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SKB validation of Scale 6.1 for fresh fuel

Summary

In this report it is shown that with the SKB methodology the Scale 6.1 code package can be used in criticality analysis for Clab, Clink and the spent fuel repository with following results

USL (Upper Subcritical Limit): 0.94026

The USL includes code bias and bias uncertainty, administrative margin of 5%, margin for trends in physical parameters and materials as well as an extra margin for correlation between experiments.

Svensk Kärnbränslehantering AB
Swedish Nuclear Fuel and Waste Management Co
PO Box 250, SE-101 24 Stockholm
Visiting address Blekholmstorget 30
Phone +46-8-459 84 00 Fax +46-8-579 386 10
www.skb.se
556175-2014 Seat Stockholm

1 Introduction

This report is a validation of the code package Scale 6.1 for use in the Swedish back-end system excluding transportation. The included facilities are

- the current interim storage facility, Clab
- the planned encapsulation plant, Clink
- the planned final repository for spent nuclear fuel

In particular the report includes

- how the experiments have been selected
- estimated bias and bias uncertainties
- appropriate safety margins

2 Purpose and overview

The purpose with this validation is to establish how well the code package Scale 6.1 can predict the neutron multiplication factor k_{eff} for SKB:s systems for storage of nuclear fuel, i.e. the canisters in Clab, Clink and the final repository. Based on this a penalty is calculated which should be added to the results in all criticality analysis made with the Scale 6.1 code package.

This is done by comparison of calculated k_{eff} with real k_{eff} (1.0) for a number of criticality experiments. Specific criticality tools are used to pick experiments which have the same neutron physic characteristics as the SKB storage canisters. In addition to this a number of experiments are added to the validation suite which have content of the same materials as the SKB storage canisters.

From the benchmark results bias and bias uncertainties are estimated using well established statistical methods. If any trends concerning materials or physical properties are found in the results penalties are added to the calculated bias.

In addition to this an extra penalty is added due to dependencies between experiments which are not handled by the applied statistical methods.

The methodology used is based on the standard ANSI/ANS-8.24-2007. More information on how the standard has been interpreted can be found in the overall criticality methodology calculation as described in SKBdoc 1369704.

3 Computer code and software system

All calculations made in this report are made on computer XP00342 with the following specs.

Computer	XP00342
Manufacturer	Hewlett-Packard Company
Model	HP Workstation z620
Processor	Intel® Xeon® CPU E5-2620 @ 2.00 GHz, 12 cores
RAM	64.0 GB
System type	Windows 7 Professional
	64-bit operating system
	Service Pack 1

Table 1. Specification of validation hardware.

The software used in this validation is shown in table 2.

Criticality	Keno Va	ORNL 2011a
Sensitivity & Uncertainty	TSUNAMI-3D, TSUNAMI-IP	ORNL 2001b
Cross-section library	ENDF/B-VII.0, 238 group	ORNL 2011c
Statistics	USLStats 1.0.16.16	Lichtenwalter et al. 1998

Table 2. Specification of validation software.

If any of the above mentioned information is changed, a verification of the benchmark validity is needed. For software changes, table 2, a new validation report should be issued. If the hardware is changed SKB should rerun validation suite confirming that the results are the same. In that case a new validation report is not necessary.

Parameters in the code have been selected to be appropriate for the individual calculations. They are in accordance with Oak Ridge National Lab (ORNL) defaults and recommendations. The most important are presented here.

- Forward Keno calculations for k_{eff} calculations
  - Number on neutron per generation (NPG): 10000
  - Minimum number of skipped per generation (NSK): 200
  - Standard deviation (SIG): 0.0001

- Forward Keno calculations in Tsunami for sensitivity calculations
  - Number on neutron per generation (NPG): 10000
  - Minimum of number of skipped per generation (NSK): 200
  - Standard deviation (SIG): 0.0002

- Adjoint Keno calculations in Tsunami for sensitivity calculations
  - Number on neutron per generation (APG): 30000
  - Minimum of number of skipped per generation (ASK): 200
  - Standard deviation (ASG): 0.002

4 Selection and modelling of benchmark experiments

The experiments for this validation have been selected based on the strategy below.

1. A large number of experiments (~200) have been chosen which are “similar” to our applications (see section 5). Similarity assessment have been made using Tsunami-IP, based on sensitivity data calculated with the Tsunami-3D. This process is shown in step 1-3 below.
2. To attain coverage of all important engineering parameters the selection have been complemented by picking experiments based on geometry, materials and neutron spectra. This process is shown in step 4 below.

With guidance from SKBdoc 1369704 the steps in the list below were performed.

1. Identification, modelling and creation of sensitivity data for application cases.
2. Collecting sensitivity data for experiments in the ICSBEP handbook (OECD/NEA 2012a).
   a. About 2900 experiments provided by OECD-NEA (IRPHE-ICSBEP-project (OECD/NEA 2012b).)

   b. About 90 experiments from the Oak Ridge National Lab VALID library (Marshall and Rearden 2011).
   c. About 20 experiments from in-house modelling.
3. Selecting experiments from the sensitivity data.
   a. Excluding experiments with unreliable results and questionable applicability (SKBdoc 1411636)
   b. Selecting the 50 best matches for each application, see appendix 1.
   c. Quality assurance of sensitivity data for the selected experiments. (see section 7)
4. Selecting experiments from engineering parameters.
   a. Performing gap-analysis between range of parameters and area of application from the experiments picked in step 3, see section 8.2.
   b. Adding experiments from ICSBEP handbook, if possible, to fill gaps in validation.

5. Quality assurance for all experiment series included in the validation have been documented and stored in SKBdoc. For more details see section 7.

5 Adequacy of the validation

Applications in table 3 have been used to derive the range of parameters for the SKB system.

Compact storage canister	BWR, PWR
Normal storage canister	BWR
Transfer cansiter	BWR, PWR
Copper disposal canister	BWR, PWR

Table 3. Specification of validation applications.

The fuel and canisters in the applications have been selected to be a good representation of the fuel and geometries in the current design of Clab, encapsulations plant and final repository. More information about this can be found in SKBdoc 1415268.

Considering the applications and the different fuel types in the systems gives the range of parameters seen in table 4

Fissile isotope	U^{235}	
Fissile form	Ceramic	
Materials	UO_2	
	Water	
	Borated Steel	
	Stainless Steel	
	Zircaloy	
	Iron	
	Copper	
	Gadolinium	
EALF (ev)	0.1 - 0.5	0.151 - 0.272
Enrichment (wt%)	2.0 - 5.0	2.0 - 5.0
Pin pitch (cm)	1.0 – 2.0	1.19 - 1.63

Table 4. Specification of validation material and parameter range. The parameters in the left column are the ones chosen to be covered by the validation while the column to the right are the parameters derived from SKBdoc 1415268 and SKBs database for nuclear fuel.

EALF is the energy of average lethargy causing fission and have been calculated for the applications using Keno Va.

The validation covers all fuel types that fulfil the materials and parameters in the left column of table 4.

To ensure compatibility with new fuel types and different geometries the parameters in this validation have been extended as shown in table 4.

6 Inadequacy of the validation

Bentonite clay is not included due to the lack of critical experiments with clay. However the effect of bentonite clay on reactivity in the KBS-3-system (outside insert and canister) is negligible.

The validation does not cover mixed oxide fuel, MOX.

For use in burn-up credit, additional analysis of actinides and fission products is needed.

7 Documentation and technical review

This document has been quality assured in accordance with SKB management system.

The Keno input files used in the validation have been quality assured in the following manner:

- For each experiment series 1-4 experiment with different characteristics have been picked for quality control.
- Based on a specific review template these files have been reviewed by an experienced Scale-user.
- Review results have been documented and if necessary input files included have been updated,

The correctness of the Tsunami calculations has been checked by performing perturbation analysis of the three most important nuclides. The results of the Tsunami-calculations have been documented together with the review results on the Keno input files.

8 Calculations

8.1 Tsunami-IP

The scan of the sensitivity files according to step 1 in section 4 results in 350 experiments, 50 for each application. Since there is a big similarity between the different applications a lot of the experiments overlap, resulting in a total of 187 individual experiments. These experiments are presented in appendix 1 – Tsunami-IP results.

8.2 Range of parameters

In accordance to ANSI/ANS-8.24-2007 and SKBdoc 1369704 the validation should cover the entire range of parameters presented in table 4, section 5. For this reason a gap-analysis was performed on those parameters with the following findings.

	Range of parameters for validation	# Experiments / Experimental range	Added experiments	Total # experiments
Fissile isotope	U^{235}	187	62	249
Fissile form	Ceramic	187	62	249
Materials	Uranium dioxide	187	62	249
	Water	187	62	249
	Borated Steel	12	0	12
	Stainless Steel	18	19	37
	Zircaloy	0	25	25
	Iron	0	0	0
	Copper	13	18	31
	Solid Gadolinium	22	0	22
EALF (eV)	0.1 - 0.5	0.011 - 1.060	62	249
Enrichment (wt%)	2.0 - 5.0	2.35 - 4.74	62	249
Pin pitch (cm)	1 - 2	1.05 - 2.54	62	249

Table 5. Summary of chosen experiments based on range of parameters.

As seen in table 5 the coverage for fissile isotope, fissile form, uranium dioxide and water are covered in every experiment.

For the materials with lower coverage, all available LCT experiments with the correct form and materials were added as shown in table 5.

For borated steel there were no more experiments available but the main experimental suite includes 14 other experiments with other boron compositions like boron carbide, boraflex and boral. The experimental suite is hence considered to be well covered for boron.

Among the LCT experiments evaluated there are none which have iron reflectors like the copper disposal canister. However there are several experiments with stainless steel reflectors. Since stainless steel is composed of roughly 70 percent iron, this is judged to be a good substitute. For this reason 19 additional stainless steel experiments were added to the experimental suite to make sure both stainless steel and iron have a good coverage. In addition to these there are 29 experiments with carbon steel, with roughly 50 percent iron, in the suite.

One of the unique properties of the applications is the copper reflector of the copper disposal canister. In order to cover this special feature 18 more experiments were added to the suite making it a total of 31 copper experiments in the experimental suite.

Note that gadolinium is not currently used in any application case for fresh fuel but since the sensitivity scan gave a good coverage for solid gadolinium it will also be a part of the validation for possible future use.

EALF and pin pitch are covered by the experiments while the enrichment lacks coverage on both ends. However the small difference on the high end (4.74 compared to 5%) is within the 10% recommended in NUREG/CR-6698 (Dean and Taylor 2001) Section 5 – Extending the Area of Applicability. Hence, there is no need for extra experiments for enrichment.

8.3 k_{eff} calculations

As expressed in ANSI/ANS-8.24-2007 a limit on the calculated reactivity (k_{eff}) value should be established to ensure that conditions calculated to be subcritical will actually be subcritical. This limit is referred to as the Upper Subcritical Limit (USL). The calculated k_{eff} for the application (k_c) + the sum of the biases, uncertainties and statistical margins derived from a set of critical benchmarks (Δk_c) and any additional administrative margins (Δk_m) should be less than the USL.

In this report the USL value will be calculated with and without the administrative margin. The administrative margin will be added to the results of the critical analysis and is 0.05 for normal and credible events, respectively 0.02 for unexpected event.

USL-1 stat in the table below uses the USL-stat methodology described in Lichtenwalter et al. (1998). The value
USL is frequently determined as a function of a key system parameter, such as pin pitch, energy of average lethargy causing fission (EALF) and fuel enrichment.

For the 249 experiments, selected according to the described process, k_{eff} was calculated with Keno Va. The results of the calculations can be found in appendix 2.

8.4 Test for normality

Normality test using Jarque-Bera goodness-of-fit test were performed for all 249 experiments included in the suite.

8.4.1 Jarque-Bera goodness-of-fit test for normal distribution

The Jarque-Bera test uses the skewness and kurtosis to reject the null-hypothesis that is that the distribution can be a normal distribution. A passed test will therefore not necessarily mean that the distribution is normal but will mean that it could be.

From Jarque and Bera (1987) we can find that the JB constant can be derived as

$$JB = n/6(S + \frac{K-3}{4})$$

Where n is the number of observations, in this case number of experiments. S and K are skewness and kurtosis. For a perfectly normal distribution the skewness is 0, kurtosis is 3 and Jarque-Bera is 0.

The JB-number obtained from the equation above is compared to the critical limit number for a Chi^2 distribution with 2 degrees of freedom. The critical limit can be obtained from NIST (n d).

Skewness	0.048
Kurtosis	2.499
Jarque-Bera	2.71
Chi^2 Critical value	5.99

Table 6. Values to verify normality.

Since the Jarque-Bera value is lower than the Chi^2 critical value, the null-hypothesis cannot be rejected.

Based on this it is assumed that the distribution can be considered as normal and the statistic from USL-stat can be used.

9 Results

The calculated k_{eff} for all experiments in the validation suite is summarised in table 7. All calculated values can be found in appendix 2. The summary of the results can be seen in table 7.

Number of experiments	249
Average Calculated/Expected k_{eff}	0.998103
Standard deviation	0.002046
95/95 limit (1.815 sd)	0.994386

Table 7. Summary of k_{eff} results.

The 95/95 limit is calculated using the k-value from Owen (1958) using the k-factor for one-sided tolerance limits for normal distributions.

9.1 Materials

The aim with this analysis is to identify if there are any trends in calculated k_{eff} that depends on which materials that were included in the experiments. The experiments were grouped together and the group's average calculated k_{eff} were compared to the average k_{eff} of the whole validation suite. The results can be seen in table 8.

	Number of Experiments	C/E k_{eff}	Δbias to total (pcm)	Consider in calculations
Borated Steel	12	1.000335	223	No
Zircaloy	25	0.997326	-78	Yes
Copper	31	0.998434	33	No
Gadolinium	22	0.998978	88	No
Stainless Steel / Iron	37	0.998539	44	No

Table 8. Summary of included materials and their average k_{eff} results respectively.

It is concluded that experiments with zircaloy have a slightly lower calculated k_{eff} that the total average. A margin of 78 pcm will be added for this. No credit is taken for the overestimation of the other materials.

9.2 Trend analysis of physical parameters

The aim in this analysis is to identify if there are any trends in calculated k_{eff} that depends on physical parameters. Calculated k_{eff} results for all critical experiments in the validation suite were plotted as functions of the parameters EALF, Enrichment and Pin Pitch. These parameters were chosen based on their neutron physical importance.

The trending and calculation of USL (Upper subcritical limit) has been made by the USLstat (Lichenwalter 1998). It is a tool that handles the statistical treatment of the calculated reactivity values and calculates a 95/95 limit, i.e. 95% probability that 95% of the values are above the calculated limit.

	95/95 limit	difference (pcm)	Consider in calculations
Trend enrichment	0.9942	-19	No
Trend pin pitch	0.9936	-79	Yes
Trend EALF	0.9943	-9	No

Table 9. Results of trending analysis

The results can be seen in table 9 and more details are found in following sections.

9.2.1 EALF

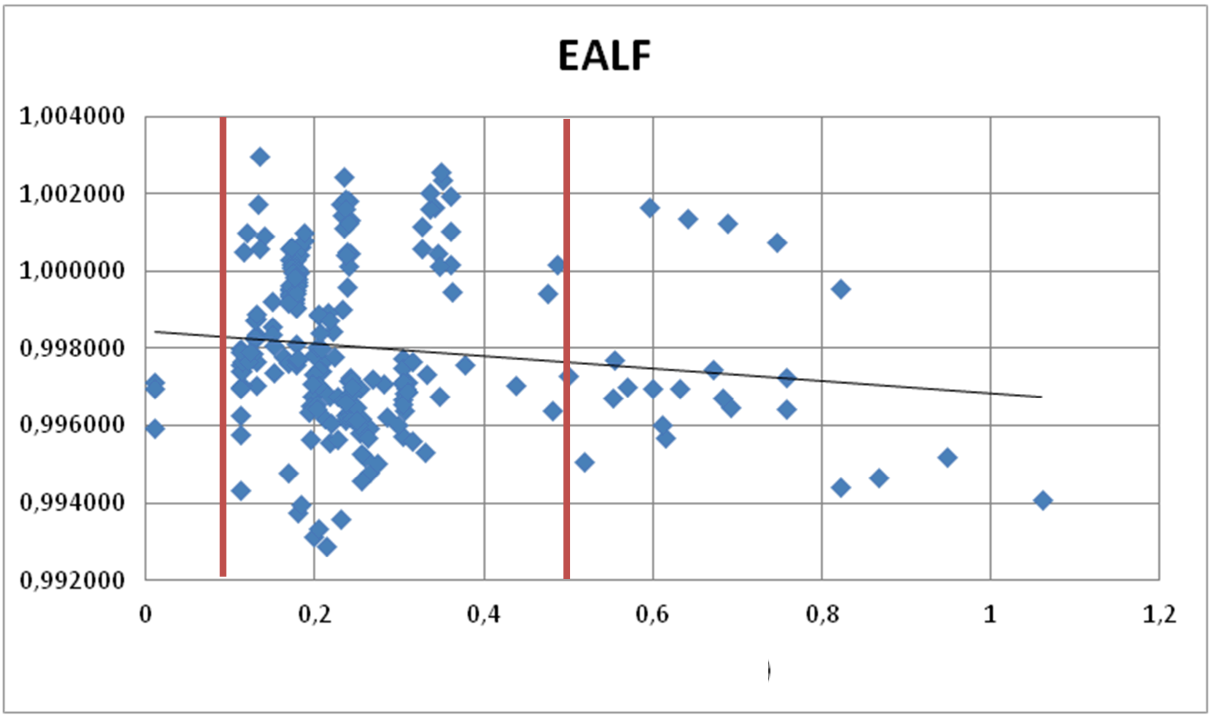

Figure 1. Trend analysis of EALF, no uncertainties added. The red lines indicate the limits chosen for the validation. Y-axis shows the reactivity of the critical experiment and x-axis shows the EALF in eV.

When calculating the limiting k_{eff} with USL-stat the result is:

EALF	**0.1 eV**	**0.5 eV**
USL Keff	0.9950	0.9943

Table 10. EALF trending results.

The trending is limited to EALF values below 0.5 eV. Since the highest EALF-value in the SKB applications is 0.272 eV there is no reason to extend the trending further. The fact that there is a trend is not obvious and can be an artefact of a few high EALF experiments with low k_{eff}. Removing the 4 highest EALF experiments that are all from the same series would remove the negative trend on high EALF. This together with the fact that all applications are in the lower end of the EALF span leads to the conclusion that the trend should not be taken into consideration in the calculations.

9.2.2 Pin pitch

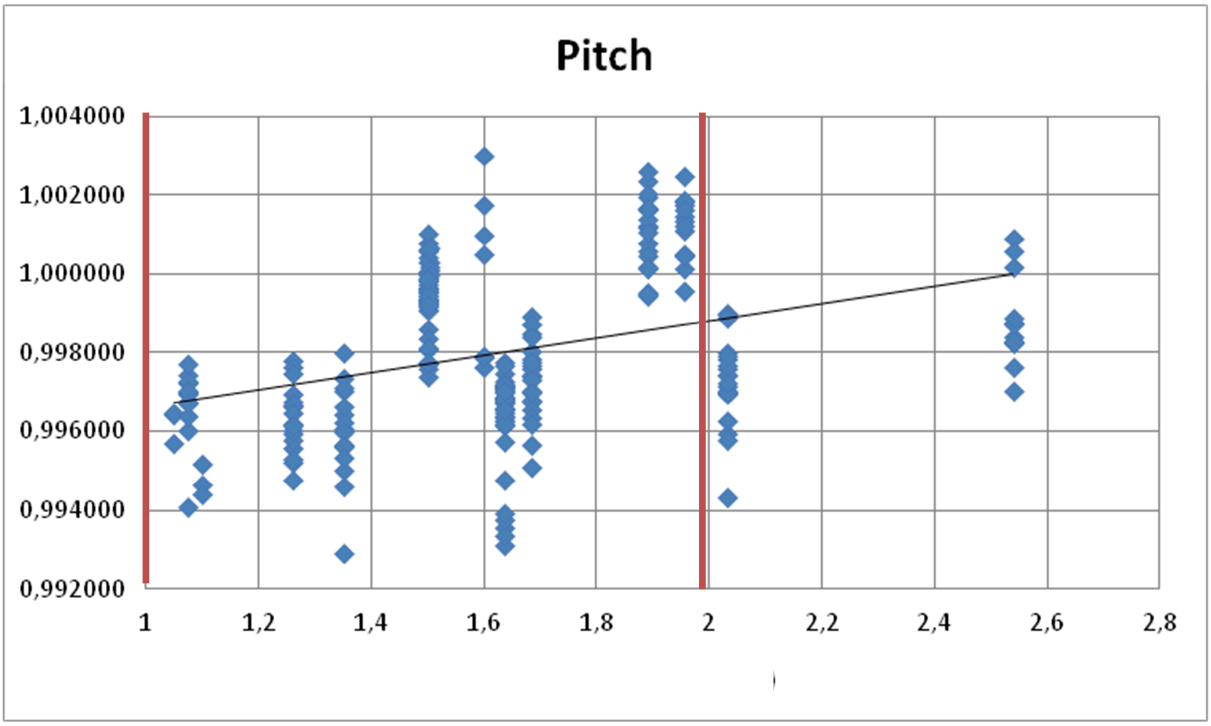

Figure 2. Trend analysis of Pin pitch, no uncertainties added. The red lines indicate the limits chosen for the validation. Y-axis shows the reactivity of the critical experiment and x-axis shows the pitch in cm.

When calculating the limiting k_{eff} with USL-stat the result is:

Pin Pitch	1 cm	2 cm
USLstat	0.9936	0.9957

Table 11. Pin pitch trending results.

The pin pitch has an obvious trend with underestimation of k_{eff} for low values. The USLstat estimation of 95/95 limit for pin pitch of 1 cm also includes a small penalty for extrapolation from the lowest experiment of 1.05. Since future fuel moves towards lower pin pitch these effects need to be considered in the calculations.

9.2.3 Enrichment

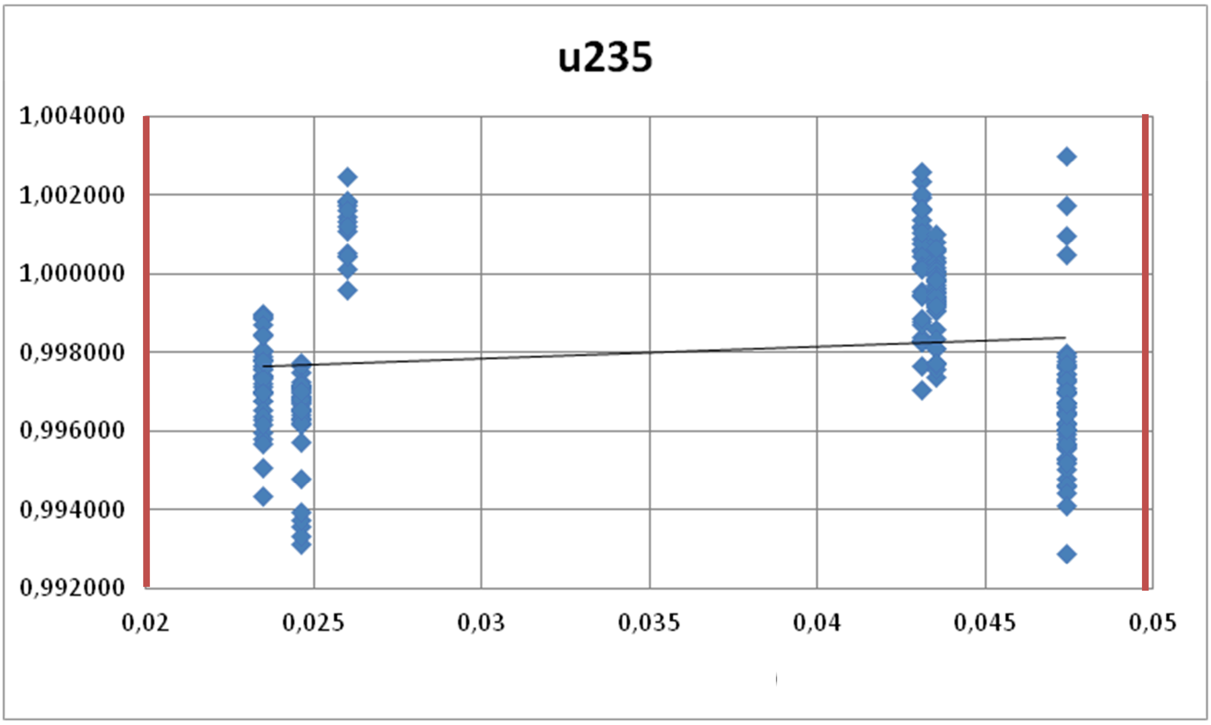

Figure 3. Trend analysis of enrichment, no uncertainties added. The red lines indicate the limits chosen for the validation. Y-axis shows the reactivity of the critical experiment and x-axis shows the enrichment in fraction of total weight.

When calculating the limiting k_{eff} with USL-stat the result is:

Enrichment	**2%**	**5%**
USLstat	0.9942	0.9952

Table 12. Enrichment trending results.

The trend on the enrichment is a small effect that is suggesting an underestimation of k_{eff} for low enrichments. The results also include a penalty for extrapolation to 2 % enrichment from the experiment with lowest enrichment of 2.35 %. Due to the fact that there is a small effect that only impact on the low enrichments this is not needed to be considered in the calculations.

9.3 Experimental correlations

It is a well known fact that there exist dependencies between the critical experiments. There are for example only a limited numbers of fuel rods used in all available critical experiments. Many experiments have the same experiment set-up with the same pin-pitch etc. This fact has historically not been addressed, neither in Sweden nor internationally. Experiments have been treated statistically as they were independent. The traditional argumentation has been that many other conservative assumptions are done in the calculation of penalties and the safety margins, so they are covering this uncertainty.

On the behalf of SKB, ORNL have done some limited sensitivity studies of correlations. The approach was to use ORNLs program Sampler to make changes in one parameter, eg enrichment, and see the effect it has on other experiment in the same series. This will give an indication of the magnitude of the correlation between experiments. The work shows that the correlation of experiments using the same fuel rods is high, but they are not fully correlated.

To fully investigate the effect of dependencies between experiments and the implications on the validation results is a very extensive job. It involves scrutinizing every critical experiment to find out how the experimental set-up has been done and to try to find the appropriate correlation factors. It will take years and needs cooperation in the international arena.

In the validation suite, 249 experiments are drawn from 28 different series. The large number of experiments from different conditions is one way to mitigate the impact of dependencies between experiments.

Assuming that experiments within one series is so strongly correlated that it is only justified to use one experiment per group. Using the average k_{eff} of that group to represent that experiment leaves us with 28 experiments with an average k_{eff} of 0.998487, and a standard deviation of 0.001862. These results will not give a larger penalty than the assumption of no correlations with average k_{eff} 0.998103 and standard deviation of 0.002046. It indicates that the results are relatively robust even if dependencies between experiments should be taken into account.

Another extreme assumption could be that only one experiment per fuel rod enrichment is allowed. This would leave us with 6 experiment groups. Taking the average k_{eff} of each group to represent that experiment group and then calculate the average k_{eff} among these 6 will give us an average k_{eff} of 0.998476 and a standard deviation of 0.001812.

	Average k_{eff}	Standard dev.	95/95 limit	Difference (pcm)
No Correlation	0.9981030	0.002046	0.994386	
1 experiment per series	0.9984870	0.001829	0.994403	2
Full correlation fuel rods	0.9984758	0.001812	0.991824	-256

Table 13. Results of correlation calculations.

The average k_{eff} and standard deviations are very similar between the cases while an extra penalty is added due to lack of statistics for the assumption that all experiments using the same fuel is fully correlated. The assumption of full correlation between fuel rods is extremely conservative. However if a conservative approach is to be taken, the calculated penalty of 256 pcm seems reasonable.

10 Conclusion

It has been shown that the methodology and codes used by SKB can be used in the criticality analysis for Clab, Clink and the spent fuel repository with the results shown in table 14.

Bias (pcm)	189
Bias uncertainty (1.815 sd)	372
Margin for zircaloy (pcm)	78
Margin for pin pitch trend (pcm)	79
Margin for correlations (pcm)	256
Administrative margin (pcm)	5000
USL with admin margin	0.94026
USL without admin margin	0.99026

Table 14. Summary of Bias, Bias uncertainty, extra margins and calculated USL.

This USL is valid for the computer system presented in section 3 and for applications fulfilling the specifications in table 15 and table 16.

Compact storage canister	BWR, PWR
Normal storage canister	BWR
Transfer cansiter	BWR, PWR
Copper disposal canister	BWR, PWR

Table 15. Specification of validation applications.

And

Fissile isotope	U^{235}
Fissile form	Ceramic
Materials	UO_2 Water Borated Steel Stainless Steel Zircaloy Iron Copper Gadolinium
EALF	0.1 - 0.5 eV
Enrichment	2.0 - 5.0 wt%
Pin pitch	1.0 – 2.0 cm

Table 16. Specification of validation validity concerning materials and parameter range.

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APPENDIX-1 – TSUNAMI IP RESULTS

BWR Compact Storage Canister

Experiment	Ck
LEU-COMP-THERM-008-017	0.9726 ± 0.0003
LEU-COMP-THERM-008-006	0.9712 ± 0.0003
LEU-COMP-THERM-008-016	0.9712 ± 0.0003
LEU-COMP-THERM-008-007	0.9708 ± 0.0003
LEU-COMP-THERM-008-004	0.9705 ± 0.0003
LEU-COMP-THERM-008-005	0.9703 ± 0.0003
LEU-COMP-THERM-008-008	0.9703 ± 0.0003
LEU-COMP-THERM-008-002	0.9701 ± 0.0003
LEU-COMP-THERM-008-009	0.9701 ± 0.0003
LEU-COMP-THERM-008-013	0.9701 ± 0.0003
LEU-COMP-THERM-008-003	0.9697 ± 0.0003
LEU-COMP-THERM-008-011	0.9696 ± 0.0003
LEU-COMP-THERM-008-014	0.9695 ± 0.0003
LEU-COMP-THERM-008-012	0.9694 ± 0.0003
LEU-COMP-THERM-008-015	0.9694 ± 0.0003
LEU-COMP-THERM-008-010	0.9688 ± 0.0003
LEU-COMP-THERM-008-001	0.9670 ± 0.0003
LEU-COMP-THERM-011-003	0.9450 ± 0.0005
LEU-COMP-THERM-011-005	0.9447 ± 0.0006
LEU-COMP-THERM-011-004	0.9443 ± 0.0006
LEU-COMP-THERM-011-006	0.9430 ± 0.0006
LEU-COMP-THERM-011-007	0.9407 ± 0.0006
LEU-COMP-THERM-011-002	0.9380 ± 0.0006
LEU-COMP-THERM-011-010	0.9322 ± 0.0006
LEU-COMP-THERM-011-011	0.9260 ± 0.0006
LEU-COMP-THERM-011-013	0.9173 ± 0.0006
LEU-COMP-THERM-011-012	0.9149 ± 0.0007
LEU-COMP-THERM-011-014	0.9082 ± 0.0007
LEU-COMP-THERM-017-026	0.9046 ± 0.0010
LEU-COMP-THERM-017-027	0.8845 ± 0.0010
LEU-COMP-THERM-017-028	0.8777 ± 0.0010
LEU-COMP-THERM-017-004	0.8728 ± 0.0009
LEU-COMP-THERM-042-003	0.8677 ± 0.0009
LEU-COMP-THERM-042-004	0.8661 ± 0.0009
LEU-COMP-THERM-017-029	0.8649 ± 0.0010
LEU-COMP-THERM-042-005	0.8619 ± 0.0009
LEU-COMP-THERM-042-007	0.8566 ± 0.0009
LEU-COMP-THERM-017-005	0.8540 ± 0.0009
LEU-COMP-THERM-042-001	0.8513 ± 0.0009
LEU-COMP-THERM-042-006	0.8483 ± 0.0010
LEU-COMP-THERM-017-006	0.8472 ± 0.0010
LEU-COMP-THERM-017-015	0.8451 ± 0.0009
LEU-COMP-THERM-017-007	0.8422 ± 0.0010
LEU-COMP-THERM-017-017	0.8417 ± 0.0009
LEU-COMP-THERM-017-016	0.8365 ± 0.0010
LEU-COMP-THERM-017-018	0.8335 ± 0.0010
LEU-COMP-THERM-017-020	0.8330 ± 0.0010
LEU-COMP-THERM-010-005	0.8289 ± 0.0010
LEU-COMP-THERM-017-021	0.8275 ± 0.0013
LEU-COMP-THERM-017-013	0.8234 ± 0.0010

BWR Normal Storage Canister

Experiment	Ck
LEU-COMP-THERM-090-001	0.9069 ± 0.0005
LEU-COMP-THERM-090-002	0.9056 ± 0.0005
LEU-COMP-THERM-090-006	0.9054 ± 0.0005
LEU-COMP-THERM-090-007	0.9045 ± 0.0005
LEU-COMP-THERM-090-003	0.9044 ± 0.0005
LEU-COMP-THERM-084-001	0.9024 ± 0.0005
LEU-COMP-THERM-043-002	0.9023 ± 0.0005
LEU-COMP-THERM-043-001	0.9019 ± 0.0005
LEU-COMP-THERM-090-005	0.9014 ± 0.0005
LEU-COMP-THERM-090-004	0.9007 ± 0.0005
LEU-COMP-THERM-090-008	0.9006 ± 0.0005
LEU-COMP-THERM-091-006	0.8994 ± 0.0005
LEU-COMP-THERM-043-004	0.8985 ± 0.0005
LEU-COMP-THERM-077-004	0.8985 ± 0.0005
LEU-COMP-THERM-043-003	0.8983 ± 0.0005
LEU-COMP-THERM-043-005	0.8982 ± 0.0005
LEU-COMP-THERM-043-006	0.8981 ± 0.0005
LEU-COMP-THERM-091-007	0.8979 ± 0.0005
LEU-COMP-THERM-091-004	0.8969 ± 0.0005
LEU-COMP-THERM-044-010	0.8968 ± 0.0005
LEU-COMP-THERM-091-001	0.8967 ± 0.0005
LEU-COMP-THERM-077-003	0.8965 ± 0.0005
LEU-COMP-THERM-043-007	0.8960 ± 0.0005
LEU-COMP-THERM-091-005	0.8955 ± 0.0005
LEU-COMP-THERM-044-008	0.8948 ± 0.0005
LEU-COMP-THERM-082-005	0.8946 ± 0.0005
LEU-COMP-THERM-044-006	0.8942 ± 0.0005
LEU-COMP-THERM-082-006	0.8942 ± 0.0005
LEU-COMP-THERM-043-009	0.8940 ± 0.0005
LEU-COMP-THERM-043-008	0.8938 ± 0.0005
LEU-COMP-THERM-082-003	0.8937 ± 0.0005
LEU-COMP-THERM-082-004	0.8931 ± 0.0005
LEU-COMP-THERM-044-007	0.8924 ± 0.0005
LEU-COMP-THERM-090-009	0.8921 ± 0.0005
LEU-COMP-THERM-044-005	0.8920 ± 0.0005
LEU-COMP-THERM-044-004	0.8917 ± 0.0005
LEU-COMP-THERM-054-008	0.8914 ± 0.0005
LEU-COMP-THERM-058-001	0.8914 ± 0.0005
LEU-COMP-THERM-054-007	0.8911 ± 0.0005
LEU-COMP-THERM-044-002	0.8909 ± 0.0005
LEU-COMP-THERM-058-004	0.8909 ± 0.0005
LEU-COMP-THERM-058-003	0.8907 ± 0.0005
LEU-COMP-THERM-044-001	0.8904 ± 0.0005
LEU-COMP-THERM-054-001	0.8904 ± 0.0005
LEU-COMP-THERM-058-002	0.8900 ± 0.0005
LEU-COMP-THERM-089-003	0.8880 ± 0.0005
LEU-COMP-THERM-089-002	0.8879 ± 0.0005
LEU-COMP-THERM-058-005	0.8877 ± 0.0005
LEU-COMP-THERM-054-003	0.8874 ± 0.0005
LEU-COMP-THERM-054-002	0.8872 ± 0.0005

BWR Transfer Storage Canister

Experiment	Ck
LEU-COMP-THERM-043-002	0.9477 ± 0.0004
LEU-COMP-THERM-090-001	0.9475 ± 0.0004
LEU-COMP-THERM-043-001	0.9474 ± 0.0004
LEU-COMP-THERM-090-006	0.9469 ± 0.0004
LEU-COMP-THERM-090-002	0.9465 ± 0.0004
LEU-COMP-THERM-090-007	0.9462 ± 0.0004
LEU-COMP-THERM-090-003	0.9462 ± 0.0004
LEU-COMP-THERM-091-006	0.9456 ± 0.0004
LEU-COMP-THERM-090-005	0.9451 ± 0.0004
LEU-COMP-THERM-084-001	0.9451 ± 0.0004
LEU-COMP-THERM-043-004	0.9451 ± 0.0004
LEU-COMP-THERM-043-003	0.9448 ± 0.0004
LEU-COMP-THERM-091-007	0.9447 ± 0.0004
LEU-COMP-THERM-090-004	0.9447 ± 0.0004
LEU-COMP-THERM-043-005	0.9447 ± 0.0004
LEU-COMP-THERM-043-006	0.9446 ± 0.0004
LEU-COMP-THERM-090-008	0.9439 ± 0.0004
LEU-COMP-THERM-091-004	0.9435 ± 0.0004
LEU-COMP-THERM-091-001	0.9435 ± 0.0004
LEU-COMP-THERM-043-007	0.9432 ± 0.0004
LEU-COMP-THERM-091-005	0.9427 ± 0.0004
LEU-COMP-THERM-082-005	0.9427 ± 0.0004
LEU-COMP-THERM-077-004	0.9426 ± 0.0004
LEU-COMP-THERM-044-010	0.9426 ± 0.0004
LEU-COMP-THERM-082-006	0.9424 ± 0.0004
LEU-COMP-THERM-082-003	0.9420 ± 0.0004
LEU-COMP-THERM-044-008	0.9419 ± 0.0004
LEU-COMP-THERM-043-009	0.9418 ± 0.0004
LEU-COMP-THERM-082-004	0.9415 ± 0.0004
LEU-COMP-THERM-044-006	0.9415 ± 0.0004
LEU-COMP-THERM-043-008	0.9415 ± 0.0004
LEU-COMP-THERM-077-003	0.9412 ± 0.0004
LEU-COMP-THERM-054-008	0.9406 ± 0.0004
LEU-COMP-THERM-058-001	0.9405 ± 0.0004
LEU-COMP-THERM-054-007	0.9403 ± 0.0004
LEU-COMP-THERM-044-007	0.9403 ± 0.0004
LEU-COMP-THERM-044-004	0.9403 ± 0.0004
LEU-COMP-THERM-058-004	0.9401 ± 0.0004
LEU-COMP-THERM-044-005	0.9401 ± 0.0004
LEU-COMP-THERM-058-003	0.9399 ± 0.0004
LEU-COMP-THERM-044-002	0.9399 ± 0.0004
LEU-COMP-THERM-054-001	0.9398 ± 0.0004
LEU-COMP-THERM-058-002	0.9394 ± 0.0004
LEU-COMP-THERM-044-001	0.9394 ± 0.0004
LEU-COMP-THERM-090-009	0.9387 ± 0.0004
LEU-COMP-THERM-089-003	0.9381 ± 0.0005
LEU-COMP-THERM-089-002	0.9379 ± 0.0005
LEU-COMP-THERM-058-005	0.9378 ± 0.0005
LEU-COMP-THERM-054-003	0.9376 ± 0.0004
LEU-COMP-THERM-054-002	0.9375 ± 0.0004

BWR Copper Disposal Canister

Experiment	Ck
LEU-COMP-THERM-043-002	0.8823 ± 0.0005
LEU-COMP-THERM-043-001	0.8815 ± 0.0005
LEU-COMP-THERM-090-001	0.8796 ± 0.0005
LEU-COMP-THERM-090-006	0.8789 ± 0.0005
LEU-COMP-THERM-077-004	0.8788 ± 0.0006
LEU-COMP-THERM-090-002	0.8785 ± 0.0005
LEU-COMP-THERM-043-003	0.8784 ± 0.0006
LEU-COMP-THERM-084-001	0.8784 ± 0.0005
LEU-COMP-THERM-043-004	0.8783 ± 0.0006
LEU-COMP-THERM-090-007	0.8780 ± 0.0005
LEU-COMP-THERM-090-003	0.8780 ± 0.0005
LEU-COMP-THERM-043-006	0.8779 ± 0.0006
LEU-COMP-THERM-043-005	0.8779 ± 0.0006
LEU-COMP-THERM-090-005	0.8761 ± 0.0005
LEU-COMP-THERM-090-004	0.8758 ± 0.0005
LEU-COMP-THERM-043-007	0.8753 ± 0.0006
LEU-COMP-THERM-090-008	0.8749 ± 0.0005
LEU-COMP-THERM-091-004	0.8743 ± 0.0005
LEU-COMP-THERM-091-006	0.8742 ± 0.0005
LEU-COMP-THERM-091-001	0.8740 ± 0.0005
LEU-COMP-THERM-044-010	0.8736 ± 0.0005
LEU-COMP-THERM-077-003	0.8734 ± 0.0006
LEU-COMP-THERM-082-005	0.8733 ± 0.0005
LEU-COMP-THERM-091-007	0.8732 ± 0.0005
LEU-COMP-THERM-091-005	0.8732 ± 0.0005
LEU-COMP-THERM-082-006	0.8730 ± 0.0005
LEU-COMP-THERM-043-008	0.8729 ± 0.0006
LEU-COMP-THERM-044-008	0.8726 ± 0.0005
LEU-COMP-THERM-043-009	0.8724 ± 0.0006
LEU-COMP-THERM-082-003	0.8723 ± 0.0005
LEU-COMP-THERM-044-006	0.8720 ± 0.0005
LEU-COMP-THERM-082-004	0.8718 ± 0.0005
LEU-COMP-THERM-058-001	0.8708 ± 0.0006
LEU-COMP-THERM-058-004	0.8705 ± 0.0006
LEU-COMP-THERM-044-004	0.8705 ± 0.0005
LEU-COMP-THERM-054-008	0.8704 ± 0.0005
LEU-COMP-THERM-044-007	0.8704 ± 0.0005
LEU-COMP-THERM-058-003	0.8702 ± 0.0006
LEU-COMP-THERM-044-005	0.8702 ± 0.0005
LEU-COMP-THERM-054-007	0.8701 ± 0.0006
LEU-COMP-THERM-044-002	0.8697 ± 0.0005
LEU-COMP-THERM-058-002	0.8695 ± 0.0006
LEU-COMP-THERM-054-001	0.8693 ± 0.0006
LEU-COMP-THERM-044-001	0.8693 ± 0.0005
LEU-COMP-THERM-090-009	0.8685 ± 0.0005
LEU-COMP-THERM-089-003	0.8681 ± 0.0006
LEU-COMP-THERM-089-002	0.8679 ± 0.0006
LEU-COMP-THERM-058-005	0.8677 ± 0.0006
LEU-COMP-THERM-054-003	0.8668 ± 0.0006
LEU-COMP-THERM-054-002	0.8665 ± 0.0006

PWR Compact Storage Canister

Experiment	Ck
LEU-COMP-THERM-010-024	0.9723 ± 0.0017
LEU-COMP-THERM-017-019	0.9660 ± 0.0012
LEU-COMP-THERM-017-018	0.9657 ± 0.0012
LEU-COMP-THERM-017-020	0.9655 ± 0.0012
LEU-COMP-THERM-017-017	0.9650 ± 0.0012
LEU-COMP-THERM-017-021	0.9648 ± 0.0012
LEU-COMP-THERM-010-025	0.9638 ± 0.0017
LEU-COMP-THERM-017-024	0.9635 ± 0.0012
LEU-COMP-THERM-017-025	0.9635 ± 0.0012
LEU-COMP-THERM-017-022	0.9627 ± 0.0013
LEU-COMP-THERM-017-016	0.9627 ± 0.0012
LEU-COMP-THERM-010-026	0.9616 ± 0.0017
LEU-COMP-THERM-065-004	0.9616 ± 0.0014
LEU-COMP-THERM-017-029	0.9610 ± 0.0012
LEU-COMP-THERM-017-015	0.9607 ± 0.0012
LEU-COMP-THERM-065-003	0.9602 ± 0.0014
LEU-COMP-THERM-017-028	0.9599 ± 0.0012
LEU-COMP-THERM-011-012	0.9598 ± 0.0008
LEU-COMP-THERM-011-014	0.9594 ± 0.0008
LEU-COMP-THERM-011-009	0.9591 ± 0.0008
LEU-COMP-THERM-065-017	0.9586 ± 0.0014
LEU-COMP-THERM-065-002	0.9585 ± 0.0014
LEU-COMP-THERM-017-023	0.9582 ± 0.0014
LEU-COMP-THERM-065-008	0.9581 ± 0.0012
LEU-COMP-THERM-065-009	0.9580 ± 0.0014
LEU-COMP-THERM-065-012	0.9578 ± 0.0014
LEU-COMP-THERM-065-015	0.9576 ± 0.0014
LEU-COMP-THERM-011-008	0.9575 ± 0.0014
LEU-COMP-THERM-065-007	0.9573 ± 0.0014
LEU-COMP-THERM-065-016	0.9573 ± 0.0008
LEU-COMP-THERM-065-010	0.9572 ± 0.0014
LEU-COMP-THERM-065-013	0.9567 ± 0.0014
LEU-COMP-THERM-017-027	0.9557 ± 0.0014
LEU-COMP-THERM-065-005	0.9555 ± 0.0014
LEU-COMP-THERM-010-027	0.9554 ± 0.0012
LEU-COMP-THERM-011-013	0.9553 ± 0.0016
LEU-COMP-THERM-011-011	0.9551 ± 0.0014
LEU-COMP-THERM-065-001	0.9547 ± 0.0017
LEU-COMP-THERM-011-007	0.9544 ± 0.0007
LEU-COMP-THERM-010-005	0.9544 ± 0.0007
LEU-COMP-THERM-010-028	0.9541 ± 0.0014
LEU-COMP-THERM-010-016	0.9540 ± 0.0007
LEU-COMP-THERM-011-015	0.9539 ± 0.0015
LEU-COMP-THERM-011-002	0.9528 ± 0.0016
LEU-COMP-THERM-017-012	0.9526 ± 0.0015
LEU-COMP-THERM-017-010	0.9525 ± 0.0008
LEU-COMP-THERM-011-010	0.9523 ± 0.0008
LEU-COMP-THERM-013-003	0.9521 ± 0.0010
LEU-COMP-THERM-017-013	0.9512 ± 0.0010
LEU-COMP-THERM-013-004	0.9508 ± 0.0015

PWR Transfer Storage Canister

Experiment	Ck
LEU-COMP-THERM-057-015	0.9799 ± 0.0007
LEU-COMP-THERM-057-014	0.9798 ± 0.0007
LEU-COMP-THERM-057-012	0.9794 ± 0.0007
LEU-COMP-THERM-057-013	0.9792 ± 0.0007
LEU-COMP-THERM-057-011	0.9786 ± 0.0007
LEU-COMP-THERM-057-010	0.9775 ± 0.0007
LEU-COMP-THERM-057-009	0.9766 ± 0.0007
LEU-COMP-THERM-057-008	0.9737 ± 0.0006
LEU-COMP-THERM-039-011	0.9733 ± 0.0007
LEU-COMP-THERM-039-001	0.9732 ± 0.0007
LEU-COMP-THERM-039-016	0.9732 ± 0.0007
LEU-COMP-THERM-039-012	0.9732 ± 0.0007
LEU-COMP-THERM-039-002	0.9731 ± 0.0007
LEU-COMP-THERM-039-017	0.9731 ± 0.0007
LEU-COMP-THERM-039-014	0.9731 ± 0.0007
LEU-COMP-THERM-039-007	0.9730 ± 0.0007
LEU-COMP-THERM-039-013	0.9730 ± 0.0007
LEU-COMP-THERM-039-015	0.9728 ± 0.0007
LEU-COMP-THERM-039-008	0.9726 ± 0.0007
LEU-COMP-THERM-039-009	0.9724 ± 0.0007
LEU-COMP-THERM-039-003	0.9721 ± 0.0007
LEU-COMP-THERM-057-027	0.9721 ± 0.0007
LEU-COMP-THERM-039-004	0.9712 ± 0.0007
LEU-COMP-THERM-057-026	0.9712 ± 0.0007
LEU-COMP-THERM-057-007	0.9704 ± 0.0006
LEU-COMP-THERM-039-010	0.9697 ± 0.0007
LEU-COMP-THERM-057-006	0.9666 ± 0.0006
LEU-COMP-THERM-057-005	0.9666 ± 0.0006
LEU-COMP-THERM-010-018	0.9660 ± 0.0007
LEU-COMP-THERM-057-016	0.9658 ± 0.0006
LEU-COMP-THERM-039-006	0.9656 ± 0.0006
LEU-COMP-THERM-010-022	0.9655 ± 0.0007
LEU-COMP-THERM-057-001	0.9655 ± 0.0006
LEU-COMP-THERM-010-023	0.9654 ± 0.0007
LEU-COMP-THERM-010-019	0.9648 ± 0.0007
LEU-COMP-THERM-013-002	0.9647 ± 0.0007
LEU-COMP-THERM-057-002	0.9647 ± 0.0006
LEU-COMP-THERM-057-004	0.9644 ± 0.0006
LEU-COMP-THERM-010-017	0.9642 ± 0.0007
LEU-COMP-THERM-057-003	0.9641 ± 0.0006
LEU-COMP-THERM-039-005	0.9638 ± 0.0006
LEU-COMP-THERM-010-021	0.9626 ± 0.0007
LEU-COMP-THERM-010-015	0.9616 ± 0.0007
LEU-COMP-THERM-010-030	0.9610 ± 0.0007
LEU-COMP-THERM-057-032	0.9609 ± 0.0006
LEU-COMP-THERM-013-004	0.9605 ± 0.0007
LEU-COMP-THERM-013-003	0.9603 ± 0.0007
LEU-COMP-THERM-010-014	0.9588 ± 0.0007
LEU-COMP-THERM-010-020	0.9586 ± 0.0007
LEU-COMP-THERM-010-029	0.9585 ± 0.0007

PWR Copper Disposal Canister

Experiment	Ck
LEU-COMP-THERM-017-015	0.9252 ± 0.0006
LEU-COMP-THERM-017-016	0.9173 ± 0.0007
LEU-COMP-THERM-010-009	0.9106 ± 0.0006
LEU-COMP-THERM-017-017	0.9101 ± 0.0006
LEU-COMP-THERM-017-010	0.9096 ± 0.0005
LEU-COMP-THERM-043-002	0.9082 ± 0.0005
LEU-COMP-THERM-017-018	0.9078 ± 0.0006
LEU-COMP-THERM-043-004	0.9074 ± 0.0005
LEU-COMP-THERM-043-006	0.9071 ± 0.0005
LEU-COMP-THERM-043-003	0.9068 ± 0.0006
LEU-COMP-THERM-043-005	0.9066 ± 0.0005
LEU-COMP-THERM-082-006	0.9059 ± 0.0006
LEU-COMP-THERM-089-003	0.9058 ± 0.0006
LEU-COMP-THERM-043-001	0.9056 ± 0.0006
LEU-COMP-THERM-091-003	0.9054 ± 0.0006
LEU-COMP-THERM-054-007	0.9051 ± 0.0006
LEU-COMP-THERM-028-016	0.9051 ± 0.0004
LEU-COMP-THERM-089-004	0.9050 ± 0.0006
LEU-COMP-THERM-091-002	0.9048 ± 0.0006
LEU-COMP-THERM-054-008	0.9047 ± 0.0006
LEU-COMP-THERM-054-006	0.9046 ± 0.0006
LEU-COMP-THERM-058-005	0.9046 ± 0.0006
LEU-COMP-THERM-043-007	0.9045 ± 0.0006
LEU-COMP-THERM-082-005	0.9045 ± 0.0006
LEU-COMP-THERM-017-019	0.9044 ± 0.0007
LEU-COMP-THERM-058-001	0.9044 ± 0.0006
LEU-COMP-THERM-058-003	0.9044 ± 0.0006
LEU-COMP-THERM-054-001	0.9042 ± 0.0006
LEU-COMP-THERM-058-002	0.9041 ± 0.0006
LEU-COMP-THERM-044-004	0.9035 ± 0.0005
LEU-COMP-THERM-082-004	0.9033 ± 0.0006
LEU-COMP-THERM-082-003	0.9033 ± 0.0006
LEU-COMP-THERM-054-002	0.9032 ± 0.0006
LEU-COMP-THERM-089-001	0.9031 ± 0.0006
LEU-COMP-THERM-054-005	0.9029 ± 0.0006
LEU-COMP-THERM-044-002	0.9029 ± 0.0006
LEU-COMP-THERM-091-001	0.9028 ± 0.0006
LEU-COMP-THERM-005-004	0.9028 ± 0.0006
LEU-COMP-THERM-054-003	0.9026 ± 0.0006
LEU-COMP-THERM-091-005	0.9023 ± 0.0006
LEU-COMP-THERM-043-009	0.9023 ± 0.0006
LEU-COMP-THERM-044-005	0.9021 ± 0.0005
LEU-COMP-THERM-054-004	0.9020 ± 0.0006
LEU-COMP-THERM-092-006	0.9019 ± 0.0006
LEU-COMP-THERM-017-012	0.9016 ± 0.0006
LEU-COMP-THERM-044-001	0.9014 ± 0.0006
LEU-COMP-THERM-092-005	0.9014 ± 0.0006
LEU-COMP-THERM-044-008	0.9014 ± 0.0005
LEU-COMP-THERM-091-004	0.9013 ± 0.0006
LEU-COMP-THERM-091-007	0.9010 ± 0.0005

APPENDIX-2 - KENO K_{eff} RESULTS

Experiment	Expected Value	Calculated k_{eff}	Calculated /Expected	Enrichment	Pin Pitch	EALF	Material
LCT-008-001	1.0007	0.997442	0.996744	2.46%	1.6358	0.348	
LCT-008-002	1.0007	0.997841	0.997143	2.46%	1.6358	0.309	
LCT-008-003	1.0007	0.998442	0.997744	2.46%	1.6358	0.304	
LCT-008-004	1.0007	0.997878	0.997180	2.46%	1.6358	0.305	
LCT-008-005	1.0007	0.997528	0.996830	2.46%	1.6358	0.305	
LCT-008-006	1.0007	0.998189	0.997491	2.46%	1.6358	0.304	
LCT-008-007	1.0007	0.997388	0.996690	2.46%	1.6358	0.304	
LCT-008-008	1.0007	0.997101	0.996404	2.46%	1.6358	0.305	
LCT-008-009	1.0007	0.997244	0.996546	2.46%	1.6358	0.304	
LCT-008-010	1.0007	0.997684	0.996986	2.46%	1.6358	0.308	
LCT-008-011	1.0007	0.998360	0.997662	2.46%	1.6358	0.315	
LCT-008-012	1.0007	0.997773	0.997075	2.46%	1.6358	0.304	
LCT-008-013	1.0007	0.997809	0.997111	2.46%	1.6358	0.304	
LCT-008-014	1.0007	0.997573	0.996875	2.46%	1.6358	0.31	
LCT-008-015	1.0007	0.997581	0.996883	2.46%	1.6358	0.31	
LCT-008-016	1.0007	0.997790	0.997092	2.46%	1.6358	0.281	
LCT-008-017	1.0007	0.997175	0.996477	2.46%	1.6358	0.243	
LCT-009-001	1	0.998385	0.998385	4.31%	2.54	0.13	S Steel
LCT-009-002	1	0.998278	0.998278	4.31%	2.54	0.129	S Steel
LCT-009-003	1	0.997653	0.997653	4.31%	2.54	0.13	S Steel
LCT-009-004	1	0.998249	0.998249	4.31%	2.54	0.129	S Steel
LCT-009-010	1	0.998299	0.998299	4.31%	2.54	0.13	Copper
LCT-009-011	1	0.998297	0.998297	4.31%	2.54	0.129	Copper
LCT-009-012	1	0.998781	0.998781	4.31%	2.54	0.13	Copper
LCT-009-013	1	0.998721	0.998721	4.31%	2.54	0.129	Copper
LCT-009-014	1	0.997039	0.997039	4.31%	2.54	0.131	Copper
LCT-009-015	1	0.998890	0.998890	4.31%	2.54	0.13	Copper
LCT-010-005	1	1.000161	1.000161	4.31%	2.54	0.487	
LCT-010-009	1	1.000900	1.000900	4.31%	2.54	0.141	
LCT-010-010	1	1.000598	1.000598	4.31%	2.54	0.135	
LCT-010-015	1	1.001954	1.001954	4.31%	1.892	0.361	
LCT-010-016	1	1.002343	1.002343	4.31%	1.892	0.351	
LCT-010-017	1	1.001653	1.001653	4.31%	1.892	0.341	
LCT-010-018	1	1.001621	1.001621	4.31%	1.892	0.335	
LCT-010-019	1	1.001182	1.001182	4.31%	1.892	0.327	
LCT-010-021	1	1.002582	1.002582	4.31%	1.892	0.349	
LCT-010-022	1	1.002043	1.002043	4.31%	1.892	0.335	
LCT-010-023	1	1.000580	1.000580	4.31%	1.892	0.326	
LCT-010-024	1	0.999548	0.999548	4.31%	1.892	0.821	
LCT-010-025	1	1.000771	1.000771	4.31%	1.892	0.747	
LCT-010-026	1	1.001236	1.001236	4.31%	1.892	0.688	

LCT-010-027	1	1.001386	1.001386	4.31%	1.892	0.641	
LCT-010-028	1	1.001679	1.001679	4.31%	1.892	0.596	
LCT-010-030	1	0.999432	0.999432	4.31%	1.892	0.475	
LCT-011-002	1.0009	0.996617	0.995721	2.46%	1.636	0.304	
LCT-011-003	1.0009	0.997053	0.996156	2.46%	1.636	0.236	
LCT-011-004	1.0009	0.997476	0.996579	2.46%	1.636	0.236	
LCT-011-005	1.0009	0.997175	0.996278	2.46%	1.636	0.237	
LCT-011-006	1.0009	0.997241	0.996344	2.46%	1.636	0.24	
LCT-011-007	1.0009	0.997177	0.996280	2.46%	1.636	0.241	
LCT-011-008	1.0009	0.997732	0.996835	2.46%	1.636	0.242	
LCT-011-009	1.0009	0.997088	0.996191	2.46%	1.636	0.244	
LCT-011-010	1.001	0.994566	0.993572	2.46%	1.636	0.23	
LCT-011-011	1.001	0.994133	0.993140	2.46%	1.636	0.199	
LCT-011-012	1.001	0.994339	0.993346	2.46%	1.636	0.205	
LCT-011-013	1.001	0.994755	0.993761	2.46%	1.636	0.179	
LCT-011-014	1.001	0.994940	0.993946	2.46%	1.636	0.183	
LCT-011-015	1.001	0.995774	0.994779	2.46%	1.636	0.168	
LCT-013-001	1	1.000466	1.000466	4.31%	1.892	0.346	S Steel
LCT-013-003	1	1.000190	1.000190	4.31%	1.892	0.36	
LCT-013-004	1	1.001048	1.001048	4.31%	1.892	0.36	
LCT-013-006	1	1.000138	1.000138	4.31%	1.892	0.348	Copper
LCT-013-007	1	0.999493	0.999493	4.31%	1.892	0.362	Copper
LCT-016-001	1	0.997433	0.997433	2.35%	2.032	0.112	S Steel
LCT-016-002	1	0.995946	0.995946	2.35%	2.032	0.0111	S Steel
LCT-016-003	1	0.997148	0.997148	2.35%	2.032	0.0111	S Steel
LCT-016-004	1	0.996275	0.996275	2.35%	2.032	0.112	S Steel
LCT-016-005	1	0.996970	0.996970	2.35%	2.032	0.0109	S Steel
LCT-016-006	1	0.997032	0.997032	2.35%	2.032	0.113	S Steel
LCT-016-007	1	0.996999	0.996999	2.35%	2.032	0.112	S Steel
LCT-016-015	1	0.996978	0.996978	2.35%	2.032	0.112	Copper
LCT-016-016	1	0.994334	0.994334	2.35%	2.032	0.112	Copper
LCT-016-017	1	0.995786	0.995786	2.35%	2.032	0.112	Copper
LCT-016-018	1	0.997588	0.997588	2.35%	2.032	0.112	Copper
LCT-016-019	1	0.998011	0.998011	2.35%	2.032	0.112	Copper
LCT-016-020	1	0.997422	0.997422	2.35%	2.032	0.113	Copper
LCT-017-004	1	0.997227	0.997227	2.35%	2.032	0.268	
LCT-017-005	1	0.999004	0.999004	2.35%	2.032	0.232	
LCT-017-006	1	0.998955	0.998955	2.35%	2.032	0.216	
LCT-017-007	1	0.998869	0.998869	2.35%	2.032	0.204	
LCT-017-010	1	0.997840	0.997840	2.35%	2.032	0.117	
LCT-017-012	1	0.997659	0.997659	2.35%	2.032	0.113	
LCT-017-013	1	0.997905	0.997905	2.35%	2.032	0.111	
LCT-017-015	1	0.996761	0.996761	2.35%	1.684	0.218	
LCT-017-016	1	0.997682	0.997682	2.35%	1.684	0.21	
LCT-017-017	1	0.998917	0.998917	2.35%	1.684	0.204	

LCT-017-018	1	0.997374	0.997374	2.35%	1.684	0.202	
LCT-017-019	1	0.997833	0.997833	2.35%	1.684	0.199	
LCT-017-020	1	0.996770	0.996770	2.35%	1.684	0.196	
LCT-017-021	1	0.996533	0.996533	2.35%	1.684	0.194	
LCT-017-022	1	0.995666	0.995666	2.35%	1.684	0.194	
LCT-017-023	1	0.997419	0.997419	2.35%	1.684	0.208	
LCT-017-024	1	0.998055	0.998055	2.35%	1.684	0.202	
LCT-017-025	1	0.996362	0.996362	2.35%	1.684	0.192	
LCT-017-026	1	0.995083	0.995083	2.35%	1.684	0.519	
LCT-017-027	1	0.997035	0.997035	2.35%	1.684	0.437	
LCT-017-028	1	0.997587	0.997587	2.35%	1.684	0.378	
LCT-017-029	1	0.997328	0.997328	2.35%	1.684	0.333	
LCT-039-001	1	0.995922	0.995922	4.74%	1.26	0.265	
LCT-039-002	1	0.996968	0.996968	4.74%	1.26	0.253	
LCT-039-003	1	0.996747	0.996747	4.74%	1.26	0.227	
LCT-039-004	1	0.995566	0.995566	4.74%	1.26	0.217	
LCT-039-005	1	0.997792	0.997792	4.74%	1.26	0.162	
LCT-039-006	1	0.997616	0.997616	4.74%	1.26	0.169	
LCT-039-007	1	0.996193	0.996193	4.74%	1.26	0.254	
LCT-039-008	1	0.996609	0.996609	4.74%	1.26	0.241	
LCT-039-009	1	0.996686	0.996686	4.74%	1.26	0.234	
LCT-039-010	1	0.997479	0.997479	4.74%	1.26	0.204	
LCT-039-011	1	0.994778	0.994778	4.74%	1.26	0.264	
LCT-039-012	1	0.995197	0.995197	4.74%	1.26	0.258	
LCT-039-013	1	0.995286	0.995286	4.74%	1.26	0.255	
LCT-039-014	1	0.995798	0.995798	4.74%	1.26	0.253	
LCT-039-015	1	0.996036	0.996036	4.74%	1.26	0.252	
LCT-039-016	1	0.996465	0.996465	4.74%	1.26	0.25	
LCT-039-017	1	0.996150	0.996150	4.74%	1.26	0.25	
LCT-042-001	1	0.996989	0.996989	2.35%	1.684	0.206	S Steel
LCT-042-003	1	0.997774	0.997774	2.35%	1.684	0.223	
LCT-042-004	1	0.998466	0.998466	2.35%	1.684	0.221	
LCT-042-005	1	0.998720	0.998720	2.35%	1.684	0.217	
LCT-042-006	1	0.998412	0.998412	2.35%	1.684	0.206	Copper
LCT-042-007	1	0.996183	0.996183	2.35%	1.684	0.211	Copper
LCT-043-001	1.0004	1.000712	1.000312	4.35%	1.5	0.177	Gd
LCT-043-002	1.0004	1.000826	1.000426	4.35%	1.5	0.181	Gd
LCT-043-003	1.0004	1.000381	0.999981	4.35%	1.5	0.181	Gd
LCT-043-004	1.0006	1.000651	1.000051	4.35%	1.5	0.178	Gd
LCT-043-005	1.0004	1.000450	1.000050	4.35%	1.5	0.18	Gd
LCT-043-006	1.0005	1.000318	0.999818	4.35%	1.5	0.18	Gd
LCT-043-007	1.0006	1.000235	0.999635	4.35%	1.5	0.18	Gd
LCT-043-008	1.0004	1.000114	0.999714	4.35%	1.5	0.18	Gd
LCT-043-009	1.0006	1.000237	0.999637	4.35%	1.5	0.178	Gd
LCT-044-001	1.0005	0.999950	0.999450	4.35%	1.5	0.171	Copper

LCT-044-002	1.0003	0.999638	0.999338	4.35%	1.5	0.172	Copper
LCT-044-003	1.0005	0.999873	0.999373	4.35%	1.5	0.171	Copper
LCT-044-004	1.0003	0.999551	0.999251	4.35%	1.5	0.172	Copper
LCT-044-005	1.0003	0.999829	0.999529	4.35%	1.5	0.171	Copper
LCT-044-006	1.0004	0.999962	0.999562	4.35%	1.5	0.17	Copper
LCT-044-007	1.0004	0.999788	0.999388	4.35%	1.5	0.171	Copper
LCT-044-008	1.0003	0.999922	0.999622	4.35%	1.5	0.171	Copper
LCT-044-009	1.0004	0.999725	0.999325	4.35%	1.5	0.173	Copper
LCT-044-010	1.0004	1.000978	1.000578	4.35%	1.5	0.17	Copper
LCT-046-018	1.00043	0.999669	0.999239	4.35%	1.5	0.148847	Copper
LCT-046-019	1.0004	0.998991	0.998592	4.35%	1.5	0.149415	Copper
LCT-046-020	1.00039	0.998752	0.998363	4.35%	1.5	0.149913	Copper
LCT-046-021	1.00039	0.998477	0.998088	4.35%	1.5	0.150795	Copper
LCT-046-022	1.00039	0.997764	0.997375	4.35%	1.5	0.151843	Copper
LCT-051-002	1.001	0.998150	0.997153	2.46%	1.636	0.239	S Steel
LCT-051-003	1.001	0.997778	0.996781	2.46%	1.636	0.239	S Steel
LCT-051-004	1.001	0.998173	0.997176	2.46%	1.636	0.242	S Steel
LCT-051-005	1.001	0.998268	0.997271	2.46%	1.636	0.242	S Steel
LCT-051-006	1.001	0.998175	0.997178	2.46%	1.636	0.243	S Steel
LCT-051-007	1.001	0.997825	0.996828	2.46%	1.636	0.244	S Steel
LCT-051-008	1.001	0.998023	0.997026	2.46%	1.636	0.244	S Steel
LCT-051-009	1.001	0.997535	0.996538	2.46%	1.636	0.202	S Steel
LCT-054-001	1.0007	0.999972	0.999273	4.35%	1.5	0.176	Gd
LCT-054-002	1.0005	0.999670	0.999170	4.35%	1.5	0.175	
LCT-054-003	1.0004	0.999722	0.999322	4.35%	1.5	0.175	
LCT-054-007	1.0005	0.999569	0.999069	4.35%	1.5	0.177	
LCT-054-008	1.0002	0.999274	0.999074	4.35%	1.5	0.177	
LCT-057-001	1	0.997339	0.997339	4.74%	1.35	0.199	
LCT-057-002	1	0.996440	0.996440	4.74%	1.35	0.202	
LCT-057-003	1	0.997028	0.997028	4.74%	1.35	0.204	
LCT-057-004	1	0.997999	0.997999	4.74%	1.35	0.207	
LCT-057-005	1	0.992902	0.992902	4.74%	1.35	0.214	
LCT-057-006	1	0.996052	0.996052	4.74%	1.35	0.219	
LCT-057-007	1	0.995636	0.995636	4.74%	1.35	0.227	
LCT-057-008	1	0.996616	0.996616	4.74%	1.35	0.237	
LCT-057-009	1	0.994599	0.994599	4.74%	1.35	0.254	
LCT-057-010	1	0.995674	0.995674	4.74%	1.35	0.263	
LCT-057-011	1	0.995019	0.995019	4.74%	1.35	0.274	
LCT-057-012	1	0.996209	0.996209	4.74%	1.35	0.285	
LCT-057-013	1	0.996000	0.996000	4.74%	1.35	0.299	
LCT-057-014	1	0.995620	0.995620	4.74%	1.35	0.315	
LCT-057-015	1	0.995320	0.995320	4.74%	1.35	0.331	
LCT-057-016	1	0.997095	0.997095	4.74%	1.35	0.196	
LCT-058-001	1.0003	0.998404	0.998105	4.35%	1.5	0.178	Gd
LCT-058-002	1.0004	0.997998	0.997599	4.35%	1.5	0.178	Gd

LCT-058-003	1.0004	0.998119	0.997720	4.35%	1.5	0.178	Gd
LCT-058-004	1.0004	0.998126	0.997727	4.35%	1.5	0.179	Gd
LCT-058-005	1.0004	0.998146	0.997747	4.35%	1.5	0.179	Gd
LCT-065-001	1	1.001467	1.001467	2.60%	1.9558	0.233	
LCT-065-002	0.9999	1.001743	1.001843	2.60%	1.9558	0.239	S Steel
LCT-065-003	0.9996	1.000062	1.000462	2.60%	1.9558	0.242	Boron
LCT-065-004	0.9997	1.001043	1.001343	2.60%	1.9558	0.241	Boron
LCT-065-005	1	1.001729	1.001729	2.60%	1.9558	0.23	
LCT-065-007	0.9991	1.001556	1.002458	2.60%	1.9558	0.234	S Steel
LCT-065-008	1	1.001875	1.001875	2.60%	1.9558	0.236	S Steel
LCT-065-009	1.0001	1.001210	1.001110	2.60%	1.9558	0.235	S Steel
LCT-065-010	1.0002	1.000714	1.000514	2.60%	1.9558	0.238	Boron
LCT-065-012	1	1.000139	1.000139	2.60%	1.9558	0.24	Boron
LCT-065-013	1.0001	0.999684	0.999584	2.60%	1.9558	0.238	Boron
LCT-065-015	0.9994	1.001037	1.001638	2.60%	1.9558	0.236	Boron
LCT-065-016	0.9998	1.001033	1.001233	2.60%	1.9558	0.239	Boron
LCT-065-017	1.0003	1.000742	1.000442	2.60%	1.9558	0.237	Boron
LCT-071-001	1	0.995188	0.995188	4.74%	1.1	0.948	Zircaloy
LCT-071-002	1	0.994651	0.994651	4.74%	1.1	0.866	Zircaloy
LCT-071-003	1	0.994421	0.994421	4.74%	1.1	0.822	Zircaloy
LCT-071-004	1	0.994093	0.994093	4.74%	1.075	1.06	Zircaloy
LCT-072-001	1	0.997888	0.997888	4.74%	1.6	0.127	Zircaloy
LCT-072-002	1	0.997648	0.997648	4.74%	1.6	0.122	Zircaloy
LCT-072-003	1	0.997921	0.997921	4.74%	1.6	0.124	Zircaloy
LCT-073-001	1	0.996440	0.996440	4.74%	1.05	0.758	Zircaloy
LCT-073-002	1	0.996478	0.996478	4.74%	1.05	0.691	Zircaloy
LCT-073-003	1	0.995688	0.995688	4.74%	1.05	0.614	Zircaloy
LCT-073-004	1	0.997239	0.997239	4.74%	1.075	0.757	Zircaloy
LCT-073-005	1	0.996738	0.996738	4.74%	1.075	0.683	Zircaloy
LCT-073-006	1	0.997450	0.997450	4.74%	1.075	0.671	Zircaloy
LCT-073-007	1	0.996965	0.996965	4.74%	1.075	0.631	Zircaloy
LCT-073-008	1	0.996031	0.996031	4.74%	1.075	0.61	Zircaloy
LCT-073-009	1	0.997703	0.997703	4.74%	1.075	0.555	Zircaloy
LCT-073-010	1	0.997284	0.997284	4.74%	1.075	0.499	Zircaloy
LCT-073-011	1	0.996391	0.996391	4.74%	1.075	0.481	Zircaloy
LCT-073-012	1	0.996982	0.996982	4.74%	1.075	0.599	Zircaloy
LCT-073-013	1	0.997026	0.997026	4.74%	1.075	0.569	Zircaloy
LCT-073-014	1	0.996708	0.996708	4.74%	1.075	0.553	Zircaloy
LCT-074-001	0.99963	1.002610	1.002981	4.74%	1.6	0.134	Zircaloy
LCT-074-002	0.99936	1.001094	1.001735	4.74%	1.6	0.133	Zircaloy
LCT-074-003	1.00028	1.001267	1.000987	4.74%	1.6	0.119	Zircaloy
LCT-074-004	0.99945	0.999953	1.000503	4.74%	1.6	0.115	Zircaloy
LCT-077-001	1.0003	1.000928	1.000628	4.35%	1.5	0.183	S Steel
LCT-077-003	1.0004	1.001196	1.000796	4.35%	1.5	0.188	
LCT-077-004	1.0004	1.001408	1.001008	4.35%	1.5	0.188	

LCT-082-002	1.0005	1.000781	1.000281	4.35%	1.5037	0.171	S Steel
LCT-082-003	1.0006	1.000757	1.000157	4.35%	1.5037	0.173	
LCT-082-004	1.0005	1.001149	1.000649	4.35%	1.5037	0.173	
LCT-082-005	1.0006	1.000703	1.000103	4.35%	1.5037	0.173	
LCT-082-006	1.0005	1.000481	0.999981	4.35%	1.5037	0.174	
LCT-084-001	1.0004	1.000287	0.999887	4.35%	1.5	0.178	S Steel
LCT-089-001	1.0003	1.000134	0.999834	4.35%	1.5	0.177	Boron
LCT-089-002	1.0005	1.000038	0.999538	4.35%	1.5	0.178	Boron
LCT-089-003	1.0003	0.999743	0.999443	4.35%	1.5	0.178	Boron
LCT-089-004	1.0003	1.000145	0.999845	4.35%	1.5	0.176	Boron
LCT-090-001	1.0005	0.999693	0.999193	4.35%	1.5	0.169	S Steel
LCT-090-002	1.0004	0.999897	0.999497	4.35%	1.5	0.168	S Steel
LCT-090-003	1.0004	0.999614	0.999214	4.35%	1.5	0.169	S Steel
LCT-090-004	1.0005	1.000663	1.000163	4.35%	1.5	0.171	S Steel
LCT-090-005	1.0005	0.999989	0.999489	4.35%	1.5	0.17	S Steel
LCT-090-006	1.0005	0.999626	0.999126	4.35%	1.5	0.169	S Steel
LCT-090-007	1.0004	0.999587	0.999187	4.35%	1.5	0.169	S Steel
LCT-090-008	1.0005	0.999757	0.999257	4.35%	1.5	0.169	S Steel
LCT-090-009	1.0005	0.999468	0.998969	4.35%	1.5	0.171	S Steel
LCT-091-001	1.0005	0.995479	0.994982	4.35%	1.5	0.173	Gd
LCT-091-002	1.0006	1.000467	0.999867	4.35%	1.5	0.175	Gd
LCT-091-003	1.0004	1.000203	0.999803	4.35%	1.5	0.174	Gd
LCT-091-004	1.0006	1.000034	0.999434	4.35%	1.5	0.174	Gd
LCT-091-005	1.0006	1.000527	0.999927	4.35%	1.5	0.173	Gd
LCT-091-006	1.0006	1.000120	0.999520	4.35%	1.5	0.151	Gd
LCT-091-007	1.0004	0.996595	0.996197	4.35%	1.5	0.152	Gd
LCT-092-003	1.00032	0.999775	0.999455	4.35%	1.5	0.161	
LCT-092-004	1.00033	0.999569	0.999239	4.35%	1.5	0.162	
Antal		249	249				
Medel		0.998338	0.998103				
STD		0.002002	0.002046				