

## Core Change Summary for Conversion from RINSC LEU Core #5 to LEU Core # 6

### Core History

The original reactor core at RINSC was fueled with HEU fuel. In August of 1993, RINSC converted its core from HEU to LEU fuel. The final total number of operating hours with HEU fuel was:

49698.01 MWH of HEU fuel operation

Cores LEU #1 through LEU #3 did not involve changing the grid positions or replacing any of the fuel elements. These configuration changes were made by changing the neutron reflection around the core to make it progressively more efficient as fuel burn-up took effect. On 24 October 2008, RINSC changed the core configuration to core LEU #4. This change involved retiring four fuel elements from the center of the core, moving all of the remaining fuel elements toward the center of the core, and adding four fresh fuel elements to the outer corners of the fueled section of the core. During an element inspection, it was discovered that the positions of fuel elements RI – 002 and RI – 010 had been transposed. Rather than returning the transposed fuel elements to their core #4 positions, a new core #5 was defined with the elements remaining in the transposed positions. Consequently, LEU Core #5 was defined to be:

Thermal Column Side

	A	B	C	D	E	F	G
1	CIC #1	G - 20	G - 17	G - 24	G - 13	G - 23	
2	G - 15	G - 18	B - 10	Reg Rod	B - 1	G - 21	G - 16
3	G - 4	B - 5	Fuel - 15	Fuel - 9	Fuel - 16	B - 15	G - 3
4	G - 2	B - 7	Fuel - 13	Fuel - 1	Fuel - 11	B - 2	G - 14
5	G - 10	B - 8	Fuel - 8	CIF	Fuel - 7	B - 14	G - 6
6	G - 12	B - 12	Fuel - 12	Fuel - 10	Fuel - 14	B - 6	G - 11
7	G - 9	B - 9	Fuel - 17	Fuel - 2	Fuel - 18	B - 16	G - 5
8	G - 19	G - 7	B - 13	B - 11	B - 4	G - 8	G - 1
9		FC					CIC #2

It was determined that the initial date that the core was in this configuration was 6 May 2009. The final operating day for core LEU #5 was 17 August 2012, which was run #8721. The total number of MWH of operation for Core LEU #5 was 2300.4 MWH.

The following table shows a summary of the LEU core history:

Core	Begin Date	End Date	Final Run Number	MWH of Operation	Total LEU MWH	Facility Lifetime MWH
HEU	7/26/64	8/13/93		49698.01	0	49698.01
LEU #1	8/20/93	5/26/94		1381.75	1381.75	51079.76
LEU #2	5/27/94	9/8/94		501.66	1883.41	51581.42
LEU #1A	9/9/94	9/4/97		3662.75	5546.16	55244.17
LEU #2	9/5/97	5/1/03		3203.34	8749.50	58447.51
LEU #3	5/2/03	10/23/08	8270	3486.76	12236.26	61934.27
LEU #4	10/24/08	5/5/09	8348	401.10	12637.36	62335.37
LEU #5	5/6/08	8/17/12	8721	1899.30	14536.66	64234.67

### Final LEU Core #5 Elemental Burn-Up

Element	Initial U	Initial U 235	Total Element Element MWH	U 235 Consumed	U 235 Remaining	Total U Remaining
RI-001	1,389.85	274.71	1,118.00	58.23	216.48	1,340.94
RI-002	1,389.76	274.71	1,044.26	54.39	220.32	1,344.07
RI-007	1,389.33	274.60	1,067.37	55.59	219.01	1,342.63
RI-008	1,389.81	274.70	1,067.37	55.59	219.11	1,343.11
RI-009	1,389.64	274.66	808.02	42.08	232.58	1,354.29
RI-010	1,388.59	274.55	881.76	45.93	228.62	1,350.01
RI-011	1,388.48	274.63	948.81	49.42	225.21	1,346.97
RI-012	1,388.71	274.67	948.81	49.42	225.25	1,347.20
RI-013	1,388.51	274.63	826.45	43.04	231.59	1,352.36
RI-014	1,389.01	274.73	826.45	43.04	231.69	1,352.86
RI-015	1,388.69	274.67	124.25	6.47	268.20	1,383.26
RI-016	1,388.59	274.65	124.25	6.47	268.18	1,383.16
RI-017	1,388.68	274.67	124.25	6.47	268.20	1,383.25
RI-018	1,388.59	274.65	124.25	6.47	268.18	1,383.16

### Transition from Core LEU #5 to Core LEU #6

On 20 August 2012, Fuel elements RI – 001, RI – 007, RI – 008, and RI – 010 were retired and put into storage. At this point the core configuration was:

LEU Core #6 Step 1 Configuration - 20 August 2012

Thermal Column Side

	A	B	C	D	E	F	G
1	CIC #1	G - 20	G - 17	G - 24	G - 13	G - 23	
2	G - 15	G - 18	B - 10	Reg Rod	B - 1	G - 21	G - 16
3	G - 4	B - 5	Fuel - 15	Fuel - 9	Fuel - 16	B - 15	G - 3
4	G - 2	B - 7	Fuel - 13		Fuel - 11	B - 2	G - 14
5	G - 10	B - 8		CIF		B - 14	G - 6
6	G - 12	B - 12	Fuel - 12		Fuel - 14	B - 6	G - 11
7	G - 9	B - 9	Fuel - 17	Fuel - 2	Fuel - 18	B - 16	G - 5
8	G - 19	G - 7	B - 13	B - 11	B - 4	G - 8	G - 1
9		FC					CIC #2

Fuel elements RI – 011, RI – 012, RI – 013, and RI – 014 were shifted counter clockwise around the center of the core. At this point the core configuration was:

LEU Core #6 Step 2 Configuration - 20 August 2012

Thermal Column Side

	A	B	C	D	E	F	G
1	CIC #1	G - 20	G - 17	G - 24	G - 13	G - 23	
2	G - 15	G - 18	B - 10	Reg Rod	B - 1	G - 21	G - 16
3	G - 4	B - 5	Fuel - 15	Fuel - 9	Fuel - 16	B - 15	G - 3
4	G - 2	B - 7		Fuel - 11		B - 2	G - 14
5	G - 10	B - 8	Fuel - 13	CIF	Fuel - 14	B - 14	G - 6
6	G - 12	B - 12		Fuel - 12		B - 6	G - 11
7	G - 9	B - 9	Fuel - 17	Fuel - 2	Fuel - 18	B - 16	G - 5
8	G - 19	G - 7	B - 13	B - 11	B - 4	G - 8	G - 1
9		FC					CIC #2

Fuel elements RI – 002, RI – 009, RI – 015, and RI – 018 were moved to the following grid locations:

RI – 002      Grid C6  
 RI – 009      Grid E4  
 RI – 015      Grid C4  
 RI – 018      Grid E6

At this point the core configuration was:

**LEU Core #6 Step 3 Configuration - 20 August 2012**

Thermal Column Side

	A	B	C	D	E	F	G
1	CIC #1	G - 20	G - 17	G - 24	G - 13	G - 23	
2	G - 15	G - 18	B - 10	Reg Rod	B - 1	G - 21	G - 16
3	G - 4	B - 5			Fuel - 16	B - 15	G - 3
4	G - 2	B - 7	Fuel - 15	Fuel - 11	Fuel - 9	B - 2	G - 14
5	G - 10	B - 8	Fuel - 13	CIF	Fuel - 14	B - 14	G - 6
6	G - 12	B - 12	Fuel - 2	Fuel - 12	Fuel - 18	B - 6	G - 11
7	G - 9	B - 9	Fuel - 17			B - 16	G - 5
8	G - 19	G - 7	B - 13	B - 11	B - 4	G - 8	G - 1
9		FC					CIC #2

On 21 August 2012, Fuel elements RI – 016 and RI – 017 were shifted counter clockwise around the center of the core. At this point the core configuration was:

LEU Core #6 Step 4 Configuration - 21 August 2012

Thermal Column Side

	A	B	C	D	E	F	G
1	CIC #1	G - 20	G - 17	G - 24	G - 13	G - 23	
2	G - 15	G - 18	B - 10	Reg Rod	B - 1	G - 21	G - 16
3	G - 4	B - 5		Fuel - 16		B - 15	G - 3
4	G - 2	B - 7	Fuel - 15	Fuel - 11	Fuel - 9	B - 2	G - 14
5	G - 10	B - 8	Fuel - 13	CIF	Fuel - 14	B - 14	G - 6
6	G - 12	B - 12	Fuel - 2	Fuel - 12	Fuel - 18	B - 6	G - 11
7	G - 9	B - 9		Fuel - 17		B - 16	G - 5
8	G - 19	G - 7	B - 13	B - 11	B - 4	G - 8	G - 1
9		FC					CIC #2

On 22 August 2012, Fuel elements RI – 019, RI – 020, and RI – 021 were installed in the corners of the core. At this point the core configuration was:

LEU Core #6 Step 5 Configuration - 22 August 2012

Thermal Column Side

	A	B	C	D	E	F	G
1	CIC #1	G - 20	G - 17	G - 24	G - 13	G - 23	
2	G - 15	G - 18	B - 10	Reg Rod	B - 1	G - 21	G - 16
3	G - 4	B - 5	Fuel - 19	Fuel - 16	Fuel - 20	B - 15	G - 3
4	G - 2	B - 7	Fuel - 15	Fuel - 11	Fuel - 9	B - 2	G - 14
5	G - 10	B - 8	Fuel - 13	CIF	Fuel - 14	B - 14	G - 6
6	G - 12	B - 12	Fuel - 2	Fuel - 12	Fuel - 18	B - 6	G - 11
7	G - 9	B - 9	Fuel - 21	Fuel - 17	Fuel - 22	B - 16	G - 5
8	G - 19	G - 7	B - 13	B - 11	B - 4	G - 8	G - 1
9		FC					CIC #2

This is the configuration for Core LEU #6.

### **Initial LEU Core #6 Critical Rod Heights**

On 23 August 2012 an approach to critical was performed. Critical rod heights were determined to be:

Shim Safety #1	16.00 inches
Shim Safety #2	16.00 inches
Shim Safety #3	16.00 inches
Shim Safety #4	16.00 inches
Regulating Rod	10.66 inches

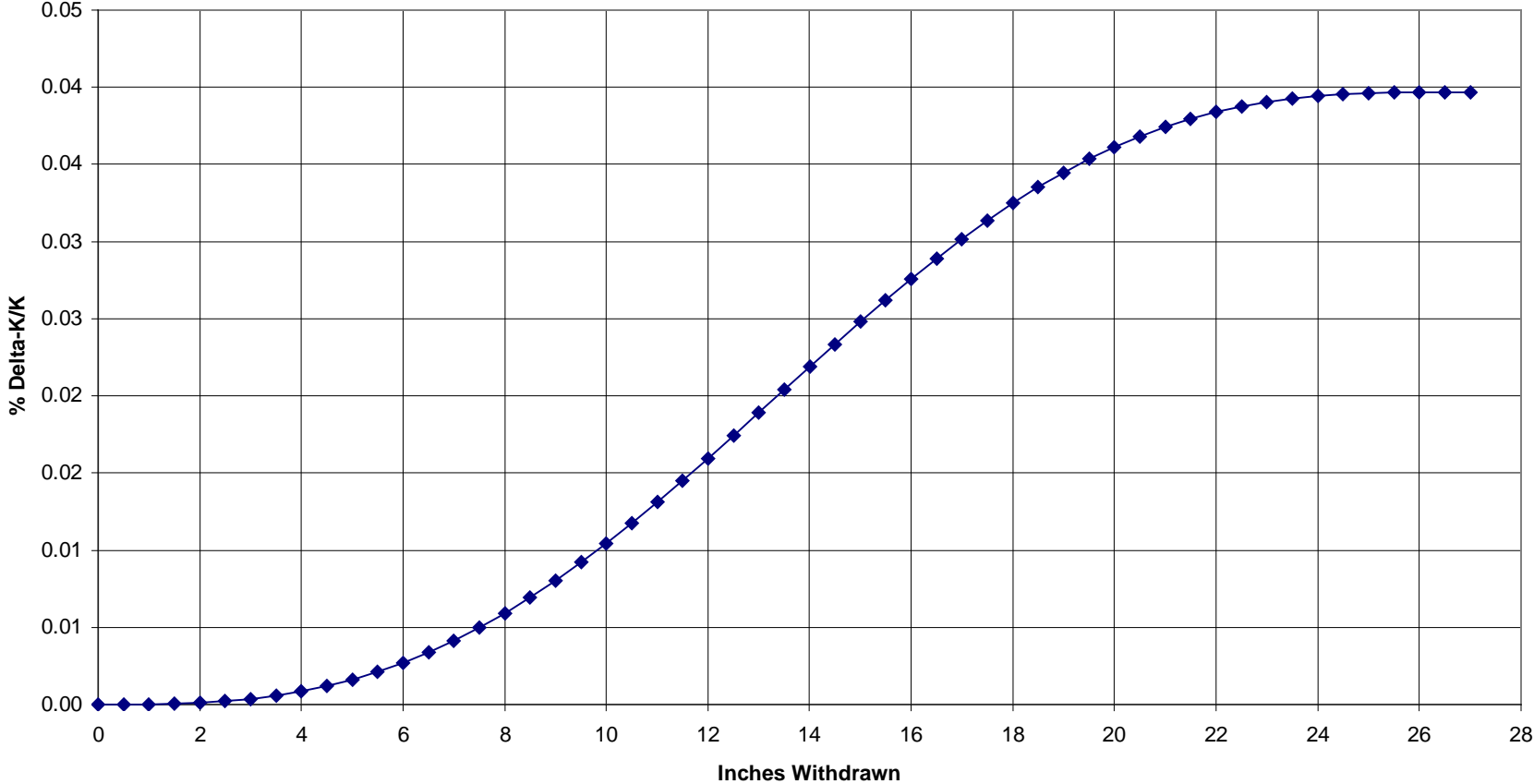
### **Initial LEU Core #6 Control Rod Worths**

On 24 August 2012 and 27 August 2012 the control rods were calibrated. The control rod worths were determined to be:

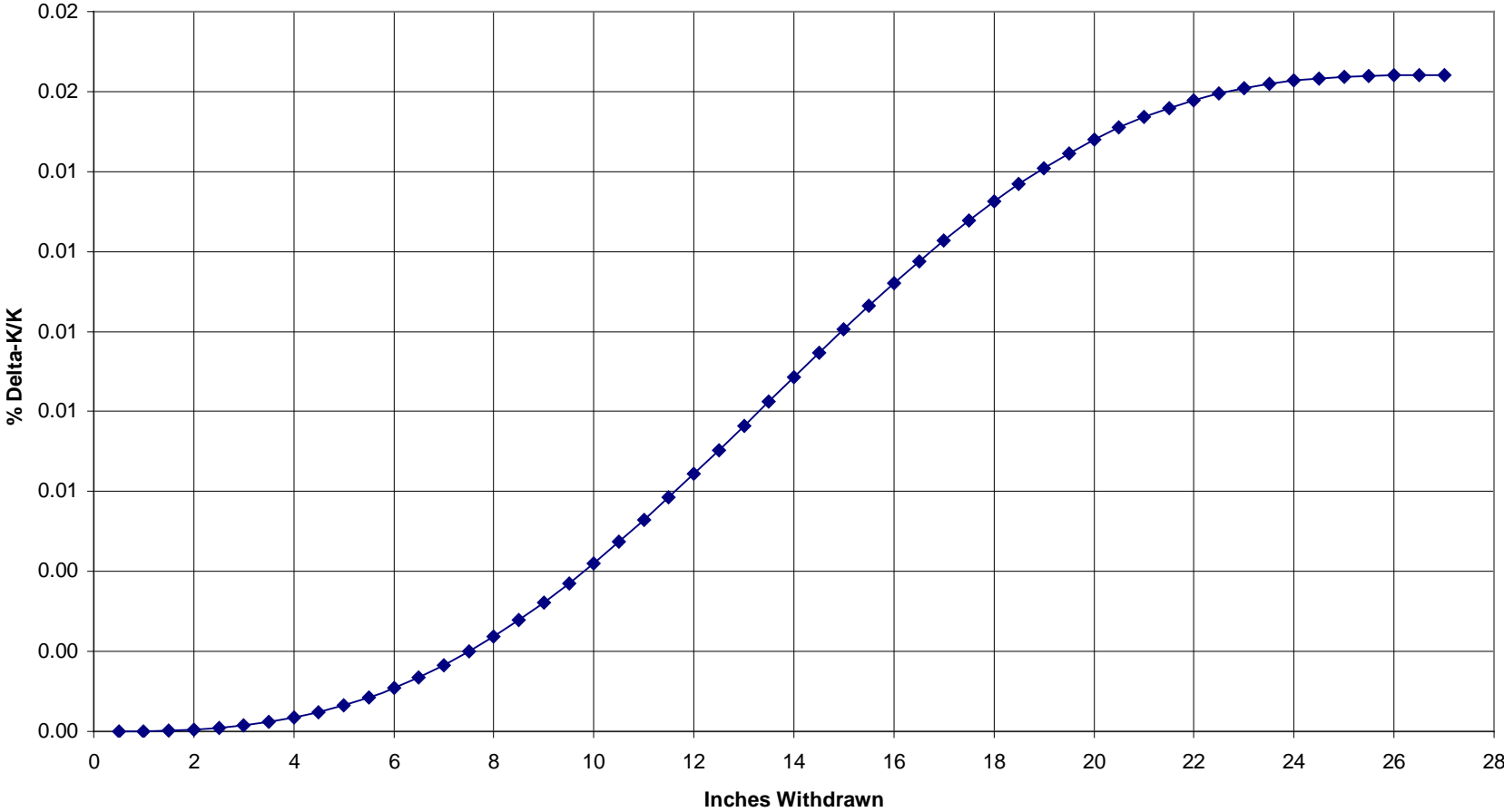
Shim Safety #1	3.97 % dk/k
Shim Safety #2	1.64 % dk/k
Shim Safety #3	1.58 % dk/k
Shim Safety #4	2.25 % dk/k
Regulating Rod	0.32 % dk/k

RINSC Technical Specification 3.1.6 requires that the reactivity worth of the regulating rod be less than 0.6 % dk/k. The control rod calibration showed that this was the case.

Blade 1 Int 8-26-2012, 3.97%

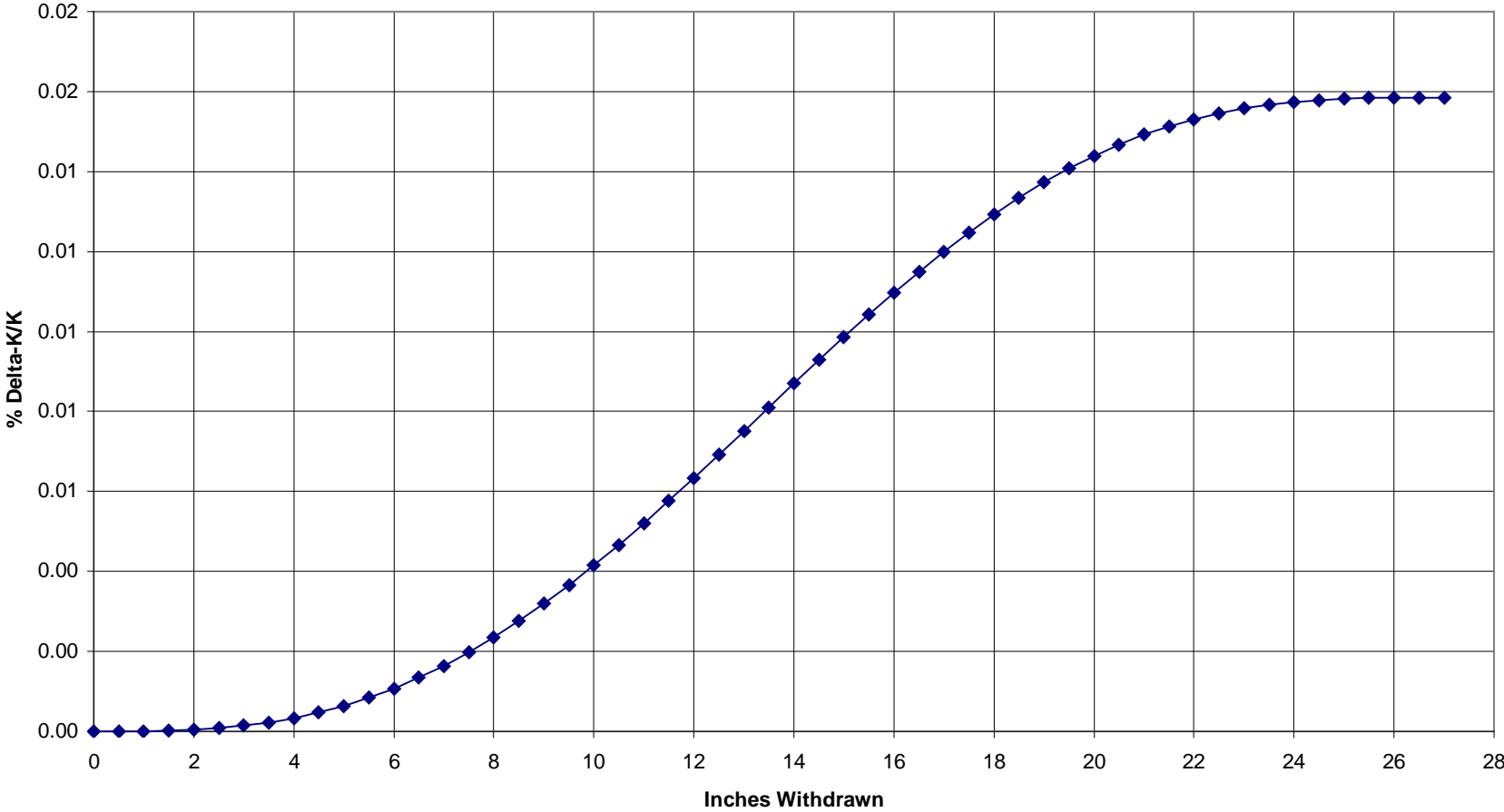


Blade 2 Int 8-26-2012, 1.64%

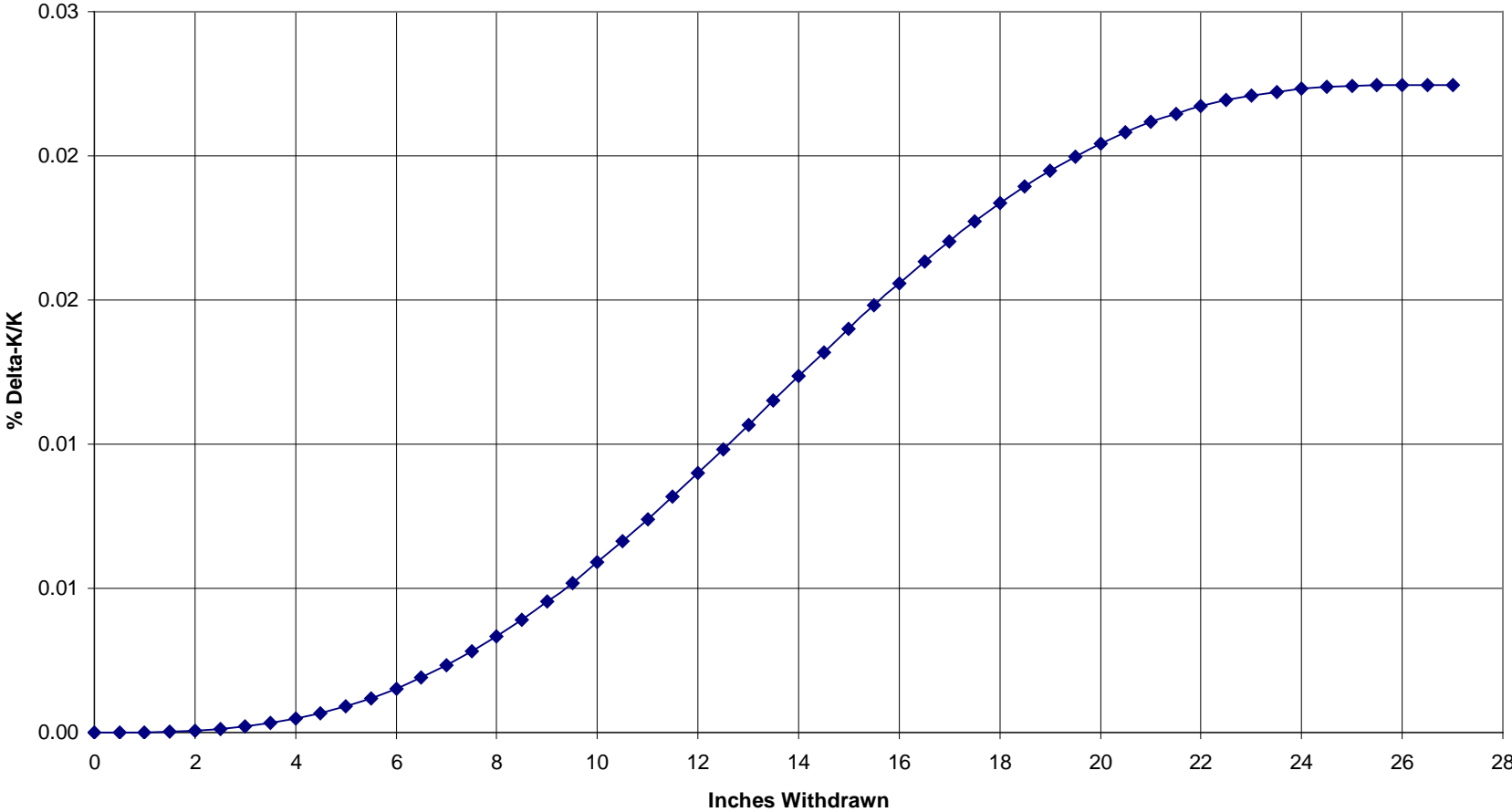




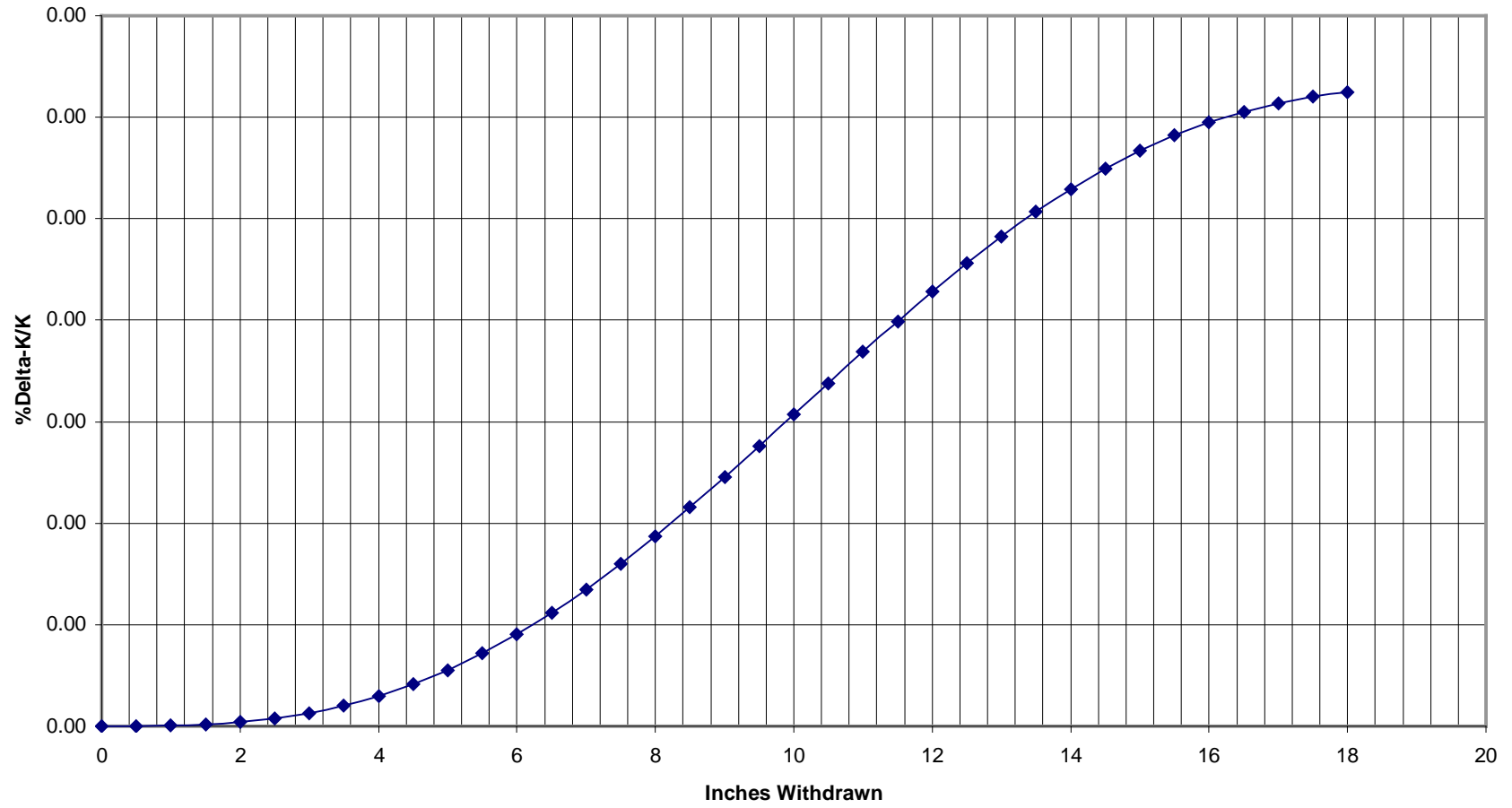
Blade 3 Int 8-26-2012, 1.58%



Blade 4 Int 8-26-2012, 2.25%



Regulating Blade 8-27-2012 0.315%



### Initial LEU Core #6 Excess and Shutdown Margin Reactivity

2012 Excess Reactivity and Shutdown Margin				
	Total Worth	Total Length	Critical Heights	Critical Worth
SS#1	3.97%	26.63	16	2.76%
SS#2	1.64%	26.92	16	1.12%
SS#3	1.58%	26.69	16	1.10%
SS#4	2.25%	26.67	16	1.56%
RR	0.32%	20.27	10.66	0.17%
Total	9.76%		Total	6.71%
<b>XS Reactivity</b> 3.05% TS 3.1.2 Requires XS Reactivity <= 4.7% dk/k				
- Total Critical Worth		-6.71%		
+ Regulating Rod Worth		0.32%		Log Book 58
+ Most Reactive SS Worth		3.97%		Page 123
<b>SD Margin</b> -2.42% TS 3.1.1 Requires that SD Margin <= -1% dk/k				

RINSC Technical Specification 3.1.1 requires that the shutdown margin be at least 1.0 % dk/k with the highest worth shim safety rod and the regulating rod fully withdrawn. The control rod calibration showed that this was the case.

RINSC Technical Specification 3.1.2 requires that the core excess reactivity not exceed 4.7 % dk/k. The control rod calibration showed that this was the case.

### Initial reactivity Insertion Rates

Rod	Total Rod Length	Total Withdrawal Time (seconds)	Total Reactivity Worth (% dk/k)	% Reactivity Insertion / second
Regulating Rod	20.30	57	0.32%	0.0001
Shim Safety #1	26.00	435	3.97%	0.0001
Shim Safety #2	26.00	435	1.64%	0.0000
Shim Safety #3	26.00	435	1.58%	0.0000
Shim Safety #4	26.00	435	2.25%	0.0001

RINSC Technical Specification 3.2.4 requires that the reactivity insertion rates of the individual control and regulating rods not exceed 0.02 %dk/k per second. The reactivity insertion rate analysis shows that this was the case.