 40 ± 5	$A = x - ts/\sqrt{n} \geq 35$	38.8	pass	DRF-08
						$B = x + ts/\sqrt{n} \leq 45$	39.2	pass	DRF-11
Particles with missing OPyC			15554		defect fraction $\leq 6.0 \times 10^{-4}$	≤4 in 15,500	0	pass	DRF-19

Comments

John Hunn

QC Supervisor

4-14-06

Date

Accept Coated particle batch (Yes or No):	Yes

M. C. Pace

QA Reviewer

4/20/06

Date

Inspection Report Form IRF-04A: Coated Particle Composites

Procedure:	AGR-CHAR-PIP-04 Rev. 2
Coated particle composite ID:	LEU01-49T
Coated particle composite description:	Variant 3 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)	104.2	7.8	237	1.651	mean 100 ± 15	A = x - ts/√n ≥ 85	103.4	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 115	105.0	pass	
				2.547	dispersion ≤0.01 ≤ 55	C = x - ks > 55	84.3	pass	
Average IPyC thickness for each particle (μm)	38.8	2.1	238	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36	38.6	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 44	39.0	pass	
				2.546	dispersion ≤0.01 ≤ 30	C = x - ks > 30	33.5	pass	
					≤0.01 ≥ 56	D = x + ks < 56	44.1	pass	
Average SiC thickness for each particle (μm)	35.9	2.1	238	1.651	mean 35 ± 3	A = x - ts/√n ≥ 32	35.7	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 38	36.1	pass	
				2.546	dispersion ≤0.01 ≤ 25	C = x - ks > 25	30.6	pass	
Average OPyC thickness for each particle (μm)	39.3	2.1	238	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36	39.1	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 44	39.5	pass	
				2.546	dispersion ≤0.01 ≤ 20	C = x - ks > 20	34.0	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/m^3)	3.2046	0.0010	41	1.684	mean ≥ 3.19	A = x - ts/√n ≥ 3.19	3.204	pass	DRF-02
				2.922	dispersion ≤0.01 ≤ 3.17	C = x - ks > 3.17	3.202	pass	
OPyC sink/float density	See IRF-04B								IRF-04B
IPyC anisotropy (BAFo equivalent)	1.029	0.002	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.030	pass	DRF-18
				3.981	dispersion ≤0.01 ≥1.06	D = x + ks < 1.06	1.037	pass	
OPyC anisotropy (BAFo equivalent)	1.021	0.003	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.023	pass	DRF-18
				3.981	dispersion ≤0.01 ≥1.06	D = x + ks < 1.06	1.033	pass	
Particles with SiC gold spot defects			12190		defect fraction ≤ 5.0×10^{-3}	≤47 in 12,000 or ≤92 in 22,000	0	pass	DRF-20
Particle aspect ratio			1709		dispersion ≤0.01 ≥1.14	≤1 in 500 or ≤7 in 1420	1	pass	DRF-07 DRF-10
Particles with SiC burn-leach defects			120660		defect fraction ≤ 1.0×10^{-4}	≤1 in 50,000 or ≤6 in 120,000	1	pass	DRF-21
Particles with missing OPyC			31178		defect fraction ≤ 3.0×10^{-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 — Date: 5-15-06

Accept coated particle composite (Yes or No):	Yes

QA Reviewer — Date: 5/15/06

Inspection Report Form IRF-04B: Outer Pyrocarbon Density

Procedure:	AGR-CHAR-PIP-04 Rev. 2
Coated particle composite ID:	LEU01-49T
Coated particle composite description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Batch 1 ID:	LEU01-24T
Batch 1 description:	Variant 3: TRISO on BWXT kernel composite 69302
Batch 2 ID:	LEU01-25T
Batch 2 description:	Variant 3: TRISO on BWXT kernel composite 69302
Batch 3 ID:	LEU01-37T
Batch 3 description:	Variant 3: 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				
Batch 1: OPyC sink/float density (Mg/m³)	1.9211	0.0094	48	1.678	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.919	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.923	pass	
				2.868	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.894	pass	
						D = x + ks < 2.00	1.948	pass	
Batch 2: OPyC sink/float density (Mg/m³)	1.8975	0.0074	41	1.684	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.896	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.899	pass	
				2.922	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.876	pass	
						D = x + ks < 2.00	1.919	pass	
Batch 3: OPyC sink/float density (Mg/m³)	1.9157	0.0073	64	1.669	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.914	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.917	pass	
				2.783	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.895	pass	
						D = x + ks < 2.00	1.936	pass	

Comments

QC Supervisor

4-26-06
Date

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

QA Reviewer

4/26/06
Date

2 Product ID's associated with LEU01-49T

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

NUCO350-30BI (IPyC density qualification batch 1)
NUCO350-37BI (IPyC density qualification batch 2)
NUCO350-29BI (IPyC density qualification batch 3)
NUCO350-66BI (composite of 30BI+37BI+29BI, for information only)
LEU01-15I (confirmation on LEUCO kernels, for information only)
LEU01-23I (confirmation on LEUCO kernels, for information only)
LEU01-26I (confirmation on LEUCO kernels, for information only)
LEU01-41I (confirmation on LEUCO kernels, for information only)

TRISO-coated particles

LEU01-24T (TRISO batch 1)
LEU01-25T (TRISO batch 2)
LEU01-37T (TRISO batch 3)
LEU01-49T (composite of 24T+25T+37T)

3 Coating process conditions

The following pages contain coating process conditions for all coated particle batches associated with the LEU01-49T coated particle composite. The AGR-1 variant 3 coated particles are similar to the AGR-1 baseline coated particles with the exception that the silicon carbide coating was deposited at a lower temperature (1425°C versus 1500°C) using argon and hydrogen gas for fluidization in the coater as opposed to just hydrogen. These particles were coated within the variant 3 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

NUCO350-30BI (IPyC density qualification batch 1)
NUCO350-37BI (IPyC density qualification batch 2)
NUCO350-29BI (IPyC density qualification batch 3)
LEU01-15I (confirmation on LEUCO kernels, for information only)
LEU01-23I (confirmation on LEUCO kernels, for information only)
LEU01-26I (confirmation on LEUCO kernels, for information only)
LEU01-41I (confirmation on LEUCO kernels, for information only)

TRISO Batches

LEU01-24T (TRISO batch 1)
LEU01-25T (TRISO batch 2)
LEU01-37T (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_2H_2 + Ar	C_2H_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_2H_2 + C_3H_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_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		

Operator: Richard A. Lowden Date: 6/17/05

QAS: M. C. [illegible] 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_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_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		

Comments/Notes:

Operator:	Richard A. Lowden	Date:	6/17/05
QAS:	[illegible]	Date:	3/30/06

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_2H_2 + Ar	C_2H_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_2H_2 + C_3H_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_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes		

Operator	Richard A Lowden	Date	6/20/05
QAS	MRG	Date:	3/30/06

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_2H_2 + Ar	C_2H_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_2H_2 + C_3H_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_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		

Operator:	Richard A. Lowden	Date:	11/3/05
QAS:	[illegible]	Date:	3/30/06

Summary for Baseline IPyC Qualification Run – NUCO350-30BI

Coating Run No.		NUCO350-30BI
Description		Baseline processing conditions for IPyC layer
Procedure		AGR-COAT-SOP-01, Rev. 1
Kernel Lot No.		NUCO350-30
Operator		R. A. Lowden
Date:		06/29/2005
Data Location:		B002249, Coating Log, Volume 1, pp. 260 - 268
Kernel Batch Wt.		61.87 g
Coated Particle Batch Wt.		104.34 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_6
TGF		9430 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		13 min
SiC		
Coating gases	H_2 + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes		

Operator	Richard A. Lowden	Date:	6/29/05
QAS:	[illegible]	Date:	3/30/06

Summary for Baseline IPyC Qualification Run – NUCO350-37BI

Coating Run No.	NUCO350-37BI
Description:	Baseline processing conditions for IPyC layer
Procedure:	AGR-COAT-SOP-01, Rev. 1
Kernel Lot No.	NUCO350-37
Operator:	R. A. Lowden
Date:	06/30/2005
Data Location:	B002249, Coating Log, Volume 1, pp. 270 - 278
Kernel Batch Wt.	61.92 g
Coated Particle Batch Wt.	103.45 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_6
TGF		9430 sccm
CGF	0 30 ± 0 03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		13 min
SiC		
Coating gases	H_2 + MTS	
TGF		
CGF	0.015 ± 0 005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		

Operator:	Richard A. Lowden	Date:	6/30/05
QAS:	[illegible]	Date:	3/30/06

Summary for Baseline IPyC Qualification Run – NUCO350-29BI

Coating Run No.		NUCO350-29BI
Description:		Baseline processing conditions for IPyC layer
Procedure:		AGR-COAT-SOP-01, Rev. 1
Kernel Lot No.		NUCO350-29
Operator:		R. A. Lowden
Date:		07/01/2005
Data Location:		B002249, Coating Log, Volume 1, pp. 279 - 287
Kernel Batch Wt.		62.52 g
Coated Particle Batch Wt.		105.56 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_6
TGF		9430 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		13 min
SiC		
Coating gases	H_2 + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		

Operator	Richard A. Lowden	Date	7/1/05
QAS:	[illegible]	Date:	3/30/06

Summary for Baseline IPyC Qualification Run – LEU01-15I

Coating Run No.		LEU01-15I
Description:		Baseline processing conditions for IPyC layer
Procedure:		AGR-COAT-SOP-01, Rev. 1
Kernel Lot No.		LEU01-15K
Operator		R. A. Lowden
Date.		11/04/2005
Data Location:		B002516, Coating Log, Volume 3, pp. 12 – 20
Kernel Batch Wt.		63.27 g
Coated Particle Batch Wt.		108.96 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_6
TGF		9430 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		13 min
SiC		
Coating gases	H_2 + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		

Operator	Richard A. Lowden	Date:	11/4/05
QAS:	[illegible]	Date:	3/30/06

Summary for Variant #3b Coating Run - LEU01-23I

Coating Run No.		LEU01-23I
Description:		Variant #3b AGR-1 processing conditions
Procedure:		AGR-COAT-SOP-01, Rev. 1
Kernel Lot No.		LEU01-23K
Operator:		R. A. Lowden
Date:		01/19/2006
Data Location:		B002516, Coating Log, Volume 3, pp. 194 – 201,203
Kernel Batch Wt.		63.42 g
Coated Particle Batch Wt		106.94 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_6
TGF		9435 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		12.33 min
SiC		
Coating gases	H_2 + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes.		

Operator:	Richard A Lowden	Date:	1/19/06
QAS:	[illegible]	Date:	3/25/06

Summary for Variant #3b Coating Run - LEU01-26I

Coating Run No.		LEU01-26I
Description.		Variant #3b AGR-1 processing conditions
Procedure.		AGR-COAT-SOP-01, Rev. 1
Kernel Lot No.		LEU01-26K
Operator:		R. A. Lowden
Date:		01/17/2006
Data Location:		B002516, Coating Log, Volume 3, pp. 186 – 193,202
Kernel Batch Wt.		63.42 g
Coated Particle Batch Wt.		106.59 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_6
TGF		9435 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		12.33 min
SiC		
Coating gases	H_2 + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		

Operator: Richard A. Lowden Date: 1/17/06

QAS: [illegible] Date: 3/28/06

Summary for Variant #3b Coating Run - LEU01-41I

Coating Run No.	LEU01-41I
Description:	Variant #3b AGR-1 processing conditions
Procedure:	AGR-COAT-SOP-01, Rev 1
Kernel Lot No.	LEU01-41K
Operator:	R. A. Lowden
Date:	01/20/2006
Data Location:	B002516, Coating Log, Volume 3, pp. 204 - 213
Kernel Batch Wt.	63.42 g
Coated Particle Batch Wt.	106.97 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_6
TGF		9435 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		12 33 min
SiC		
Coating gases	H_2 + MTS	
TGF		
CGF	0.015 ± 0.005	
Temperature	1500 ± 25°C	
Time		
OPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	
TGF		
CGF	0.30 ± 0.03	
CGR	0.85 ± 0.085	
Temperature	1290 ± 40°C	
Time		
Comments/Notes:		

Operator: Richard A. Lowden Date: 1/20/06

QAS: [illegible] Date: 3/28/06

Summary for Variant #3a Coating Run - LEU01-24T

Coating Run No.		LEU01-24T
Description:		Variant #3a AGR-1 processing conditions
Procedure:		AGR-COAT-SOP-01, Rev. 1
Kernel Lot No.		LEU01-24K
Operator:		R. A. Lowden
Date:		03/22/2006
Data Location:		B002517, Coating Log, Volume 4, pp. 96 - 105
Kernel Batch Wt.		63.35 g
Coated Particle Batch Wt.		183.65 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_6
TGF		9435 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		12.33 min
SiC		
Coating gases	H_2 + Ar + MTS	H_2 + MTS
TGF		10,605 sccm
H_2 to Ar Ratio	1:1	1:1
CGF	0.015 ± 0.005	0.0193
Temperature	~ 1400°C	1425°C
Time		145 min
OPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_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:	Richard A. Lowden	Date:	3/22/06
QAS:	J. S. Rery for M. C. Kane	Date:	6/20/06

Summary for Variant #3a Coating Run - LEU01-25T

Coating Run No.		LEU01-25T
Description:		Variant #3a AGR-1 processing conditions
Procedure:		AGR-COAT-SOP-01, Rev. 1
Kernel Lot No.		LEU01-25K
Operator:		R. A. Lowden
Date:		03/24/2006
Data Location:		B002517, Coating Log, Volume 4, pp. 116 - 125
Kernel Batch Wt.		63.38 g
Coated Particle Batch Wt.		188.99 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_6
TGF		9435 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		12.33 min
SiC		
Coating gases	H_2 + Ar + MTS	H_2 + MTS
TGF		10,614 sccm
H_2 to Ar Ratio	1:1	1.1
CGF	0.015 ± 0.005	0.0201
Temperature	~ 1400°C	1425°C
Time		145 min
OPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_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:	Richard A Lowden	Date:	3/24/06
QAS:	J. S. Quarg for M.C. Vance	Date:	6/20/06

Summary for Variant #3a Coating Run - LEU01-37T

Coating Run No.		LEU01-37T
Description:		Variant #3a AGR-1 processing conditions
Procedure:		AGR-COAT-SOP-01, Rev. 1
Kernel Lot No.		LEU01-37K + LEU01-25K (0.24 g)
Operator:		R. A. Lowden
Date:		04/05/2006
Data Location:		B002517, Coating Log, Volume 4, pp. 138 - 147
Kernel Batch Wt.		63.41 g
Coated Particle Batch Wt.		177.67 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 ± 25°C	1450°C
Time		5 min
IPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_6
TGF		9435 sccm
CGF	0.30 ± 0.03	0.30
CGR	0.85 ± 0.085	0.85
Temperature	1265 ± 25°C	1265°C
Time		12.33 min
SiC		
Coating gases	H_2 + Ar + MTS	H_2 + MTS
TGF		10,604 sccm
H_2 to Ar Ratio	1:1	1:1
CGF	0.015 ± 0.005	0.0192
Temperature	~ 1400°C	1425°C
Time		135 min
OPyC		
Coating gases	Ar + C_2H_2 + C_3H_6	Ar + C_2H_2 + C_3H_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:	Richard A. Lowden	Date:	4/5/06
QAS:	J.S. Grey for M.C. Nunc	Date:	6/20/06

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.

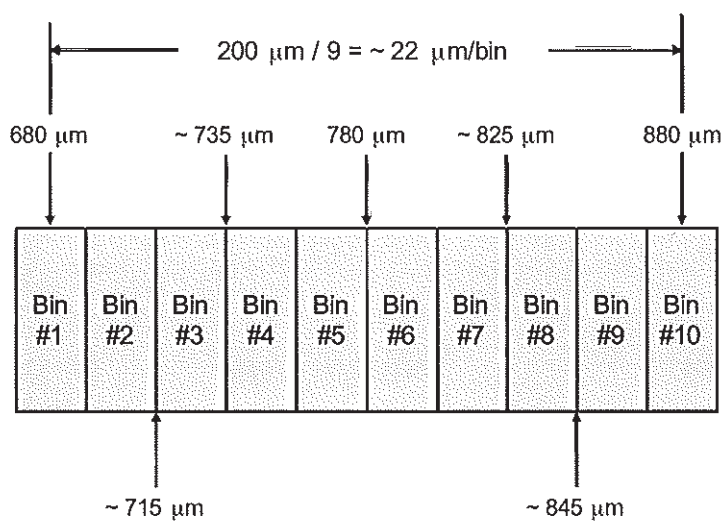


Figure 4.1. Schematic of the collection bins and roller spacing showing relationship between roller gap and particle size.

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 the figure. 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 LEU01-49T coated particle composite.

TRISO batches

LEU01-24T (TRISO batch 1)
LEU01-25T (TRISO batch 2)
LEU01-37T (TRISO batch 3)

Sizing & Removal of Aspherical Particles for LEU01-24T

Summary for Sizing of Kernels or Coated Particles

Procedure:		AGR-ROLLER-SOP-01, Rev. 0		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-24T		
Kernel/Coated Particle Description:		Variant #3a, full TRISO on 350 μm LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 62		
Date	Batch Weight (g)	Sized Batch Weight (g)	Scrap (g)	Loss (g)
03/23/2006	183.65	176.12	7.55	+ 0.02
Comments:				
Operator:	Richard A. Lowden		Date:	3/24/06
QAS:	[illegible]		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:		LEU01-24T		
Kernel/Coated Particle Description:		Variant #3a, full TRISO on 350 μm LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 63		
Date	Batch Weight (g)	Tabled Batch Weight (g)	Scrap (g)	Loss (g)
03/24/2006	176.12	167.84	8.31	+ 0.03
Comments:				
Operator:	Richard A. Lowden		Date:	3/24/06
QAS:	[illegible]		Date:	3/28/06

Sizing & Removal of Aspherical Particles for LEU01-25T

Summary for Sizing of Kernels or Coated Particles

Procedure:		AGR-ROLLER-SOP-01, Rev. 0		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-25T		
Kernel/Coated Particle Description:		Variant #3a, full TRISO on 350 μm LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 66		
Date	Batch Weight (g)	Sized Batch Weight (g)	Scrap (g)	Loss (g)
03/27/2006	188.99	181.59	7.42	+ 0.02
Comments:				
Operator:	Richard A Lowden		Date:	3/27/06
QAS:	[illegible]		Date:	5/4/06

Summary for Tabling of Kernels or Coated Particles

Procedure:		AGR-TABLE-SOP-01, Rev. 1		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-36T		
Kernel/Coated Particle Description:		Variant #3a, full TRISO on 350 μm LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 67		
Date	Batch Weight (g)	Tabled Batch Weight (g)	Scrap (g)	Loss (g)
03/29/2006	181.59	171.02	10.55	(0.02)
Comments:				
Operator:	Richard A Lowden		Date:	3/29/06
QAS:	[illegible]		Date:	5/4/06

Sizing & Removal of Aspherical Particles for LEU01-37T

Summary for Sizing of Kernels or Coated Particles

Procedure:		AGR-ROLLER-SOP-01, Rev 0		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-37T		
Kernel/Coated Particle Description:		Variant #3a, full TRISO on 350 μm LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 70		
Date	Batch Weight (g)	Sized Batch Weight (g)	Scrap (g)	Loss (g)
04/05/2006	177.67	159.22	18.54	+ 0.09
Comments:				
Operator:	Richard A Lowden		Date:	4/5/06
QAS:	[illegible]		Date:	5/4/06

Summary for Tabling of Kernels or Coated Particles

Procedure:		AGR-TABLE-SOP-01, Rev. 1		
Operator:		R. A. Lowden		
Kernel/Coated Particle ID:		LEU01-37T		
Kernel/Coated Particle Description:		Variant #3a, full TRISO on 350 μm LEUCO		
Data Location:		B002163, Sizing & Tabling, p. 71		
Date	Batch Weight (g)	Tabled Batch Weight (g)	Scrap (g)	Loss (g)
04/06/2006	159.22	150.10	9.10	(0.02)
Comments:				
Operator:	Richard A Lowden		Date:	4/6/06
QAS:	[illegible]		Date:	5/4/06

5 Blend of coated particle composites

Three batches of TRISO-coated particles were blended into composite LEU01-49T. The mass of each batch added to the composite is shown in the following table.

Batch ID	Amount added to LEU01-49T composite (g)
LEU01-24T	149.0861
LEU01-25T	151.9319
LEU01-37T	132.3124
Total	433.3304

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

Three batches of buffer/IPyC-coated particles were blended into composite NUCO350-66BI. The mass of each batch added to the composite is shown in the following table.

Batch ID	Amount added to NUCO350-66BI composite (g)
NUCO350-30BI	96.9421
NUCO350-37BI	96.1568
NUCO350-29BI	98.2502
Total	291.3491

6 Characterization of LEUCO kernel composite

This section contains data on the kernel composite used for LEU01-49T. 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 $(2.47\pm0.01)\cdot10^{-4}$ grams per kernel to $(2.418\pm0.006)\cdot10^{-4}$ 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 15.

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/√n ≥ 340	349.5	DRF-06 DRF-09
						B = x + ts/√n ≤ 360	349.9	
				2.38	dispersion ≤0.01 < 300 ≤0.01 > 400	C = x - ks > 300	328.3	
						D = x + ks < 400	371.1	
Kernel ellipticity (Dmax/Dmin)	1.021		4304		dispersion ≤0.10 ≥1.05	≤1 in 50 or ≤7 in 142	94	DRF-06 DRF-09
Kernel envelope density (Mg/m³)	10.924	0.015	5	2.132	mean ≥10.4	A = x - ts/√n ≥ 10.4	10.91	DRF-15 DRF-22

Comments

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

QC Supervisor — Date: 2-16-06

QA Reviewer — Date: 3/29/06

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:	~~LEUCO350-01B~~ 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. µm

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

Date 05/19/05

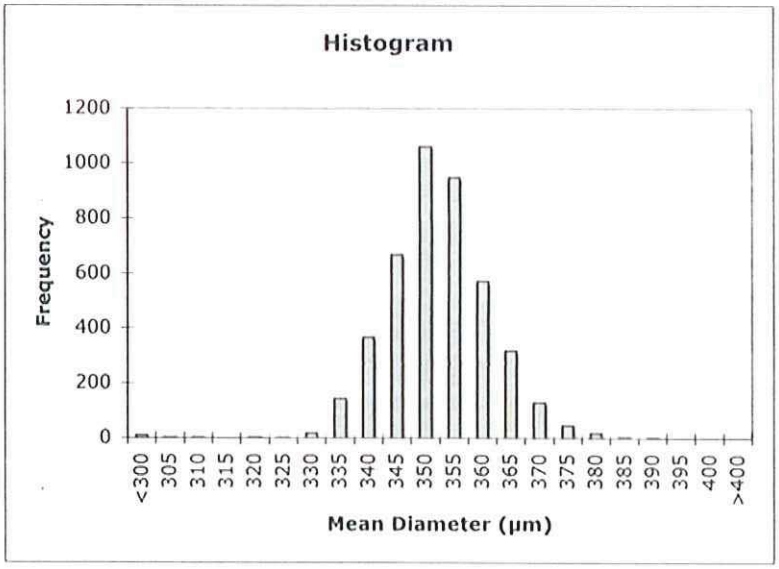
Data Report Form DRF-09A: Measurement of Kernel Diameter

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 AK 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

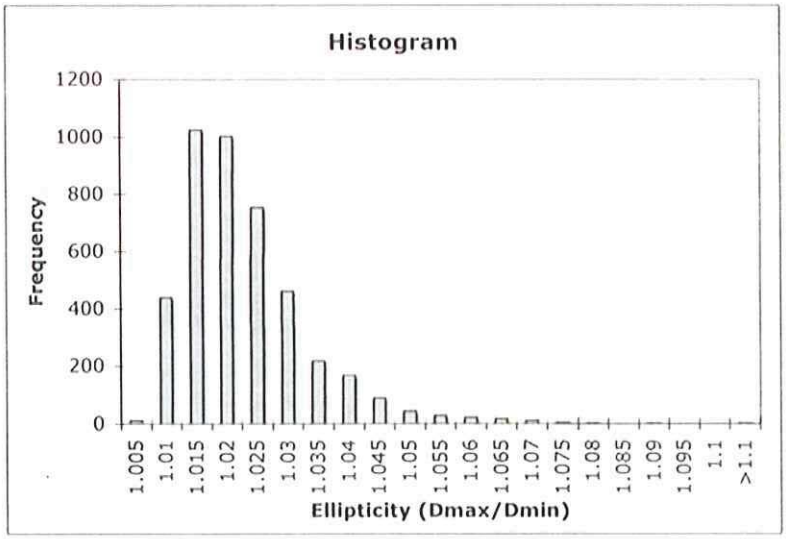
Data Report Form DRF-09B: Measurement of Kernel Ellipticity (Dmax/Dmin)

Procedure:	AGR-CHAR-DAM-09 Rev. 0
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05051902
Sample ID:	~~LEUCO350-01B~~ renamed LEU01-01K-B JH 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
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



Operator

May 23, 2005
Date

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

Procedure:	AGR-CHAR-DAM-15 Rev. 2
Operator:	S. D. NUNN
Kernel Lot ID:	~~LEUCO350-01~~ renamed LE001-01 K gh 4-17-06
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

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 and IPyC 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 $(2.39\pm0.03)\cdot10^{-4}$ grams per kernel to $(2.308\pm0.009)\cdot10^{-4}$ 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 15.

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 ≤0.01 < 300 ≤0.01 > 400	$C = x - ks > 300$	309.2	
						$D = x + ks < 400$	380.6	
Kernel ellipticity (Dmax/Dmin)	1.022		4202		dispersion ≤0.10 ≥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 — Date: 2-20-06

QA Reviewer — Date: 2/22/06

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 um 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 µm

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

Operator **Date** 5/25/2005

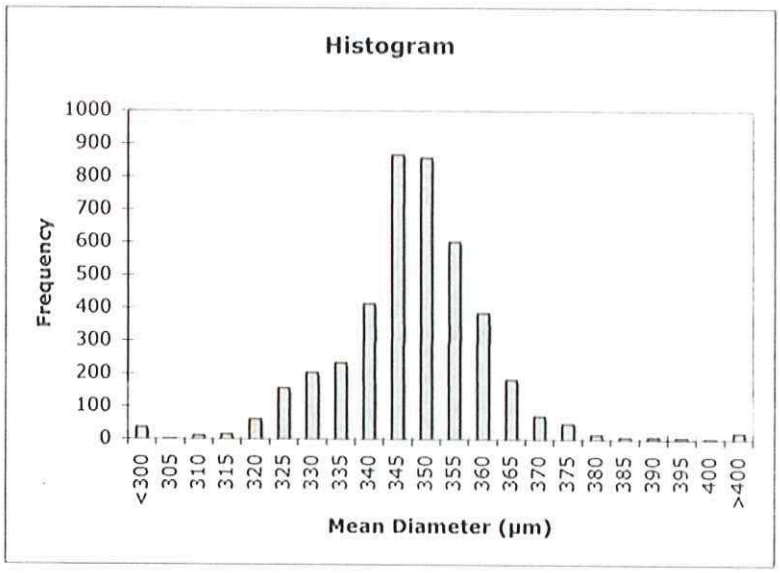
Data Report Form DRF-09A: Measurement of Kernel Diameter

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

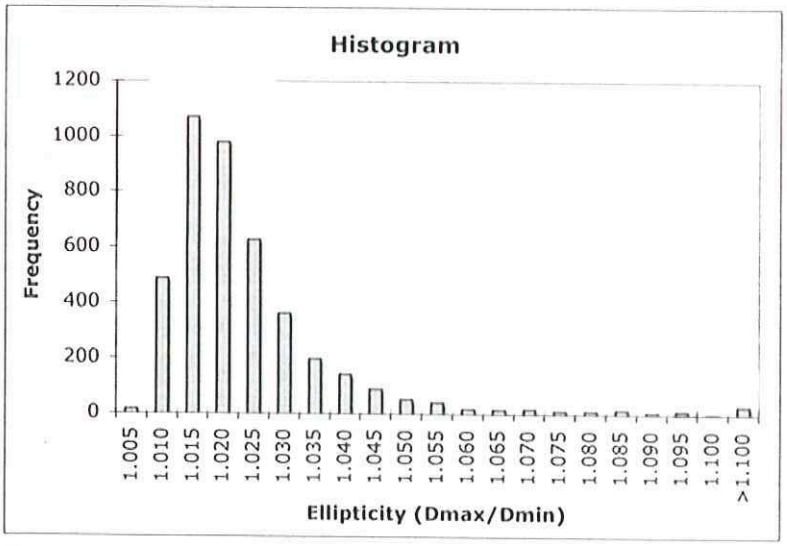
Data Report Form DRF-09B: Measurement of Kernel Ellipticity (Dmax/Dmin)

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



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

5/14/06
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

John Hunn
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 LEU01-49T 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 15. 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 DRF-22
						$B = x + ts/\sqrt{n} \leq 1.18$	1.12	pass	
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 DRF-22
						$B = x + ts/\sqrt{n} \leq 1.18$	1.16	pass	
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 DRF-22
						$B = x + ts/\sqrt{n} \leq 1.18$	1.15	pass	

Comments

Standard deviations are √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.

John Henn
QC Supervisor

3-10-06
Date

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

QA Reviewer

3/29/06
Date

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

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

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

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

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

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

S D Nunn
Operator

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

Operator

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

Operator

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

Operator

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

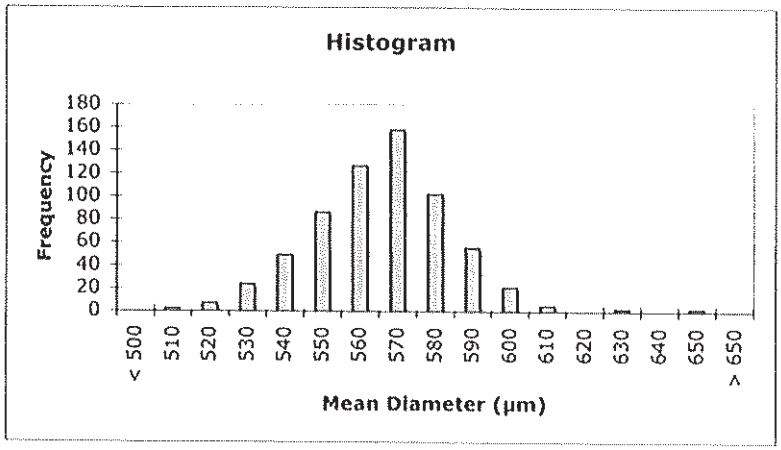
Data Report Form DRF-10A: Measurement of Particle Diameter

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

6/27/2025

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

Dixie Barker
Operator

11-7-05
Date

9 Characterization of IPyC on interrupted batches

This section contains data on the inner pyrocarbon (IPyC) coating density and other properties for particles removed from the coater after deposition of only the buffer and IPyC layers. The data was obtained according to product inspection plan AGR-CHAR-PIP-02R4. The IPyC on these particles was deposited under similar conditions as the IPyC on the particles in composite LEU01-49T 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 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 IPyC. A confirmatory batch using LEUCO kernels from G73D-20-69302 was coated and characterized to verify this assumption.

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. The process conditions used to deposit the IPyC layer were determined to be sufficient to satisfy the specifications in section 5.3 of EDF 4380, Rev. 6.

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

Procedure:	AGR-CHAR-PIP-02 Rev. 4
Batch 1 ID:	NUCO350-30BI
Batch 1 description:	IPyC/Buffer on BWXT kernel composite 69300
Batch 2 ID:	NUCO350-37BI
Batch 2 description:	IPyC/Buffer on BWXT kernel composite 69300
Batch 3 ID:	NUCO350-29BI
Batch 3 description:	IPyC/Buffer on 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)	k or t value	INL EDF-4380 Rev. 6				
Batch 1: IPyC sink/float density (Mg/m³)	1.8917	0.0113	25	1.711	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.888	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.896	pass	
				3.158	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.856	pass	
						D = x + ks < 2.00	1.927	pass	
Batch 2: IPyC sink/float density (Mg/m³)	1.9038	0.0153	21	1.725	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.898	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.910	pass	
				3.262	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.854	pass	
						D = x + ks < 2.00	1.954	pass	
Batch 3: IPyC sink/float density (Mg/m³)	1.9112	0.0142	20	1.729	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.906	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.917	pass	
				3.295	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.864	pass	
						D = x + ks < 2.00	1.958	pass	

Comments

95% confidence interval for Buffer thickness in composite = (104μm, 106μm) with <1% ≤55μm.
95% confidence interval for IPyC thickness in composite = (34.2μm, 34.9μm) with >1% ≤30μm and <1% ≥56μm.
Confirmatory batch on LEUCO kernels, LEU01-15I: mean IPyC density = 1.9074 g/cc.

QC Supervisor — Date: 3-10-06

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

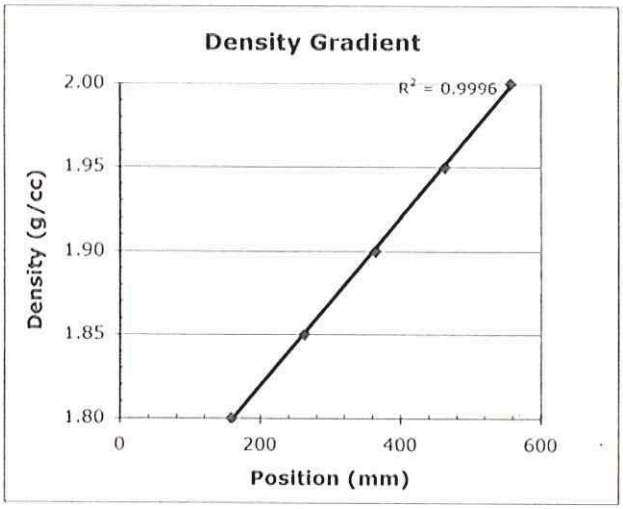
QA Reviewer — Date: 3/29/06

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

Procedure:	AGR-CHAR-DAM-03 Rev. 1
Operator:	Dixie Barker
Filename:	\\mc-agr\AGR\DensityColumn\D05062901_DRF03R1.xls
Sample ID:	NUCO350-30BI-B
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300
Float Expiration Date:	07/2007
Gauge Expiration Date:	01/2006
Bath Temperature:	23.1C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	154.64	163.83	159.24
1.850	258.61	266.87	262.74
1.900	361.46	367.13	364.30
1.950	459.26	467.16	463.21
2.000	553.39	560.32	556.86

Linear Fit			
slope	StDev	intercept	StDev
5.02E-04	3.18E-06	1.72E+00	1.25E-03



Sample Density			
Particle Number	Particle Position	Calculated Density	Standard Error
1	295.22	1.8668	0.0016
2	304.23	1.8714	0.0016
3	325.99	1.8823	0.0016
4	326.44	1.8825	0.0016
5	326.76	1.8827	0.0016
6	328.81	1.8837	0.0016
7	326.67	1.8826	0.0016
8	333.83	1.8862	0.0016
9	335.75	1.8872	0.0016
10	334.07	1.8863	0.0016
11	335.11	1.8869	0.0016
12	336.64	1.8876	0.0016
13	348.87	1.8938	0.0017
14	348.31	1.8935	0.0017
15	350.33	1.8945	0.0017
16	351.97	1.8953	0.0017
17	355.50	1.8971	0.0017
18	357.75	1.8982	0.0017
19	359.46	1.8991	0.0017
20	364.06	1.9014	0.0017
21	363.84	1.9013	0.0017
22	362.42	1.9006	0.0017
23	368.25	1.9035	0.0017
24	385.58	1.9122	0.0018
25	390.04	1.9144	0.0018
Average Density		1.8917	0.0003
Standard Deviation		0.0113	

Dixie Barker
Operator

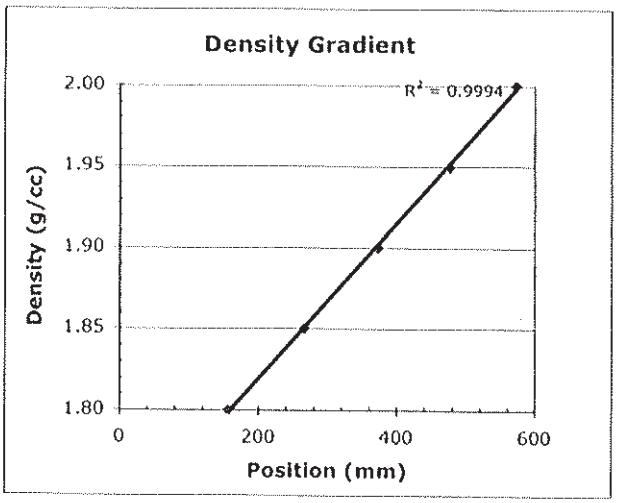
6-29-05
Date

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

Procedure:	AGR-CHAR-DAM-03 Rev. 1
Operator:	Dixie Barker
Filename:	\\mc-agr\AGR\DensityColumn\D05063001_DRF03R1.xls
Sample ID:	NUCO350-37BI-B
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300
Float Expiration Date:	07/2007
Gauge Expiration Date:	01/2006
Bath Temperature:	22.9C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	151.98	161.42	156.70
1.850	262.34	270.69	266.52
1.900	370.32	376.20	373.26
1.950	473.40	480.73	477.07
2.000	569.44	576.52	572.98

Linear Fit			
slope	StDev	Intercept	StDev
4.79E-04	2.94E-06	1.72E+00	1.17E-03



Sample Density			
Particle Number	Particle Position	Calculated Density	Standard Error
1	313.15	1.8731	0.0015
2	329.08	1.8807	0.0015
3	335.13	1.8836	0.0015
4	342.49	1.8872	0.0015
5	349.04	1.8903	0.0016
6	351.34	1.8914	0.0016
7	365.21	1.8980	0.0016
8	367.09	1.8989	0.0016
9	367.27	1.8990	0.0016
10	378.19	1.9043	0.0016
11	382.30	1.9062	0.0016
12	386.45	1.9082	0.0016
13	387.67	1.9088	0.0016
14	389.34	1.9096	0.0016
15	390.40	1.9101	0.0016
16	404.73	1.9170	0.0017
17	409.36	1.9192	0.0017
18	412.62	1.9207	0.0017
19	412.95	1.9209	0.0017
20	418.50	1.9236	0.0017
21	428.34	1.9283	0.0017
22			
23			
24			
25			
Average Density		1.9038	0.0004
Standard Deviation		0.0153	

Dixie Barker
Operator

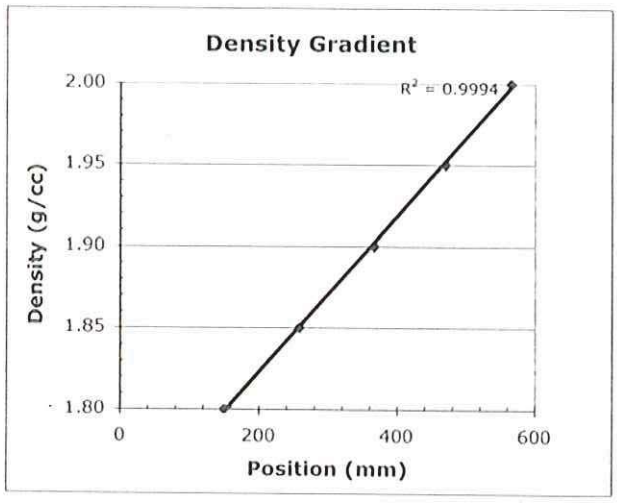
6-30-05
Date

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

Procedure:	AGR-CHAR-DAM-03 Rev. 1
Operator:	Dixie Barker
Filename:	\\mc-agr\AGR\DensityColumn\D05070101_DRF03R1.xls
Sample ID:	NUCO350-29BI-B
Sample Description:	Ipyc/Buffer on BWXT kernel composite 69300
Float Expiration Date:	07/2007
Gauge Expiration Date:	01/2006
Bath Temperature:	23.3C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	145.75	154.69	150.22
1.850	254.86	262.94	258.90
1.900	363.03	368.69	365.86
1.950	466.04	473.41	469.73
2.000	561.98	569.07	565.53

Linear Fit			
slope	StDev	intercept	StDev
4.80E-04	3.17E-06	1.73E+00	1.15E-03



Sample Density			
Particle Number	Particle Position	Calculated Density	Standard Error
1	321.45	1.8805	0.0015
2	336.71	1.8878	0.0016
3	341.90	1.8903	0.0016
4	358.02	1.8981	0.0016
5	368.37	1.9030	0.0016
6	374.74	1.9061	0.0017
7	373.30	1.9054	0.0017
8	379.31	1.9083	0.0017
9	382.20	1.9097	0.0017
10	383.00	1.9101	0.0017
11	390.54	1.9137	0.0017
12	390.54	1.9137	0.0017
13	405.88	1.9210	0.0017
14	406.48	1.9213	0.0017
15	408.91	1.9225	0.0017
16	409.63	1.9228	0.0017
17	414.97	1.9254	0.0017
18	423.66	1.9296	0.0018
19	429.22	1.9322	0.0018
20	410.67	1.9233	0.0017
21			
22			
23			
24			
25			
Average Density		1.9112	0.0004
Standard Deviation		0.0142	

Dixie Barker
Operator

7-1-05
Date

For Information Only

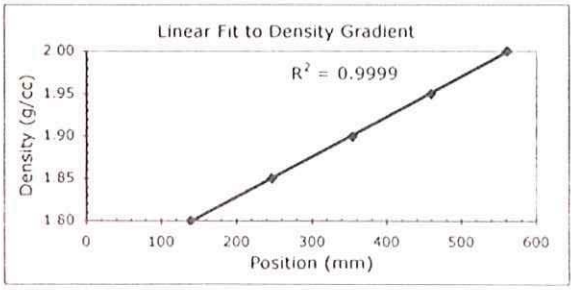
The information in the remainder of this section reports results of measurements not required by the fuel specification and is provided for information only.

Data Report Form DRF-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\D05110801_DRF03R2.xls
Sample ID:	LEU01-15I-B01
Sample description:	IPyC/Buffer on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2006
Bath temperature:	22.7 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	134.80	144.21	139.51
1.850	243.34	251.54	247.44
1.900	351.28	357.11	354.20
1.950	456.05	463.23	459.64
2.000	557.73	565.05	561.39

Linear Fit			
slope	StDev	intercept	StDev
4.73E-04	2.74E-06	1.73E+00	9.73E-04



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	304.62	1.8774	26	370.16	1.9084	51		
2	311.60	1.8807	27	370.85	1.9087	52		
3	316.86	1.8832	28	369.53	1.9081	53		
4	324.68	1.8869	29	374.00	1.9102	54		
5	328.13	1.8885	30	375.99	1.9112	55		
6	332.97	1.8908	31	381.77	1.9139	56		
7	334.87	1.8917	32	382.71	1.9143	57		
8	338.02	1.8932	33	384.42	1.9151	58		
9	338.84	1.8936	34	385.50	1.9157	59		
10	340.51	1.8944	35	386.44	1.9161	60		
11	341.77	1.8950	36	386.80	1.9163	61		
12	341.09	1.8946	37	387.69	1.9167	62		
13	341.09	1.8946	38	388.54	1.9171	63		
14	351.54	1.8996	39	391.14	1.9183	64		
15	352.97	1.9003	40	392.11	1.9188	65		
16	354.39	1.9009	41	393.13	1.9193	66		
17	358.58	1.9029	42	396.08	1.9207	67		
18	359.74	1.9035	43	397.78	1.9215	68		
19	358.62	1.9029	44	399.01	1.9221	69		
20	360.57	1.9039	45	400.37	1.9227	70		
21	361.40	1.9042	46	403.99	1.9244	71		
22	362.69	1.9049	47	407.97	1.9263	72		
23	365.05	1.9060	48	408.28	1.9264	73		
24	367.05	1.9069	49	420.44	1.9322	74		
25	369.10	1.9079	50	428.33	1.9359	75		

Average density of PyC fragments:	1.9074
Standard deviation in density of PyC fragments:	0.0136
Uncertainty in calculated density of PyC fragments:	0.0015

Dixie Barker
Operator

11-8-05
Date

Summary of "info only" measurements

Coating Thickness

		Buffer thickness (μm)	IPyC thickness (μm)
Batch 1	NUCO350-30BI-C	99	36.3
Batch 2	NUCO350-37BI-C	102	35.1
Batch 3	NUCO350-29BI-C	107	33.9
Average		103	35.1
Composite	NUCO350-66BI-C	105	34.5

Open Porosity

		Average particle weight (g)	Open porosity (ml/m^2)
Composite	NUCO350-66BI	3.95E-04	1.65
Confirmatory	LEU01-15I	4.26E-04	1.56

Note: The open porosity measurement on the IPyC was calculated from the mercury intrusion between 250 psi and 10000 psi per table 5.3 in EDF-4380, Rev. 6. In the upper half of this pressure range, there is some compression of the buffer layer that results in a value for open porosity that is higher than the actual value. The open porosity of the IPyC in LEU01-15I, calculated from the mercury intrusion between 250 psi and 5000 psi, was 1.20 ml/m^2 which corresponds well with the open porosity measured for OPyC deposited under similar conditions. The open porosity of the IPyC in NUCO350-66BI, calculated from the mercury intrusion between 250 psi and 5000 psi, was 1.19 ml/m^2. Porosimetry measurements on OPyC, where compression between 5000 psi and 10000 psi is negligible, show little mercury intrusion above 5000 psi.

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

Procedure:	AGR-CHAR-DAM-08 Rev. 0
Operator:	Andrew K. Kercher
Sample ID:	NUCO350-30BI-C
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300 -- repolished
Mount Number(s):	M05062902
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05070101

DMR Calibration Expiration Date:	3/24/06
Stage Micrometer Calibration Expiration Date:	2/17/07
Measured Value for 500 μm in Stage Micrometer Image:	500.4 μm

Operator

07/01/05
Date

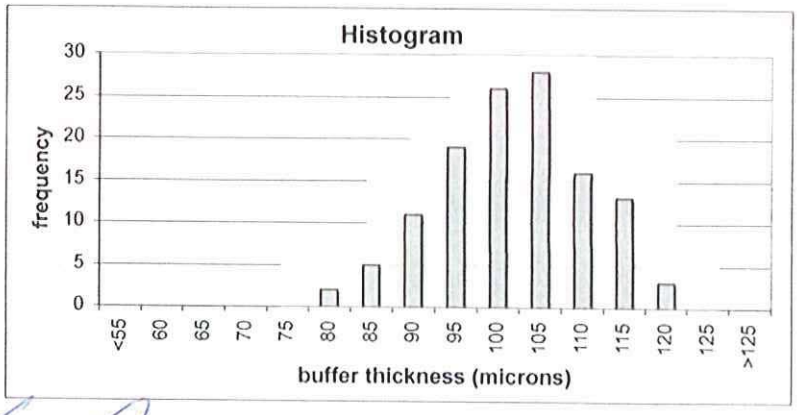
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070101\
Sample ID:	NUCO350-30BI-C (repolished sample)
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070101_output\

Number of buffer layers analyzed:	123
Mean of the average buffer thickness of each particle (μm):	99.4
Standard deviation in the average buffer thickness of each particle (μm):	8.8

Distribution of the average buffer layer thickness (top binned)

Buffer Thickness (μm)	*Frequency*
<55	0
60	0
65	0
70	0
75	0
80	2
85	5
90	11
95	19
100	26
105	28
110	16
115	13
120	3
125	0
>125	0



Operator

July 19, 2025
Date

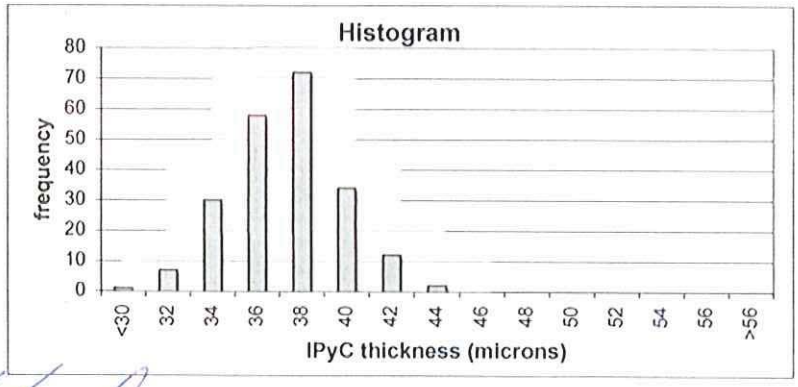
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070101\
Sample ID:	NUCO350-30BI-C (repolished sample)
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070101_output\

Number of inner pyrocarbon layers analyzed:	216
Mean of the average IPyC thickness of each particle (μm):	36.3
Standard deviation in the average IPyC thickness of each particle (μm):	2.4

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	*Frequency*
<30	1
32	7
34	30
36	58
38	72
40	34
42	12
44	2
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



Operator

July 19, 2005
Date

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

Procedure:	AGR-CHAR-DAM-08 Rev. 0
Operator:	Andrew K. Kercher
Sample ID:	NUCO350-37BI-C
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300
Mount Number(s):	M05063001
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05070501\

DMR Calibration Expiration Date:	3/24/06
Stage Micrometer Calibration Expiration Date:	2/17/07
Measured Value for 500 μm in Stage Micrometer Image:	500.7 μm

Andrew K. Kercher — Operator

07/05/05 — Date

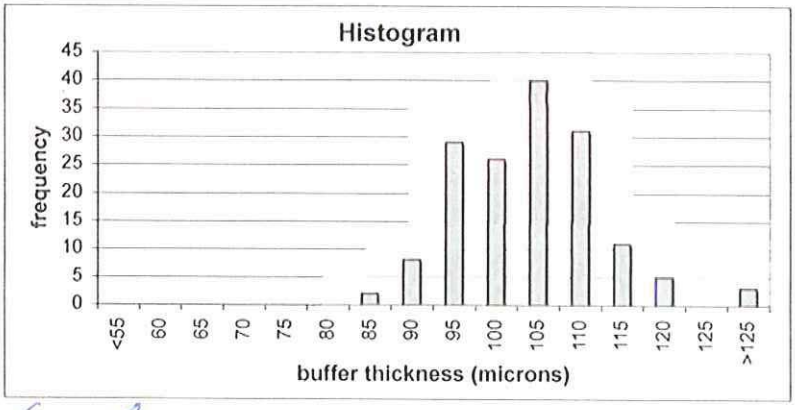
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070501\
Sample ID:	NUCO350-37BI-C
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070501_output\

Number of buffer layers analyzed:	155
Mean of the average buffer thickness of each particle (μm):	101.5
Standard deviation in the average buffer thickness of each particle (μm):	8.9

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	2
90	8
95	29
100	26
105	40
110	31
115	11
120	5
125	0
>125	3



Andrew K. Kercher July 19, 2005

Operator Date

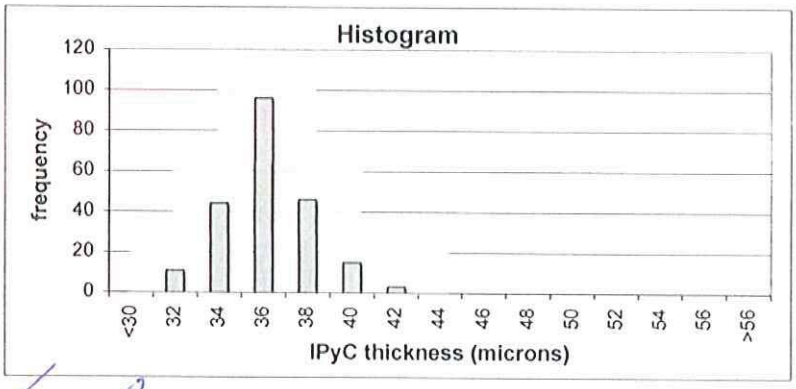
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070501\
Sample ID:	NUCO350-37BI-C
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070501_output\

Number of inner pyrocarbon layers analyzed:	215
Mean of the average IPyC thickness of each particle (μm):	35.1
Standard deviation in the average IPyC thickness of each particle (μm):	2.0

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	*Frequency*
<30	0
32	11
34	44
36	96
38	46
40	15
42	3
44	0
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



Andrew K. Kercher July 19, 2005

Operator Date

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

Procedure:	AGR-CHAR-DAM-08 Rev. 0
Operator:	Andrew K. Kercher
Sample ID:	NUCO350-29BI-C
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300
Mount Number(s):	M05070101
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05070601\

DMR Calibration Expiration Date:	3/24/06
Stage Micrometer Calibration Expiration Date:	2/17/07
Measured Value for 500 μm in Stage Micrometer Image:	499.6 μm

Operator

07/06/05
Date

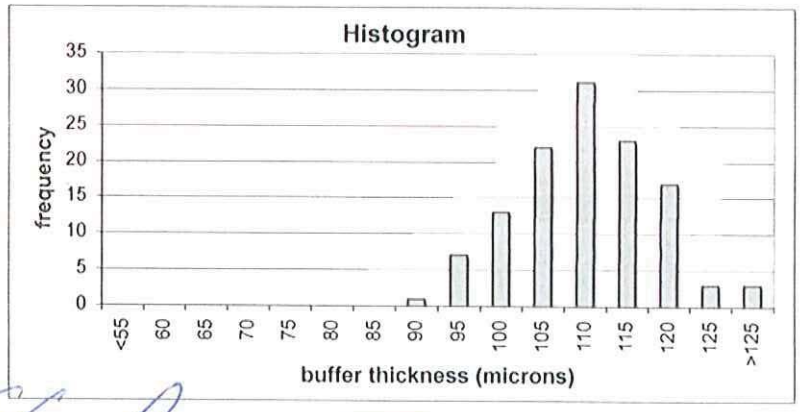
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070601\
Sample ID:	NUCO350-29BI-C
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070601_output\

Number of buffer layers analyzed:	120
Mean of the average buffer thickness of each particle (μm):	107.3
Standard deviation in the average buffer thickness of each particle (μm):	8.0

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	0
90	1
95	7
100	13
105	22
110	31
115	23
120	17
125	3
>125	3



Operator

July 19, 2005

Date

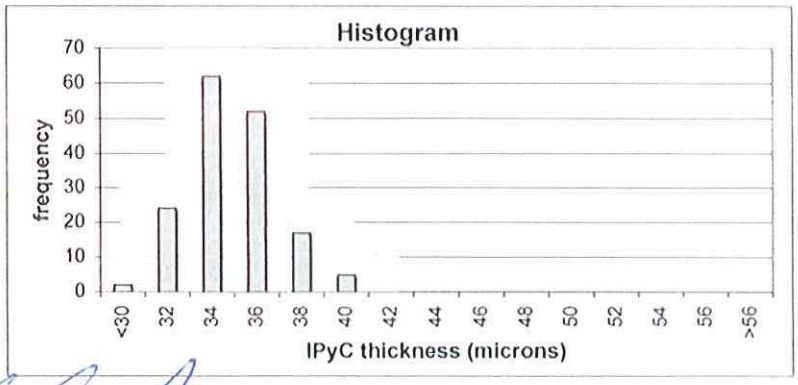
Data Report Form DRF-11B; Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070601\
Sample ID:	NUCO350-29BI-C
Sample Description:	IPyC/Buffer on BWXT kernel composite 69300
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070601_output\

Number of inner pyrocarbon layers analyzed:	162
Mean of the average IPyC thickness of each particle (μm):	33.9
Standard deviation in the average IPyC thickness of each particle (μm):	2.0

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	*Frequency*
<30	2
32	24
34	62
36	52
38	17
40	5
42	0
44	0
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



Operator

July 19, 2005
Date

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

Procedure:	AGR-CHAR-DAM-08 Rev. 0
Operator:	Andrew K. Kercher
Sample ID:	NUCO350-66BI-C
Sample Description:	Composite (30BI+37BI+29BI) IPyC/Buffer on BWXT composite 69300
Mount Number(s):	M05070601
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P05070602\

DMR Calibration Expiration Date:	3/24/06
Stage Micrometer Calibration Expiration Date:	2/17/07
Measured Value for 500 µm in Stage Micrometer Image:	499.6 µm

Operator

07/06/05

Date

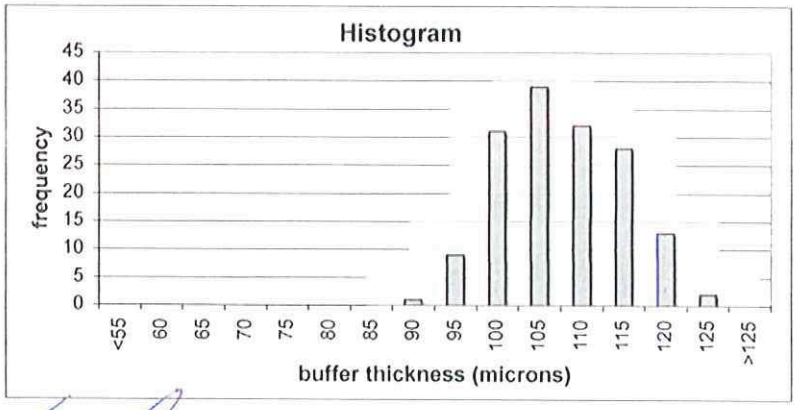
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070602\
Sample ID:	NUCO350-66BI-C
Sample Description:	Composite (30BI+37BI+29BI) IPyC/Buffer on BWXT composite 69300
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070602_output\

Number of buffer layers analyzed:	155
Mean of the average buffer thickness of each particle (μm):	105.3
Standard deviation in the average buffer thickness of each particle (μm):	7.2

Distribution of the average buffer layer thickness (top binned)

Buffer Thickness (μm)	*Frequency*
<55	0
60	0
65	0
70	0
75	0
80	0
85	0
90	1
95	9
100	31
105	39
110	32
115	28
120	13
125	2
>125	0



Andrew K. Kercher — July 19, 2005

Operator — Date

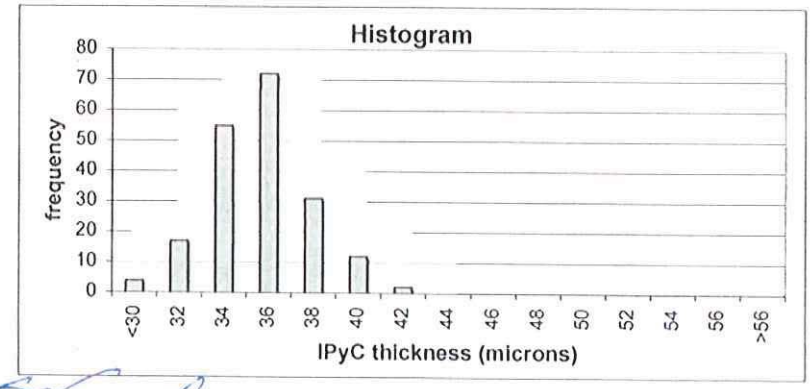
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070602\
Sample ID:	NUCO350-66BI-C
Sample Description:	Composite (30BI+37BI+29BI) IPyC/Buffer on BWXT composite 69300
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P05070602_output\

Number of inner pyrocarbon layers analyzed:	193
Mean of the average IPyC thickness of each particle (μm):	34.5
Standard deviation in the average IPyC thickness of each particle (μm):	2.2

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	*Frequency*
<30	4
32	17
34	55
36	72
38	31
40	12
42	2
44	0
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



Operator

July 19, 2005
Date

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

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	NUCO350-66BI
Particle Lot Description:	Composite (30BI+37BI+29BI) IPyC/Buffer on BWXT 69300
Filename:	\\mc-agr\AGR\ParticleWeight\W05072101__DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	7.92E-02	9.73E-02	8.60E-02	8.78E-02	7.42E-02
Number of particles:	201	246	218	222	188
Average weight/particle (g):	3.94E-04	3.96E-04	3.94E-04	3.95E-04	3.95E-04

Mean average weight/particle (g):	3.95E-04
Uncertainty in mean average weight/particle (g):	2.92E-07

Dixie Barker
Operator

7-21-05
Date

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

Procedure:	AGR-CHAR-DAM-31 Rev. 0
Operator:	S. D. Nunn
Coated particle batch ID:	NUCO350-66BI-E
Batch Description:	IPyC coated BWXT NUCO composite 69300
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05071402\S05071402_DRF31R0.xls

Mean average weight/particle (g):	3.95E-04
Uncertainty in mean average weight/particle (g):	2.92E-07

Weight of particles (g):	4.1698
Approximate number of particles:	10556
Uncertainty in number of particles:	8
Total envelope volume of sample (cc):	1.391
Average envelope volume/particle (cc):	1.32E-04
Sample envelope density (g/cc):	2.998

Average particle diameter (microns):	6.31E+02
Average surface area/particle (cm2):	1.25E-02
Total sample surface area (cm2):	1.32E+02
Intruded mercury volume from 250-10,000 psia (cc):	2.18E-02
Open porosity (ml/m2):	1.65E+00

S. D. Nunn
Operator

12/1/05
Date

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

Procedure:	AGR-CHAR-DAM-22 Rev. 1
Operator:	Dixie Barker
Particle Lot ID:	LEUC0-15I-CO1
Particle Lot Description:	Buffer on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W05110702_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	6.97E-02	6.15E-02	5.69E-02	5.93E-02	6.72E-02
Number of particles:	163	144	134	139	159
Average weight/particle (g):	4.28E-04	4.27E-04	4.25E-04	4.27E-04	4.23E-04

Mean average weight/particle (g):	4.26E-04
Uncertainty in mean average weight/particle (g):	9.19E-07

Dixie Barker
Operator

11-1-05
Date

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

Procedure:	AGR-CHAR-DAM-31 Rev. 0
Operator:	S. D. Nunn
Coated particle batch ID:	LEU01-15I-D01
Batch Description:	IPyC coated BWXT composite 69302
Thermocouple Expiration Date:	5/23/06
Penetrometer Expiration Date:	5/25/06
Completed DRF Filename:	\\mc-agr\AGR\Porosimeter\S05110801\S05110801_DRF31R0.xls

Mean average weight/particle (g):	4.26E-04
Uncertainty in mean average weight/particle (g):	9.19E-07

Weight of particles (g):	4.0001
Approximate number of particles:	9390
Uncertainty in number of particles:	20
Total envelope volume of sample (cc):	1.344
Average envelope volume/particle (cc):	1.43E-04
Sample envelope density (g/cc):	2.976

Average particle diameter (microns):	6.49E+02
Average surface area/particle (cm2):	1.32E-02
Total sample surface area (cm2):	1.24E+02
Intruded mercury volume from 250-10,000 psia (cc):	1.93E-02
Open porosity (ml/m2):	1.56E+00

S. D. Nunn
Operator

Date

10 Characterization of IPyC on additional interrupted batches

This section reports results not required by the fuel specification and is provided for information only.

An additional three batches of particles were removed from the coater after deposition of only the buffer and IPyC layers. These particles contained LEUCO kernels and were fabricated for use in the production of TRISO particles where the coating was interrupted between the IPyC and SiC deposition steps. This section contains data on the inner pyrocarbon (IPyC) coating density and other properties for these particles. The data was obtained according to product inspection plan AGR-CHAR-PIP-02R2 with the exception that no other samples were riffled from the batch other than the one for the IPyC density measurement. The IPyC on these particles was deposited under similar conditions as the IPyC on the particles in composite LEU01-49T and should therefore be representative of the IPyC on the particles in that composite. The results of these measurements are included here because they provide further confirmation of the results in section 9 of the acceptability of the IPyC deposition process for IPyC density. These additional results are valuable because they are for coatings on the same LEUCO kernel composite as that used for LEU01-49T and they were obtained with a newer revision of the data acquisition method for IPyC density measurement which called for measurement on a greater number of coating fragments for improved sampling statistics.

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.

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

Procedure:	AGR-CHAR-PIP-02 Rev. 4
Batch 1 ID:	LEU01-231
Batch 1 description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Batch 2 ID:	LEU01-261
Batch 2 description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Batch 3 ID:	LEU01-411
Batch 3 description:	Variant 3b: IPyC/Buffer 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: IPyC sink/float density (Mg/m³)	1.9056	0.0127	48	1.678	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.903	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.909	pass	
				2.868	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.869	pass	
						D = x + ks < 2.00	1.942	pass	
Batch 2: IPyC sink/float density (Mg/m³)	1.9016	0.0144	51	1.676	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.898	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.905	pass	
				2.848	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.861	pass	
						D = x + ks < 2.00	1.943	pass	
Batch 3: IPyC sink/float density (Mg/m³)	1.9045	0.0130	46	1.679	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.901	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.908	pass	
				2.882	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.867	pass	
						D = x + ks < 2.00	1.942	pass	

Comments

The process conditions for IPyC and Buffer were the same as the AGR-1 baseline process conditions.
These results demostrate that the baseline IPyC process conditions satisfy the IPyC density specification with the exception that they were not obtained prior to baseline fuel manufacture.

QC Supervisor — Date: 3-2-06

Accept process for IPyC density (Yes or No):	N/A

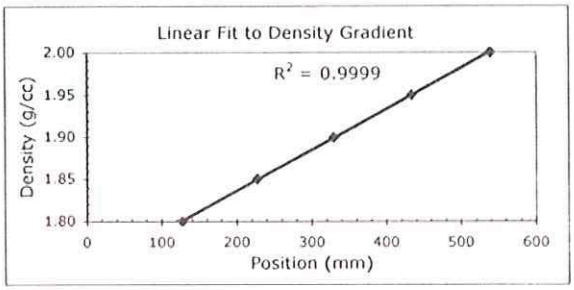
QA Reviewer — Date: 3/27/06

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\D06012501_DRF03R2.xls
Sample ID:	LEU01-23I-B01
Sample description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	22.9 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	122.58	132.72	127.65
1.850	223.47	231.53	227.50
1.900	326.68	332.74	329.71
1.950	429.77	437.46	433.62
2.000	535.93	543.23	539.58

Linear Fit			
slope	StDev	intercept	StDev
4.85E-04	2.89E-06	1.74E+00	9.64E-04



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	276.61	1.8733	26	351.30	1.9096	51		
2	282.13	1.8760	27	352.03	1.9099	52		
3	287.38	1.8785	28	354.21	1.9110	53		
4	291.23	1.8804	29	354.85	1.9113	54		
5	299.63	1.8845	30	355.47	1.9116	55		
6	310.91	1.8900	31	355.47	1.9116	56		
7	313.07	1.8910	32	356.37	1.9120	57		
8	317.71	1.8933	33	357.52	1.9126	58		
9	318.83	1.8938	34	358.02	1.9128	59		
10	323.08	1.8959	35	358.34	1.9130	60		
11	324.22	1.8964	36	360.37	1.9140	61		
12	328.36	1.8984	37	361.54	1.9145	62		
13	330.91	1.8997	38	361.54	1.9145	63		
14	332.69	1.9005	39	362.17	1.9148	64		
15	333.78	1.9011	40	365.31	1.9164	65		
16	334.56	1.9014	41	366.52	1.9169	66		
17	337.37	1.9028	42	368.35	1.9178	67		
18	342.48	1.9053	43	370.63	1.9189	68		
19	343.07	1.9056	44	373.61	1.9204	69		
20	345.44	1.9067	45	377.86	1.9224	70		
21	345.97	1.9070	46	379.11	1.9231	71		
22	346.79	1.9074	47	380.42	1.9237	72		
23	347.45	1.9077	48	381.00	1.9240	73		
24	348.31	1.9081	49			74		
25	350.73	1.9093	50			75		

Average density of PyC fragments:	1.9056
Standard deviation in density of PyC fragments:	0.0127
Uncertainty in calculated density of PyC fragments:	0.0015

Dixie Barker
Operator

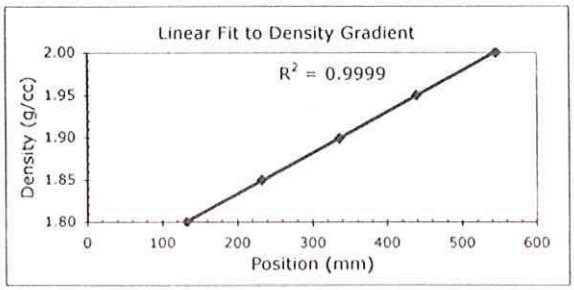
1-25-06
Date

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\D06012601_DRF03R2.xls
Sample ID:	LEU01-26I-B01
Sample description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	22.5 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	128.13	136.87	132.50
1.850	228.36	236.83	232.60
1.900	333.25	338.84	336.05
1.950	435.49	443.49	439.49
2.000	541.90	548.97	545.44

Linear Fit			
slope	StDev	intercept	StDev
4.84E-04	2.90E-06	1.74E+00	9.84E-04



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	266.79	1.8659	26	346.54	1.9045	51	393.01	1.9270
2	285.87	1.8751	27	346.54	1.9045	52		
3	288.11	1.8762	28	347.31	1.9049	53		
4	288.60	1.8765	29	350.49	1.9064	54		
5	292.72	1.8785	30	351.77	1.9070	55		
6	298.39	1.8812	31	353.96	1.9081	56		
7	300.12	1.8820	32	353.96	1.9081	57		
8	301.41	1.8827	33	355.69	1.9089	58		
9	305.86	1.8848	34	356.71	1.9094	59		
10	313.26	1.8884	35	357.96	1.9100	60		
11	317.17	1.8903	36	360.26	1.9112	61		
12	318.36	1.8909	37	361.24	1.9116	62		
13	319.60	1.8915	38	362.33	1.9122	63		
14	320.91	1.8921	39	363.79	1.9129	64		
15	322.75	1.8930	40	363.79	1.9129	65		
16	323.99	1.8936	41	365.03	1.9135	66		
17	326.39	1.8948	42	365.91	1.9139	67		
18	330.64	1.8968	43	366.71	1.9143	68		
19	331.75	1.8974	44	371.41	1.9166	69		
20	338.46	1.9006	45	372.46	1.9171	70		
21	339.67	1.9012	46	375.13	1.9184	71		
22	341.79	1.9022	47	379.10	1.9203	72		
23	343.23	1.9029	48	380.17	1.9208	73		
24	344.00	1.9033	49	380.17	1.9208	74		
25	344.93	1.9037	50	383.89	1.9226	75		

Average density of PyC fragments:	1.9016
Standard deviation in density of PyC fragments:	0.0144
Uncertainty in calculated density of PyC fragments:	0.0015

Dixie Barker
Operator

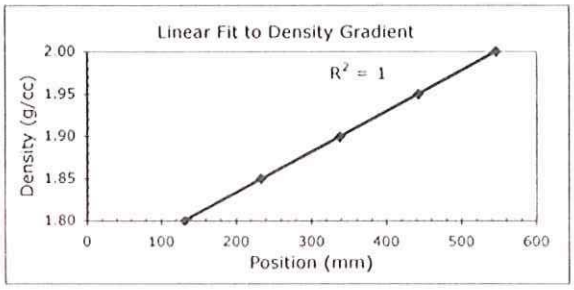
1-26-06
Date

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\D06013001_DRF03R2.xls
Sample ID:	LEU01-41I-B01
Sample description:	Variant 3b: 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	127.12	136.14	131.63
1.850	229.50	237.55	233.53
1.900	335.50	340.95	338.23
1.950	439.00	446.59	442.80
2.000	542.50	549.76	546.13

Linear Fit			
slope	StDev	intercept	StDev
4.82E-04	2.92E-06	1.74E+00	9.95E-04



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	286.46	1.8750	26	348.83	1.9050	51		
2	294.85	1.8790	27	352.30	1.9067	52		
3	305.28	1.8840	28	353.32	1.9072	53		
4	308.22	1.8854	29	353.81	1.9074	54		
5	310.52	1.8865	30	358.69	1.9097	55		
6	312.28	1.8874	31	359.79	1.9103	56		
7	320.59	1.8914	32	361.05	1.9109	57		
8	323.40	1.8927	33	362.21	1.9114	58		
9	325.20	1.8936	34	363.30	1.9120	59		
10	325.90	1.8939	35	363.30	1.9120	60		
11	329.06	1.8955	36	365.45	1.9130	61		
12	332.16	1.8970	37	368.29	1.9144	62		
13	332.16	1.8970	38	373.79	1.9170	63		
14	333.34	1.8975	39	376.08	1.9181	64		
15	336.83	1.8992	40	376.49	1.9183	65		
16	338.18	1.8999	41	379.22	1.9196	66		
17	340.70	1.9011	42	380.71	1.9203	67		
18	341.74	1.9016	43	383.98	1.9219	68		
19	341.74	1.9016	44	390.28	1.9250	69		
20	344.81	1.9031	45	392.92	1.9262	70		
21	345.54	1.9034	46	416.92	1.9378	71		
22	346.21	1.9037	47			72		
23	346.46	1.9039	48			73		
24	346.94	1.9041	49			74		
25	348.16	1.9047	50			75		

Average density of PyC fragments:	1.9045
Standard deviation in density of PyC fragments:	0.0130
Uncertainty in calculated density of PyC fragments:	0.0016

Dixie Barker
Operator

1-30-06
Date

Summary of "info only" measurements

Coating Thickness

		Buffer thickness (μm)	IPyC thickness (μm)
Batch 1	LEU01-23I	109	35.2
Batch 2	LEU01-26I	108	35.1
Batch 3	LEU01-41I	110	35.0
Average		109	35.1

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:	LEU01-23I-B01
Sample description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Mount ID number:	M06012401L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06013001\P0601300101\

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

Polish-down distance n,m (μm)			
2,2	2,8	8,2	8,8
298	283	297	280

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
174	104	36		

Operator

Date

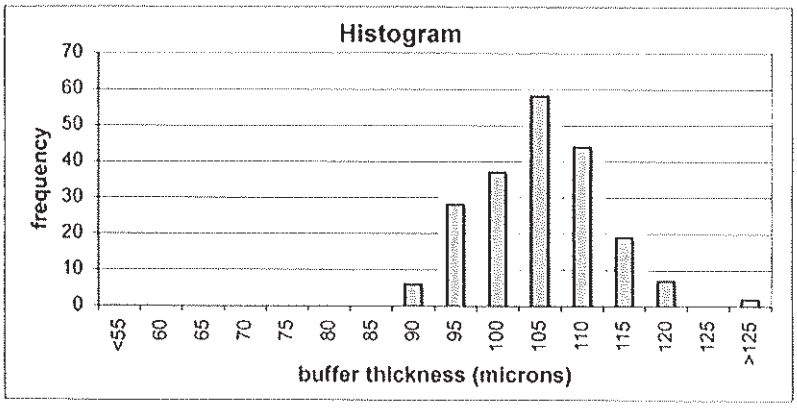
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06013001\
Sample ID:	LEU01-23I-B01
Sample Description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06013001_output\

Number of buffer layers analyzed:	77
Mean of the average buffer thickness of each particle (μm):	109.0
Standard deviation in the average buffer thickness of each particle (μm):	7.4

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	6
95	28
100	37
105	58
110	44
115	19
120	7
125	0
>125	2



Operator

01/31/06
Date

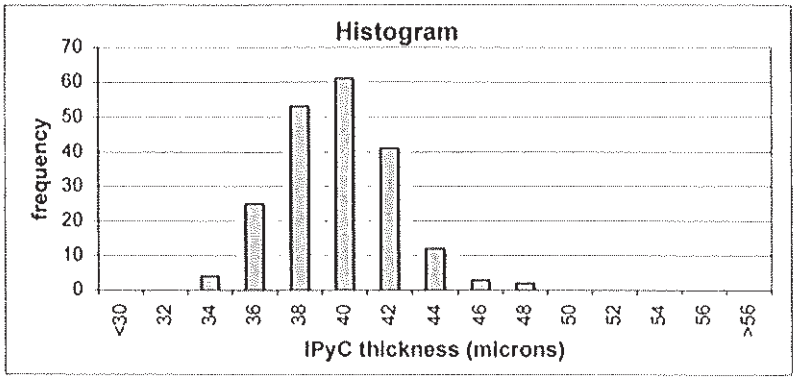
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06013001\
Sample ID:	LEU01-23I-B01
Sample Description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06013001_output\

Number of inner pyrocarbon layers analyzed:	80
Mean of the average IPyC thickness of each particle (μm):	35.2
Standard deviation in the average IPyC thickness of each particle (μm):	2.4

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	*Frequency*
<30	0
32	0
34	4
36	25
38	53
40	61
42	41
44	12
46	3
48	2
50	0
52	0
54	0
56	0
>56	0



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:	LEU01-26I-B01
Sample description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Mount ID number:	M06012501L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06020701\P0602070101\

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
296	303	290	298

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
175	100	37		

Operator

02/07/06
Date

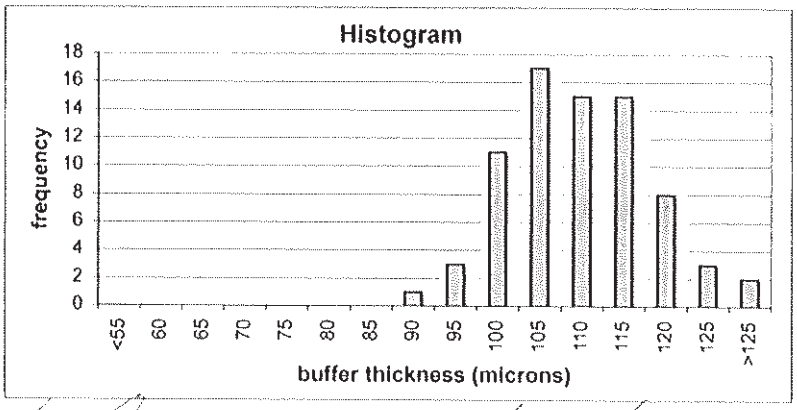
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020701\
Sample ID:	LEU01-26I-B01
Sample Description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020701_output\

Number of buffer layers analyzed:	75
Mean of the average buffer thickness of each particle (μm):	107.6
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	1
95	3
100	11
105	17
110	15
115	15
120	8
125	3
>125	2



Operator

02/09/06
Date

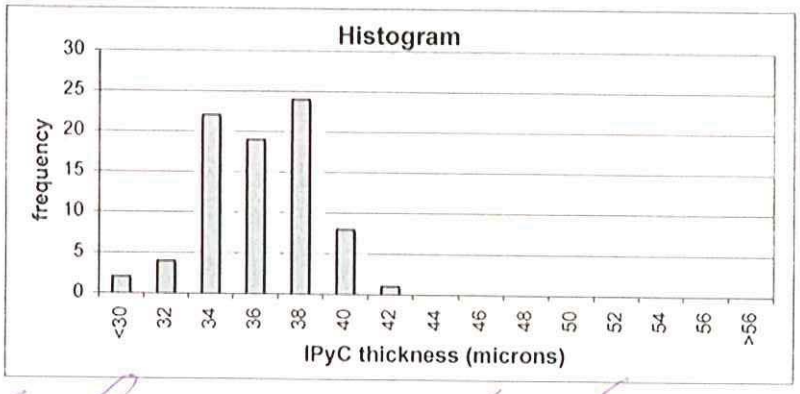
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020701\
Sample ID:	LEU01-26I-B01
Sample Description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020701_output\

Number of inner pyrocarbon layers analyzed:	80
Mean of the average IPyC thickness of each particle (μm):	35.1
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	2
32	4
34	22
36	19
38	24
40	8
42	1
44	0
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



Operator

02/09/06
Date

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

Procedure:	AGR-CHAR-DAM-08 Rev. 2
Operator:	Andrew K. Kercher
Sample ID:	LEU01-41I-B01
Sample description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Mount ID number:	M06012701L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06020702\P0602070201\

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
308	297	314	300

Approximate layer width in polish plane (µm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
168	111	36		

Operator

2/07/06

Date

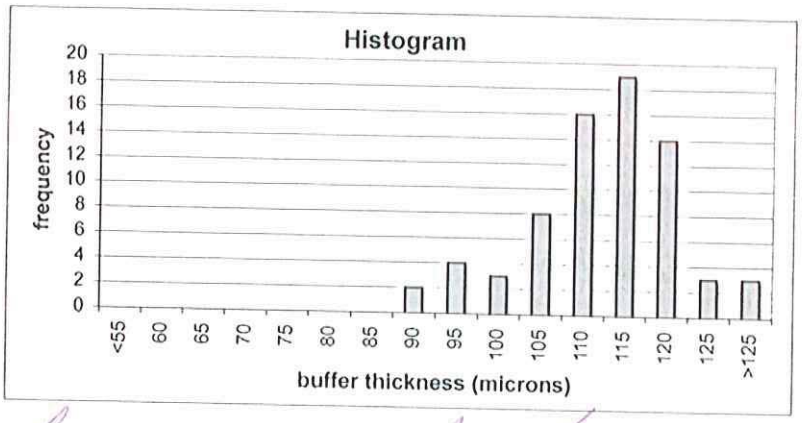
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020702\
Sample ID:	LEU01-41I-B01
Sample Description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020702_output\

Number of buffer layers analyzed:	72
Mean of the average buffer thickness of each particle (μm):	110.1
Standard deviation in the average buffer thickness of each particle (μm):	9.4

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	2
95	4
100	3
105	8
110	16
115	19
120	14
125	3
>125	3



Operator

02/09/06
Date

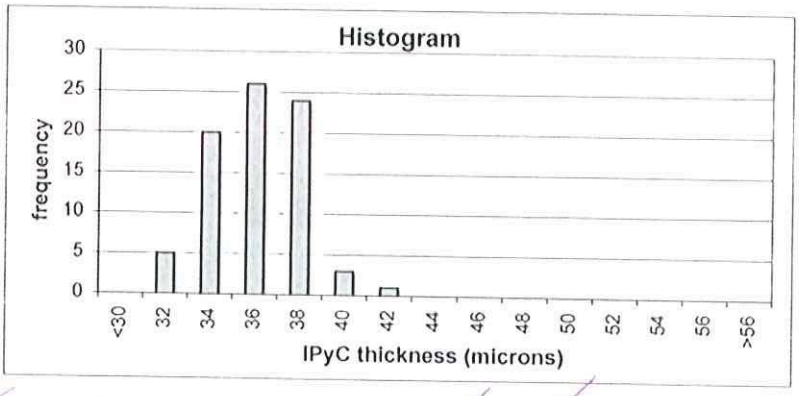
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 1
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020702\
Sample ID:	LEU01-41I-B01
Sample Description:	Variant 3b: IPyC/Buffer on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06020702_output\

Number of inner pyrocarbon layers analyzed:	79
Mean of the average IPyC thickness of each particle (μm):	35.0
Standard deviation in the average IPyC thickness of each particle (μm):	2.0

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	*Frequency*
<30	0
32	5
34	20
36	26
38	24
40	3
42	1
44	0
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



Operator

02/09/06
Date

11 Characterization of first batch of TRISO-coated particles

This section contains data on LEU01-24T, the first batch of TRISO-coated particles used for the LEU01-49T 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. 7.

Inspection Report Form IRF-03: Coated Particle Batches

Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-24T
Coated particle batch description:	Variant 3: 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. 7				
Average buffer thickness for each particle (μm)	102.6	7.8	228	1.652	mean 100 ± 15	A = x - ts/√n ≥ 85	101.7	pass	DRF-08
						B = x + ts/√n ≤ 115	103.5	pass	DRF-11
Average IPyC thickness for each particle (μm)	38.2	2.0	238	1.651	mean 40 ± 5	A = x - ts/√n ≥ 35	38.0	pass	DRF-08
						B = x + ts/√n ≤ 45	38.4	pass	DRF-11
Average SiC thickness for each particle (μm)	36.3	0.9	238	1.651	mean 35 ± 4	A = x - ts/√n ≥ 31	36.2	pass	DRF-08
						B = x + ts/√n ≤ 39	36.4	pass	DRF-11
Average OPyC thickness for each particle (μm)	38.7	1.8	238	1.651	mean 40 ± 5	A = x - ts/√n ≥ 35	38.5	pass	DRF-08
						B = x + ts/√n ≤ 45	38.9	pass	DRF-11
Particles with missing OPyC			15566		defect fraction ≤ 6.0 x 10^{-4}	≤4 in 15,500	0	pass	DRF-19

Comments

QC Supervisor

4-19-06
Date

Accept Coated particle batch (Yes or No):	Yes

QA Reviewer

4/20/06
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:	LEU01-24T-B01
Sample description:	Variant 3: TRISO on BWXT kernel composite 69302
Mount ID number:	M06032701L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06032801\P0603280101\

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
369	379	365	377

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
182	102	37	37	38

Andrew K. Kercher
Operator

March 28, 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:	LEU01-24T-B01
Sample description:	Variant 3: TRISO on BWXT kernel composite 69302
Mount ID number:	M06032702L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06032801\P0603280102\

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
379	376	373	373

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
179	102	37	37	39

Operator

March 28, 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:	LEU01-24T-B01
Sample description:	Variant 3: TRISO on BWXT kernel composite 69302
Mount ID number:	M06032703L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06032801\P0603280103\

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
386	436	363	365

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
177	105	38	38	38

Andrew K. Kercher — Operator

March 28, 2006 — Date

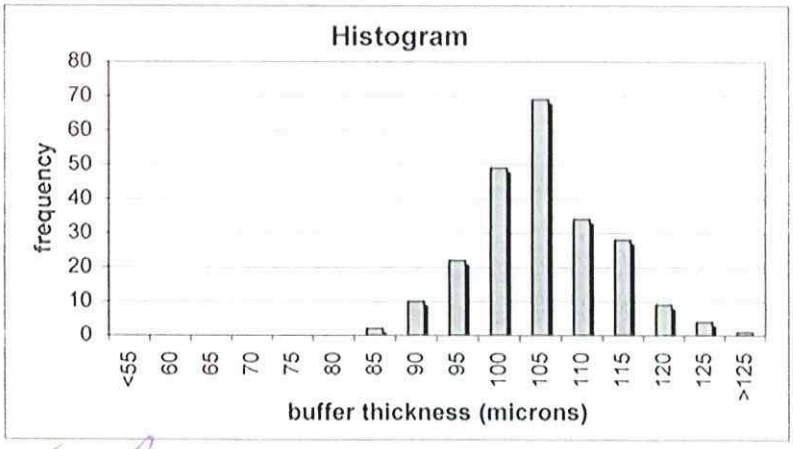
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06032801\
Sample ID:	LEU01-24T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06032801_output\

Number of buffer layers analyzed:	228
Mean of the average buffer thickness of each particle (μm):	102.6
Standard deviation in the average buffer thickness of each particle (μm):	7.8

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	2
90	10
95	22
100	49
105	69
110	34
115	28
120	9
125	4
>125	1



Andrew K. Kercher
Operator

March 29, 2006
Date

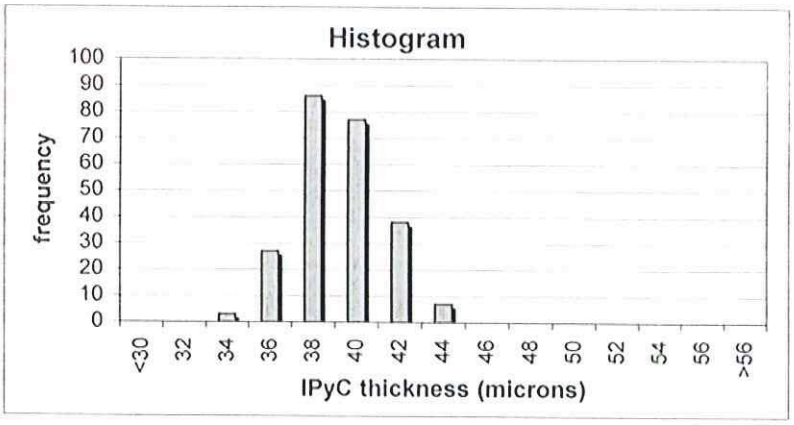
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06032801\
Sample ID:	LEU01-24T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06032801_output\

Number of inner pyrocarbon layers analyzed:	238
Mean of the average IPyC thickness of each particle (μm):	38.2
Standard deviation in the average IPyC thickness of each particle (μm):	2.0

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	*Frequency*
<30	0
32	0
34	3
36	27
38	86
40	77
42	38
44	7
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



Andrew K. Kercher
Operator

March 29, 2006
Date

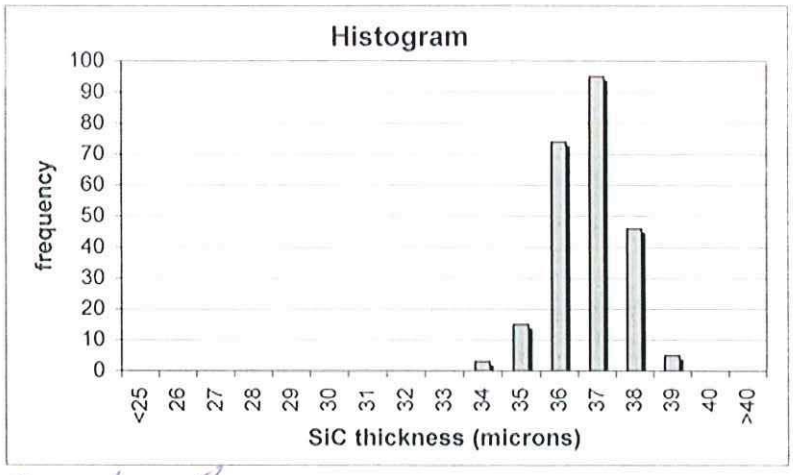
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06032801\
Sample ID:	LEU01-24T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06032801_output\

Number of silicon carbide layers analyzed:	238
Mean of the average SiC thickness of each particle (μm):	36.3
Standard deviation in the average SiC thickness of each particle (μm):	0.9

Distribution of the average SiC layer thickness (top binned)

SiC Thickness (μm)	*Frequency*
<25	0
26	0
27	0
28	0
29	0
30	0
31	0
32	0
33	0
34	3
35	15
36	74
37	95
38	46
39	5
40	0
>40	0



Andrew K. Kercher — Operator

March 29, 2006 — Date

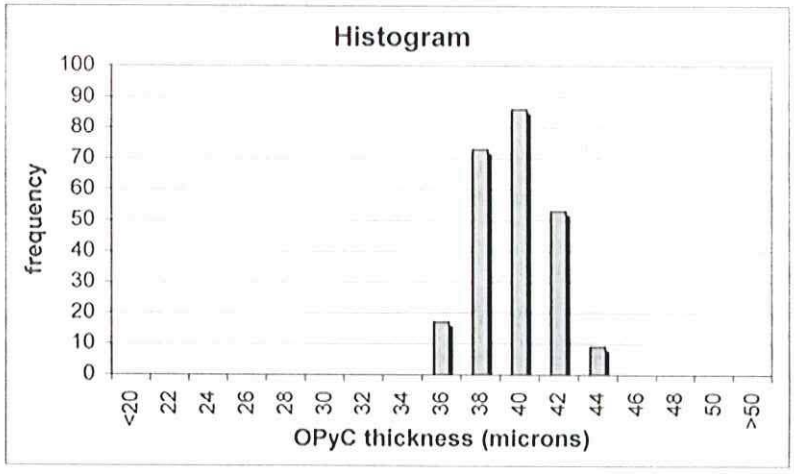
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06032801\
Sample ID:	LEU01-24T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06032801_output\

Number of outer pyrocarbon layers analyzed:	238
Mean of the average OPyC thickness of each particle (μm):	38.7
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	73
40	86
42	53
44	9
46	0
48	0
50	0
>50	0



Operator

March 29, 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:	LEU01-24T-C01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06032901_DRF19R1.xls

Mean average weight/particle (g):	7.26E-04
Uncertainty in average weight/particle (g):	5.58E-07
Weight of sample of particles (g):	11.301
Approximate number of particles in sample:	15566
Uncertainty in number of particles in sample:	12

Number of particles with missing OPyC layer:	0

Comments on unusual visual characteristics of OPyC

Operator

3-29-06

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:	LEUO1-24T-D01
Particle Lot Description:	Variant 3: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06032701_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	9.66E-02	8.06E-02	9.73E-02	9.37E-02	1.05E-01
Number of particles:	133	111	134	129	145
Average weight/particle (g):	7.26E-04	7.26E-04	7.26E-04	7.26E-04	7.23E-04

Mean average weight/particle (g):	7.26E-04
Standard error in mean average weight/particle (g):	5.58E-07

Dixie Barker
Operator

3-29-06
Date

12 Characterization of second batch of TRISO-coated particles

This section contains data on LEU01-25T, the second batch of TRISO-coated particles used for the LEU01-49T 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. 7.

Inspection Report Form IRF-03: Coated Particle Batches

Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-251
Coated particle batch description:	Variant 3: 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. 7				
Average buffer thickness for each particle (μm)	103.6	7.4	222	1.652	mean 100 ± 15	A = x - ts/√n ≥ 85	102.8	pass	DRF-08
						B = x + ts/√n ≤ 115	104.4	pass	DRF-11
Average IPyC thickness for each particle (μm)	39.2	1.9	236	1.651	mean 40 ± 5	A = x - ts/√n ≥ 35	39.0	pass	DRF-08
						B = x + ts/√n ≤ 45	39.4	pass	DRF-11
Average SiC thickness for each particle (μm)	38.1	1.0	236	1.651	mean 35 ± 4	A = x - ts/√n ≥ 31	38.0	pass	DRF-08
						B = x + ts/√n ≤ 39	38.2	pass	DRF-11
Average OPyC thickness for each particle (μm)	40.5	1.9	236	1.651	mean 40 ± 5	A = x - ts/√n ≥ 35	40.3	pass	DRF-08
						B = x + ts/√n ≤ 45	40.7	pass	DRF-11
Particles with missing OPyC			15636		defect fraction ≤ 6.0 x 10^{-4}	≤4 in 15,500	0	pass	DRF-19

Comments

QC Supervisor — Date: 4-19-06

Accept Coated particle batch (Yes or No):	Yes

QA Reviewer — Date: 4/20/06

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:	LEU01-25T-B01
Sample description:	Variant 3: TRISO on BWXT kernel composite 69302
Mount ID number:	M06032901L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06033002\P0603300201\

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
375	382	382	394

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
178	97	39	39	41

Andrew K. Kercher
Operator

March 30, 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:	LEU01-25T-B01
Sample description:	Variant 3: TRISO on BWXT kernel composite 69302
Mount ID number:	M06032902L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06033002\P0603300202\

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
367	367	375	371

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
171	108	40	40	41

Operator

March 30, 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:	LEU01-25T-B01
Sample description:	Variant 3: TRISO on BWXT kernel composite 69302
Mount ID number:	M06032903L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06033002\P0603300203\

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
402	392	371	369

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
173	114	36	39	38

Andrew K. Kercher
Operator

March 30, 2006
Date

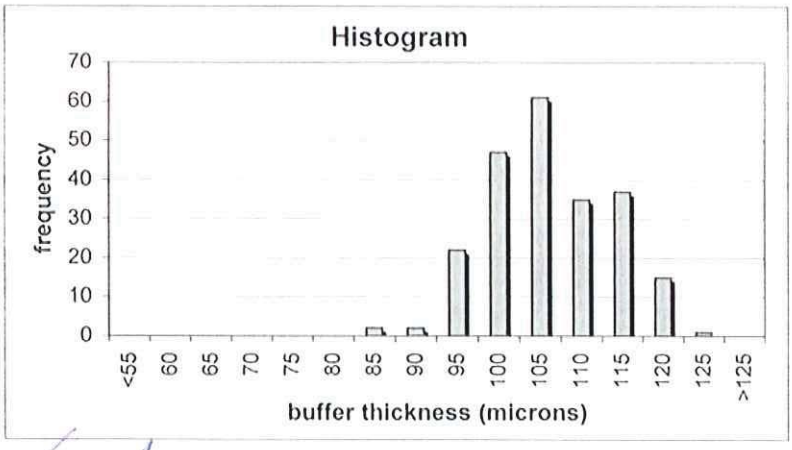
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06033002\
Sample ID:	LEU01-25T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06033002_output\

Number of buffer layers analyzed:	222
Mean of the average buffer thickness of each particle (μm):	103.6
Standard deviation in the average buffer thickness of each particle (μm):	7.4

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	2
90	2
95	22
100	47
105	61
110	35
115	37
120	15
125	1
>125	0



Andrew K. Kercher — Operator

March 31, 2006 — Date

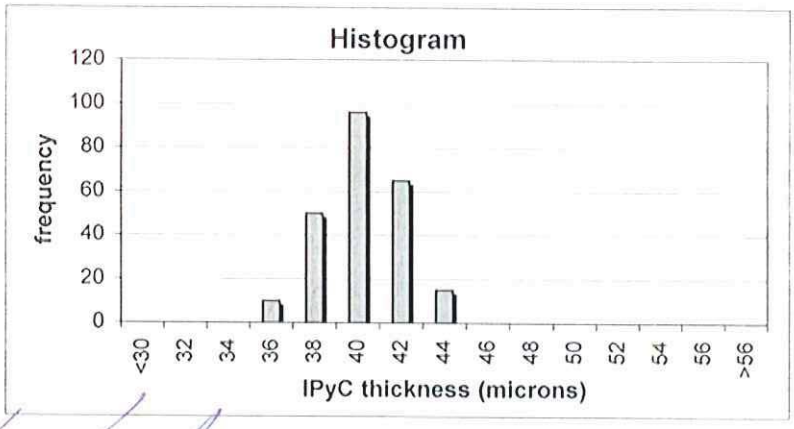
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06033002\
Sample ID:	LEU01-25T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06033002_output\

Number of inner pyrocarbon layers analyzed:	236
Mean of the average IPyC thickness of each particle (μm):	39.2
Standard deviation in the average IPyC thickness of each particle (μm):	1.9

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	*Frequency*
<30	0
32	0
34	0
36	10
38	50
40	96
42	65
44	15
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



Andrew K. Kercher — Operator

March 31, 2006 — Date

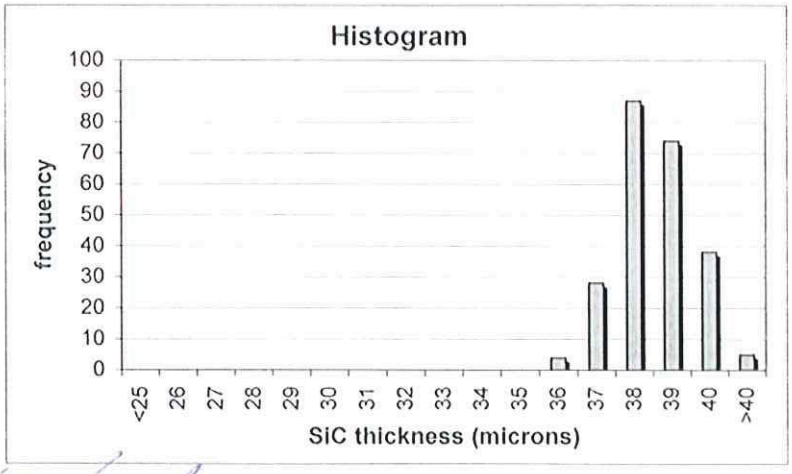
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06033002\
Sample ID:	LEU01-25T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06033002_output\

Number of silicon carbide layers analyzed:	236
Mean of the average SiC thickness of each particle (μm):	38.1
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	0
34	0
35	0
36	4
37	28
38	87
39	74
40	38
>40	5



Andrew K. Kercher — Operator

March 31, 2006 — Date

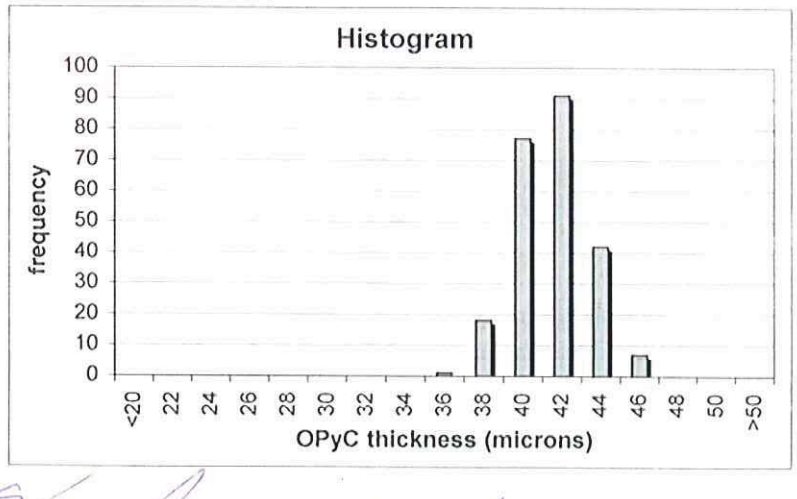
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06033002\
Sample ID:	LEU01-25T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06033002_output\

Number of outer pyrocarbon layers analyzed:	236
Mean of the average OPyC thickness of each particle (μm):	40.5
Standard deviation in the average OPyC thickness of each particle (μm):	1.9

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	1
38	18
40	77
42	91
44	42
46	7
48	0
50	0
>50	0



Operator

March 31, 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:	LEU01-25T-C01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06032903_DRF19R1.xls

Mean average weight/particle (g):	7.42E-04
Uncertainty in average weight/particle (g):	1.69E-06
Weight of sample of particles (g):	11.602
Approximate number of particles in sample:	15636
Uncertainty in number of particles in sample:	36

Number of particles with missing OPyC layer:	0

Comments on unusual visual characteristics of OPyC

John Hunn
Operator

3-29-06
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:	LEU01-25T-D01
Particle Lot Description:	Variant 3: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06032901_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	1.02E-01	9.31E-02	7.93E-02	8.16E-02	8.61E-02
Number of particles:	138	126	107	110	115
Average weight/particle (g):	7.41E-04	7.39E-04	7.41E-04	7.42E-04	7.49E-04

Mean average weight/particle (g):	7.42E-04
Standard error in mean average weight/particle (g):	1.69E-06

D. Barker
Operator

3 Nov 06
Date

13 Characterization of third batch of TRISO-coated particles

This section contains data on LEU01-37T, the third batch of TRISO-coated particles used for the LEU01-49T 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. 7.

Inspection Report Form IRF-03: Coated Particle Batches

Procedure:	AGR-CHAR-PIP-03 Rev. 2
Coated particle batch ID:	LEU01-37T
Coated particle batch description:	Variant 3: 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. 7				
Average buffer thickness for each particle (μm)	101.7	6.9	195	1.653	mean 100 ± 15	A = x - ts/√n ≥ 85	100.9	pass	DRF-08
						B = x + ts/√n ≤ 115	102.5	pass	DRF-11
Average IPyC thickness for each particle (μm)	38.5	2.0	215	1.652	mean 40 ± 5	A = x - ts/√n ≥ 35	38.3	pass	DRF-08
						B = x + ts/√n ≤ 45	38.7	pass	DRF-11
Average SiC thickness for each particle (μm)	33.2	1.0	217	1.652	mean 35 ± 4	A = x - ts/√n ≥ 31	33.1	pass	DRF-08
						B = x + ts/√n ≤ 39	33.3	pass	DRF-11
Average OPyC thickness for each particle (μm)	39.0	1.9	218	1.652	mean 40 ± 5	A = x - ts/√n ≥ 35	38.8	pass	DRF-08
						B = x + ts/√n ≤ 45	39.2	pass	DRF-11
Particles with missing OPyC			15554		defect fraction ≤ 6.0 x 10^{-4}	≤4 in 15,500	0	pass	DRF-19

Comments

QC Supervisor

4-19-06
Date

Accept Coated particle batch (Yes or No):	Yes

QA Reviewer

4/20/06
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:	LEU01-37T-B01
Sample description:	Variant 3: TRISO on BWXT kernel composite 69302
Mount ID number:	M06041701L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06041801\P0604180101\

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
400	392	399	398

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
177	97	37	34	42

Andrew K. Kercher — Operator

April 18, 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:	LEU01-37T-B01
Sample description:	Variant 3: TRISO on BWXT kernel composite 69302
Mount ID number:	M06041702L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06041801\P0604180102\

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
389	384	389	380

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
173	107	38	36	38

Andrew K. Kercher — Operator

April 18, 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:	LEU01-37T-B01
Sample description:	Variant 3: TRISO on BWXT kernel composite 69302
Mount ID number:	M06041703L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06041801\P0604180103\

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
381	376	364	359

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
177	102	40	36	39

Andrew K. Kercher
Operator

April 18, 2006
Date

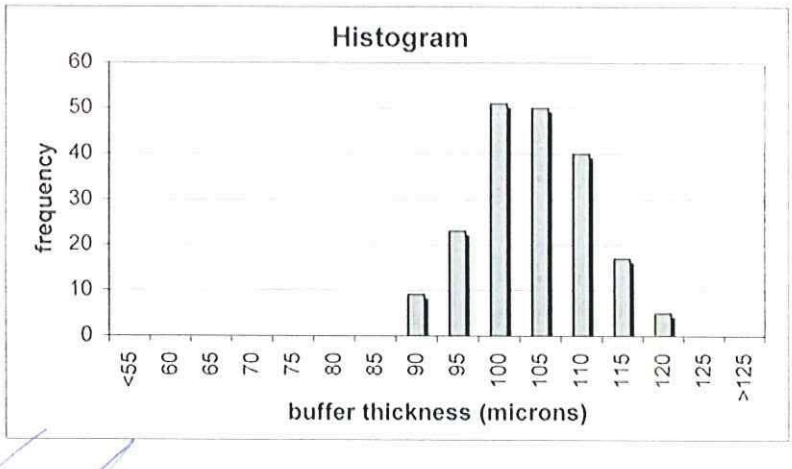
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06041801\
Sample ID:	LEU01-37T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06041801_output\

Number of buffer layers analyzed:	195
Mean of the average buffer thickness of each particle (μm):	101.7
Standard deviation in the average buffer thickness of each particle (μm):	6.9

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	9
95	23
100	51
105	50
110	40
115	17
120	5
125	0
>125	0



Operator

April 19, 2006
Date

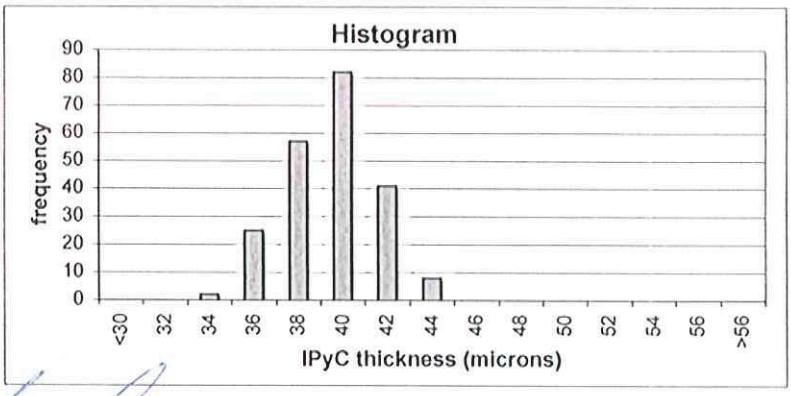
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06041801\
Sample ID:	LEU01-37T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06041801_output\

Number of inner pyrocarbon layers analyzed:	215
Mean of the average IPyC thickness of each particle (μm):	38.5
Standard deviation in the average IPyC thickness of each particle (μm):	2.0

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	*Frequency*
<30	0
32	0
34	2
36	25
38	57
40	82
42	41
44	8
46	0
48	0
50	0
52	0
54	0
56	0
>56	0



Operator

April 19, 2006
Date

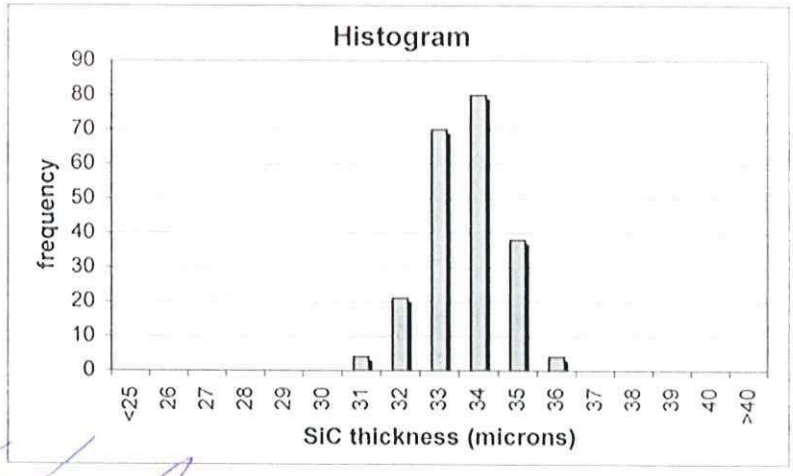
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06041801\
Sample ID:	LEU01-37T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06041801_output\

Number of silicon carbide layers analyzed:	217
Mean of the average SiC thickness of each particle (μm):	33.2
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	4
32	21
33	70
34	80
35	38
36	4
37	0
38	0
39	0
40	0
>40	0



Operator

April 19, 2006
Date

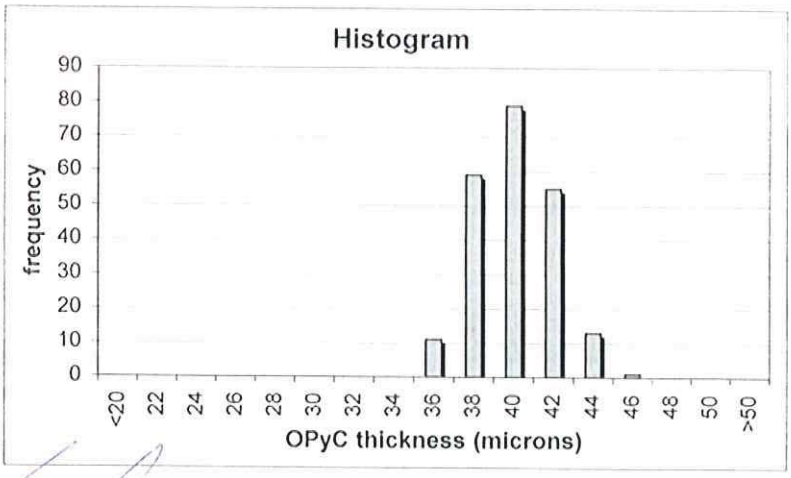
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06041801\
Sample ID:	LEU01-37T-B01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06041801_output\

Number of outer pyrocarbon layers analyzed:	218
Mean of the average OPyC thickness of each particle (μm):	39.0
Standard deviation in the average OPyC thickness of each particle (μm):	1.9

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	11
38	59
40	79
42	55
44	13
46	1
48	0
50	0
>50	0



Operator

April 19, 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:	LEU01-37T-C01
Sample Description:	Variant 3: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06041101_DRF19R1.xls

Mean average weight/particle (g):	7.04E-04
Uncertainty in average weight/particle (g):	9.69E-07
Weight of sample of particles (g):	10.950
Approximate number of particles in sample:	15554
Uncertainty in number of particles in sample:	21

Number of particles with missing OPyC layer:	0

Comments on unusual visual characteristics of OPyC

Operator

4-11-06
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:	LEU01-37T-D01
Particle Lot Description:	Variant 3: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06041002_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	1.02E-01	1.09E-01	9.04E-02	1.04E-01	1.05E-01
Number of particles:	145	154	129	147	150
Average weight/particle (g):	7.05E-04	7.05E-04	7.01E-04	7.06E-04	7.03E-04

Mean average weight/particle (g):	7.04E-04
Standard error in mean average weight/particle (g):	9.69E-07

Dixie Barker
Operator

4-11-06
Date

14 Characterization of TRISO-coated particle composite

This section contains data on the TRISO-coated particle composite, LEU01-49T. 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 LEU01-49T 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:	LEU01-49T
Coated particle composite description:	Variant 3 composite: TRISO on BWXT kernel composite 69302

Property	Measured Data Mean (x)	Std. Dev. (s)	# measured (n)	k or t value	Specification INL EDF-4380 Rev. 8	Acceptance Criteria	Acceptance Test Value	Pass or fail	Data Records
Average buffer thickness for each particle (μm)	104.2	7.8	237	1.651	mean 100 ± 15	A = x - ts/√n ≥ 85	103.4	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 115	105.0	pass	
				2.547	dispersion ≤0.01 ≤ 55	C = x - ks > 55	84.3	pass	
Average IPyC thickness for each particle (μm)	38.8	2.1	238	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36	38.6	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 44	39.0	pass	
				2.546	dispersion ≤0.01 ≤ 30	C = x - ks > 30	33.5	pass	
					≤0.01 ≥ 56	D = x + ks < 56	44.1	pass	
Average SiC thickness for each particle (μm)	35.9	2.1	238	1.651	mean 35 ± 3	A = x - ts/√n ≥ 32	35.7	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 38	36.1	pass	
				2.546	dispersion ≤0.01 ≤ 25	C = x - ks > 25	30.6	pass	
Average OPyC thickness for each particle (μm)	39.3	2.1	238	1.651	mean 40 ± 4	A = x - ts/√n ≥ 36	39.1	pass	DRF-08 DRF-11
						B = x + ts/√n ≤ 44	39.5	pass	
				2.546	dispersion ≤0.01 ≤ 20	C = x - ks > 20	34.0	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)	3.2046	0.0010	41	1.684	mean ≥ 3.19	A = x - ts/√n ≥ 3.19	3.204	pass	DRF-02
				2.922	dispersion ≤0.01 ≤ 3.17	C = x - ks > 3.17	3.202	pass	
OPyC sink/float density	See IRF-04B								IRF-04B
IPyC anisotropy (BAFo equivalent)	1.029	0.002	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.030	pass	DRF-18
				3.981	dispersion ≤0.01 ≥1.06	D = x + ks < 1.06	1.037	pass	
OPyC anisotropy (BAFo equivalent)	1.021	0.003	10	1.833	mean ≤ 1.035	B = x + ts/√n ≤ 1.035	1.023	pass	DRF-18
				3.981	dispersion ≤0.01 ≥1.06	D = x + ks < 1.06	1.033	pass	
Particles with SiC gold spot defects			12190		defect fraction ≤ 5.0×10^{-3}	≤47 in 12,000 or ≤92 in 22,000	0	pass	DRF-20
Particle aspect ratio			1709		dispersion ≤0.01 ≥1.14	≤1 in 500 or ≤7 in 1420	1	pass	DRF-07 DRF-10
Particles with SiC burn-leach defects			120660		defect fraction ≤ 1.0×10^{-4}	≤1 in 50,000 or ≤6 in 120,000	1	pass	DRF-21
Particles with missing OPyC			31178		defect fraction ≤ 3.0×10^{-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 — Date: 5-15-06

Accept coated particle composite (Yes or No): Yes

QA Reviewer — Date: 5/15/06

Inspection Report Form IRF-048: Outer Pyrocarbon Density

Procedure:	AGR-CHAR-PIP-04 Rev. 2
Coated particle composite ID:	LEU01-49T
Coated particle composite description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Batch 1 ID:	LEU01-24T
Batch 1 description:	Variant 3: TRISO on BWXT kernel composite 69302
Batch 2 ID:	LEU01-25T
Batch 2 description:	Variant 3: TRISO on BWXT kernel composite 69302
Batch 3 ID:	LEU01-37T
Batch 3 description:	Variant 3: 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. B				
Batch 1: OPyC sink/float density (Mg/m³)	1.9211	0.0094	48	1.678	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.919	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.923	pass	
				2.868	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.894	pass	
						D = x + ks < 2.00	1.948	pass	
Batch 2: OPyC sink/float density (Mg/m³)	1.8975	0.0074	41	1.684	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.896	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.899	pass	
				2.922	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.876	pass	
						D = x + ks < 2.00	1.919	pass	
Batch 3: OPyC sink/float density (Mg/m³)	1.9157	0.0073	64	1.669	mean 1.90 ± 0.05	A = x - ts/√n ≥ 1.85	1.914	pass	DRF-03
						B = x + ts/√n ≤ 1.95	1.917	pass	
				2.783	dispersion ≤0.01 ≤ 1.80 ≤0.01 ≥ 2.00	C = x - ks > 1.80	1.895	pass	
						D = x + ks < 2.00	1.936	pass	

Comments

QC Supervisor — Date: 4-26-06

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

QA Reviewer — Date: 4/26/06

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:	LEU01-49T-B01
Sample description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Mount ID number:	M06042601L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06042702\P0604270201\

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
381	382	390	387

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
173	99	40	37	38

Operator

April 27, 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:	LEU01-49T-B01
Sample description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Mount ID number:	M06042602L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06042702\P0604270202\

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
379	375	381	372

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
172	109	36	38	40

Andrew K. Kercher
Operator

May 1, 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:	LEU01-49T-B01
Sample description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Mount ID number:	M06042603L
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06042702\P0604270203\

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
391	394	385	391

Approximate layer width in polish plane (μm)				
Kernel radius	Buffer	IPyC	SiC	OPyC
179	102	38	39	41

Andrew K. Kercher
Operator

May 1, 2006
Date

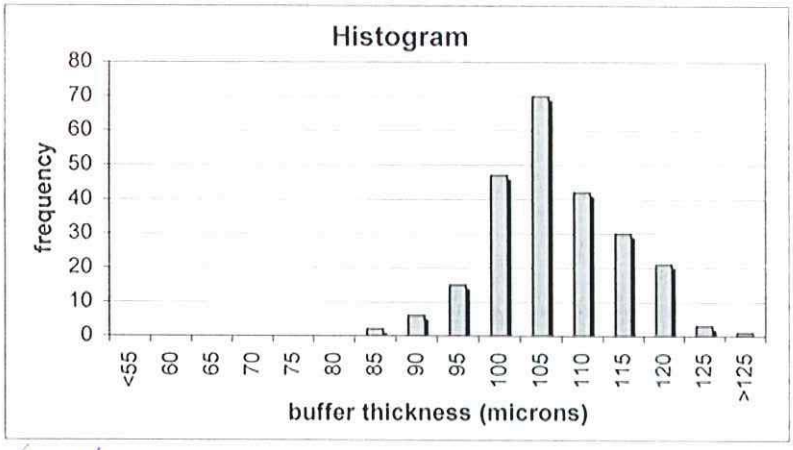
Data Report Form DRF-11A: Measurement of Buffer Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06042702\
Sample ID:	LEU01-49T-B01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06042702_output\

Number of buffer layers analyzed:	237
Mean of the average buffer thickness of each particle (μm):	104.2
Standard deviation in the average buffer thickness of each particle (μm):	7.8

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	2
90	6
95	15
100	47
105	70
110	42
115	30
120	21
125	3
>125	1



Andrew K. Kercher
Operator

May 1, 2006
Date

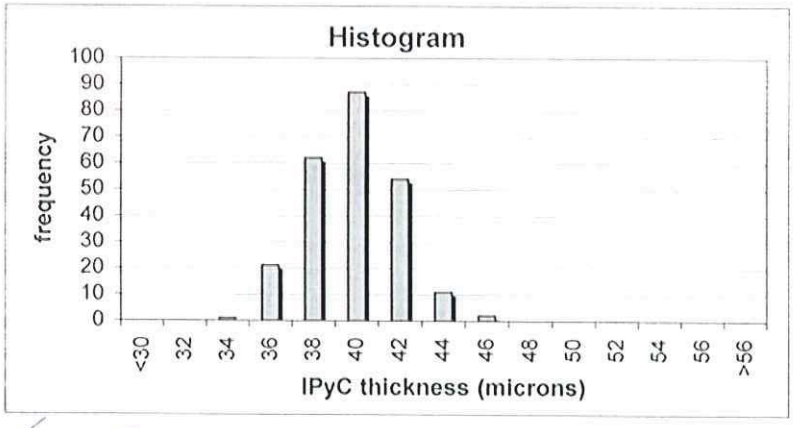
Data Report Form DRF-11B: Measurement of Inner Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06042702\
Sample ID:	LEU01-49T-B01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06042702_output\

Number of inner pyrocarbon layers analyzed:	238
Mean of the average IPyC thickness of each particle (μm):	38.8
Standard deviation in the average IPyC thickness of each particle (μm):	2.1

Distribution of the average IPyC layer thickness (top binned)

IPyC Thickness (μm)	*Frequency*
<30	0
32	0
34	1
36	21
38	62
40	87
42	54
44	11
46	2
48	0
50	0
52	0
54	0
56	0
>56	0



Andrew K. Kercher
Operator

May 1, 2006
Date

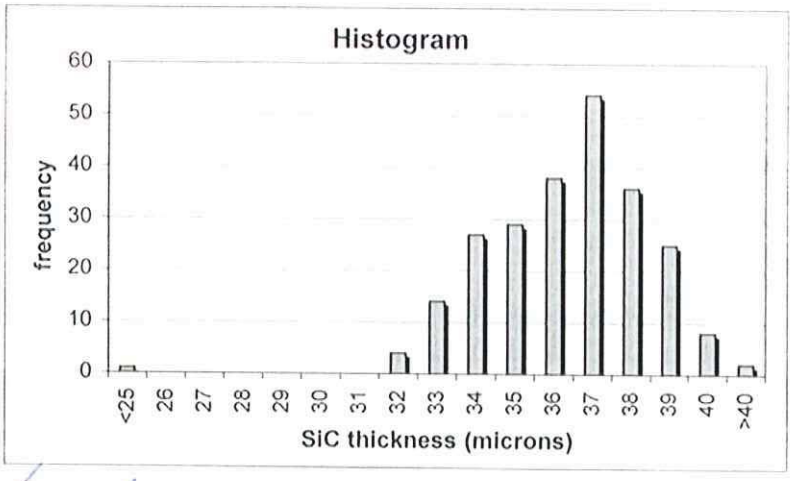
Data Report Form DRF-11C: Measurement of Silicon Carbide Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06042702\
Sample ID:	LEU01-49T-B01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06042702_output\

Number of silicon carbide layers analyzed:	238
Mean of the average SiC thickness of each particle (μm):	35.9
Standard deviation in the average SiC thickness of each particle (μm):	2.1

Distribution of the average SiC layer thickness (top binned)

SiC Thickness (μm)	*Frequency*
<25	1
26	0
27	0
28	0
29	0
30	0
31	0
32	4
33	14
34	27
35	29
36	38
37	54
38	36
39	25
40	8
>40	2



Operator

May 1, 2006
Date

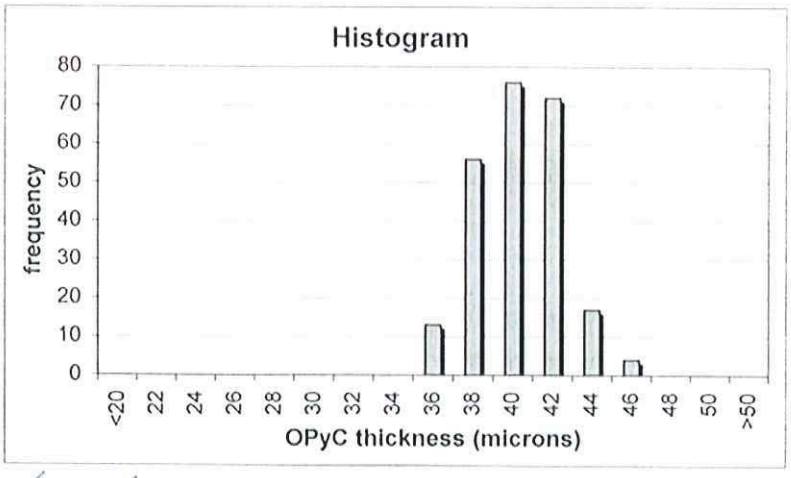
Data Report Form DRF-11D: Measurement of Outer Pyrocarbon Layer Thickness

Procedure:	AGR-CHAR-DAM-11 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06042702\
Sample ID:	LEU01-49T-B01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Layers\P06042702_output\

Number of outer pyrocarbon layers analyzed:	238
Mean of the average OPyC thickness of each particle (μm):	39.3
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	13
38	56
40	76
42	72
44	17
46	4
48	0
50	0
>50	0



Andrew K. Kercher
Operator

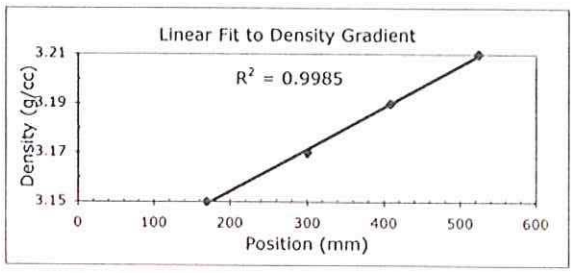
May 1, 2006
Date

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\D06042401_DRF02R3.xls
Sample ID:	LEU01-49T-E01
Sample description:	Variant 3 Composite:TRISO 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
3.150	156.08	175.78	169.21
3.170	284.21	308.38	300.32
3.190	393.91	416.29	408.83
3.210	508.66	532.65	524.65

Linear Fit			
slope	StDev	intercept	StDev
1.70E-04	3.24E-06	3.12E+00	1.11E-03



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	482.81	3.2025	26	497.90	3.2051	51		
2	483.96	3.2027	27	498.43	3.2051	52		
3	484.79	3.2028	28	498.97	3.2052	53		
4	485.95	3.2030	29	499.38	3.2053	54		
5	486.26	3.2031	30	500.32	3.2055	55		
6	487.99	3.2034	31	500.79	3.2055	56		
7	488.22	3.2034	32	501.35	3.2056	57		
8	488.39	3.2034	33	502.04	3.2058	58		
9	489.77	3.2037	34	502.04	3.2058	59		
10	490.30	3.2038	35	502.64	3.2059	60		
11	490.98	3.2039	36	503.22	3.2060	61		
12	492.00	3.2040	37	502.65	3.2059	62		
13	492.79	3.2042	38	502.65	3.2059	63		
14	493.38	3.2043	39	500.23	3.2054	64		
15	494.01	3.2044	40	501.93	3.2057	65		
16	493.92	3.2044	41	498.77	3.2052	66		
17	494.36	3.2044	42			67		
18	494.71	3.2045	43			68		
19	495.04	3.2046	44			69		
20	495.72	3.2047	45			70		
21	495.94	3.2047	46			71		
22	496.71	3.2048	47			72		
23	496.71	3.2048	48			73		
24	497.05	3.2049	49			74		
25	497.39	3.2050	50			75		

Average density of SiC fragments:	3.2046
Standard deviation in density of SiC fragments:	0.0010
Uncertainty in calculated density of SiC fragments:	0.0020

Dixie Barker
Operator

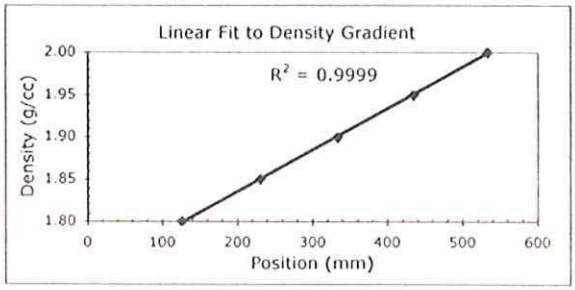
4-27-06
Date

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\D06032701_DRF03R2.xls
Sample ID:	LEUCO-24T-E01
Sample description:	OPyC from Variant 3: TRISO 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	122.24	131.34	126.79
1.850	227.24	235.60	231.42
1.900	330.72	336.43	333.58
1.950	430.67	438.09	434.38
2.000	529.67	537.00	533.34

Linear Fit			
slope	StDev	intercept	StDev
4.92E-04	2.99E-06	1.74E+00	9.98E-04



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	317.15	1.8927	26	376.40	1.9219	51		
2	344.50	1.9062	27	377.39	1.9224	52		
3	352.02	1.9099	28	378.22	1.9228	53		
4	352.83	1.9103	29	378.22	1.9228	54		
5	355.81	1.9118	30	378.96	1.9232	55		
6	356.54	1.9121	31	380.23	1.9238	56		
7	356.54	1.9121	32	381.02	1.9242	57		
8	357.67	1.9127	33	382.11	1.9247	58		
9	359.07	1.9134	34	382.71	1.9250	59		
10	360.62	1.9141	35	383.84	1.9256	60		
11	361.14	1.9144	36	385.23	1.9262	61		
12	362.02	1.9148	37	385.23	1.9262	62		
13	362.89	1.9152	38	386.96	1.9271	63		
14	363.79	1.9157	39	389.34	1.9283	64		
15	364.06	1.9158	40	392.03	1.9296	65		
16	364.63	1.9161	41	393.11	1.9301	66		
17	365.54	1.9166	42	394.53	1.9308	67		
18	366.67	1.9171	43	394.87	1.9310	68		
19	366.92	1.9172	44	399.35	1.9332	69		
20	368.39	1.9180	45	402.19	1.9346	70		
21	369.27	1.9184	46	403.92	1.9354	71		
22	370.00	1.9187	47	414.55	1.9407	72		
23	370.81	1.9191	48	428.48	1.9475	73		
24	372.68	1.9201	49			74		
25	375.10	1.9213	50			75		

Average density of PyC fragments:	1.9211
Standard deviation in density of PyC fragments:	0.0094
Uncertainty in calculated density of PyC fragments:	0.0016

Dixie Barker
Operator

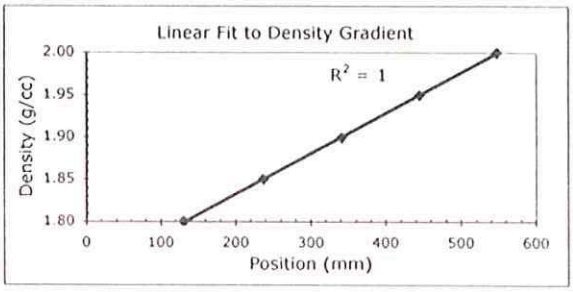
3-28-06
Date

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

Procedure:	AGR-CHAR-DAM-03 Rev. 2
Operator:	Dixie Barker
Filename:	\\mc-agr\AGR\DensityColumn\D06032901_DRF03R2.xls
Sample ID:	LEU01-25T-E01
Sample description:	OPyC from Variant 3: TRISO on BWXT kernel composite 69302
Float expiration date:	07/2007
Gauge expiration date:	01/2007
Bath temperature:	23.6 °C

Calibrated Floats			
Density	Top of Float	Bottom of Float	Center of Mass
1.800	126.61	135.68	131.15
1.850	233.19	241.19	237.19
1.900	338.87	344.83	341.85
1.950	441.18	449.15	445.17
2.000	543.88	551.21	547.55

Linear Fit			
slope	StDev	intercept	StDev
4.80E-04	2.89E-06	1.74E+00	9.92E-04



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	313.89	1.8872	26	337.21	1.8984	51		
2	313.89	1.8872	27	337.50	1.8985	52		
3	316.25	1.8883	28	337.86	1.8987	53		
4	320.08	1.8902	29	339.26	1.8994	54		
5	321.12	1.8907	30	341.04	1.9002	55		
6	321.29	1.8907	31	342.51	1.9009	56		
7	321.29	1.8907	32	344.89	1.9021	57		
8	320.53	1.8904	33	346.21	1.9027	58		
9	322.22	1.8912	34	345.16	1.9022	59		
10	324.31	1.8922	35	347.09	1.9031	60		
11	325.17	1.8926	36	347.60	1.9034	61		
12	325.65	1.8928	37	348.24	1.9037	62		
13	328.74	1.8943	38	348.63	1.9039	63		
14	329.76	1.8948	39	353.83	1.9064	64		
15	330.07	1.8949	40	367.80	1.9131	65		
16	331.04	1.8954	41	398.05	1.9276	66		
17	331.36	1.8956	42			67		
18	331.83	1.8958	43			68		
19	332.96	1.8963	44			69		
20	333.38	1.8965	45			70		
21	333.87	1.8968	46			71		
22	334.43	1.8970	47			72		
23	335.82	1.8977	48			73		
24	336.05	1.8978	49			74		
25	336.24	1.8979	50			75		

Average density of PyC fragments:	1.8975
Standard deviation in density of PyC fragments:	0.0074
Uncertainty in calculated density of PyC fragments:	0.0015

Dixie Barker
Operator

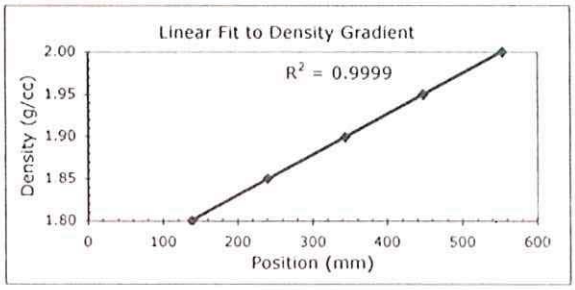
3-29-06
Date

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\D06041001_DRF03R2.xls
Sample ID:	LEU01-37T-E01
Sample description:	OPyC from Variant 3: TRISO 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	134.63	143.49	139.06
1.850	236.29	244.76	240.53
1.900	341.22	346.77	344.00
1.950	445.00	451.92	448.46
2.000	550.26	557.27	553.77

Linear Fit			
slope	StDev	intercept	StDev
4.82E-04	2.91E-06	1.73E+00	1.01E-03



Sample Density								
Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density	Fragment Number	Fragment Position	Calculated Density
1	340.52	1.8978	26	370.14	1.9120	51	389.59	1.9214
2	348.04	1.9014	27	370.79	1.9124	52	390.64	1.9219
3	352.54	1.9036	28	372.68	1.9133	53	391.96	1.9226
4	357.59	1.9060	29	373.59	1.9137	54	392.67	1.9229
5	358.56	1.9065	30	374.65	1.9142	55	392.90	1.9230
6	361.16	1.9077	31	375.30	1.9145	56	393.82	1.9235
7	361.58	1.9079	32	375.83	1.9148	57	397.84	1.9254
8	360.05	1.9072	33	376.84	1.9153	58	398.52	1.9257
9	362.50	1.9084	34	379.14	1.9164	59	399.59	1.9262
10	363.55	1.9089	35	379.85	1.9167	60	400.25	1.9265
11	364.51	1.9093	36	380.40	1.9170	61	404.12	1.9284
12	365.82	1.9100	37	381.95	1.9177	62	404.85	1.9288
13	366.30	1.9102	38	382.44	1.9180	63	405.55	1.9291
14	366.30	1.9102	39	382.68	1.9181	64	414.65	1.9335
15	366.90	1.9105	40	383.13	1.9183	65		
16	367.04	1.9105	41	384.02	1.9187	66		
17	368.02	1.9110	42	384.79	1.9191	67		
18	368.26	1.9111	43	385.72	1.9195	68		
19	365.27	1.9097	44	386.01	1.9197	69		
20	366.55	1.9103	45	386.29	1.9198	70		
21	367.67	1.9108	46	386.59	1.9200	71		
22	368.24	1.9111	47	386.97	1.9201	72		
23	369.19	1.9116	48	387.77	1.9205	73		
24	369.19	1.9116	49	387.94	1.9206	74		
25	369.63	1.9118	50	388.48	1.9209	75		

Average density of PyC fragments:	1.9157
Standard deviation in density of PyC fragments:	0.0073
Uncertainty in calculated density of PyC fragments:	0.0016

Dixie Barker
Operator

4-10-06
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:	M06042501L
Sample ID:	LEU01-49T-B01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Folder containing data:	\\mc-agr\AGR\2-MGEM\R06042801\

Particle #	Grid Position	Diattenuation			Equivalent BAFo		
		Average	St. Dev.	Ave. Error	Average	St. Dev.	Ave. Error
1	4,4	0.0106	0.0034	0.0012	1.0318	0.0102	0.0036
2	4,5	0.0085	0.0029	0.0012	1.0255	0.0087	0.0036
3	4,6	0.0099	0.0029	0.0012	1.0297	0.0087	0.0036
4	5,4	0.0102	0.0031	0.0011	1.0306	0.0093	0.0033
5	5,6	0.0090	0.0027	0.0011	1.0270	0.0081	0.0033
6	6,4	0.0106	0.0034	0.0012	1.0318	0.0102	0.0036
7	6,5	0.0091	0.0027	0.0011	1.0273	0.0081	0.0033
8	6,6	0.0104	0.0029	0.0011	1.0312	0.0087	0.0033
9	4,7	0.0093	0.0027	0.0013	1.0279	0.0081	0.0039
10	4,8	0.0102	0.0028	0.0011	1.0306	0.0084	0.0033
Average		0.0098	0.0030	0.0012	1.0293	0.0089	0.0035

Mean of average BAFo per particle:	1.0293
Standard deviation of average BAFo per particle:	0.0022

Comments

G. E. Jellison
Operator

4/28/06
Date

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

Procedure:	AGR-CHAR-DAM-18 Rev. 1
Operator:	G. E. Jellison
Mount ID:	M06042501L
Sample ID:	LEU01-49T-B01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Folder containing data:	\\mc-agr\AGR\2-MGEM\R06042801\

Particle #	Grid Position	Diattenuation			Equivalent BAFo		
		Average	St. Dev.	Ave. Error	Average	St. Dev.	Ave. Error
1	4,4	0.0066	0.0029	0.0018	1.0198	0.0087	0.0054
2	4,5	0.0061	0.0026	0.0011	1.0183	0.0078	0.0033
3	4,6	0.0074	0.0030	0.0012	1.0222	0.0090	0.0036
4	5,4	0.0069	0.0028	0.0012	1.0207	0.0084	0.0036
5	5,6	0.0061	0.0026	0.0011	1.0183	0.0078	0.0033
6	6,4	0.0081	0.0031	0.0012	1.0243	0.0093	0.0036
7	6,5	0.0074	0.0030	0.0011	1.0222	0.0090	0.0033
8	6,6	0.0065	0.0025	0.0011	1.0195	0.0075	0.0033
9	4,7	0.0075	0.0031	0.0012	1.0225	0.0093	0.0036
10	4,8	0.0086	0.0033	0.0011	1.0258	0.0099	0.0033
Average		0.0071	0.0029	0.0012	1.0214	0.0087	0.0036

Mean of average BAFo per particle:	1.0214
Standard deviation of average BAFo per particle:	0.0025

Comments

G. E. Jellison
Operator

4/28/06
Date

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

Procedure:	AGR-CHAR-DAM-20 Rev. 1
Operator:	John Hunn
Sample ID:	LEU01-49T-D02
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\GoldSpots\G06042601_DRF20R1.xls

Mean average weight/particle (g):	7.26E-04
Uncertainty in average weight/particle (g):	7.80E-07
Weight of sample of particles (g):	8.850
Approximate number of particles in sample:	12190
Uncertainty in number of particles in sample:	13

Number of particles with gold spot defects:	0

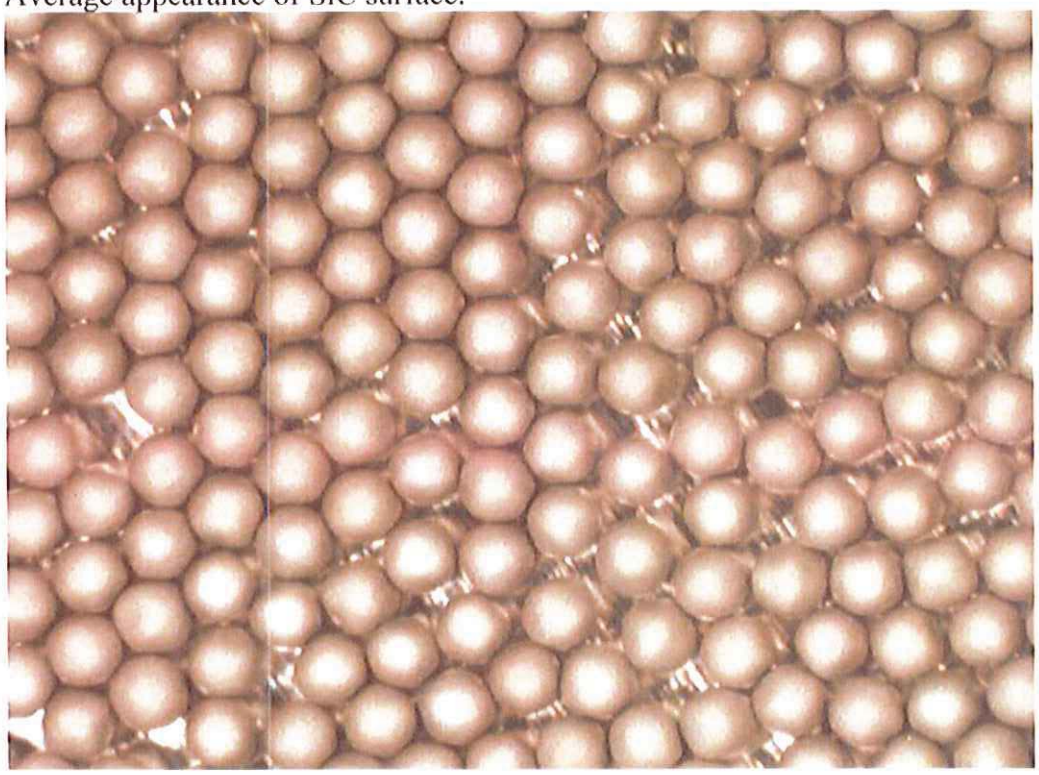
Comments on unusual visual characteristics of SiC

6 particles with an area of lumpy SiC were observed. These features were caused by carbon soot inclusion at the IPyC/SiC interface. However, for the purpose of this acceptance test, they were not counted as particles with SiC gold spot defects because they could not be classified as such according to the visual standard.

John Hunn
Operator

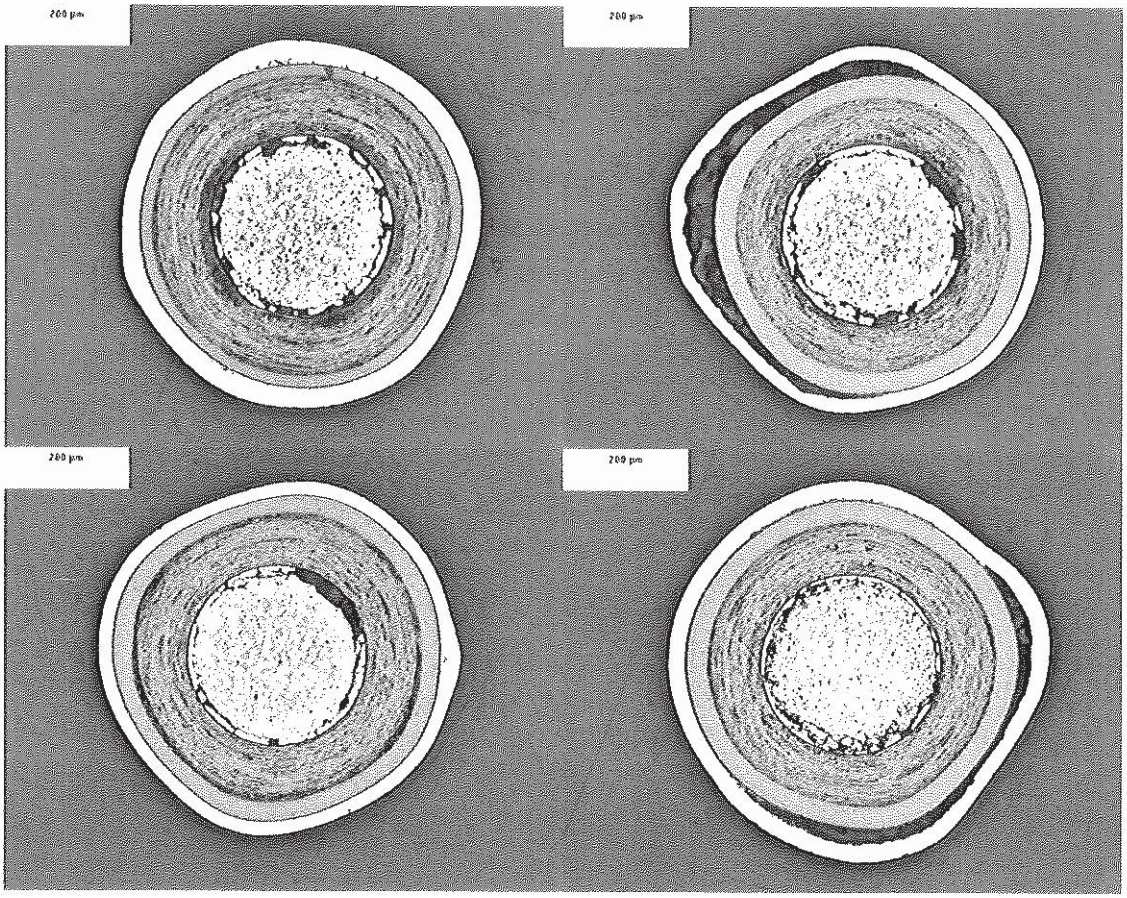
4-28-06
Date

Average appearance of SiC surface.



0/12190 gold spots found. However 6/12190 particles were observed with lumpy surfaces.

These lumpy surface features were revealed in optical cross section to be caused by varying degrees of carbon soot inclusion at the IPyC/SiC interface. These inclusions are the same type of coating defect that gives rise to the appearance of gold spots on the SiC surface. These inclusions did not manifest as gold spots in the LEU01-49T composite because of the difference in the SiC morphology associated with this variant. The mixed Ar/H SiC deposition produced a significantly smaller grain size than the baseline SiC deposition condition, as desired. This smaller grain size apparently resulted in more optical scatter at the surface which overshadowed the optical effect that would cause these defects to appear as gold spots.



Because these lumpy particles could not be categorized as gold spot defects according to the visual standard in section 5.3 of EDF 4380, they were not official counted for determination of product acceptance.

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:	LEU01-49T-C01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\P06042601\

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

Operator

April 26, 2006
Date

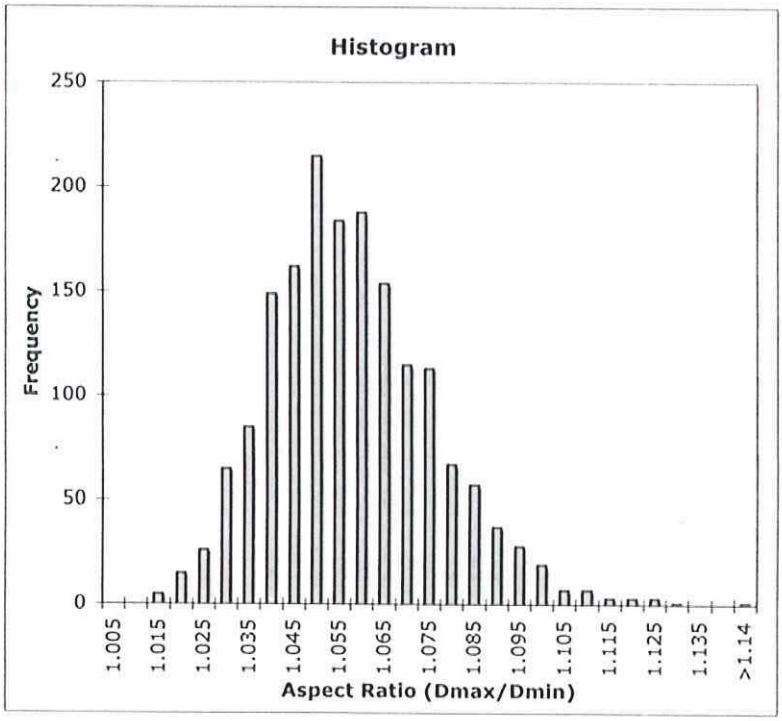
Data Report Form DRF-10B: Measurement of Particle Aspect Ratio (Dmax/Dmin)

Procedure:	AGR-CHAR-DAM-10 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06042601\
Sample ID:	LEU01-49T-C01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06042601_output\

Number of particles analyzed:	1709
Number of particles with aspect ratio ≥ 1.14	1
Average particle aspect ratio:	1.055

Distribution of the aspect ratio (top binned)

Aspect Ratio (D)	*Frequency*
1.005	0
1.010	0
1.015	5
1.020	15
1.025	26
1.030	65
1.035	85
1.040	149
1.045	162
1.050	215
1.055	184
1.060	188
1.065	154
1.070	115
1.075	113
1.080	67
1.085	57
1.090	37
1.095	28
1.100	19
1.105	7
1.110	7
1.115	3
1.120	3
1.125	3
1.130	1
1.135	0
1.140	0
>1.14	1



Operator

April 27, 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:	LEU01-49T-F01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\BurnLeach\QCData\B06042601_DRF21R1.xls

Mean average weight/particle (g):	7.26E-04
Uncertainty in mean average weight/particle (g):	7.80E-07
Weight of sample of particles (g):	36.4308
Approximate number of particles in sample:	50161
Uncertainty in number of particles in sample:	54

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	B0605040101	B0605080102		
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	060510-001	060510-003		
Weight uranium leached (g):	3.16E-07	1.55E-07		4.71E-07
Uncertainty in weight uranium leached (g):	3.20E-08	1.60E-08		3.58E-08
Calculated number of particles with SiC defects:	0	0		0
Uncertainty in number of particles with SiC defects:	1.47E-04	7.35E-05		1.64E-04

Comments

U checked by FCM against official analysis results IPA14268 on 5/15/06.

Fred C Montgomery
Operator

5-15-06
Date

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

Procedure:	AGR-CHAR-DAM-21 Rev. 1
Operator:	Montgomery
Sample ID:	LEU01-49T-G01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\BurnLeach\QCData\B06042602_DRF21R1.xls

Mean average weight/particle (g):	7.26E-04
Uncertainty in mean average weight/particle (g):	7.80E-07
Weight of sample of particles (g):	51.2017
Approximate number of particles in sample:	70499
Uncertainty in number of particles in sample:	76

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	B0605040201	B0605080202		
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	060510-002	060510-004		
Weight uranium leached (g):	2.53E-04	1.85E-05		2.72E-04
Uncertainty in weight uranium leached (g):	2.50E-05	1.90E-06		2.51E-05
Calculated number of particles with SiC defects:	1	0		1
Uncertainty in number of particles with SiC defects:	1.15E-01	8.73E-03		1.15E-01

Comments

U checked by FCM against official analysis results IPA14268 on 5/15/06.

Fred C Montgomery
Operator

5-15-06
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:	LEU01-49T-D01
Sample Description:	Variant 3 Composite:TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\MissingOPyC\X06042501_DRF19R1.xls

Mean average weight/particle (g):	7.26E-04
Uncertainty in average weight/particle (g):	7.80E-07
Weight of sample of particles (g):	22.635
Approximate number of particles in sample:	31178
Uncertainty in number of particles in sample:	33

Number of particles with missing OPyC layer:	0

Comments on unusual visual characteristics of OPyC

John Hunn
Operator

4-25-06
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\E06042601_DRF23R0.xls
Sample ID:	LEU01-49T-B01
Sample Description:	LEU01-49T-B01
Mount Number(s):	M06042101L
Folder name containing images:	\\mc-agr\AGR\SEM\

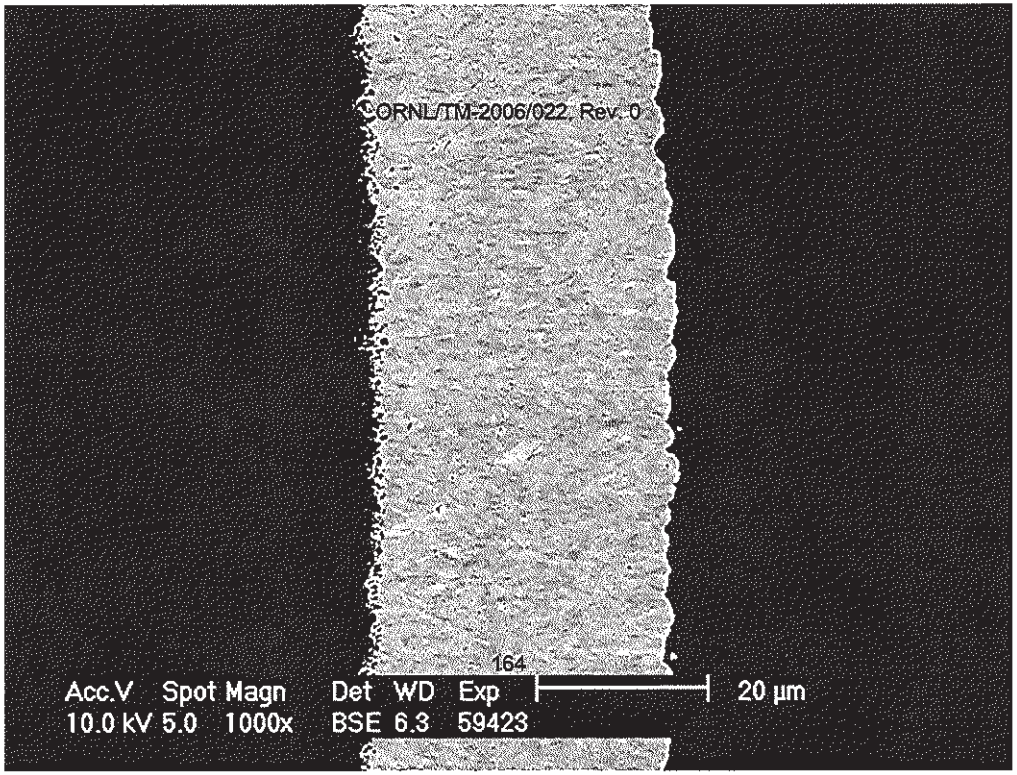
Images of SiC grain structure			
	particle 1	particle 2	particle 3
1000x image filename	59423	59431	59435
2500x image filename	59424	59432	59436
grain structure acceptable	yes	yes	yes

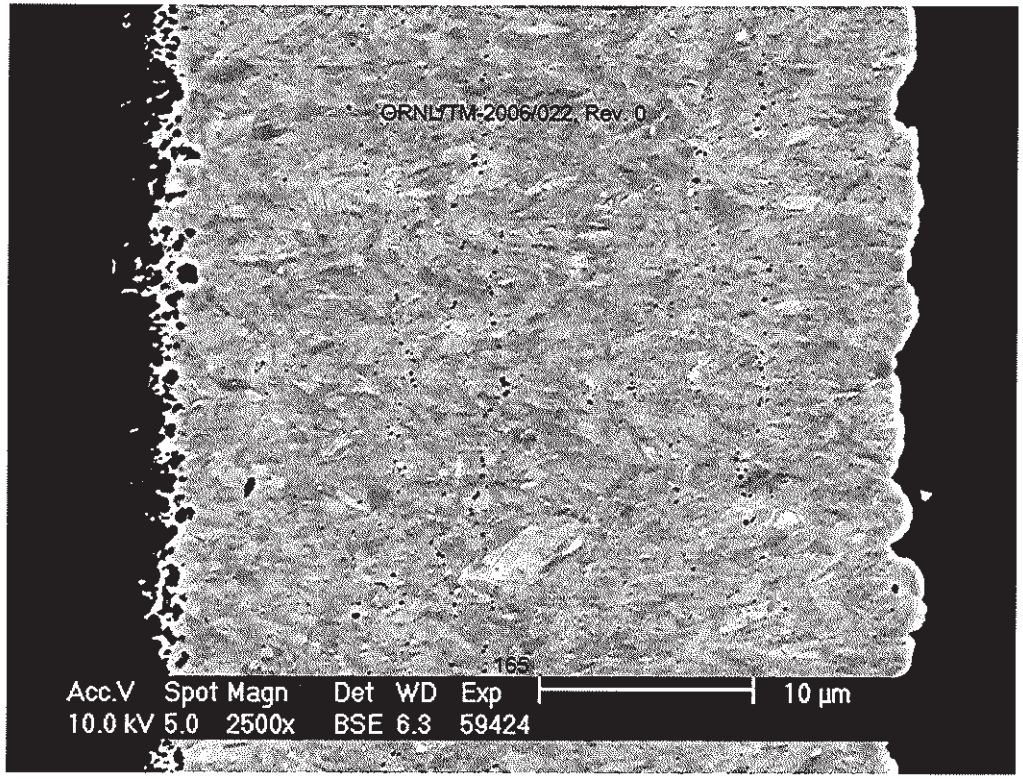
Comments

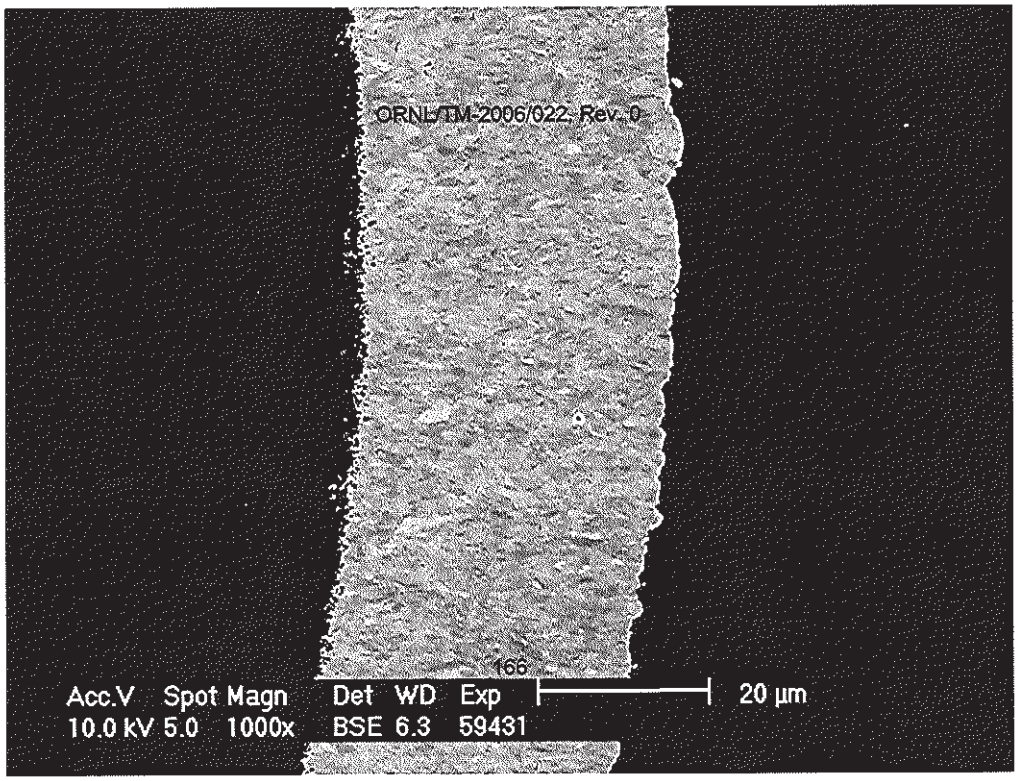
Operator — Date: 4-26-06

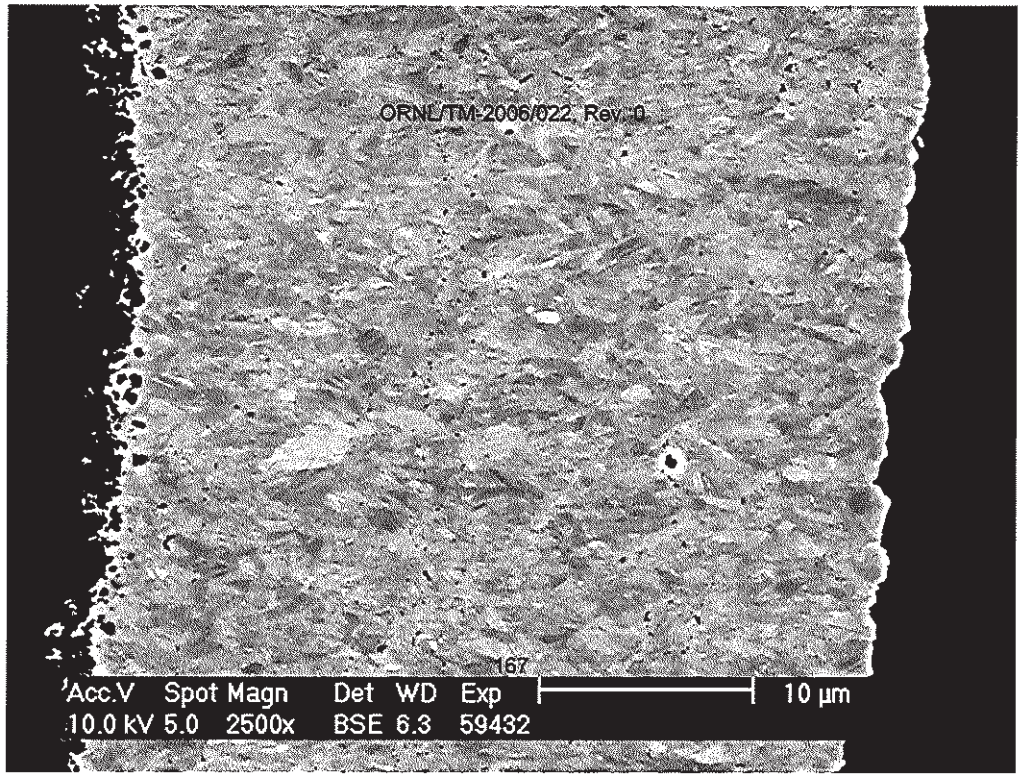
QC Supervisor — Date: 4-26-06

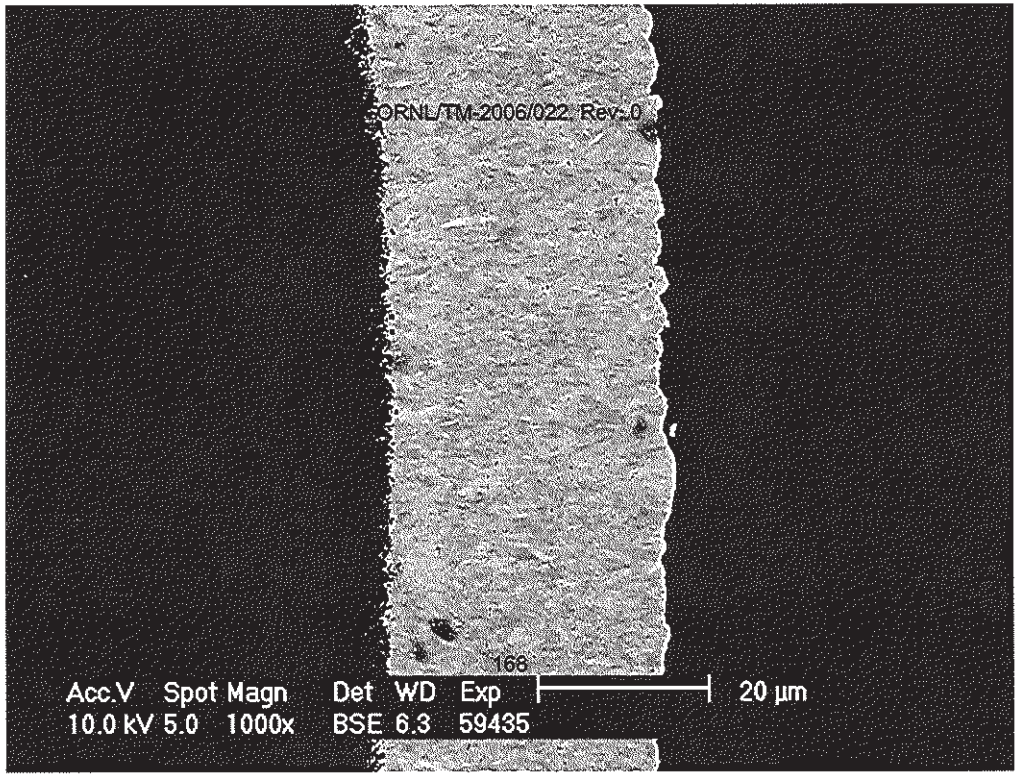
QA Reviewer — Date: 5/2/06

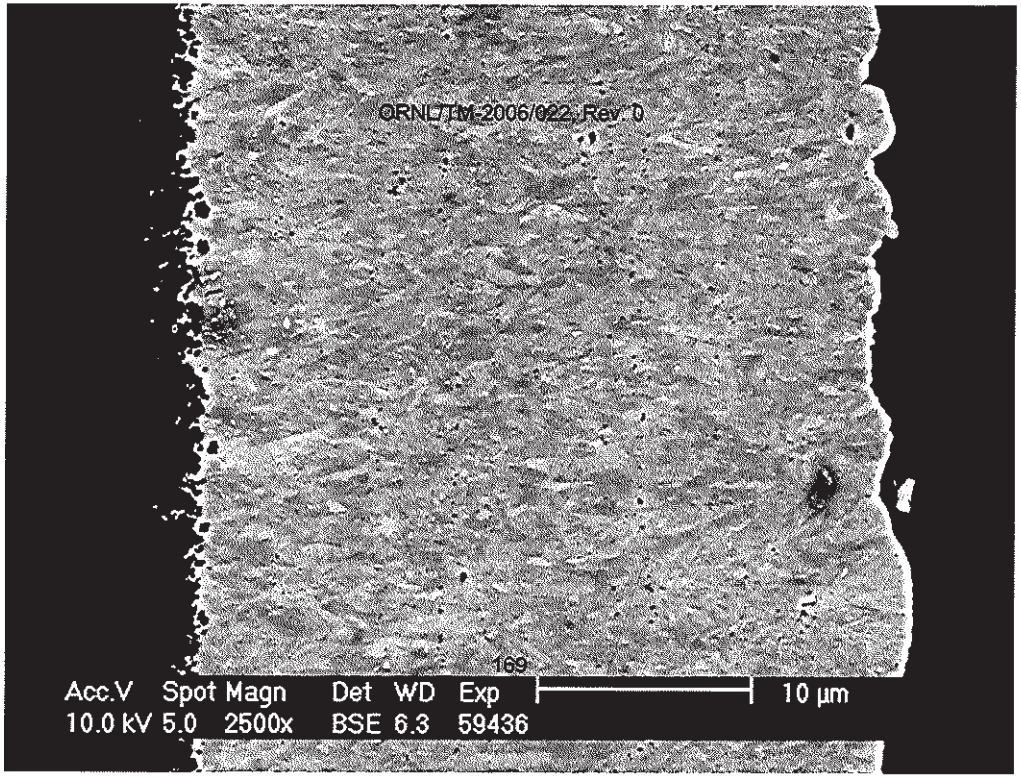

ORNL/TM-2006/022, Rev. 0
164
Acc.V Spot Magn Det WD Exp
10.0 kV 5.0 1000x BSE 6.3 59423
20 µm


ORNL/TM-2006/022, Rev. 0
165
Acc.V Spot Magn Det WD Exp
10.0 kV 5.0 2500x BSE 6.3 59424
10 µm


ORNL/TM-2006/022, Rev. 0
166
Acc.V Spot Magn Det WD Exp
10.0 kV 5.0 1000x BSE 6.3 59431
20 µm


Acc.V Spot Magn Det WD Exp
10.0 kV 5.0 2500x BSE 6.3 59432
10 µm


ORNL/TM-2006/022, Rev. 0
168
Acc.V Spot Magn Det WD Exp
10.0 kV 5.0 1000x BSE 6.3 59435
20 µm


ORNL/TM-2006/022, Rev. 0
169
Acc.V Spot Magn Det WD Exp
10.0 kV 5.0 2500x BSE 6.3 59436
10 µm

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:	LEU01-49T-H01
Particle Lot Description:	Variant 3 Composite:TRISO on BWXT kernel comp 69302
Filename:	\\mc-agr\AGR\ParticleWeight\W06042001_DRF22R1.xls

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Weight of particles (g):	9.30E-02	9.24E-02	7.28E-02	9.19E-02	8.78E-02
Number of particles:	128	127	100	127	121
Average weight/particle (g):	7.27E-04	7.28E-04	7.28E-04	7.24E-04	7.26E-04

Mean average weight/particle (g):	7.26E-04
Standard error in mean average weight/particle (g):	7.80E-07

Dixie Barker
Operator

4-20-06
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:	LEU01-49T-I01
Batch Description:	Variant 3 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\S06042401\S06042401_DRF31R1.xls

Mean average weight/particle (g):	7.26E-04
Standard error in mean average weight/particle (g):	7.80E-07

Weight of particles (g):	3.5113
Approximate number of particles:	4837
Uncertainty in number of particles:	5
Total envelope volume of sample (cc):	1.266
Average envelope volume/particle (cc):	2.62E-04
Sample envelope density (g/cc):	2.773

Average particle diameter (microns):	7.94E+02
Average surface area/particle (cm2):	1.98E-02
Total sample surface area (cm2):	9.57E+01
Intruded mercury volume from 250-10,000 psia (cc):	9.50E-03
Open porosity (ml/m2):	9.93E-01

Comments

S. D. Nunn
Operator

1/24/06
Date

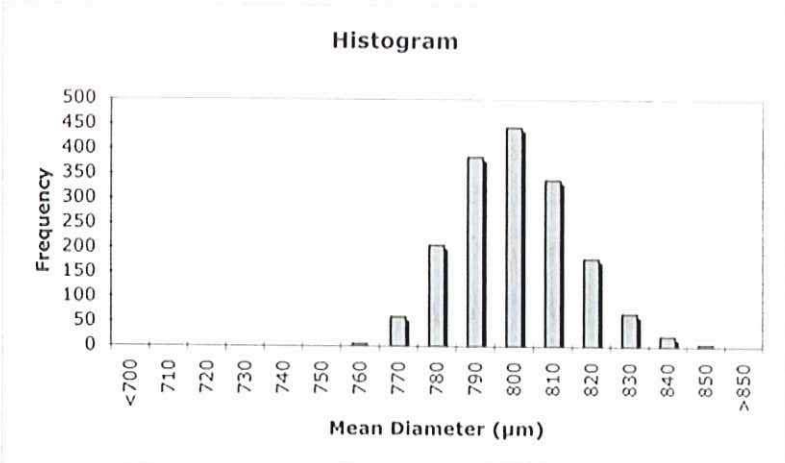
Data Report Form DRF-10A: Measurement of Particle Diameter

Procedure:	AGR-CHAR-DAM-10 Rev. 2
Operator:	Andrew K. Kercher
Folder name containing images:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06042601\
Sample ID:	LEU01-49T-C01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Folder name containing processed data:	\\mc-agr\AGR\ImageProcessing\Completed_Shadow\P06042601_output\

Number of particles analyzed:	1709
Mean of the average diameter of each particle (μm):	795.1
Standard deviation in the average diameter of each particle (μm):	15

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	5
770	60
780	206
790	384
800	444
810	338
820	179
830	67
840	21
850	5
>850	0



Andrew K. Kercher
Operator

April 27, 2006
Date

Supplement to DRF-21: Impurity Analysis Data

Procedure:	AGR-CHAR-DAM-21 Rev. 1
Operator:	Montgomery
Sample ID:	LEU01-49T-F01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\BurnLeach\QCData\B06042601_DRF21R1.xls

	Leach 1	Leach 2	Leach 3	
Sample number: RMAL Analysis Number:	B0605040101 060510-001	B0605080102 060510-003		Total µg
Fe content of leach solution (µg)	9.31	0.93		10.24
Uncertainty in measured Fe content (µg)	0.93	0.19		0.95
Cr content of leach solution (µg)	< 1.70	< 0.71		< 2.41
Uncertainty in measured Cr content (µg)				
Mn content of leach solution (µg)	< 0.24	< 0.10		< 0.34
Uncertainty in measured Mn content (µg)				
Co content of leach solution (µg)	< 0.68	< 0.28		< 0.96
Uncertainty in measured Co content (µg)				
Ni content of leach solution (µg)	6.02	< 0.50		< 6.52
Uncertainty in measured Ni content (µg)	0.60			0.60
Cr + Mn + Co + Ni (µg)	< 8.64	< 1.59		<10.23
Uncertainty in Cr + Mn + Co + Ni (µg)	0.60			0.60
Ca content of leach solution (µg)	22.20	8.55		30.75
Uncertainty in measured Ca content (µg)	2.20	0.86		2.36
Al content of leach solution (µg)	16.80	4.52		21.32
Uncertainty in measured Al content (µg)	3.40	0.90		3.52
Ti content of leach solution (µg)	< 2.06	< 0.86		< 2.92
Uncertainty in measured Ti content (µg)				
V content of leach solution (µg)	< 0.94	< 0.39		< 1.33
Uncertainty in measured V content (µg)				
Ti + V content of leach solution (µg)	< 3.00	< 1.25		< 4.25
Uncertainty in measured Ti + V content (µg)				

Comments

Impurities checked by FCM against official analysis results IPA14268 on 5/15/06.

Fred C. Montgomery
Operator

5-15-06
Date

Supplement to DRF-21: Impurity Analysis Data

Procedure:	AGR-CHAR-DAM-21 Rev. 1
Operator:	Montgomery
Sample ID:	LEU01-49T-G01
Sample Description:	Variant 3 composite: TRISO on BWXT kernel composite 69302
Filename:	\\mc-agr\AGR\BurnLeach\QCData\B06042602_DRF21R1.xls

	Leach 1	Leach 2	Leach 3	
Sample number: RMAL Analysis Number:	B0605040201 060510-002	B0605080202 060510-004		Total µg
Fe content of leach solution (µg)	6.20	1.78		7.98
Uncertainty in measured Fe content (µg)	0.62	0.18		0.65
Cr content of leach solution (µg)	< 0.71	< 0.71		< 1.41
Uncertainty in measured Cr content (µg)				
Mn content of leach solution (µg)	0.11	< 0.10		< 0.21
Uncertainty in measured Mn content (µg)	0.02			0.02
Co content of leach solution (µg)	< 0.28	< 0.28		< 0.56
Uncertainty in measured Co content (µg)				
Ni content of leach solution (µg)	3.85	< 0.50		< 4.35
Uncertainty in measured Ni content (µg)	0.39			0.39
Cr + Mn + Co + Ni (µg)	< 4.95	< 1.59		< 6.54
Uncertainty in Cr + Mn + Co + Ni (µg)	0.39			0.39
Ca content of leach solution (µg)	11.50	9.98		21.48
Uncertainty in measured Ca content (µg)	1.20	1.00		1.56
Al content of leach solution (µg)	7.23	4.72		11.95
Uncertainty in measured Al content (µg)	1.40	0.94		1.69
Ti content of leach solution (µg)	< 0.86	< 0.86		< 1.72
Uncertainty in measured Ti content (µg)				
V content of leach solution (µg)	< 0.39	< 0.39		< 0.78
Uncertainty in measured V content (µg)				
Ti + V content of leach solution (µg)	< 1.25	< 1.25		< 2.50
Uncertainty in measured Ti + V content (µg)				

Comments

Impurities checked by FCM against official analysis results IPA14268 on 5/15/06.

Fred C. Montgomery
Operator

5-15-06
Date

15 Superceded data

This section contains data related to the LEU01-49T 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 $(2.47\pm0.01)\cdot10^{-4}$ grams per kernel to $(2.418\pm0.006)\cdot10^{-4}$ grams per kernel. The measured value of the NUCO average kernel weight changed from $(2.39\pm0.03)\cdot10^{-4}$ grams per kernel to $(2.308\pm0.009)\cdot10^{-4}$ 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 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:	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

Expended 2-14 OL

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

Superceded 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

Approved 2366 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-4390				
Batch 1: Buffer envelope density	0.97	0.09	5	2.132	mean 0.95 ± 0.15	A = x - ts/√n ≥ 0.80	0.89	pass	DRF-16
						B = x + ts/√n ≤ 1.10	1.05	pass	DRF-22
Batch 2: Buffer envelope density	1.01	0.09	5	2.132	mean 0.95 ± 0.15	A = x - ts/√n ≥ 0.80	0.93	pass	DRF-16
						B = x + ts/√n ≤ 1.10	1.09	pass	DRF-22
Batch 3: Buffer envelope density	1.01	0.09	5	2.132	mean 0.95 ± 0.15	A = x - ts/√n ≥ 0.80	0.93	pass	DRF-16
						B = x + ts/√n ≤ 1.10	1.09	pass	DRF-22
Composite buffer envelope density	0.99	0.08	5	2.132	mean 0.95 ± 0.15	A = x - ts/√n ≥ 0.80	0.92	pass	DRF-16
						B = x + ts/√n ≤ 1.10	1.07	pass	DRF-22

Comments

Standard deviations are √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 — Date: 6-28-05

Accept for buffer density (Yes or No):	Yes

QA Reviewer — Date: 8/2/05

Superceded 3-10 06

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:	NUCO35Q-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

superceded 2-14-06 JH

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

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

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

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

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

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

S. D. Nunn
Operator

6/21/05
Date

superceded 2-14-06 JH

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

Procedure:	AGR-CHAR-DAM-16 Rev. 2
Operator:	S. D.NUNN
Buffer-coated kernel batch ID:	NUCO350-54B
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

6/22/05
Date

superseded 2-14-06 [illegible]

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:	\\mc-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