

ENCLOSURE 5

**TN Calculation NUH32PHB-0603, USL Evaluation for NUHOMS 32PHB
System**

	Form 3.2-1 Calculation Cover Sheet TIP 3.2 (Revision 4)	Calculation No.: NUH32PHB-0603	
		Revision No.: 0	
		Page: 1 of 16	
DCR NO (if applicable) : N/A	PROJECT NAME: NUHOMS® - 32PHB System		
PROJECT NO: 10955	CLIENT: CENG - Calvert Cliff Nuclear Power Plant (CCNPP)		
CALCULATION TITLE: USL Evaluation for NUHOMS 32PHB System			
SUMMARY DESCRIPTION: 1) Calculation Summary The purpose of this calculation package is to determine the upper subcritical limit (USL) for the NUHOMS®-32PHB System. 2) Storage Media Description Secure network server initially, then redundant tape backup containing the SCALE 6 and USLSTATS 6 input and output files, the spreadsheets used in the calculation, and the Word file with the text of the calculation			
If original issue, is licensing review per TIP 3.5 required? Yes ☐ No ☒ (explain below) Licensing Review No.: _____ This calculation is prepared to support a Site Specific License Application by CCNPP that will be reviewed and approved by the NRC. Therefore, a 10CFR72.48 licensing review per TIP 3.5 is not applicable.			
Software Utilized (subject to test requirements of TIP 3.3): SCALE 6 XP		Version: C00750MNYCP00	
Calculation is complete:  Originator Name and Signature: David Lee		Date: 4/12/10	
Calculation has been checked for consistency, completeness and correctness:  Checker Name and Signature: Andrew Gerlach		Date: 4/12/10	
Calculation is approved for use: Project Engineer Name and Signature: Kamran Tavassoli 		Date: 4/15/10	

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

Calculation

Calculation No.: NUH32PHB-0603

Revision No.: 0

Page: 2 of 16

Revision Summary

Revision	Description	Affected Pages
0	Initial Issue	All

Licensing Documents: N/A

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

 AREVA TRANSNUCLEAR INC.	Calculation	Calculation No.:	NUH32PHB-0603
		Revision No.:	0
		Page:	3 of 16

TABLE OF CONTENTS

	<u>Page</u>
1.0 PURPOSE	5
2.0 REFERENCE	5
3.0 METHODOLOGY	5
3.1 USL Parameters	5
3.2 Critical Experiment Selection	6
4.0 ASSUMPTIONS	6
5.0 COMPUTATION	6
5.1 SCALE 6 Input	6
5.2 USLSTATS 6 Input	7
6.0 RESULTS and CONCLUSIONS	8
6.1 SCALE 6 Calculation Results	8
6.2 USL Functions	8
7.0 Appendix	13

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

 AREVA TRANSNUCLEAR INC.	Calculation	Calculation No.:	NUH32PHB-0603
		Revision No.:	0
		Page:	4 of 16

LIST OF TABLES

Table 1 Critical Experiment Benchmark Results..... 9

Table 2 USL Functions..... 12

Table 3 USLSTATS Input and Output..... 13

Table 4 SCALE 6 Input and Output..... 14

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

	Calculation	Calculation No.:	NUH32PHB-0603
		Revision No.:	0
		Page:	5 of 16

1.0 PURPOSE

This calculation is to evaluate the upper subcritical limit (USL) for use in the criticality analysis of the NUHOMS®-32PHB system. The USL is expressed as functions of the geometrical and material compositional characteristics of the NUHOMS®-32PHB system.

2.0 REFERENCE

- 2.1 Transnuclear E-28667, Rev. 0 "Test Report for Verifying the SCALE-6 Program Running on TN-CBA-CALC-02", 10/27/2009.
- 2.2 USLSTATS: A Utility to Calculate Upper Subcritical Limits for Criticality Safety Applications, Version 6, Oak Ridge National Laboratory, January 26, 2009.
- 2.3 Oak Ridge National Laboratory, "NUREG/CR-6361 LWR Fuel Validation Cases," 12/20/2006.
- 2.4 Transnuclear Calculation 1095-52, "Criticality Analysis of NUHOMS®-32P for Calvert Cliffs ISFSI," Rev. 0.
- 2.5 Transnuclear Calculation 1095-42, "Criticality Benchmarks," Rev. 0.
- 2.6 Transnuclear Design Criteria Document NUH32PHB.0101, Rev 0.

3.0 METHODOLOGY

Critical experiments with their geometry and material composition similar to that of the NUHOMS®-32PHB system are selected. The SCALE 6 Program [Ref. 2.1] is used to perform KENO V.a $K_{EFFECTIVE}$ calculation for the selected critical experiments. In the KENO V.a calculation, the v5-44 cross section library and the NITAWL option are used.

The USLSTATS 6 Program [Ref. 2.2] is used to evaluate the USL functions with the USL Method 1 [Ref. 2.3].

3.1 USL Parameters

The parameters of USL functions are U-235 enrichment, energy of average lethargy of fission (EALF), H₂O/UO₂ volume ratio, the fuel rod pitch, the separation distance between fuel lattice and the soluble boron loading.

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

	Calculation	Calculation No.:	NUH32PHB-0603
		Revision No.:	0
		Page:	6 of 16

3.2 Critical Experiment Selection

The criticality analysis of the NUHOMS[®]-32P System for Calvert Cliffs ISFSI [Ref. 2.4 & 2.5] uses 121 LWR critical experiments provided by Oak Ridge National Laboratory (ORNL) [Ref. 2.3]. This calculation selects 102 out of the above 121 experiments.

For the soluble boron, all 30 experiments that have boron data are selected for developing the USL function. Two boron loadings are considered in this calculation; 2450 and 2550 PPM. The range of soluble boron concentration of the 30 experiments is between 15 PPM and 3389 PPM. The fuel loading in the NUHOMS[®]-32PHB system separates adjacent fuel lattices by about 1" [Ref. 2.6]. For the separation distance, all 72 experiments that have separation distance data are selected for developing the USL function. The range of their separation distances are between 0.18973 and 20.78 cm.

The H₂O/UO₂ volume ratio of the NUHOMS[®]-32PHB system is between 1.61 and 1.66 [Ref. 2.6]. Thus, 69 out of the 102 experiments are selected for developing H₂O/UO₂ USL function. The volume ratio in the 69 experiments ranges from 1.376 to 1.933. The energy of average lethargy of fission of the NUHOMS[®]-32P system is about 0.9 eV [Ref. 2.4]. All 102 experiments are selected for developing lethargy USL function. The lethargy in the 102 experiments ranges from 0.0826 and 1.4006 EV.

The fuel rod pitch of the NUHOMS[®]-32PHB system is 0.58" [Ref. 2.6]. Thus, 49 out of the 102 experiments are selected for developing pitch USL function. The pitch in the 49 experiments ranges from 1.209 to 1.715 cm. For U-235 enrichment, all 102 experiments are used for developing enrichment USL function. The range of enrichment in the 102 experiments is between 2.35 and 5.74 wt%.

4.0 ASSUMPTIONS

The critical experiments that are used in this calculation have been checked in the NUHOMS[®]-32P Criticality Analysis [Ref. 2.4].

5.0 COMPUTATION

5.1 SCALE 6 Input

The SCALE input files of the 102 critical experiments that are used in the NUHOMS[®]-32P System are modified by adding "parm=nitawl" in the end of the control sequence specification line.

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc., It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

	Calculation	Calculation No.:	NUH32PHB-0603
		Revision No.:	0
		Page:	7 of 16

5.2 USLSTATS 6 Input

The USLSTATS inputs are prepared in accordance to *User's Manual for USLSTATS V1.0* [Ref. 2.3 Appendix C.3]. The input consists of a title and seven (7) parameters followed by a set of triplets; USL parameter value, $K_{EFFECTIVE}$ and its standard deviation.

The parameter input values are described as below.

$P = 0.995$

This input is the proportion of population falling above lower tolerance level. The typical value is 0.995. It is a statistical parameter that is used only in the USL Method 2.

$1 - \gamma = 0.95$

This input is the confidence level.

$\sigma = 0.95$

This input represents the confidence on the proportion P. The typical value is 0.95.

$X_{MINIMUM} = 0.0$

The lower limit of the parameter input value. The value of 0.0 indicates that no lower limit is imposed on the input values.

$X_{MAXIMUM} = 0.0$

The upper limit of the parameter input value. The value of 0.0 indicates that no upper limit is imposed on the input values.

$\sigma_{SAMPLE} = 0.0$

It is the standard deviation for all $K_{EFFECTIVE}$ values. The value of 0.0 indicates that each $K_{EFFECTIVE}$ has its own standard deviation.

$\Delta K_M = 0.05$

It is the administrative margin.

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc., It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

	Calculation	Calculation No.:	NUH32PHB-0603
		Revision No.:	0
		Page:	8 of 16

6.0 RESULTS and CONCLUSIONS

6.1 SCALE 6 Calculation Results

The SCALE 6 runs for the 102 critical experiments that are described in Section 3.2 are performed with their $K_{\text{EFFECTIVE}}$ satisfy the Chi**2 test for the normality at either 95% or 99% level. The SCALE 6 calculation results ($K_{\text{EFFECTIVE}}$, σ and EALF) along with the critical experiment parameters are listed in Table 1. The $K_{\text{EFFECTIVE}}$ and standard deviation are needed for the USLSTATS 6 calculations.

The SCALE input and output listings are provided in Section 7.0.

6.2 USL Functions

The USL functions are developed against six (6) USL parameters: U-235 enrichment in wt%, the fuel rod pitch in cm, the fuel lattice separation distance in cm, the $\text{H}_2\text{O}/\text{UO}_2$ volume ratio, the energy of average lethargy of fission and the soluble boron loading in PPM.

For each USL parameters, the selection of the experiments is made in accordance with Section 3.2. All the 6 USLSTATS 6 runs meet the normality test. The USL 1 functional forms with their applicable range are given in Table 2.

A linear regression correlation is calculated for each parameter versus k_{eff} . The correlation coefficients for the USL parameters are,

- -0.02 for EALF
- 0.12 for Boron Loading
- 0.71 for Separation Distance
- 0.47 for Enrichment
- -0.26 for $\text{H}_2\text{O}/\text{UO}_2$ Volume Ratio
- 0.02 for Pitch

The separation distance has the strongest correlation to the k_{eff} .

The input and output listings are provided in Section 7.0.

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

Table 1 Critical Experiment Benchmark Results

Experiment ID	U-235 Enrichment in wt%	Fuel Rod Pitch in cm	H ₂ O/UO ₂ Volume Ratio	Boron Loading in PPM	Separation Distance in cm	EALF in eV	K _{EFFECTIVE}	σ
b1645so1	2.46	1.41	1.015	1068	1.78	0.4088	0.9958	0.0009
b1645so2	2.46	1.41	1.015	1156	1.78	0.4159	0.9999	0.0009
bw1231b1	4.02	1.511	1.139	1152	-	0.7300	0.9953	0.0008
bw1231b2	4.02	1.511	1.139	3389	-	1.1985	0.9961	0.0007
bw1273m	2.46	1.511	1.376	1675	-	0.5209	0.9952	0.0007
bw1484a1	2.46	1.636	1.841	15	1.64	0.1952	0.9975	0.0008
bw1484a2	2.46	1.636	1.841	72	4.92	0.1530	0.9922	0.0008
bw1484b1	2.46	1.636	1.841	1037	-	0.2498	0.9982	0.0008
bw1484b2	2.46	1.636	1.841	769	1.64	0.1924	0.9964	0.0008
bw1484b3	2.46	1.636	1.841	143	4.92	0.1481	0.9970	0.0007
bw1484c1	2.46	1.636	1.841	-	1.64	0.1901	0.9924	0.0009
bw1484c2	2.46	1.636	1.841	-	1.64	0.1486	0.9951	0.0009
bw1484s1	2.46	1.636	1.841	432	1.64	0.1968	0.9987	0.0007
bw1484s2	2.46	1.636	1.841	514	1.64	0.1933	0.9991	0.0008
bw1484sl	2.46	1.636	1.841	-	6.54	0.1387	0.9954	0.0009
bw1645s1	2.46	1.209	0.383	746	1.78	1.3362	0.9981	0.0008
bw1645s2	2.46	1.209	0.383	886	1.78	1.4006	1.0018	0.0007
bw1810a	2.46	1.636	1.841	1239	-	0.2478	0.9990	0.0006
bw1810b	2.46	1.636	1.841	1170	-	0.2463	0.9991	0.0006
bw1810d	2.46	1.636	1.841	1654	0.18973	0.3386	0.9963	0.0008
bw1810e	2.46	1.636	1.841	1579	-	0.3319	0.9982	0.0008
bw1810f	2.46	1.636	1.841	1337	-	0.2463	1.0034	0.0008
bw1810h	2.46	1.636	1.841	1899	-	0.3585	0.9993	0.0008
bw1810i	2.46	1.636	1.841	1250	-	0.2471	1.0017	0.0007
bw1810j	2.46	1.636	1.532	1635	-	0.3343	0.9991	0.0008
epru65b	2.35	1.562	1.196	463	-	0.3190	0.9986	0.0010
epru65	2.35	1.562	1.196	-	-	0.2571	0.9966	0.0010
epru75b	2.35	1.905	2.408	568	-	0.1421	0.9992	0.0010
epru75	2.35	1.905	2.408	-	-	0.1131	0.9966	0.0008
epru87b	2.35	2.21	3.687	286	-	0.0930	0.9999	0.0007
epru87	2.35	2.21	3.687	-	-	0.0826	0.9983	0.0008
p2438ba	2.35	2.032	2.918	-	5.05	0.0980	0.9972	0.0009
p2438slq	2.35	2.032	2.918	-	8.39	0.0957	0.9960	0.0008
p2438ss	2.35	2.032	2.918	-	6.88	0.0963	0.9969	0.0008

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

Table 1 Critical Experiment Benchmark Results (continued)

Experiment ID	U-235 Enrichment in wt%	Fuel Rod Pitch in cm	H ₂ O/UO ₂ Volume Ratio	Boron Loading in PPM	Separation Distance in cm	EALF in eV	K _{EFF} CTIVE	σ
p2438zr	2.35	2.032	2.918	-	8.79	0.0955	0.9958	0.0007
p2615ba	4.31	2.54	3.883	-	6.72	0.1155	0.9973	0.0010
p2615ss	4.31	2.54	3.883	-	8.58	0.1143	0.9991	0.0009
p2827I1	2.35	2.032	2.918	-	13.72	0.0972	1.0014	0.0007
p2827I2	2.35	2.032	2.918	-	11.25	0.0948	0.9991	0.0008
p2827I3	4.31	2.54	3.883	-	20.78	0.1169	1.0100	0.0009
p2827I4	4.31	2.54	3.883	-	19.04	0.1151	1.0075	0.0008
p2827slg	2.35	2.032	2.918	-	8.31	0.0949	0.9957	0.0010
p3314ba	4.31	1.892	1.6	-	4.8	0.3252	1.0007	0.0009
p3314bc	4.31	1.892	1.6	-	3.53	0.3188	1.0004	0.0010
p3314bf1	4.31	1.892	1.6	-	3.6	0.3158	1.0027	0.0009
p3314bf2	4.31	1.892	1.6	-	4.94	0.3197	1.0024	0.0010
p3314bs1	2.35	1.684	1.6	-	3.86	0.1746	0.9952	0.0009
p3314bs2	2.35	1.684	1.6	-	3.46	0.1760	0.9936	0.0008
p3314bs3	4.31	1.892	1.6	-	7.23	0.2941	0.9979	0.0011
p3314bs4	4.31	1.892	1.6	-	6.63	0.2980	0.9996	0.0009
p3314slg	4.31	1.892	1.6	-	10.86	0.2337	0.9974	0.0009
p3314ss1	4.31	1.892	1.6	-	3.38	0.2372	0.9988	0.0009
p3314ss2	4.31	1.892	1.6	-	11.55	0.2568	1.0018	0.0009
p3314ss3	4.31	1.892	1.6	-	4.47	0.2436	0.9985	0.0010
p3314ss4	4.31	1.892	1.6	-	8.36	0.2572	0.9969	0.0009
p3314ss5	2.35	1.684	1.6	-	7.8	0.1680	0.9957	0.0011
p3314ss6	4.31	1.892	1.6	-	10.52	0.2819	1.0009	0.0009
p3314w1	4.31	1.892	1.6	-	-	0.1996	1.0010	0.0009
p3314w2	2.35	1.684	1.6	-	-	0.1501	0.9974	0.0008
p3602bb	4.31	1.892	1.6	-	8.3	0.3056	1.0030	0.0009
p3602bs1	2.35	1.684	1.6	-	4.8	0.1785	1.0003	0.0008
p3602bs2	4.31	1.892	1.6	-	9.83	0.3026	1.0035	0.0011
p3602n11	2.35	1.684	1.6	-	8.98	0.1795	1.0029	0.0010
p3602n12	2.35	1.684	1.6	-	9.58	0.1739	1.0039	0.0009
p3602n13	2.35	1.684	1.6	-	9.66	0.1672	1.0006	0.0009
p3602n14	2.35	1.684	1.6	-	8.54	0.1617	0.9987	0.0009
p3602n21	2.35	2.032	2.918	-	10.36	0.0957	0.9997	0.0009
p3602n22	2.35	1.892	2.918	-	11.2	0.0983	1.0016	0.0009

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc., It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

Table 1 Critical Experiment Benchmark Results (continued)

Experiment ID	U-235 Enrichment in wt%	Fuel Rod Pitch in cm	H ₂ O/UO ₂ Volume Ratio	Boron Loading in PPM	Separation Distance in cm	EALF in eV	K _{EFF} CTIVE	σ
p3602n31	4.31	1.892	1.6	-	14.87	0.3169	1.0083	0.0010
p3602n32	4.31	1.892	1.6	-	15.74	0.3042	1.0069	0.0009
p3602n33	4.31	1.892	1.6	-	15.87	0.2945	1.0064	0.0010
p3602n34	4.31	1.892	1.6	-	15.84	0.2871	1.0045	0.0010
p3602n35	4.31	1.892	1.6	-	15.45	0.2819	1.0049	0.0009
p3602n36	4.31	2.54	1.6	-	13.82	0.2761	1.0021	0.0009
p3602n41	4.31	2.54	3.883	-	12.89	0.1237	1.0126	0.0009
p3602n42	4.31	2.54	3.883	-	14.12	0.1168	1.0098	0.0008
p3602n43	4.31	1.684	3.883	-	12.44	0.1140	1.0038	0.0008
p3602ss2	4.31	1.684	1.6	-	13.75	0.2937	1.0039	0.0010
p3926l1	2.35	1.684	1.6	-	10.06	0.1741	1.0003	0.0008
p3926l2	2.35	1.684	1.6	-	10.11	0.1676	1.0000	0.0007
p3926l3	2.35	1.684	1.6	-	8.5	0.1601	0.9977	0.0008
p3926l4	4.31	1.892	1.6	-	17.74	0.3045	1.0069	0.0009
p3926l5	4.31	1.892	1.6	-	18.18	0.2951	1.0058	0.0009
p3926l6	4.31	1.892	1.6	-	17.43	0.2837	1.0024	0.0009
p3926sl1	2.35	1.684	1.6	-	6.59	0.1597	0.9945	0.0008
p3926sl2	4.31	1.892	1.6	-	12.97	0.2780	1.0000	0.0009
p4267b1	4.31	1.89	1.59	2150	-	0.5539	0.9969	0.0008
p4267b2	4.31	1.89	1.59	2550	-	0.6135	1.0022	0.0010
p4267b3	4.31	1.715	1.09	1030	-	0.7892	1.0042	0.0009
p4267b4	4.31	1.715	1.09	1820	-	0.9554	0.9987	0.0009
p4267b5	4.31	1.715	1.09	2550	-	1.1237	1.0005	0.0008
p4267sl1	4.31	1.89	1.59	-	-	0.2894	1.0010	0.0010
p4267sl2	4.31	1.715	1.09	-	-	0.5452	0.9989	0.0009
p62f231	4.31	1.891	1.6	-	5.67	0.3636	1.0026	0.0009
p71f14f3	4.31	1.891	1.6	-	5.19	0.3796	1.0002	0.0009
p71f14v3	4.31	1.891	1.6	-	5.19	0.3677	0.9988	0.0009
p71f14v5	4.31	1.891	1.6	-	5.19	0.3707	0.9989	0.0009
p71f214r	4.31	1.891	1.6	-	5.19	0.3673	0.9975	0.0009
w3269sl2	5.7	1.422	1.932	-	-	0.3179	1.0038	0.0009
w3269w2	5.7	1.422	1.932	-	-	0.3063	1.0010	0.0010
w3385sl1	5.74	1.422	1.933	-	-	0.2983	0.9965	0.0010
w3385sl2	5.74	2.011	5.067	-	-	0.1031	1.0019	0.0009

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

Calculation

Calculation No.: NUH32PHB-0603

Revision No.: 0

Page: 12 of 16

Table 2 USL Functions

Parameter	Applicable Range	USL Function	
EALF in eV	[0.0826, 1.4006]	$0.9429 - 2.4237E-04 * X$	$X > 0.093812$
		0.9428	$X \leq 0.093812$
Boron Loading in PPM	[15, 3389]	$0.9429 + 3.8975E-07 * X$	
Separation Distance in cm	[0.18973, 20.78]	$0.9398 + 5.9633E-04 * X$	$X < 7.9338$
		0.9445	$X \geq 7.9338$
U-235 Enrichment in wt%	[2.35, 5.74]	$0.9382 + 1.6994E-03 * X$	$X < 3.4333$
		0.9440	$X \geq 3.4333$
H ₂ O/UO ₂ Volume Ratio	[1.376, 1.933]	$0.9560 - 7.3789E-03 * X$	$X > 1.6517$
		0.9438	$X \leq 1.6517$
Pitch in cm	[1.209, 1.715]	$0.9418 + 4.0604E-04 * X$	

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

7.0 Appendix

The USLSTATS 6 runs are documented in Table 3. The SCALE 6 runs are documented in Table 4. The timestamp and file size are listed along with the filename.

Table 3 USLSTATS Input and Output

filename	Timestamp	File size
boron-concentration-ppm.inp	Jan 22 15:33	652
enrichment-w3385s11-12.inp	Nov 30 13:07	2003
h2o-to-uo2-w3385s11-12.inp	Nov 30 13:14	1359
lethargy.inp	Jan 22 15:43	2316
pitch-w3385s11-12.inp	Nov 30 13:12	1033
separation.inp	Jan 22 15:36	1507
boron-concentration-ppm.out	Jan 22 15:48	6462
enrichment-w3385s11-12.out	Nov 30 13:19	12043
h2o-to-uo2-w3385s11-12.out	Nov 30 13:19	9781
lethargy.out	Jan 22 16:02	12195
pitch-w3385s11-12.out	Nov 30 13:19	8112
separation.out	Jan 22 16:14	9868

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

Table 4 SCALE 6 Input and Output

Case ID	input		output	
	timestamp	File size	timestamp	File size
b1645so1	Nov 22 13:10	1551	Nov 22 13:17	396487
b1645so2	Nov 22 13:10	1539	Nov 22 13:18	395942
bw1231b1	Nov 22 13:10	2991	Nov 22 13:19	446984
bw1231b2	Nov 22 13:10	5698	Nov 22 13:20	554436
bw1273m	Nov 22 13:10	3124	Nov 22 13:21	444369
bw1484a1	Nov 22 13:10	2602	Nov 22 13:23	410188
bw1484a2	Nov 22 13:10	2624	Nov 22 13:24	410975
bw1484b1	Nov 22 13:10	1158	Nov 22 13:26	389554
bw1484b2	Nov 22 13:10	1175	Nov 22 13:27	389752
bw1484b3	Nov 22 13:10	2069	Nov 22 13:28	400792
bw1484c1	Nov 22 17:42	2665	Nov 22 17:45	415221
bw1484c2	Nov 22 13:10	3471	Nov 22 13:30	422205
bw1484s1	Nov 22 13:10	2723	Nov 22 13:32	422717
bw1484s2	Nov 22 13:10	2668	Nov 22 13:33	423395
bw1484sl	Nov 22 13:10	1104	Nov 22 13:35	387871
bw1645s1	Nov 22 13:10	1673	Nov 22 13:36	405039
bw1645s2	Nov 22 13:10	1656	Nov 22 13:38	404816
bw1810a	Nov 22 13:10	2533	Nov 22 13:39	442676
bw1810b	Nov 22 13:10	2598	Nov 22 13:40	441544
bw1810d	Nov 22 13:10	3296	Nov 22 13:42	463046
bw1810e	Nov 22 13:10	3355	Nov 22 13:43	462675
bw1810f	Nov 22 13:10	1987	Nov 22 13:45	401338
bw1810h	Nov 22 13:10	2538	Nov 22 13:46	425077
bw1810i	Nov 22 13:10	2226	Nov 22 13:48	420415
bw1810j	Nov 22 13:10	2390	Nov 22 13:49	428570
epru65b	Nov 22 13:10	2857	Nov 22 13:50	429039
epru65	Nov 22 13:10	2877	Nov 22 13:52	419794
epru75b	Nov 22 13:10	2722	Nov 22 13:53	428884
epru75	Nov 22 13:10	2091	Nov 22 13:55	407220
epru87b	Nov 22 13:10	2637	Nov 22 13:56	422038
epru87	Nov 22 13:10	3279	Nov 22 13:58	416771
p2438ba	Nov 22 13:10	1409	Nov 22 14:00	400385
p2438slg	Nov 22 13:10	855	Nov 22 14:02	384816
p2438ss	Nov 22 13:10	1306	Nov 22 14:04	401063

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

Table 4 SCALE 6 Input and Output (continued)

Case ID	input		output	
	timestamp	File size	timestamp	File size
p2438zr	Nov 22 13:10	1279	Nov 22 14:06	427820
p2615ba	Nov 22 13:10	2937	Nov 22 14:08	406888
p2615ss	Nov 22 13:10	2707	Nov 22 14:10	407775
p2827I1	Nov 22 13:10	1076	Nov 22 14:11	390238
p2827I2	Nov 22 13:10	1071	Nov 22 14:13	390632
p2827I3	Nov 22 13:10	1251	Nov 22 14:15	398238
p2827I4	Nov 22 13:10	1276	Nov 22 14:17	400804
p2827slg	Nov 22 13:10	901	Nov 22 14:19	388033
p3314ba	Nov 22 13:10	2949	Nov 22 14:21	443801
p3314bc	Nov 22 13:10	2270	Nov 22 14:22	419937
p3314bf1	Nov 22 13:10	2091	Nov 22 14:24	419057
p3314bf2	Nov 22 17:44	2492	Nov 22 17:47	422691
p3314bs1	Nov 22 13:10	2345	Nov 22 14:25	413812
p3314bs2	Nov 22 13:10	2355	Nov 22 14:27	413288
p3314bs3	Nov 22 13:10	2767	Nov 22 14:29	420630
p3314bs4	Nov 22 13:10	2767	Nov 22 14:31	421110
p3314slg	Nov 22 13:10	1596	Nov 22 14:33	401488
p3314ss1	Nov 22 13:10	2228	Nov 22 14:34	426841
p3314ss2	Nov 22 13:10	2227	Nov 22 14:36	427148
p3314ss3	Nov 22 13:10	2228	Nov 22 14:38	426917
p3314ss4	Nov 22 13:10	2230	Nov 22 14:40	427108
p3314ss5	Nov 22 13:10	2238	Nov 22 14:42	410573
p3314ss6	Nov 22 13:10	2568	Nov 22 14:44	418711
p3314w1	Nov 22 13:10	1267	Nov 22 14:46	398112
p3314w2	Nov 22 13:10	1057	Nov 22 14:48	387106
p3602bb	Nov 22 13:10	1633	Nov 22 14:49	418170
p3602bs1	Nov 22 17:46	1613	Nov 22 17:49	421774
p3602bs2	Nov 22 13:10	1766	Nov 22 14:51	430408
p3602n11	Nov 22 13:10	1320	Nov 22 14:52	407596
p3602n12	Nov 22 13:10	1294	Nov 22 14:53	406627
p3602n13	Nov 22 13:10	1294	Nov 22 14:55	406654
p3602n14	Nov 22 13:10	1295	Nov 22 14:56	406901
p3602n21	Nov 22 13:10	1219	Nov 22 14:58	405139
p3602n22	Nov 22 13:10	1218	Nov 22 14:59	405461

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc., It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.

Table 4 SCALE 6 Input and Output (continued)

Case ID	input		output	
	timestamp	File size	timestamp	File size
p3602n31	Nov 22 13:10	1410	Nov 22 15:01	415983
p3602n32	Nov 22 13:10	1411	Nov 22 15:02	415141
p3602n33	Nov 22 13:10	1361	Nov 22 15:04	414467
p3602n34	Nov 22 13:10	1412	Nov 22 15:05	416031
p3602n35	Nov 22 13:10	1412	Nov 22 15:07	416473
p3602n36	Nov 22 13:10	1412	Nov 22 15:09	415283
p3602n41	Nov 22 13:10	1400	Nov 22 15:10	415286
p3602n42	Nov 22 13:10	1405	Nov 22 15:12	415004
p3602n43	Nov 22 13:10	1406	Nov 22 15:13	415447
p3602ss2	Nov 22 13:10	1664	Nov 22 15:15	427701
p3926l1	Nov 22 13:10	1141	Nov 22 15:17	393183
p3926l2	Nov 22 13:10	1148	Nov 22 15:19	393520
p3926l3	Nov 22 13:10	1138	Nov 22 15:20	392772
p3926l4	Nov 22 13:10	1278	Nov 22 15:22	401568
p3926l5	Nov 22 13:10	1278	Nov 22 15:24	401125
p3926l6	Nov 22 13:10	1274	Nov 22 15:26	401038
p3926sl1	Nov 22 13:10	975	Nov 22 15:28	389896
p3926sl2	Nov 22 13:10	1122	Nov 22 15:30	399328
p4267b1	Nov 22 13:10	2352	Nov 22 15:31	422596
p4267b2	Nov 22 13:10	2354	Nov 22 15:32	423025
p4267b3	Nov 22 13:10	2358	Nov 22 15:34	422283
p4267b4	Nov 22 13:10	2356	Nov 22 15:35	422712
p4267b5	Nov 22 13:10	2351	Nov 22 15:37	424081
p4267sl1	Nov 22 13:10	2259	Nov 22 15:39	416167
p4267sl2	Nov 22 13:10	2267	Nov 22 15:41	416663
p62ft231	Nov 22 13:10	2707	Nov 22 15:42	427689
p71f14f3	Nov 22 13:10	3230	Nov 22 15:44	432625
p71f14v3	Nov 22 13:10	3482	Nov 22 15:46	432607
p71f14v5	Nov 22 13:10	3287	Nov 22 15:47	434219
p71f214r	Nov 22 13:10	2649	Nov 22 15:49	426075
w3269sl2	Nov 22 13:10	1728	Nov 22 15:50	418675
w3269w2	Nov 22 13:10	2300	Nov 22 15:52	422130
w3385sl1	Nov 22 13:10	2130	Nov 22 15:54	426469
w3385sl2	Nov 22 13:10	2184	Nov 22 15:56	423199

PROPRIETARY NOTICE

This document, including the information contained herein and all associated attachments and enclosures, is the property of Transnuclear, Inc.. It contains proprietary information and may not be furnished to others without the express written permission of Transnuclear, Inc. This document and any drawings and any copies that may have been made must be returned to Transnuclear, Inc. upon request.