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Calculation Cover Sheet

Complete only applicable items.

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Page: 1 Of: 26

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Table of Contents

1. Purpose

The purpose of this engineering calculation is to estimate the frequency of misloading spent nuclear fuel (SNF) assemblies that would result in exceeding the criticality design basis of a waste package (WP). This type of misload -- a reactivity misload -- results from the incorrect placement of one or more fuel assemblies into a waste package such that the criticality controls do not match the required controls for the fuel assemblies. An actual criticality event can not occur in an WP unless a moderator (e.g., water) is present While a thermal misload is possible (load fuel that exceeds the thermal limits of a WP), it is not addressed in this analysis.

2. Method

Decision trees with mutually exclusive branch points have been developed to estimate the probability that a particular WP will result in a reactivity (criticality) misload. For each branch point on the decision tree, a probability is developed or assumed. For each decision tree sequence, the probabilities at each branch point are multiplied together to estimate the probability for the entire sequence.

Headers for the decision tree reflect operator errors and the expected distribution of DCs and their associated fuel assemblies. A consequence matrix is developed to determine the consequence of difference combinations of misloads (as represented by sequences/end states of the decision tree). For example, some misloads could result in only an economic, not criticality, consequence. The endstate probabilities for sequences resulting in a potential reactivity consequence are summed to determine the total probability of a fuel misload that results in exceeding the criticality loading limits or criteria for the WP.

The probability of a misload is multiplied by the expected number of WPs processed per year; this result is the frequency (per yr) of a fuel assembly misload that would result in exceeding the criticality design basis of a WP. Decision trees are developed for both pressurized water reactor (PWR) fuel assemblies and boiling water reactor (BWR) fuel assemblies. Because the criticality control mechanism for a high-criticality PWR fuel assembly is not contained in the WP, a variety of cases, with different assumptions have been developed.

3. Assumptions

3.1 The criticality misload analysis assumes that there are five different types of PWR waste packages available; these are type numbers 1 through 5, as delineated in the Preliminary List of Waste Package Designs for VA (Ref. 7.1). Further, this analysis assumes there are three types of BWR waste packages; these are type numbers 6 through 8, as delineated in Reference 7.1. These include:

21-PWR - No Absorber (1)
21-PWR - Absorber Plates (2)
21-PWR - Absorber Rods (no plates) (3)
12-PWR - No Absorber (4)
12-PWR - Absorber Plates/Long (South Texas) (5)
44-BWR - No Absorber (6)
44-BWR - Absorber Plates (7)
24-BWR - Thick Absorber Plates (8)

This assumption is used throughout the calculation.

3.2 It is assumed, that since the length of package types 1 through 4 are identical, that these waste packages are visually indistinguishable. Similarly, waste package types 6 through 8 are assumed to be visually indistinguishable. It should be noted that the 21-PWR waste packages are distinguishable from the 12-PWR waste packages by noting the difference in the number of cells, however, waste packages with a smaller number of cells were developed to handle thermal loads. Since the number of cells do not have an effect on exceeding the criticality design basis (see Assumption 3.4), waste package types 1 through 4 will be assumed to be identical. A similar argument can be applied to the BWR waste packages.

This assumption is used throughout the calculation and specifically in Section 5.3.2.

3.3 Because the criticality misload analysis for PWR and BWR fuel assemblies are separate and independent, it is assumed there are no potential consequences for loading (or trying to load) a PWR fuel assembly in a BWR waste package because the PWR assembly is larger than a BWR assembly. Any attempt to load a PWR assembly into a BWR waste package would be immediately detected and corrected. Similarly, there are no criticality concerns for the reverse operation -- loading a BWR fuel assembly into a PWR waste package. In addition to the smaller size of a BWR assembly being immediately discovered, the PWR waste packages are designed to store about one-half the number of assemblies as the BWR waste packages. Therefore, even if a PWR waste package was filled with BWR fuel assemblies, no criticality loading limits or criteria would be approached.

This assumption is used in Section 5.1.

3.4 It is assumed, in terms of the ability to control/limit reactivity consequences, that waste package types 1 and 4 are identical, and that package types 2 and 5 are identical. Therefore, fuel assemblies with comparable reactivity will be subject to the same criticality constraints, whether in package type 1 or 4.

This assumption used throughout the calculation.

3.5 It is assumed that the distribution of fuel assemblies (e.g., the waste stream mix expected to be delivered to the site over a 24-year period) will be proportional to the waste package types available.

This assumption is used throughout the calculation.

3.6 The use of a detector is assumed when the fuel assemblies are unloaded. The detector is used to characterize the thermal load and burnup of the removed fuel assembly. This is consistent with recommendations of Reg. Guide 3.58 (Ref. 7.3), which states that when burnup credit is taken, the amount of burnup needs to be confirmed by reactivity measurements. One detector device capable of performing this function is the Fork+ radiation measurement system discussed in Appendix B.2 of Reference 7.4.

This assumption is used in Sections 3.7(a) and 5.2.

3.7 The following human errors are assumed to occur during the fuel assembly unloading process from the transportation cask and the subsequent loading into the waste packages (Ref. 7.5, 7.6). These are actions are assumed to occur because there have not been any formal procedures for fuel assembly loading developed at this time.

(a) During the cask unloading process, the operator will need to record the assembly identification, the associated heat rate and burnup from the licensing paperwork, and to perform a verification measurement with a detector (Ref. 7.3); see Assumption 3.6. It is assumed that the operator will fail to identify a discrepancy between the licensing paperwork and the detector reading with a human error probability (HEP) of 0.001 (Ref. 7.7, p. 20-26). The error may occur due to either faulty paperwork or a faulty detector. In either case, applying an HEP to the decision tree will generate a set of endstates three orders of magnitude lower (i.e., insignificant endstates) than the rest of the endstates, therefore this error will not be explicitly treated in the development of the decision trees.

This assumption is used throughout the calculation.

(b) The Assembly Transfer System Line operator (Line operator) determines what type of waste package (disposal container, DC) is to be used, informs the Empty DC Preparation Area operator (DC Area operator), who selects the desired WP type (by methods unknown at this time), loads the WP on a WP cart and positions it under one of three transfer ports. This process can result in a variety of human errors, particularly with the required communications between the Line operator and the DC Area operator. It is therefore assumed that recovery is limited to correcting another operator's error (rather than an operator's own error).

The types of human errors possible include conceptual and selection error. A conceptual error would be if the Line operator decided on the wrong WP type and requested the wrong WP from the DC Area operator. The HEP (human error probability) is approximated by a rule-based action after a diagnosis of an event without recovery; taken from Reference 7.7 (p. 20-18), the HEP is 0.05 following an abnormal event. Since this occurs under normal operating conditions, assume the HEP is at its lower bounds (using an error factor of 10), 0.005. There is no unusual or stress conditions requiring an additional multiplier.

The other possible human error is a selection error for which the HEP is approximated by an error of commission in selecting the wrong control on a panel of similar looking controls that are arranged in well-defined functional group; the HEP is 0.001 (Reference 7.7, p. 20-25). This selection error is assumed to include either the selection of an incorrect WP (different than requested) or placement of the WP on the wrong WP cart (arrives at the wrong Assembly Transfer System Line). Consistent with the first paragraph of this Section, it is assumed that the Line operator can recover from the DC Area operator's error. It is assumed the DC Area operator can only make a selection error.

A human reliability analysis (see Attachment VII) shows that the conceptual error by the Line operator (endstate HEP-4 in Attachment VII) dominates over the selection error by the DC Area operator (endstate HEP-3 in Attachment VII) (due to recovery). Because HEP-4 dominates, the WP selection error (HEP-3) is not developed in the decision trees, and an incorrect WP is assumed to occur only due to a conceptual error on the part of the Line operator. Further, if a concept error occurs, the Line operator is assumed to be loading into the *original, intended* WP (i.e., ignoring the original conceptual error) unless the Line operator subsequently makes a conceptual error selecting the fuel assembly. (The assumption can be modified by applying a recovery factor.) Whenever this conceptual error (for fuel assemblies) occurs, ***it is assumed that the Line operator behaves as if the WP is appropriate for the fuel assembly that was (erroneously) selected.***

These assumptions are used throughout the calculation.

(c) The Line operator determines what type of fuel assembly is to be loaded into the WP, selects the desired fuel assembly basket from the Assembly Storage Rack (by methods unknown at this time), transfers the basket up the incline, into the Assembly Drying Stations, and finally positions it over a transfer port to be placed into the WP. This could result in a conceptual human error or selection human error. The concept error would be deciding on the wrong fuel assembly basket type. The HEPs are assumed to be the same as developed in item (b). Any recovery action is assumed to occur during the verification step (see item (d)).

This assumption is used throughout the calculation.

(d) The physical verification occurs after the fuel assembly is loaded into the WP. This includes verifying the fuel assembly identity (e.g., via a remote camera), and confirming the fuel assembly's characteristics and the appropriateness of the WP into which it has been loaded. The HEP is estimated at 0.01 as failure to use written operating procedures under normal operating conditions (Ref. 7.7, p. 20-22).

In the instance of a conceptual error (versus a selection error), since the operator will be checking a WP completely misloaded (i.e., the effect of a conceptual error), the lower limit of the HEP is used, e.g., 0.001.

This assumption is used throughout the calculation.

(e) As a sensitivity analysis, it is assumed that for each operator action (e.g., selection of a WP and selection of a fuel assembly) that there exists a specialized error recovery mechanism. This may be another operator shadowing the first operator or some sort of automated checking system. This value can vary from zero (0.0), i.e., no recovery possible, to one (1.0), i.e., recovery is always successful. Since the loading procedures and processes are unknown, a recovery factor of 0.9 was assumed to develop bounds on the results.

This assumption is used in Section 6.

3.8 Because the criticality control mechanism for high-criticality PWR fuel assemblies are contained within the fuel assembly itself, and not in the WP, four cases for PWR fuel assemblies were developed with the following assumptions, used throughout the calculation:

(a) Case PWR-A: Treat the no absorber WP and the absorber rod WP as distinct and unique, as if the DC Area operator has a means to distinguish them from each other. Further, assume that the Line operator loads the absorber rods into the fuel assemblies only when the Line operator recognizes the use of an absorber rod WP or believes a high-criticality (HK) fuel assembly is being loaded into the WP. Failure to load the absorber rods is 100% dependent on operator failure to recognize the use of an absorber rod WP (and therefore is not explicitly modeled in the decision tree).

(b) Case PWR-B: Treat the no absorber WP and the absorber rod WP as the same and indistinguishable; the DC Area operator will only be requested to load one of two types of WPs: no absorber or absorber plate. Further, assume that the Line operator loads the absorber rods into the fuel assemblies only when the Line operator recognizes the use of an absorber rod WP. Failure to load the absorber rods is 100% dependent on operator failure to recognize the use of an absorber rod WP (and therefore is not explicitly modeled in the decision tree).

(c) Case PWR-C: Assume another method of criticality control for the high-criticality fuel assemblies that is intrinsic to the WP. Assume this criticality control mechanism makes this WP distinct and unique from a no absorber WP. For convenience, this WP will continue to be referred to as an absorber rod WP. This is similar to the BWR case.

(d) Case PWR-D: Assume that the absorber rods are properly inserted into the appropriate fuel assemblies at the nuclear power plant prior to transport, and that except for confirmation, repository personnel have no responsibility for loading absorber rods. Accordingly, it is assumed that the no absorber WP and the absorber rod WP are the same and indistinguishable. This case represents a non-conservative assumption.

3.9 It is assumed that the likelihood of selecting an incorrect fuel assembly to load into the WP is based on the percentage of fuel assemblies with specific characteristics from the total number of fuel assemblies to be delivered to the site over the 24-year period.

This assumption is used throughout the calculation.

3.10 In Section 5.1, each of the five cases was developed for only uncanistered fuel (UCF). It is assumed because canistered fuel (if any is shipped to the repository), in most cases, will be taken out of the canister and placed directly into the DC, there is no opportunity for misloading errors.

4. Use of Computer Software

4.1 Software Approved for QA Work

No software approved for QA work was used in this calculation.

4.2 Software Routines

The only software used to support this engineering calculation is Microsoft's spreadsheet package Excel (Version: Microsoft Excel 97). The spreadsheet was executed on a personal computer (PC) under the Windows NT 4.0 operating system. The use of Excel in this calculation does not generate data. All calculations performed by the Excel spreadsheet are verified by visual inspection and/or hand calculations. The five decision trees were developed and quantified using Excel. Excel was also used to generate the regression analysis results.

5. Calculation

5.1 Introduction

The purpose of this section is to estimate the frequency of a fuel assembly misload that would result in exceeding the criticality design basis of a waste package. This analysis considers three items:

a) the operational handling of the fuel assemblies from when they are removed from the transport casks to when they are placed (or loaded) into the disposal container (Section 5.2),
b) the consequence of loading any one of the fuel assemblies into any one of the waste packages (Section 5.3.1), and
c) estimating the probability/frequency for the consequences that are identified as being undesirable (Section 5.3.2).

Decision trees have been developed for five cases:

Case	Consequence	Comment
PWR-A	Exceed Criticality Design Basis	See Assumption 3.8 (a). Decision tree is in Attachment I.
PWR-B	Exceed Criticality Design Basis	See Assumption 3.8 (b). Decision tree is in Attachment II.
PWR-C	Exceed Criticality Design Basis	See Assumption 3.8 (c). Decision tree is in Attachment III.
PWR-D	Exceed Criticality Design Basis	See Assumption 3.8 (d). Decision tree is in Attachment IV.
BWR	Exceed Criticality Design Basis	Decision tree is in Attachment V.

There are four PWR cases to account for the assumptions related the fact that the criticality control mechanism for high-criticality PWR fuel assemblies is separate from the WP itself. The assumptions range from conservative to non-conservative.

The PWR and BWR fuel assembly evaluation are separate and independent. There are no consequences for loading (trying to load) a PWR fuel assemblies into a BWR WP because the PWR assemblies are larger than a BWR UCF assembly. Any attempt to load a PWR assembly into a BWR WP would be immediately detected and corrected. Similarly, there are no criticality concerns for the reverse -- loading a BWR fuel assembly into a WP. In addition to the smaller size of the BWR assemblies being immediately discovered, the PWR waste packages are designed to hold about one-half the number of assemblies as the BWR packages. Therefore, even if a PWR package was filled with BWR fuel assemblies, no criticality limits would be approached.

Based on the analysis in Reference 7.2, the waste package mix in case L1-T4-C1 is used to determine the nominal percentage of waste package types. From Reference 7.2, the nominal waste stream coverage for PWRs for scenario C1 is[1]:

21 PWR (no absorber) (1)	- 35.5%
21 PWR (absorber plates) (2)	- 55.5%
21 PWR (absorber rods) (3)	- 3.5%
12 PWR (no absorber) (4)	- 3.5%
12 PWR (ST, absorber plates) (5)	- 2.0%

Types 1 and 4, and types 2 and 5 are identical from a criticality point of view.

From Reference 7.2, the nominal waste stream coverage for BWRs for scenario C1 is:

44 BWR (no absorber) (6)	- 27.5%
44 BWR (absorber plates) (7)	- 71.5%
24 PWR (absorber rods) (8)	- 1.0%

There are no equivalent types for BWR waste packages, in terms of criticality control.

However, to enhance flexibility and permit the development of a regression expression for misload probability as a function of waste stream composition, the Excel spreadsheets (e.g., decision trees) were developed to permit the entry of a variety of WP allocations (e.g., different percentages for each type of WP).

5.2 Waste Package/Fuel Assembly Operational Process

At a minimum, the process in which the fuel assemblies are unloaded from the transportation casks and are readied for loading into a WP must be considered. As discussed in Reference 7.8, the transport casks are delivered to the repository by truck or rail. They are inspected, decontaminated, if necessary, and upended in the Carrier Washdown Station and the Carrier Bay. They are then delivered to the Assembly Transfer System, where in the Cask Preparation Area, the transport cask's lid is removed. The cask is placed in the Cask Unload Pool, where the Assembly Transfer Machine removes fuel assemblies and places them into Assembly Baskets (with capacities of either four PWR assemblies or eight BWR assemblies). The Assembly Baskets are moved through the Transfer Canal to the Assembly Cell, where an Assembly Transfer Machine places Assembly Baskets into an Assembly Drying Station and finally the individual assemblies into a waste package positioned under a transfer port. Assembly baskets continue through the

[1] The values presented here are the averages of the coverage ranges taken from a Check Copy of Ref. 7.2. The REV 00 version of Ref. 7.2 provides slightly different coverage ranges. However, since the values shown here are still within the ranges shown in Ref. 7.2, they will be used as the nominal coverage values for PWRs for this document.

Transfer Canal until there are sufficient fuel assemblies to fill the waste package. There are three independent Assembly Transfer System Lines.

The empty waste package is retrieved from the Empty DC Preparation Area. The Assembly Transfer System Line operator (Line operator) makes a request of the Empty DC Preparation Area operator (DC Area operator), who places the appropriate WP on a WP cart that conveys the WP to the appropriate transfer port.

During the unloading process, the Line operator will need to record the assembly identification and associated heat rate and burnup from the licensing paperwork and a detector (Ref. 7.3). In this way, the characteristics of each assembly in the Assembly Baskets will be known. Mis-identification of the fuel assembly's characteristics and/or location is the first opportunity for a human error that can contribute to a misload (reading the paperwork incorrectly or misreading the detector output). This error does not significantly contribute to the overall misload frequency (see Assumption 3.7 (a). Based on the characterization of the fuel assemblies removed from the transport casks, the Line operator must decide what type of WP is to be used. The Line operator requests the desired WP type (by methods unknown at this time) from the DC Area operator, who places it on a WP cart and positions it under a transfer port. Deciding on an inappropriate WP type or selecting the wrong WP type is another opportunity for a human error.

Operator treatment of absorber rods is described in Assumptions 3.8 (a) through 3.8 (d) to reflect a range of actions, from conservative to non-conservative.

The selection of fuel assemblies (from the Assembly Storage Rack) to be placed in the WP is another opportunity for human error. The operator can select an incorrect assembly (conceptual error), or after selecting the correct assembly for the WP, make a manipulation error with the Assembly Transfer Machine and transfer the wrong assembly (selection error).

After placing the fuel assemblies into the WP, the Line operator will perform a physical verification (e.g., ensure that the fuel assembly that was intended to be loaded was correctly loaded). The physical verification process is an opportunity for human error recovery. The loaded WP is then moved to an area where an inner lid is seal-welded in place.

5.3 Misload (Criticality) Analysis

5.3.1 Consequence Matrix

This section develops and discusses the PWR and BWR consequence matrices, which consider the placement of any of the possible transported fuel assemblies into any one of the designed WPs. The WP types, with the criticality ranges, were taken from Case L1-T4-C1 tabulated in Reference 7.2.

The following explains the cell designations in the PWR and BWR Consequence Matrices shown in Tables 5-1 and 5-2:

1. Those cells labeled *As Designed* indicate that a fuel assembly was placed into a WP appropriate for that fuel assembly's criticality characteristics.

2. Those cells labeled *Possible Criticality* indicate that some percentage of the fuel assemblies placed in the specified WP may exceed the criticality design basis of the WP. The reactivity level (i.e., k_∞) is determined by curves attached to each licensed transport cask. Note further that transport casks are licensed for use employing no burn-up credit, i.e., as if the fuel were fresh fuel, and therefore the value of k_∞ is not a deciding parameter for the selection of a transport cask. The value of k_∞ becomes important when determining what WP is to be used because the waste package design takes credit for burnup. Therefore, for any WPs that do not required fuel assemblies with absorber rods as criticality control (e.g., use absorber plates or no absorber), it is possible, via human error, to place a fuel assembly into a WP and to exceed the criticality design basis.

   Some combinations are not credible and will not be explicitly considered. If a South Texas (ST) fuel assembly is placed in any waste package except PWR 12 (absorber plates), it would be immediately discovered and detected due to the extra length of a ST fuel assembly. However, the converse is not true; if a fuel assembly requiring absorber rods is placed in a ST waste package, then there is the possibility of a criticality concern.

3. Those cells labeled *Possible Economic* indicate that some percentage of the fuel assemblies placed in the specified WP will exceed the economic considerations for the use of a WP. The WP does not contain absorber rods for criticality control; the absorber rods are placed directly into the fuel assemblies. Therefore, if a fuel assembly received absorber rods when not necessary, this is an appropriate use of resources, i.e., an economic concern. Similarly, if a fuel assembly with absorber rods (when required) is placed into an WP with absorber plates, then the WP usage is not economical.

Those cells labeled *Possible Criticality* represent potential misload situations, which would require the introduction of a moderator (e.g., water). The estimation of probability/frequency of misloads is discussed in Section 5.3.2.

Table 5-1.
Fuel Assembly to Waste Package (PWR) Consequence Matrix

	Fuel Assembly Characterization		
Type of Waste Package	Low-criticality (LK)	Mid-criticality (MK)	High-criticality (HK)
21 PWR (no absorber)	As designed	***Possible Criticality***	***Possible Criticality***
21 PWR (absorber plate)	Possible Economic	As designed	***Possible Criticality***
21 PWR (absorber rod)	Possible Economic	Possible Economic	As designed
12 PWR (no absorber)	As designed	***Possible Criticality***	***Possible Criticality***
12 PWR (ST/absorber plate)	Possible Economic	As designed	***Possible Criticality***

Table 5-2.
Fuel Assembly to Waste Package (BWR) Consequence Matrix

	Fuel Assembly Characterization		
Type of Waste Package	Low-criticality (LK)	Mid-criticality (MK)	High-criticality (HK)
44 BWR (no absorber)	As designed	***Possible Criticality***	***Possible Criticality***
44 BWR (absorber plate)	Possible Economic	As designed	***Possible Criticality***
24 BWR (thick absorber plate)	Possible Economic	Possible Economic	As designed

5.3.2 Misload Frequency Determination

Decision trees (Figures I through IV, located in Attachments I through IV, respectively) were developed to evaluate exceeding the criticality design basis due to misload errors for PWR fuel assemblies loaded into the available waste packages under a variety of assumptions for the treatment of absorber rods (see Assumption 3.8). A fifth decision tree (Figure V, Attachment V) was developed to similarly evaluate BWR fuel assemblies. Figures I through V show the nominal WP percentages.

The sequence development is not automatic and relies on a careful consideration of which fuel assemblies are being loaded into which waste packages, and what human errors are being committed. The consequence matrices are used to determine whether a sequence has a criticality consequence.

The following is some information used in the development of the decision trees:

- The likelihood of selecting an incorrect fuel assembly to load into the waste package is estimated based on the percentage of fuel assemblies with specific characteristics *from the total number of fuel assemblies to be delivered to the site over the 24-year period.*

- The South Texas (ST) waste packages are approximately two feet longer than any of the other PWR waste packages to accommodate the long ST fuel assemblies. Accordingly, when a ST fuel assembly is misloaded into any other waste package, it is assumed to be immediately recoverable and corrected. Likewise, when any non-ST fuel assembly is misloaded into the ST disposal container, it is assumed to be immediately recoverable and corrected. This assumption implies a verification HEP equal to 1.0, and is so reflected in the decision tree.

  The ST waste package is not explicitly represented on the PWR-C decision tree. PWR-C was based on the BWR decision tree, since for BWRs, the waste package designed for high-criticality fuel assemblies does indeed have the criticality controls designed into the WP. This omission is conservative in light of the assumption that all assemblies misloaded into a ST package are immediately detected and corrected.

- For cases PWR-B and PWR-D (see Attachments II and IV), there is no explicit mention of the absorber rod waste packages, since the assumptions for these cases state that the "no absorber" and "absorber rod" packages are of identical construction. The waste package in the decision tree, whether for low-criticality or high-criticality fuel assemblies, is referred to as "no absorber."

The calculation performed on the decision tree to generate the endstate probability is simply the product of the probabilities on each node of the endstate sequence. For example, in Figure I (Attachment I), endstate PA-4's probability is calculated as the product of:

Decision Tree Header	**Probability**
WP Usage (no absorber)	0.390
Select WP (intended WP)	0.995
Select FA (concept)	0.005
FA Type (MK)	0..951
Verification (failure)	0.001
Endstate Probability (Product)	1.84×10^{-6}

This endstate also represents a possible criticality concern, e.g., possibility of exceeding a criticality design basis. The total probability of misload leading to exceeding criticality design basis per disposal container (shown at the bottom of the decision trees and in the summary tables in Sections 6.1 through 6.5) is computed by simply adding all the endstates denoted with *criticality*. These endstates are further highlighted on the decision tree with a double-lined border.

The only exception to the straight multiplication method to calculate an endstate probability is for those endstates derived from a Select FA state of *(selection)*. In these cases, the product is multiplied by the number of assemblies in the waste package, since any of the individual assemblies could be misloaded. So if for $n_a = 21$ PWR, the probability was $p_1 = 2.25 \times 10^{-6}$, then the probability of the endstate would be $(2.25 \times 10^{-6})(21) = 4.73 \times 10^{-5}$ (see endstate PA-10 in Figure I, Attachment I). To determine the probability that two assemblies are misloaded, the calculation is:

$$(p_1)(n_a)(p_1)(n_a\text{-}1) = (p_1)^2(n_a)(n_a\text{-}1)$$

This calculation is used for all of the "selection (2)" sequences to compute the probability of a misload leading to a possible criticality concern with a mission success definition of two misloaded assemblies representing a possible consequence.

5.3.3 Parameterization and Sensitivity Analysis

The decision trees, within Excel, were structured to permit a parametric examination of the percentage of the types of waste packages that are available. These percentages are directly related to the expected percentage of types of fuel assemblies to be place in the repository. For examples, if the percentages of WPs for PWR SNF are the nominal values given in Section 5.1, then the expected fuel assembly percentages would be:

LK (no absorber: WP 1, WP 4)	35% + 4% = 39%
MK (absorber plates: WP 2, WP 5)	56% + 2% = 58%
HK (absorber rods: WP 3)	3% = 3%

Therefore, as the percentages for WPs change in the spreadsheet, the fuel assembly percentages would vary accordingly. The regression expressions were developed as a function of the fuel assembly percentages.

The base development of the decision trees included a single verification/recovery action at the end of the event sequence. This single action was established due to the uncertainty concerning the procedures and processes to be established for WP loading. To explore a range of possibilities in the (to be developed) loading procedures and processes, an additional verification/recovery action was added for both the WP selection and the fuel assembly (FA) selection human error. This recovery may take the form of an additional operator or supervisor overseeing the process, or some sort of electronic/automated system to "look over the shoulder" of the operator. This recovery action can be varied from zero (0.0), i.e., no recovery, to one (1.0), i.e., error detection always occurs. Interactively, this value can be changed on the Excel "Data" tab (shown in Attachment VI) for both the PWR and BWR cases.

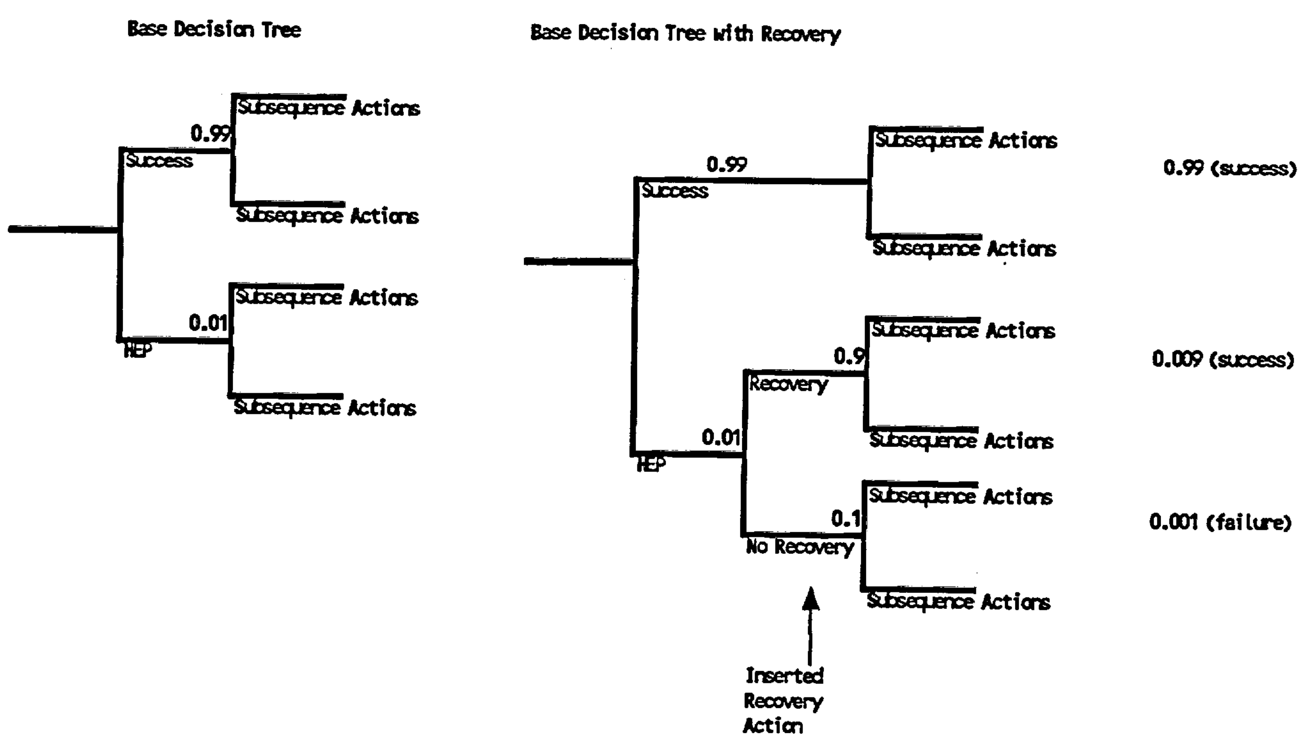
Typically, to model a recovery action, an additional branch point is added to the decision tree. To account for this sensitivity analysis, the HEP for the "recovered" action was modified as follows:

HEP for "Select FA" = Base Failure Probability * (1 - Recovery Probability)

As the recovery probability varies from zero to one, the HEP will vary from the original failure probability to zero (i.e., absolute error detection and recovery). The modified HEP is used in the originally developed decision tree.

Modeling the recovery action is this way can be justified by looking at a small portion of a tree (see Figure 5-1 below), where a recovery action has been inserted. The failure probability with the recovery action is 0.001, while the total probability for the success sequences is 0.999. If the failure probability is calculated as the original HEP multiplied by (1 - recovery probability), and inserted in the original tree, then the probability of the failure sequences will be (0.01)(0.1) = 0.001, which is the same as the failure probability with the recovery action. Accordingly, if the success path for the HEP is (1 - HEP) = 1 - 0.001 = 0.999, the success sequences will be equivalent to the sum of the success sequences in the tree with the recovery actions. Accordingly, the HEPs are modified as indicated above to emulate the recovery action.

Figure 5-1.
Decision Trees to Support Recovery Action Model



5.3.4 Selection of Waste Package HEP

The HEP for the selection of the WP is more complex than the selection error for fuel assemblies because there are two operators (Line operator and DC Area operator) involved. For this reason a separate human reliability analysis tree was developed to estimate the "Select WP" HEP. This tree is provided in Attachment VII. In the spreadsheet, the HEP calculated in this tree is automatically transferred to the "Data" tab (see Attachment VI). The relatively small value of the selection error versus the conceptual error is the basis for the assumptions developed in Section 3.7 (b).

6. Results

The total probability of misload is partitioned into different cases along two dimensions. The first dimension looks at the cause for the misload: conceptual versus selection error. The selection error is calculated for the resulting misload being one or two fuel assemblies ("selection (2)"). As the results show (see Sections 6.1, 6.3 and 6.5), the frequency of misloading two fuel assemblies (with a selection human error) is three to four orders of magnitude less than for one fuel assembly. Accordingly, the "selection (2)" frequencies are only provided for the PWR-A decision tree (Attachment I) for all selection sequences. For PWR-C and BWR decision trees (Attachments III and V), the "selection (2)" frequency are only given for the "criticality" sequences. Further, the "selection (2)" are not discussed below because of the insignificant contribution.

The second dimension examined is the waste package type into which the misloaded fuel assemblies were placed. Typically, the WP designed for the high-criticality (HK) fuel assemblies had few or no misloads; accordingly, the regression expressions were developed only for the WP designed to handle low-criticality (LK) and mid-criticality (MK) fuel assemblies.

6.1 Results for Case PWR-A

For the nominal values of the PWR-A case, the following table summarizes the results, i.e., the probability of a misload leading to exceeding criticality design basis:

	No Absorber	Absorber Plates	Absorber Rods	(Total)
Concept	4.41E-06	0.00E+00	1.33E-07	4.54E-06
Selection	5.50E-05	3.65E-06	3.77E-08	5.37E-05
Selection (2)	2.13E-09	1.26E-11	6.87E-07	2.15E-09
Total	**5.44E-05**	**3.65E-06**	**1.71E-07**	**5.83E-05**

As indicated above, the "Selection (2)" results (for misloading two fuel assemblies on selection errors) is orders of magnitude less than either the conceptual or selection errors. The selection error is approximately an order and half magnitude greater than the conceptual error. There can not be a conceptual error when loading an absorber plate package, since if the Line operator is aware of high-criticality (HK) fuel assembly that is being loaded, absorber rods will be placed into the fuel assembly. If the number of PWR WPs expected to be loaded in one year is 200 packages (from Key Assumption 3, Reference 7.9), then the frequency of a PWR waste package being misloaded such that the criticality design basis could be exceeded is $(5.83 \times 10^{-5})(200) = 1.17 \times 10^{-2}$/yr. (The expected number of PWR WPs to be loaded is estimated by summing the total number of the five types of PWR WPs shown in Table 3.9 of Ref. 7.9 and dividing by 24 years, the time required to load all of the fuel assemblies.)

When considering a recovery factor of 0.9 for both the WP selection and FA selection, the total probability of misload resulting in potentially exceeding the criticality design basis is 5.82×10^{-6}. This probability is estimated by changing the value of the recovery factor for WP-incorrect, FA-concept, and FA-select from 0.0 to 0.9 (see Attachment VI). This will change the appropriate values of the HEP with recovery for these three actions in the decision tree as per the discussion in Section 5.3.3. Since the HEPs are integrated in the decision tree logic, the result is not a straight multiplication of the probability with a 0.0 recovery factor. Accordingly, the frequency of a PWR waste package misload resulting in potentially exceeding the criticality design basis is $(5.82 \times 10^{-6})(200) = 1.16 \times 10^{-3}$/yr. Depending on the actual procedures and processes used to load the fuel assemblies into the waste packages, the expected frequency would be bounded by these values.

The results of the regression analysis for both the no absorber and the absorber plate cases for PWR-A are summarized below. The R-squared (R^2) value shown below indicates the ability of the regression expression to predict the misload probability; the closer to 1.0, the better the predictive value. Other factors that can be examined to evaluate the regression fit are the *Significance F* for the regression and the *P-value* for the coefficients; the smaller these values, the better the regression fit. These parameters and other details of the regression analysis are available in Attachment VIII. Note the *P-value* for the intercept of the regression expression is relatively large, but the intercept is considered a necessary part of the model and retained regardless of the *P-value*. These observations are also applicable to the results in Sections 6.2 through 6.5.

PWR-A	No Absorber
R-squared	**0.999300532**
Coefficients	
Intercept	1.0639E-06
LK^2	-0.00019831
MK^2	7.90505E-06
LK*MK	2.68078E-05
LK	0.000201046
MK	-5.8763E-06

PWR-A	Absorber Plate
R-squared	**0.9986142**
Coefficients	
Intercept	5.96767E-06
MK^2	-0.00020824
MK	0.000208447
LK*MK	-0.0002103

6.2 Results for Case PWR-B

For the nominal values of the PWR-B case, the following table summarizes the results, i.e., the probability of a misload leading to exceeding criticality design basis:

	No Absorber	Absorber Plates	(Total)
Concept	4.76E-06	0.00E+00	4.76E-06
Selection	5.35E-05	1.74E-07	5.37E-05
Total	**5.83E-05**	**1.74E-07**	**5.85E-05**

As indicated above, the "Selection (2)" results (for misloading two fuel assemblies on selection errors) is orders of magnitude less than either the conceptual or selection errors, and and therefore was not evaluated for this case. The selection error is approximately an order and half magnitude greater than the conceptual error. There can not be a conceptual error when loading an absorber plate package, since if the Line operator is aware a high-criticality (HK) fuel assembly is being loaded, absorber rods will be placed into the fuel assembly. Since the no absorber package and the absorber rod package are identical, the "no absorber" label is used for both types. If the number of PWR WPs expected to be loaded in one year is 200 packages (from Key Assumption

3, reference 7.9), the frequency of a PWR waste package being misloaded such that the criticality design basis could be exceeded is $(5.85 \times 10^{-5})(200) = 1.17 \times 10^{-2}$/yr.

When considering a recovery factor of 0.9 for both the WP selection and FA selection, the total probability of misload resulting in potentially exceeding the criticality design basis is 5.87×10^{-6}. Thus the frequency of a PWR waste package misload resulting in potentially exceeding the criticality design basis is $(5.87 \times 10^{-6})(200) = 1.17 \times 10^{-3}$/yr. Depending on the actual procedures and processes used to load the fuel assemblies into the waste packages, the expected frequency would be bounded by these values.

The results of the regression analysis for both the no absorber and the absorber plate cases for PWR-B are summarized below. Details of the regression analysis are available in Attachment VIII.

PWR-B	No Absorber
R-squared	**0.998837064**
Coefficients	
Intercept	0.000209131
LK*MK	0.000209584
LK	-0.00020638
MK	-0.00020371

PWR-B	Absorber Plate
R-squared	**0.998523718**
Coefficients	
Intercept	5.96135E-09
MK^2	-9.9905E-06
MK	909895E-06
LK*MK	-1.0087E-05

6.3 Results for Case PWR-C

For the nominal values of the PWR-C case, the following table summarizes the results, i.e., the probability of a misload leading to exceeding criticality loading criteria:

	No Absorber	Absorber Plates	Absorber Rods	(Total)
Concept	4.68E-06	2.96E-07	0.00E+00	4.98E-06
Selection	5.01E-05	3.65E-06	0.00E+00	5.37E-05
Selection (2)	2.13E-09	1.26E-11	0.00E+00	2.15E-09
Total	**5.47E-05**	**3.94E-06**	**0.00E+00**	**5.87E-05**

As indicated above, the "Selection (2)" results (for misloading two fuel assemblies on selection errors) is orders of magnitude less than either the conceptual or selection errors. The selection error is approximately an order and half magnitude greater than the conceptual error. There can be no misload into the "rod" packages, since the criticality control is assumed inherent in the package in this case. If the number of PWR WPs expected to be loaded in one year is 200 packages (from Key Assumption 3, Reference 7.9), then the frequency of a PWR waste package being misloaded such that the criticality design basis could be exceeded is $(5.87 \times 10^{-5})(200) = 1.17 \times 10^{-2}$/yr.

When considering a recovery factor of 0.9 for both the WP selection and FA selection, the total probability of misload resulting in potentially exceeding the criticality design basis is 8.45×10^{-6}. Thus the frequency of a PWR waste package misload resulting in potentially exceeding the criticality design basis is $(8.45 \times 10^{-6})(200) = 1.69 \times 10^{-3}$/yr. Depending on the actual procedures and processes used to load the fuel assemblies into the waste packages, the expected frequency would be bounded by these values.

The results of the regression analysis for both the no absorber and the absorber plate cases for PWR-C are summarized below. Details of the regression analysis are available in Attachment VIII.

PWR-C	No Absorber
R-squared	**0.999544201**
Coefficients	
Intercept	4.23477E-06
LK^2	-0.00021378
MK^2	1.91724E-05
LK*MK	1.72634E-05
LK	0.000214066
MK	-1.8396E-05

PWR-C	Absorber Plate
R-squared	0.997872071
Coefficients	
Intercept	4.35403E-07
MK^2	-0.00022734
MK	0.000227933
LK*MK	-0.00023353

6.4 Results for Case PWR-D

For the nominal values of the PWR-D case, the following table summarizes the results, i.e., the probability of a misload leading to exceeding criticality loading criteria:

	No Absorber	Absorber Plates	(Total)
Concept	4.86E-06	0.00E+00	4.86E-06
Selection	5.09E-05	0.00E+00	5.09E-05
Total	**5.58E-05**	**0.00E+00**	**5.58E-05**

As indicated above, the "Selection (2)" results (for misloading two fuel assemblies on selection errors) is orders of magnitude less than either the conceptual or selection errors, and therefore was not evaluated for this case. The selection error is approximately an order and half magnitude greater than the conceptual error. There can neither a conceptual nor selection error when loading an absorber plate package, since this case assumes the absorber rods are already loaded in the high-criticality (HK) fuel assemblies. Since the no absorber package and the absorber rod package are indistinguishable in this case, the "no absorber" label is used for both types. If the number of PWR WPs expected to be loaded in one year is 200 packages (from Key Assumption 3, Reference 7.9), then the frequency of a PWR waste package being misloaded such that the criticality design basis could be exceeded is $(5.58 \times 10^{-5})(200) = 1.12 \times 10^{-2}$/yr.

When considering a recovery factor of 0.9 for both the WP selection and FA selection, the total probability of misload resulting in potentially exceeding the criticality design basis is 5.60×10^{-6}. Thus the frequency of a PWR waste package misload resulting in potentially exceeding the criticality design basis is $(5.60 \times 10^{-6})(200) = 1.12 \times 10^{-3}$/yr. Depending on the actual procedures and processes used to load the fuel assemblies into the waste packages, the expected frequency would be bounded by these values.

The results of the regression analysis for the no absorber case for PWR-D are summarized below. For case PWR-D, no misloads into a WP with absorber plates is possible, since absorber rods are preloaded into the fuel assemblies. Details of the regression analysis are available in Attachment VIII.

PWR-D	No Absorber
R-squared	0.999814996
Coefficients	
Intercept	4.85696E-06
MK^2	-0.00021173
MK	0.000210616

6.5 Results for Case BWR

For the nominal values of the BWR case, the following table summarizes the results, i.e., the probability of a misload leading to exceeding criticality loading criteria:

	No Absorber	Plates	Thick Plates	(Total)
Concept	4.82E-06	1.61E-07	0.00E+00	4.98E-06
Selection	8.84E-05	3.14E-06	0.00E+00	9.15E-05
Selection (2)	7.24E-09	9.58E-12	0.00E+00	7.25E-09
Total	**9.32E-05**	**3.30E-06**	**0.00E+00**	**9.65E-05**

As indicated above, the "Selection (2)" results (for misloading two fuel assemblies on selection errors) is orders of magnitude less than either the conceptual or selection errors. The selection error is approximately an order and half magnitude greater than the conceptual error. There can not be a misload into the Thick Plate waste package. If the number of BWR WPs expected to be loaded in one year is 120 packages (from Key Assumption 3, reference 7.9), the frequency of a BWR waste package being misloaded such that the criticality design basis could be exceeded is $(9.65 \times 10^{-5})(120) = 1.16 \times 10^{-2}$/yr. The number of expected BWR waste packages to be loaded per years is calculated in a manner similar to PWRs described in Section 6.1.

When considering a recovery factor of 0.9 for both the WP selection and FA selection, the total probability of misload resulting in potentially exceeding the criticality design basis is 9.59×10^{-6}. Thus the frequency of a BWR waste package misload resulting in potentially exceeding the criticality design basis is $(9.59 \times 10^{-6})(120) = 1.15 \times 10^{-3}$/yr. Depending on the actual procedures and processes used to load the fuel assemblies into the waste packages, the expected frequency would be bounded by these values.

The results of the regression analysis for both the no absorber and the absorber plate cases for BWR are summarized below. Details of the regression analysis are available in Attachment VIII.

BWR	No absorber
R-squared	**0.999374599**
Coefficients	
Intercept	4.69836E-07
LK^2	-0.000453153
LK	0.00045624

BWR	Absorber Plate
R-squared	**0.93357571**
Coefficients	
Intercept	5.17856E-06
MK^2	-0.000350922
MK	0.000393047
LK*MK	-0.000475537

6.6 Final Observations

Despite the number of differing assumptions made to generate cases PWR-A, PWR-B, PWR-C, and PWR-D, the results do not substantially differ. The most non-conservative case (PWR-D) is only marginally better than the other cases. On the whole, the probability of a misload leading exceeding criticality design basis is approximately 0.01 package/year. This is true for both PWR and BWR fuel assemblies.

The expected number of PWR waste packages to be misloaded over the entire loading period (24 years) is approximately (0.01)(24) = 0.24 waste packages. Similarly, the expected number of misloaded BWR waste packages is 0.24 waste packages. Therefore, it is expected that less than one waste package/waste form combination will be misloaded in the entire repository at the completion of the loading phase.

The tables following the decision trees in Attachments I through V show the results based on the waste package type (e.g., for PWRs, no absorber, absorber plate, and absorber rod). These results show that the no absorber waste package are more likely to be misloaded; this is expected since there is no additional criticality controls built into these waste packages. Without the no absorber waste packages available for loading (i.e., eliminate that waste package design), the frequency of misload would drop by approximately one order of magnitude.

The sensitivity analysis performed by including a recovery factor for the human error when they occurred (and not just at the end of the loading process), decreased the probability of a misload leading to exceeding criticality loading criteria by about an order of magnitude. This was driven by the choice of the recovery factor of 0.9. A more representative value can be used when there is a greater understanding of the loading process, and what checks and balances exist for confirming operator actions. However, when using a recovery factor of 0.9, the expected number of misloaded waste packages (either PWR or BWR) over the entire loading period (24 years) is approximately 0.001 x 24 = 0.024 waste packages.

The R-squared values for each of the regression expressions is high, indicating the generated regression expressions will be good predictors of the probability of a misload leading to exceeding the criticality design basis as a function of fuel assembly percentages.

Relying on these results from a distinct criticality concern is conservative. Human errors will not be made on a strictly criticality basis (i.e., errors will result in a combination of criticality and thermal limit concerns). From examination of the decision trees, it is clear that they only approximate the large number of combinations in which a misload might occur. As an alternative to the methods presented here, a simulation (e.g., Monte Carlo simulation) could be performed that would accurately model the combination of errors leading to a waste package with a possible thermal and/or criticality consequence. Such a simulation could more comprehensively consider the arrangement of the storage area, the actual number of stored assemblies, the distribution of fuel assemblies as they arrive in the transport casks, the probability that the absorber rod is not present (when required), etc. These issues were too complex to handle within the decision tree framework.

This analysis should be revisited as the details are developed of how the fuel assemblies are handled from the time they are removed from the transport casks to the time they are placed into a waste package. Details concerning the procedures and operational practices can be used to further refine the human error probabilities used in this analysis.

7. References

7.1 *Preliminary List of Waste Package Designs for VA*, Document Identifier (DI) Number: BBA000000-01717-3300-00008 REV 02, Civilian Radioactive Waste Management System (CRWMS), Management & Operating Contractor (M&O).

7.2 *Determination of Waste Package Design Configurations*, DI Number: BBAA00000-01717-0200-00017 REV 00, CRWMS M&O.

7.3 *Criticality Safety for Handling, Sorting, and Transporting LWR Fuel at Fuels and Materials Facilities*, Regulatory Guide 3.58, NRC, October 1986.

7.4 *Topical Report on Actinide-Only Burnup Credit for PWR Spent Nuclear Fuel Packages, Draft Revision 1*, Office of Civilian Radioactive Waste Management (OCRWM), DOE/RW-0472 Rev. 1, April 1997.

7.5 *Reference Design Description for a Geologic Repository*, DI Number: B000000000-01717-5707-00002 REV 01, CRWMS, M&O.

7.6 *Assembly Transfer System Design Analysis (Draft)*, DI Number: BCBD00000-01717-0200-00007 REV 00A, CRWMS, M&O.

7.7 Swain, A. D. and Guttman, H. E., *Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications*, Sandia National Laboratories, prepared for the U.S. Nuclear Regulatory Commission, NUREG/CR-1278, August 1983.

7.8 *Mined Geological Disposal System Concept of Operations*, DI Number: B00000000-01717-00004 REV 01, CRWMS M&O.

7.9 *Controlled Design Assumptions Document*, DI Number: B000000000-01717-4600-00032 REV 04, ICN2, CRWMS M&O.

8. Attachments

The following attachments are provided to support this engineering calculation:

Attachment I - PWR-A Exceeding Criticality Loading Criteria Decision Tree and Endstate Notes

Attachment II - PWR-B Exceeding Criticality Loading Criteria Decision Tree

Attachment III - PWR-C Exceeding Criticality Loading Criteria Decision Tree

Attachment IV - PWR-D Exceeding Criticality Loading Criteria Decision Tree

Attachment V - BWR Exceeding Criticality Loading Criteria Decision Tree

Attachment VI - Data "tab" for PWR and BWR Cases

Attachment VII - Select WP Human Reliability Analysis

Attachment VIII - Summary of PWR/BWR Regression Analysis Results

ATTACHMENT I

PWR-A EXCEEDING CRITICALITY LOADING CRITERIA DECISION TREE AND ENDSTATE NOTES

Figure I - PWR-A Exceeding Criticality Loading Criteria Decision Tree

	WP Usage	Select WP	Select FA	FA Type	Verification			Endstate		
	0.390	0.995	0.994		0.990	3.82E-01		PA-1		
	(no absorber)	(intended WP)	(intended FA)	(LK)	(success)	(no conseq.)				
					0.010	3.86E-03		PA-2		
					(failure)	(no conseq.)				
			0.005	0.951	0.999	1.84E-03		PA-3		
			(concept)	(MK)	(success)	(no conseq.)				
					0.001	1.84E-06		PA-4		
					(failure)	(criticality)				
				0.049	0.999	9.53E-05		PA-5		
				(HK)	(success)	(no conseq.)				
					0.001	9.54E-08		PA-6		
					(failure)	(no conseq.)				
			0.001	0.390	0.990	3.15E-03		PA-7	9.43E-06	
			(selection)	(LK)	(success)	(no conseq.)				
					0.010	3.18E-05		PA-8	9.62E-10	
					(failure)	(no conseq.)				
				0.580	0.990	4.68E-03		PA-9	2.09E-05	
				(MK)	(success)	(no conseq.)				
					0.010	4.73E-05		PA-10	2.13E-09	
					(failure)	(criticality)				
				0.030	0.990	2.42E-04		PA-11	5.58E-08	
				(HK)	(success)	(no conseq.)				
					0.010	2.44E-06		PA-12	5.69E-12	
					(failure)	(criticality)				
		0.005	0.918	0.994	0.999	1.78E-03		PA-13		
		(wrong WP)	(plate)	(intended FA)	(success)	(no conseq.)				
					0.001	1.78E-06		PA-14		
					(failure)	(no conseq.)				
				0.005	0.951	0.999	8.52E-06	PA-15		
				(concept)	(MK)	(success)	(no conseq.)			
						0.001	8.53E-09	PA-16		
						(failure)	(no conseq.)			
					0.049	0.999	4.41E-07	PA-17		
					(HK)	(success)	(no conseq.)			
						0.001	4.41E-10	PA-18		
						(failure)	(no conseq.)			
				0.001	0.390	0.990	1.45E-05	PA-19	2.01E-10	
				(selection)	(LK)	(success)	(no conseq.)			
						0.010	1.47E-07	PA-20	2.06E-14	
						(failure)	(no conseq.)			
					0.580	0.990	2.16E-05	PA-21	4.46E-10	
					(MK)	(success)	(no conseq.)			
						0.010	2.18E-07	PA-22	4.55E-14	
						(failure)	(no conseq.)			
					0.030	0.990	1.12E-06	PA-23	1.19E-12	
					(HK)	(success)	(no conseq.)			
						0.010	1.13E-08	PA-24	1.22E-16	
						(failure)	(criticality)			
			0.049	0.994	0.999	9.54E-05		PA-25		
			(rod)	(intended FA)	(success)	(no conseq.)				
					0.001	9.55E-08		PA-26		

Figure I - PWR-A Exceeding Criticality Loading Criteria Decision Tree

					(failure)	(no conseq.)				
				0.005	0.951	0.999	4.56E-07	PA-27		
				(concept)	(MK)	(success)	(no conseq.)			
						0.001	4.57E-10	PA-28		
						(failure)	(criticality)			
					0.049	0.999	2.36E-08	PA-29		
					(HK)	(success)	(no conseq.)			
						0.001	2.36E-11	PA-30		
						(failure)	(no conseq.)			
				0.001	0.390	0.990	7.79E-07	PA-31	5.78E-13	
				(selection)	(LK)	(success)	(no conseq.)			
						0.010	7.87E-09	PA-32	5.90E-17	
						(failure)	(no conseq.)			
					0.580	0.990	1.16E-06	PA-33	1.28E-12	
					(MK)	(success)	(no conseq.)			
						0.010	1.17E-08	PA-34	1.30E-16	
						(failure)	(criticality)			
					0.030	0.990	5.99E-08	PA-35	3.42E-15	
					(HK)	(success)	(no conseq.)			
						0.010	6.05E-10	PA-36	3.49E-19	
						(failure)	(criticality)			
			0.033	1.000	1.000	6.41E-05		PA-37		
			(ST)	(any FA)	(success)	(no conseq.)				
	0.580	0.995	0.994		0.990	5.68E-01		PA-38		
	(plate/ST)	(intended WP)	(intended FA)	(MK)	(success)	(no conseq.)				
					0.010	5.74E-03		PA-39		
					(failure)	(no conseq.)				
			0.005	0.929	0.999	2.68E-03		PA-40		
			(concept)	(LK)	(success)	(no conseq.)				
					0.001	2.68E-06		PA-41		
					(failure)	(no conseq.)				
				0.071	0.999	2.06E-04		PA-42		
				(HK)	(success)	(no conseq.)				
					0.001	2.06E-07		PA-43		
					(failure)	(no conseq.)				
			0.001	0.390	0.990	4.68E-03		PA-44	2.09E-05	
			(selection)	(LK)	(success)	(no conseq.)				
					0.010	4.73E-05		PA-45	2.13E-09	
					(failure)	(no conseq.)				
				0.580	0.990	6.96E-03		PA-46	4.61E-05	
				(MK)	(success)	(no conseq.)				
					0.010	7.03E-05		PA-47	4.71E-09	
					(failure)	(no conseq.)				
				0.030	0.990	3.60E-04		PA-48	1.23E-07	
				(HK)	(success)	(no conseq.)				
					0.010	3.64E-06		PA-49	1.26E-11	
					(failure)	(criticality)				
		0.005	0.886	0.994	0.999	2.56E-03		PA-50		
		(wrong WP)	(no absorber)	(intended FA)	(success)	(no conseq.)				
					0.001	2.56E-06		PA-51		
					(failure)	(criticality)				
				0.005	0.929	0.999	1.19E-05	PA-52		

Figure I - PWR-A Exceeding Criticality Loading Criteria Decision Tree

				(concept)	(LK)	(success)	(no conseq.)			
						0.001	1.20E-08	PA-53		
						(failure)	(no conseq.)			
					0.071	0.999	9.19E-07	PA-54		
					(HK)	(success)	(no conseq.)			
						0.001	9.20E-10	PA-55		
						(failure)	(criticality)			
				0.001	0.390	0.990	2.09E-05	PA-56	4.15E-10	
				(selection)	(LK)	(success)	(no conseq.)			
						0.010	2.11E-07	PA-57	4.24E-14	
						(failure)	(no conseq.)			
					0.580	0.990	3.11E-05	PA-58	9.19E-10	
					(MK)	(success)	(no conseq.)			
						0.010	3.14E-07	PA-59	9.37E-14	
						(failure)	(criticality)			
					0.030	0.990	1.61E-06	PA-60	2.46E-12	
					(HK)	(success)	(no conseq.)			
						0.010	1.62E-08	PA-61	2.51E-16	
						(failure)	(criticality)			
			0.068	0.994	0.999	1.32E-04		PA-62		
			(rod)	(intended FA)	(success)	(no conseq.)				
					0.001	1.32E-07		PA-63		
					(failure)	(criticality)				
				0.005	0.929	0.999	6.18E-07	PA-64		
				(concept)	(LK)	(success)	(no conseq.)			
						0.001	6.19E-10	PA-65		
						(failure)	(criticality)			
					0.071	0.999	4.75E-08	PA-66		
					(HK)	(success)	(no conseq.)			
						0.001	4.76E-11	PA-67		
						(failure)	(no conseq.)			
				0.001	0.390	0.990	1.61E-06	PA-68	2.46E-12	
				(selection)	(LK)	(success)	(no conseq.)			
						0.010	1.62E-08	PA-69	2.51E-16	
						(failure)	(no conseq.)			
					0.580	0.990	2.39E-06	PA-70	5.44E-12	
					(MK)	(success)	(no conseq.)			
						0.010	2.41E-08	PA-71	5.65E-16	
						(failure)	(criticality)			
					0.030	0.990	1.24E-07	PA-72	1.45E-14	
					(HK)	(success)	(no conseq.)			
						0.010	1.25E-09	PA-73	1.48E-18	
						(failure)	(criticality)			
			0.045	1.000	1.000	1.32E-04		PA-74		
			(ST)	(any FA)	(success)	(no conseq.)				
	0.030	0.995	1.000		0.990	2.96E-02		PA-75		
	(rod)	(intended WP)	(any FA)		(success)	(no conseq.)				
					0.010	2.98E-04		PA-76		
					(failure)	(no conseq.)				
		0.005	0.402	0.994	0.999	6.00E-05		PA-77		
		(wrong WP)	(no absorber)	(intended FA)	(success)	(no conseq.)				
					0.001	6.01E-08		PA-78		
					(failure)	(no conseq.)				

Figure I - PWR-A Exceeding Criticality Loading Criteria Decision Tree

				0.005	0.402	0.999	1.21E-07	PA-79		
				(concept)	(LK)	(success)	(no conseq.)			
						0.001	1.21E-10	PA-80		
						(failure)	(no conseq.)			
					0.598	0.999	1.80E-07	PA-81		
					(MK)	(success)	(no conseq.)			
						0.001	1.81E-10	PA-82		
						(failure)	(criticality)			
				0.001	1.000	0.990	1.26E-06	PA-83	1.50E-12	
				(selection)	(any FA)	(success)	(no conseq.)			
						0.010	1.27E-08	PA-84	1.53E-16	
						(failure)	(no conseq.)			
			0.577	0.994	0.990	8.54E-05		PA-85		
			(plate)	(intended FA)	(success)	(no conseq.)				
					0.010	8.62E-07		PA-86		
					(failure)	(no conseq.)				
				0.005	0.402	0.999	1.74E-07	PA-87		
				(concept)	(LK)	(success)	(no conseq.)			
						0.001	1.74E-10	PA-88		
						(failure)	(no conseq.)			
					0.598	0.999	2.59E-07	PA-89		
					(MK)	(success)	(no conseq.)			
						0.001	2.59E-10	PA-90		
						(failure)	(no conseq.)			
				0.001	1.000	0.990	8.59E-08	PA-91		
				(selection)	(any FA)	(success)	(no conseq.)			
						0.010	8.68E-10	PA-92		
						(failure)	(no conseq.)			
			0.021	1.000	1.000	3.10E-06		PA-93		
			(ST)	(any FA)	(success)	(no conseq.)				
			No Absorber		Plates		Rods		(Total)	
		Concept	4.41E-06		0.00E+00		1.33E-07		4.54E-06	
		Selection	5.00E-05		3.65E-06		3.77E-08		5.37E-05	
		Selection (2)	2.13E-09		1.26E-11		6.87E-16		2.15E-09	
		Total	5.44E-05		3.65E-06		1.71E-07		5.83E-05	
		Probability of Misload Leading to Exceeding Criticality Loading Criteria due to Concept Error per Waste Package			4.54E-06		Probability of Misload Leading to Exceeding Criticality Loading Criteria a No Absorber package			5.44E-05
		Probability of Misload Leading to Exceeding Criticality Loading Criteria due to Selection Error per Waste Package			5.37E-05		Probability of Misload Leading to Exceeding Criticality Loading Criteria an Absorber Plate package			3.65E-06
		Probability of Misload Leading to Exceeding Criticality Loading Criteria due to Selection (2) Error per Waste Package			2.15E-09		Probability of Misload Leading to Exceeding Criticality Loading Criteria an Absorber Rod package			1.71E-07

Table I.
PWR-A Decision Tree Endstate Notes

Endstate notes are provided for just the PWR-A decision tree. The other PWR cases and the BWR case decision trees are of a similar structure as PWR-A such that these endstate notes should serve as an illustrative example to permit the reader to follow and understand the decision tree event sequences for any of the decision trees in Attachments I – V.

Endstate	Endstate Notes for Case PWR-A Exceeding Criticality Loading Criteria Decision Tree
PA-1	For criticality concerns, the operator performed every task correctly. That is, one of the *no-absorber* waste packages was selected for a low reactivity fuel assembly.
PA-2	For criticality concerns, the operator performed every task correctly, except the final verification. Therefore, there is no criticality concern due to misloading, however, the fuel assembly records are likely to be corrupted.
PA-3	The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., MK, HK). A mid-range criticality (MK) fuel assembly is loaded into a waste package with no absorber plates, but the error is identified and corrected through successful verification.
PA-4	The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., MK, HK). A mid-range criticality (MK) fuel assembly is loaded into a waste package with no absorber plates, but the error is **not** identified or corrected through verification, creating a possible criticality concern due to misloading. No credit is given for recovery as fuel assemblies are continued to be loaded.
PA-5/PA-6	The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., MK, HK). A high-range criticality (HK) fuel assembly is loaded into a waste package with no absorber plates, but since this is a conceptual selection error, the Line operator will load absorber rods into the fuel assembly prior to loading, therefore, there is no criticality concern, only an economic one, for using a waste package with absorber plates unnecessarily. If verification is not successful, the fuel assembly records are likely to be corrupted.
PA-7/PA-8	The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended. The operator has selected a fuel assembly of the same type intended for this waste package. Therefore, with or without successful verification, there is no criticality concern due to misloading, however, without successful verification, the fuel assembly records are likely to be corrupted.
PA-9	The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended. The operator has selected a mid-criticality (MK) fuel assembly, but the error is identified and corrected through successful verification.
PA-10	The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended. The operator has selected a mid-criticality (MK) fuel assembly, but the error is **not** identified or corrected through verification, creating a possible criticality concern due to misloading.
PA-11	The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended. The operator has selected a high-criticality (HK) fuel assembly, but the error is identified and corrected through successful verification.
PA-12	The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended. The operator has selected a high-criticality (HK) fuel assembly, but the error is **not** identified or corrected through verification, creating a possible criticality concern due to misloading. Note: since this was a selection error, the operator will not place absorber rods in the fuel assembly.

Endstate	Endstate Notes for Case PWR-A Exceeding Criticality Loading Criteria Decision Tree
PA-13/PA-14	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator selects the intended fuel assembly (low-criticality) , and since this package can handle any fuel assembly in the low-criticality and mid-criticality range, there is no chance of a criticality concern. However, unless corrected through successful verification (i.e., PA-13), the fuel assembly records are likely to be corrupted and an economic impact may occur (i.e., PA-14).
PA-15/PA-16	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., MK, HK). A mid-range criticality (MK) fuel assembly is loaded into a waste package with absorber plates which would not lead to a criticality concern. However, unless corrected through successful verification (i.e., PA-15), the fuel assembly records are likely to be corrupted and an economic impact may occur (i.e., PA-16).
PA-17/PA-18	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., MK, HK). A high-range criticality (HK) fuel assembly is loaded into a waste package with absorber plates, but since this is a conceptual selection error, the Line operator will load absorber rods into the fuel assembly prior to loading, therefore, there is no criticality concern, only an economic one, for using a waste package with absorber plates unnecessarily. If verification is not successful, the fuel assembly records are likely to be corrupted.
PA-19/PA-20	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (LK). The operator has selected a fuel assembly of the same type intended for this waste package. Therefore, with or without successful verification, there is no criticality concern due to misloading, however, without successful verification, the fuel assembly records are likely to be corrupted.
PA-21/PA-22	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (LK). The operator has selected a fuel assembly in the mid-criticality range, for which this waste package with absorber plates is designed to handle. Therefore, with or without successful verification, there is no criticality concern due to misloading, however, without successful verification, the fuel assembly records are likely to be corrupted.
PA-23	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (LK). The operator has selected a fuel assembly in the high-criticality range for an absorber plate package (possible criticality concern), but the error is identified and corrected through successful verification. Note: since this was a selection error, the operator will not place absorber rods in the fuel assembly.
PA-24	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (LK). The operator has selected a fuel assembly in the high-criticality range for an absorber plate package (possible criticality concern), but the error is **not** identified or corrected through verification, creating a possible criticality concern due to misloading. Note: since this was a selection error, the operator will not place absorber rods in the fuel assembly.

Endstate	Endstate Notes for Case PWR-A Exceeding Criticality Loading Criteria Decision Tree
PA-25/PA-26	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator selects the intended fuel assembly (low-criticality) , and since this package can handle fuel assemblies in the low-criticality, there is no chance of a criticality concern. However, unless corrected through successful verification (i.e., PA-25), the fuel assembly records are likely to be corrupted and an economic impact may occur (i.e., PA-126).
PA-27	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., MK, HK). A mid-range criticality (MK) fuel assembly is loaded into a waste package with no absorber plates which could lead to a criticality concern, but the error is identified and corrected through successful verification.
PA-28	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., MK, HK). A mid-range criticality (MK) fuel assembly is loaded into a waste package with no absorber plates which could lead to a criticality concern, but the error is not identified or corrected through verification, creating a possible criticality concern due to misloading.
PA-29/PA-30	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., MK, HK). A high-range criticality (HK) fuel assembly is loaded into a no absorber waste package, but since this is a conceptual selection error, the Line operator will load absorber rods into the fuel assembly prior to loading, therefore, there is no criticality concern. If verification is not successful, the fuel assembly records are likely to be corrupted.
PA-31/PA-32	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (LK). The operator has selected a fuel assembly of the same type intended for this waste package. Therefore, with or without successful verification, there is no criticality concern due to misloading, however, without successful verification, the fuel assembly records are likely to be corrupted.
PA-33	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (LK). The operator has selected a mid-criticality (MK) fuel assembly, but the error is identified and corrected through successful verification.
PA-34	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (LK). The operator has selected a mid-criticality (MK) fuel assembly, but the error is not identified or corrected through verification, creating a possible criticality concern due to misloading.
PA-35	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (LK). The operator has selected a mid-criticality (HK) fuel assembly, but the error is identified and corrected through successful verification.

Endstate	Endstate Notes for Case PWR-A Exceeding Criticality Loading Criteria Decision Tree
PA-36	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (LK). The operator has selected a high-criticality (HK) fuel assembly, but the error is **not** identified or corrected through verification, creating a possible criticality concern due to misloading. Note: since this was a selection error, the operator will not place absorber rods in the fuel assembly.
PA-37	For criticality concerns, the operator has selected the wrong waste package (an ST package). If anything but an ST fuel assembly is loaded into this package, the error will be always be corrected through verification. If an ST fuel assembly is loaded into this package, and verification is not successful (not shown on the decision tree), then there is still no criticality concern, however, the fuel assembly records are likely to be corrupted.
PA-38	For criticality concerns, the operator performed every task correctly. That is, one of the absorber plate waste packages was selected for a mid-range reactivity fuel assembly.
PA-39	For criticality concerns, the operator performed every task correctly, except the final verification. Therefore, there is no criticality concern due to misloading, however, the fuel assembly records are likely to be corrupted.
PA-40/PA-41	The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, HK). A low-range criticality (LK) fuel assembly is loaded into a waste package with absorber plates which would not lead to a criticality concern. However, unless corrected through successful verification (i.e., PA-40), the fuel assembly records are likely to be corrupted and an economic impact may occur (i.e., PA-41).
PA-42/PA-43	The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, HK). A high-range criticality (HK) fuel assembly is loaded into a waste package with absorber plates, but since this is a conceptual selection error, the Line operator will load absorber rods into the fuel assembly prior to loading, therefore, there is no criticality concern, only an economic one, for using a waste package with absorber plates unnecessarily. If verification is not successful, the fuel assembly records are likely to be corrupted.
PA-44/PA-45	The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended. The operator has selected a low-criticality fuel assembly (LK). Therefore, with or without successful verification, there is no criticality concern due to misloading, however, without successful verification, the fuel assembly records are likely to be corrupted.
PA-46/PA-47	The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended. The operator has selected a fuel assembly of the same type intended for this waste package (MK). Therefore, with or without successful verification, there is no criticality concern due to misloading, however, without successful verification, the fuel assembly records are likely to be corrupted.
PA-48	The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended. The operator has selected a high-criticality (HK) fuel assembly, but the error is identified and corrected through successful verification.
PA-49	The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended. The operator has selected a high-criticality (HK) fuel assembly, but the error is **not** identified or corrected through verification, creating a possible criticality concern due to misloading. Note: since this was a selection error, the operator will not place absorber rods in the fuel assembly.

Endstate	Endstate Notes for Case PWR-A Exceeding Criticality Loading Criteria Decision Tree
PA-50	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator selects the intended fuel assembly (mid-criticality), and since this package can not handle the MK fuel assembly, there is a chance of a criticality concern, but the error is identified and corrected through successful verification.
PA-51	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator selects the intended fuel assembly (mid-criticality), and since this package can not handle the MK fuel assembly, there is a chance of a criticality concern, but the error is not identified or corrected through verification, creating a possible criticality concern due to misloading.
PA-52/PA-53	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, HK). A low-range criticality (LK) fuel assembly is loaded into a waste package with no absorber which would not lead to a criticality concern. However, unless corrected through successful verification (i.e., PA-52), the fuel assembly records are likely to be corrupted and an economic impact may occur (i.e., PA-53).
PA-54/PA-55	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, HK). A high-range criticality (HK) fuel assembly is loaded into a waste package with no absorber, but since this is a conceptual selection error, the Line operator will load absorber rods into the fuel assembly prior to loading, therefore, there is no criticality concern. If verification is not successful, the fuel assembly records are likely to be corrupted.
PA-56/PA-57	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (MK). The operator has selected a low-criticality (LK) fuel assembly which will be place in a no absorber waste package with no criticality concerns. Therefore, with or without successful verification, there is no criticality concern due to misloading, however, without successful verification, the fuel assembly records are likely to be corrupted.
PA-58	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (MK). The operator has selected a mid-criticality (MK) fuel assembly, but the error is identified and corrected through successful verification.
PA-59	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (MK). The operator has selected a mid-criticality (MK) fuel assembly, but the error is not identified or corrected through verification, creating a possible criticality concern due to misloading.
PA-60	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (MK). The operator has selected a high-criticality (HK) fuel assembly, but the error is identified and corrected through successful verification.

Endstate	Endstate Notes for Case PWR-A Exceeding Criticality Loading Criteria Decision Tree
PA-61	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (MK). The operator has selected a high-criticality (HK) fuel assembly, but the error is **not** identified or corrected through verification, creating a possible criticality concern due to misloading. Note: since this was a selection error, the operator will not place absorber rods in the fuel assembly.
PA-62	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator selects the intended fuel assembly (mid-criticality), and since this package can not handle the MK fuel assembly, there is a chance of a criticality concern, but the error is identified and corrected through successful verification.
PA-63	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator selects the intended fuel assembly (mid-criticality), and since this package can not handle the MK fuel assembly, there is a chance of a criticality concern, but the error is **not** identified or corrected through verification, creating a possible criticality concern due to misloading.
PA-64/PA-65	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (package intended for fuel assemblies with absorber rods). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, HK). A low-range criticality (LK) fuel assembly is loaded into a waste package with no absorber which would not lead to a criticality concern. However, unless corrected through successful verification (i.e., PA-64), the fuel assembly records are likely to be corrupted and an economic impact may occur (i.e., PA-65).
PA-66/PA-67	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (package intended for fuel assemblies with absorber rods). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, HK). A high-range criticality (HK) fuel assembly is loaded into a waste package with no absorber, but since this is a conceptual selection error, the Line operator will load absorber rods into the fuel assembly prior to loading, therefore, there is no criticality concern. If verification is not successful, the fuel assembly records are likely to be corrupted.
PA-68/PA-69	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package intended for fuel assemblies with absorber rods). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (MK). The operator has selected a low-criticality (LK) fuel assembly which will be place in a no absorber waste package with no criticality concerns. Therefore, with or without successful verification, there is no criticality concern due to misloading, however, without successful verification, the fuel assembly records are likely to be corrupted.
PA-70	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (package intended for fuel assemblies with absorber rods). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (MK). The operator has selected a mid-criticality (MK) fuel assembly, but the error is identified and corrected through successful verification.
PA-71	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (package intended for fuel assemblies with absorber rods). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (MK). The operator has selected a mid-criticality (MK) fuel assembly, but the error is **not** identified or corrected through verification, creating a possible criticality concern due to misloading.

Endstate	Endstate Notes for Case PWR-A Exceeding Criticality Loading Criteria Decision Tree
PA-72	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (package intended for fuel assemblies with absorber rods). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (MK). The operator has selected a high-criticality (HK) fuel assembly, but the error is identified and corrected through successful verification.
PA-73	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (package intended for fuel assemblies with absorber rods). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (MK). The operator has selected a high-criticality (HK) fuel assembly, but the error is not identified or corrected through verification, creating a possible criticality concern due to misloading. Note: since this was a selection error, the operator will not place absorber rods in the fuel assembly.
PA-74	For criticality concerns, the operator has selected the wrong waste package (an ST package). If anything but an ST fuel assembly is loaded into this package, the error will be always be corrected through verification. If an ST fuel assembly is loaded into this package, and verification is not successful (not shown on the decision tree), then there is still no criticality concern, however, the fuel assembly records are likely to be corrupted.
PA-75	For criticality concerns, the operator performed every task correctly. That is, one of packages intended for fuel assemblies with absorber rods was selected for a high-range reactivity fuel assembly.
PA-76	For criticality concerns, the operator performed every task correctly, except the final verification. Therefore, there is no criticality concern due to misloading, however, the fuel assembly records are likely to be corrupted.
PA-77/PA-78	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator selects the intended fuel assembly (high-criticality) , and since the Line operator believes a "rod" package is being load, absorber rods will be placed into the fuel assembly. However, unless corrected through successful verification (i.e., PA-77), the fuel assembly records are likely to be corrupted (i.e., PA-78).
PA-79/PA-80	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, MK). A low-range criticality (LK) fuel assembly is loaded into a waste package with no absorber which would not lead to a criticality concern. However, unless corrected through successful verification (i.e., PA-78), the fuel assembly records are likely to be corrupted (i.e., PA-79).
PA-81	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, MK). A mid-range criticality (MK) fuel assembly is loaded into a waste package with no absorber which could lead to a criticality concern, but the error is identified and corrected through successful verification.
PA-82	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, MK). A mid-range criticality (MK) fuel assembly is loaded into a waste package with no absorber which could lead to a criticality concern, but the error is not identified or corrected through verification, creating a possible criticality concern due to misloading.

Endstate	Endstate Notes for Case PWR-A Exceeding Criticality Loading Criteria Decision Tree
PA-83/PA-84	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with no absorber). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (HK). Since the Line operator believes a "rod" package is being load, absorber rods will be placed into the fuel assembly (no matter which is selected). However, unless corrected through successful verification (i.e., PA-83), the fuel assembly records are likely to be corrupted and an economic impact may occur (i.e., PA-84).
PA-85/PA-86	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator selects the intended fuel assembly (high-criticality) , and since the Line operator believes a "rod" package is being load, absorber rods will be placed into the fuel assembly. However, unless corrected through successful verification (i.e., PA-85), the fuel assembly records are likely to be corrupted (i.e., PA-86).
PA-87/PA-88	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, MK). A low-range criticality (LK) fuel assembly is loaded into a waste package with absorber plates which would not lead to a criticality concern. However, unless corrected through successful verification (i.e., PA-87), the fuel assembly records are likely to be corrupted and an economic impact may occur (i.e., PA-88).
PA-89/PA-90	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator made a conceptual error deciding which fuel assembly to load, so the decision tree is limited to only incorrect fuel assemblies (i.e., LK, MK). A mid-range criticality (MK) fuel assembly is loaded into a waste package with absorber plates which would not lead to a criticality concern. However, unless corrected through successful verification (i.e., PA-89), the fuel assembly records are likely to be corrupted and an economic impact may occur (i.e., PA-90).
PA-91/PA-92	For criticality concerns, the operator has selected (via a conceptual error) the wrong waste package (a package with absorber plates). The operator makes a fuel assembly selection error. The operator can select from all of the available fuel assembly types, with any of the possible criticality ranges, including the type that was originally intended (HK). Since the Line operator believes a "rod" package is being load, absorber rods will be placed into the fuel assembly (no matter which is selected). However, unless corrected through successful verification (i.e., PA-91), the fuel assembly records are likely to be corrupted and an economic impact may occur (i.e., PA-92).
PA-93	For criticality concerns, the operator has selected the wrong waste package (an ST package). If anything but an ST fuel assembly is loaded into this package, the error will be always be corrected through verification. If an ST fuel assembly is loaded into this package, and verification is not successful (not shown on the decision tree), then there is still no criticality concern, however, the fuel assembly records are likely to be corrupted.

ATTACHMENT II

PWR-B EXCEEDING CRITICALITY LOADING CRITERIA DECISION TREE

Figure II - PWR-B Exceeding Criticality Loading Criteria Decision Tree

	WP Usage	Select WP	Select FA	FA Type	Verification			Endstate
	0.420	0.995	0.994		0.990	4.11E-01		PB-1
	(no absorber)	(intended WP)	(intended FA)	(LK)	(success)	(no conseq.)		
					0.010	4.15E-03		PB-2
					(failure)	(no conseq.)		
			0.005	0.951	0.999	1.98E-03		PB-3
			(concept)	(MK)	(success)	(no conseq.)		
					0.001	1.99E-06		PB-4
					(failure)	(criticality)		
				0.049	0.999	1.03E-04		PB-5
				(HK)	(success)	(no conseq.)		
					0.001	1.03E-07		PB-6
					(failure)	(criticality)		
			0.001	0.390	0.990	3.39E-03		PB-7
			(selection)	(LK)	(success)	(no conseq.)		
					0.010	3.42E-05		PB-8
					(failure)	(no conseq.)		
				0.580	0.990	5.04E-03		PB-9
				(MK)	(success)	(no conseq.)		
					0.010	5.09E-05		PB-10
					(failure)	(criticality)		
				0.030	0.990	2.61E-04		PB-11
				(HK)	(success)	(no conseq.)		
					0.010	2.63E-06		PB-12
					(failure)	(criticality)		
		0.005	0.966	0.994	0.999	2.02E-03		PB-13
		(wrong WP)	(plate)	(intended FA)	(success)	(no conseq.)		
					0.001	2.02E-06		PB-14
					(failure)	(no conseq.)		
				0.005	0.951	0.999	9.65E-06	PB-15
				(concept)	(MK)	(success)	(no conseq.)	
						0.001	9.66E-09	PB-16
						(failure)	(no conseq.)	
					0.049	0.999	4.99E-07	PB-17
					(HK)	(success)	(no conseq.)	
						0.001	5.00E-10	PB-18
						(failure)	(no conseq.)	
				0.001	0.390	0.990	7.84E-07	PB-19
				(selection)	(LK)	(success)	(no conseq.)	
						0.010	7.92E-09	PB-20

Figure II - PWR-B Exceeding Criticality Loading Criteria Decision Tree

						(failure)	(no conseq.)	
					0.580	0.990	1.17E-06	PB-21
					(MK)	(success)	(no conseq.)	
						0.010	1.18E-08	PB-22
						(failure)	(no conseq.)	
					0.030	0.990	6.03E-08	PB-23
					(HK)	(success)	(no conseq.)	
						0.010	6.09E-10	PB-24
						(failure)	(criticality)	
			0.034	1.000	1.000	7.26E-05		PB-25
			(ST)	(any FA)	(success)	(no conseq.)		
	0.580	0.995	0.994		0.990	5.68E-01		PB-26
	(plate)	(intended WP)	(intended FA)		(success)	(no conseq.)		
					0.010	5.74E-03		PB-27
					(failure)	(no conseq.)		
			0.005	0.929	0.999	2.68E-03		PB-28
			(concept)	(LK)	(success)	(no conseq.)		
					0.001	2.68E-06		PB-29
					(failure)	(no conseq.)		
				0.071	0.999	2.06E-04		PB-30
				(HK)	(success)	(no conseq.)		
					0.001	2.06E-07		PB-31
					(failure)	(no conseq.)		
			0.001	0.390	0.990	2.23E-04		PB-32
			(selection)	(LK)	(success)	(no conseq.)		
					0.010	2.25E-06		PB-33
					(failure)	(no conseq.)		
				0.580	0.990	3.31E-04		PB-34
				(MK)	(success)	(no conseq.)		
					0.010	3.35E-06		PB-35
					(failure)	(no conseq.)		
				0.030	0.990	1.71E-05		PB-36
				(HK)	(success)	(no conseq.)		
					0.010	1.73E-07		PB-37
					(failure)	(criticality)		
		0.005	0.955	0.994		0.999	2.77E-03	PB-38
		(wrong WP)	(no absorber)	(intended FA)		(success)	(no conseq.)	
						0.001	2.77E-06	PB-39
						(failure)	(criticality)	
				0.005	0.929	0.999	1.29E-05	PB-40
				(concept)	(LK)	(success)	(no conseq.)	
						0.001	1.29E-08	PB-41

Figure II - PWR-B Exceeding Criticality Loading Criteria Decision Tree

						(failure)	(no conseq.)	
					0.071	0.999	9.90E-07	PB-42
					(HK)	(success)	(no conseq.)	
						0.001	9.91E-10	PB-43
						(failure)	(no conseq.)	
				0.001	0.390	0.990	1.07E-06	PB-44
				(selection)	(LK)	(success)	(no conseq.)	
						0.010	1.08E-08	PB-45
						(failure)	(no conseq.)	
					0.580	0.990	1.59E-06	PB-46
					(MK)	(success)	(no conseq.)	
						0.010	1.61E-08	PB-47
						(failure)	(criticality)	
					0.030	0.990	8.24E-08	PB-48
					(HK)	(success)	(no conseq.)	
						0.010	8.32E-10	PB-49
						(failure)	(criticality)	
			0.045	1.000	1.000	1.32E-04		PB-50
			(ST)	(any FA)	(success)	(no conseq.)		
	No Absorber		Plates		(Total)			
Concept	4.76E-06		0.00E+00		4.76E-06	(Total Concept)		
Selection	5.35E-05		1.74E-07		5.37E-05	(Total Selection)		
Total	**5.83E-05**		**1.74E-07**		**5.85E-05**			
Probability of Misload Leading					Probability of Misload Leading			
to Exceeding Criticality Loading Criteria					to Exceeding Criticality Loading Criteria			
due to Concept Error per Waste					a No Absorber package			5.83E-05
Package			4.76E-06					
					Probability of Misload Leading			
Probability of Misload Leading					to Exceeding Criticality Loading Criteria			
to Exceeding Criticality Loading Criteria					an Absorber Plate package			1.74E-07
due to Selection Error per Waste								
Package			5.37E-05					

ATTACHMENT III

PWR-C EXCEEDING CRITICALITY LOADING CRITERIA DECISION TREE

Figure III - PWR-C Exceeding Criticality Loading Criteria Decision Tree

	WP Usage	Select WP	Select FA	FA Type	Verification			Endstate	
	0.390	0.995	0.994		0.990	3.82E-01		PC-1	
	(no absorber)	(intended WP)	(intended FA)	(LK)	(success)	(no conseq.)			
					0.010	3.86E-03		PC-2	
					(failure)	(no conseq.)			
			0.005	0.951	0.999	1.84E-03		PC-3	
			(concept)	(MK)	(success)	(no conseq.)			
					0.001	1.84E-06		PC-4	
					(failure)	(criticality)			
				0.049	0.999	9.53E-05		PC-5	
				(HK)	(success)	(no conseq.)			
					0.001	9.54E-08		PC-6	
					(failure)	(criticality)			
			0.001	0.390	0.990	3.15E-03		PC-7	
			(selection)	(LK)	(success)	(no conseq.)			
					0.010	3.18E-05		PC-8	
					(failure)	(no conseq.)			
				0.580	0.990	4.68E-03		PC-9	
				(MK)	(success)	(no conseq.)			
					0.010	4.73E-05		PC-10	2.13E-09
					(failure)	(criticality)			
				0.030	0.990	2.42E-04		PC-11	
				(HK)	(success)	(no conseq.)			
					0.010	2.44E-06		PC-12	5.69E-12
					(failure)	(criticality)			
		0.005	0.951	0.994	0.999	1.84E-03		PC-13	
		(wrong WP)	(plate)	(intended FA)	(success)	(no conseq.)			
					0.001	1.85E-06		PC-14	
					(failure)	(no conseq.)			
				0.005	0.951	0.999	8.82E-06	PC-16	
				(concept)	(MK)	(success)	(no conseq.)		
						0.001	8.83E-09	PC-17	
						(failure)	(no conseq.)		
					0.049	0.999	4.56E-07	PC-18	
					(HK)	(success)	(no conseq.)		
						0.001	4.57E-10	PC-19	
						(failure)	(criticality)		
				0.001	0.390	0.990	1.51E-05	PC-20	
				(selection)	(LK)	(success)	(no conseq.)		

Figure III - PWR-C Exceeding Criticality Loading Criteria Decision Tree

						0.010	1.52E-07	PC-21	
						(failure)	(no conseq.)		
					0.580	0.990	2.24E-05	PC-22	
					(MK)	(success)	(no conseq.)		
						0.010	2.26E-07	PC-23	
						(failure)	(no conseq.)		
					0.030	0.990	1.16E-06	PC-24	
					(HK)	(success)	(no conseq.)		
						0.010	1.17E-08	PC-25	1.30E-16
						(failure)	(criticality)		
			0.049	1.000	0.990	9.51E-05		PC-26	
			(rod)	any FA	(success)	(no conseq.)			
					0.010	9.61E-07		PC-27	
					(failure)	(no conseq.)			
	0.580	0.995	0.994		0.990	5.68E-01		PC-28	
	(plate)	(intended WP)	(intended FA)	(MK)	(success)	(no conseq.)			
					0.010	5.74E-03		PC-29	
					(failure)	(no conseq.)			
			0.005	0.929	0.999	2.68E-03		PC-30	
			(concept)	(LK)	(success)	(no conseq.)			
					0.001	2.68E-06		PC-31	
					(failure)	(no. conseq.)			
				0.071	0.999	2.06E-04		PC-32	
				(HK)	(success)	(no conseq.)			
					0.001	2.06E-07		PC-33	
					(failure)	(criticality)			
			0.001	0.390	0.990	4.68E-03		PC-34	
			(selection)	(LK)	(success)	(no conseq.)			
					0.010	4.73E-05		PC-35	
					(failure)	(no conseq.)			
				0.580	0.990	6.96E-03		PC-36	
				(MK)	(success)	(no conseq.)			
					0.010	7.03E-05		PC-37	
					(failure)	(no conseq.)			
				0.030	0.990	3.60E-04		PC-38	
				(HK)	(success)	(no conseq.)			
					0.010	3.64E-06		PC-39	1.26E-11
					(failure)	(criticality)			
		0.005	0.929	0.994	0.999	2.68E-03		PC-40	
		(wrong WP)	(no absorber)	(intended FA)	(success)	(no conseq.)			
					0.001	2.68E-06		PC-41	
					(failure)	(criticality)			

Figure III - PWR-C Exceeding Criticality Loading Criteria Decision Tree

			0.005	0.929	0.999	1.25E-05	PC-42		
			(concept)	(LK)	(success)	(no conseq.)			
					0.001	1.25E-08	PC-43		
					(failure)	(no conseq.)			
				0.071	0.999	9.63E-07	PC-44		
				(HK)	(success)	(no conseq.)			
					0.001	9.64E-10	PC-45		
					(failure)	(criticality)			
			0.001	0.390	0.990	2.19E-05	PC-46		
			(selection)	(LK)	(success)	(no conseq.)			
					0.010	2.21E-07	PC-47		
					(failure)	(no conseq.)			
				0.580	0.990	3.25E-05	PC-48		
				(MK)	(success)	(no conseq.)			
					0.010	3.29E-07	PC-49	1.03E-13	
					(failure)	(criticality)			
				0.030	0.990	1.68E-06	PC-50		
				(HK)	(success)	(no conseq.)			
					0.010	1.70E-08	PC-51	2.75E-16	
					(failure)	(criticality)			
		0.071	1.000	0.990	2.05E-04		PC-52		
		(rod)	(any FA)	(success)	(no conseq.)				
				0.010	2.08E-06		PC-53		
				(failure)	(no conseq.)				
0.030	0.995	0.994		0.990	2.94E-02		PC-54		
(rod)	(intended WP)	(any FA)		(success)	(no conseq.)				
				0.010	2.97E-04		PC-55		
				(failure)	(no conseq.)				
	0.005	0.402	0.994	0.999	6.00E-05		PC-56		
	(wrong WP)	(no absorber)	(intended FA)	(success)	(no conseq.)				
				0.001	6.01E-08		PC-57		
				(failure)	(criticality)				
			0.005	0.402	0.999	1.21E-07	PC-58		
			(concept)	(LK)	(success)	(no conseq.)			
					0.001	1.21E-10	PC-59		
					(failure)	(no conseq.)			
				0.598	0.999	1.80E-07	PC-60		
				(MK)	(success)	(no conseq.)			
					0.001	1.81E-10	PC-61		
					(failure)	(criticality)			

Figure III - PWR-C Exceeding Criticality Loading Criteria Decision Tree

				0.001	0.390	0.990	4.90E-07	PC-62	
				(selection)	(LK)	(success)	(no conseq.)		
						0.010	4.95E-09	PC-63	
						(failure)	(no conseq.)		
					0.580	0.990	7.29E-07	PC-64	
					(MK)	(success)	(no conseq.)		
						0.010	7.36E-09	PC-65	5.16E-17
						(failure)	(criticality)		
					0.030	0.990	3.77E-08	PC-66	
					(HK)	(success)	(no conseq.)		
						0.010	3.81E-10	PC-67	1.38E-19
						(failure)	(criticality)		
			0.598	0.994	0.999	8.92E-05		PC-68	
			(plate)	(intended FA)	(success)	(no conseq.)			
					0.001	8.93E-08		PC-69	
					(failure)	(criticality)			
				0.005	0.402	0.999	1.80E-07	PC-70	
				(concept)	LK	(success)	(no conseq.)		
						0.001	1.81E-10	PC-71	
						(failure)	(no conseq.)		
					0.598	0.999	2.68E-07	PC-72	
					MK	(success)	(no conseq.)		
						0.001	2.69E-10	PC-73	
						(failure)	(no conseq.)		
				0.001	0.390	0.990	7.29E-07	PC-74	
				(selection)	LK	(success)	(no conseq.)		
						0.010	7.36E-09	PC-75	
						(failure)	(no conseq.)		
					0.580	0.990	1.08E-06	PC-76	
					MK	(success)	(no conseq.)		
						0.010	1.09E-08	PC-77	
						(failure)	(no conseq.)		
					0.030	0.990	5.61E-08	PC-78	
					HK	(success)	(no conseq.)		
						0.010	5.66E-10	PC-79	3.05E-19
						(failure)	(criticality)		

Figure III - PWR-C Exceeding Criticality Loading Criteria Decision Tree

		No Absorber		Plates		Rods		(Total)	
	Concept	4.68E-06		2.96E-07		0.00E+00		4.98E-06	
	Selection	5.01E-05		3.65E-06		0.00E+00		5.37E-05	
	Selection (2)	2.13E-09		1.26E-11		0.00E+00		2.15E-09	
	Total	**5.47E-05**		**3.94E-06**		**0.00E+00**		**5.87E-05**	
	Probability of Misload Leading					Probability of Misload Leading			
	to Exceeding Criticality Loading Criteria					to Exceeding Criticality Loading Criteria			
	due to **Concept** Error per Waste					a **No Absorber** package			5.47E-05
	Package			4.98E-06					
						Probability of Misload Leading			
	Probability of Misload Leading					to Exceeding Criticality Loading Criteria			
	to Exceeding Criticality Loading Criteria					an **Absorber Plate** package			3.94E-06
	due to **Selection** Error per Waste								
	Package			5.37E-05		Probability of Misload Leading			
						to Exceeding Criticality Loading Criteria			
	Probability of Misload Leading					a **Absorber Rod** package			0.00E+00
	to Exceeding Criticality Loading Criteria								
	due to **Selection (2)** Error per Waste								
	Package			2.15E-09					

ATTACHMENT IV

PWR-D EXCEEDING CRITICALITY LOADING CRITERIA DECISION TREE

Figure IV - PWR-D Exceeding Criticality Loading Criteria Decsion Tree

WP Usage	Select WP	Select FA	FA Type	Verification			Endstate
0.420	0.995	0.994		0.990	4.11E-01		PD-1
(no absorber)	(intended WP)	(intended FA)		(success)	(no conseq.)		
				0.010	4.15E-03		PD-2
				(failure)	(no conseq.)		
		0.005	1.000	0.999	2.09E-03		PD-3
		(concept)	(MK)	(success)	(no conseq.)		
				0.001	2.09E-06		PD-4
				(failure)	(criticality)		
		0.001	0.420	0.990	3.65E-03		PD-5
		(selection)	(LK/HK)	(success)	(no conseq.)		
				0.010	3.69E-05		PD-6
				(failure)	(no conseq.)		
			0.580	0.990	5.04E-03		PD-7
			(MK)	(success)	(no conseq.)		
				0.010	5.09E-05		PD-8
				(failure)	(criticality)		
	0.005	0.966	0.994	0.999	2.02E-03		PD-9
	(wrong WP)	(plate)	(intended FA)	(success)	(no conseq.)		
				0.001	2.02E-06		PD-10
				(failure)	(no conseq.)		
			0.005	1.000	0.999	1.01E-05	PD-11
			(concept)	(MK)	(success)	(no conseq.)	
					0.001	1.02E-08	PD-12
					(failure)	(no conseq.)	
			0.001	0.420	0.990	8.45E-07	PD-13
			(selection)	(LK/HK)	(success)	(no conseq.)	
					0.010	8.53E-09	PD14
					(failure)	(no conseq.)	
				0.580	0.990	1.17E-06	PD-15
				(MK)	(success)	(no conseq.)	
					0.010	1.18E-08	PD-16
					(failure)	(no conseq.)	
		0.034	1.000	1.000	7.26E-05		PD-17
		(ST)	(any FA)	(success)	(no conseq.)		
0.580	0.995	0.994		0.990	5.68E-01		PD-18
(plate)	(intended WP)	(intended FA)		(success)	(no conseq.)		
				0.010	5.74E-03		PD-19
				(failure)	(no conseq.)		

Figure IV - PWR-D Exceeding Criticality Loading Criteria Decsion Tree

			0.005	1.000	0.999	2.88E-03		PD-20
			(concept)	(LK/HK)	(success)	(no conseq.)		
					0.001	2.89E-06		PD-21
					(failure)	(no conseq.)		
			0.001	0.580	0.990	3.31E-04		PD-22
			(selection)	(MK)	(success)	(no conseq.)		
					0.010	3.35E-06		PD-23
					(failure)	(no conseq.)		
				0.420	0.990	2.40E-04		PD-24
				(LK/HK)	(success)	(no conseq.)		
					0.010	2.42E-06		PD-25
					(failure)	(no conseq.)		
		0.005	0.955	0.994		0.999	2.77E-03	PD-26
		(wrong WP)	(no absorber)	(intended FA)		(success)	(no conseq.)	
						0.001	2.77E-06	PD-27
						(failure)	(criticality)	
				0.005	1.000	0.999	1.39E-05	PD-28
				(concept)	(LK/HK)	(success)	(no conseq.)	
						0.001	1.39E-08	PD-29
						(failure)	(no conseq.)	
				0.001	0.580	0.990	1.59E-06	PD-30
				(selection)	(MK)	(success)	(no conseq.)	
						0.010	1.61E-08	PD-31
						(failure)	(criticality)	
					0.420	0.990	1.15E-06	PD-32
					(LK/HK)	(success)	(no conseq.)	
						0.010	1.16E-08	PD-33
						(failure)	(no conseq.)	
			0.045	1.000	1.000	1.32E-04		PD-34
			(ST)	(any FA)	(success)	(no conseq.)		

Figure IV - PWR-D Exceeding Criticality Loading Criteria Decsion Tree

	No Absorber		Plates		(Total)			
Concept	4.86E-06		0.00E+00		4.86E-06	(Total Concept)		
Selection	5.09E-05		0.00E+00		5.09E-05	(Total Selection)		
Total	**5.58E-05**		**0.00E+00**		**5.58E-05**			
Probability of Misload Leading					Probability of Misload Leading			
to Exceeding Criticality Loading Criteria					to Exceeding Criticality Loading Criteria			
due to **Concept** Error per Waste					a **No Absorber** package			5.58E-05
Package			4.86E-06					
					Probability of Misload Leading			
Probability of Misload Leading					to Exceeding Criticality Loading Criteria			
to Exceeding Criticality Loading Criteria					an **Absorber Plate** package			0.00E+00
due to **Selection** Error per Waste								
Package			5.09E-05					

ATTACHMENT V

BWR EXCEEDING CRITICALITY LOADING CRITERIA DECISION TREE

Figure V - BWR Exceeding Criticality Loading Criteria Decision Tree

	WP Usage	Select WP	Select FA	FA Type	Verification			Endstate	
	0.275	0.995	0.994		0.990	2.69E-01		B-1	
	(no absorber)	(intended WP)	(intended FA)	(LK)	(success)	(no conseq.)			
					0.010	2.72E-03		B-2	
					(failure)	(no conseq.)			
			0.005	0.986	0.999	1.35E-03		B-3	
			(concept)	(MK)	(success)	(no conseq.)			
					0.001	1.35E-06		B-4	
					(failure)	(criticality)			
				0.014	0.999	1.89E-05		B-5	
				(HK)	(success)	(no conseq.)			
					0.001	1.89E-08		B-6	
					(failure)	(criticality)			
			0.001	0.275	0.990	3.28E-03		B-7	
			(selection)	(LK)	(success)	(no conseq.)			
					0.010	3.31E-05		B-8	
					(failure)	(no conseq.)			
				0.715	0.990	8.52E-03		B-9	
				(MK)	(success)	(no conseq.)			
					0.010	8.61E-05		B-10	7.24E-09
					(failure)	(criticality)			
				0.010	0.990	1.19E-04		B-11	
				(HK)	(success)	(no conseq.)			
					0.010	1.20E-06		B-12	1.42E-12
					(failure)	(criticality)			
		0.005	0.986	0.994	0.999	1.35E-03		B-13	
		(wrong WP)	(plate)	(intended FA)	(success)	(no conseq.)			
					0.001	1.35E-06		B-14	
					(failure)	(no conseq.)			
				0.005	0.986	0.999	6.69E-06	B-16	
				(concept)	(MK)	(success)	(no conseq.)		
						0.001	6.70E-09	B-17	
						(failure)	(no conseq.)		
					0.014	0.999	9.36E-08	B-18	
					(HK)	(success)	(no conseq.)		
						0.001	9.37E-11	B-19	
						(failure)	(criticality)		
				0.001	0.275	0.990	1.63E-05	B-20	
				(selection)	(LK)	(success)	(no conseq.)		
						0.010	1.64E-07	B-21	
						(failure)	(no conseq.)		
					0.715	0.990	4.23E-05	B-22	
					(MK)	(success)	(no conseq.)		
						0.010	4.27E-07	B-23	
						(failure)	(no conseq.)		

Figure V - BWR Exceeding Criticality Loading Criteria Decision Tree

					0.010	0.990	5.92E-07	B-24	
					(HK)	(success)	(no conseq.)		
						0.010	5.98E-09	B-25	3.49E-17
						(failure)	(criticality)		
			0.014	1.000	0.990	1.88E-05		B-26	
			(thick plate)	any FA	(success)	(no conseq.)			
					0.010	1.90E-07		B-27	
					(failure)	(no conseq.)			
	0.715	0.995	0.994		0.990	7.00E-01		B-28	
	(plate)	(intended WP)	(intended FA)	(MK)	(success)	(no conseq.)			
					0.010	7.07E-03		B-29	
					(failure)	(no conseq.)			
			0.005	0.965	0.999	3.43E-03		B-30	
			(concept)	(LK)	(success)	(no conseq.)			
					0.001	3.43E-06		B-31	
					(failure)	(no. conseq.)			
				0.035	0.999	1.25E-04		B-32	
				(HK)	(success)	(no conseq.)			
					0.001	1.25E-07		B-33	
					(failure)	(criticality)			
			0.001	0.275	0.990	8.52E-03		B-34	
			(selection)	(LK)	(success)	(no conseq.)			
					0.010	8.61E-05		B-35	
					(failure)	(no conseq.)			
				0.715	0.990	2.22E-02		B-36	
				(MK)	(success)	(no conseq.)			
					0.010	2.24E-04		B-37	
					(failure)	(no conseq.)			
				0.010	0.990	3.10E-04		B-38	
				(HK)	(success)	(no conseq.)			
					0.010	3.13E-06		B-39	9.58E-12
					(failure)	(criticality)			
		0.005	0.965	0.994	0.999	3.43E-03		B-40	
		(wrong WP)	(no absorber)	(intended FA)	(success)	(no conseq.)			
					0.001	3.44E-06		B-41	
					(failure)	(criticality)			
				0.005	0.965	0.999	1.67E-05	B-42	
				(concept)	(LK)	(success)	(no conseq.)		
						0.001	1.67E-08	B-43	
						(failure)	(no conseq.)		
					0.035	0.999	6.06E-07	B-44	
					(HK)	(success)	(no conseq.)		
						0.001	6.06E-10	B-45	
						(failure)	(criticality)		
				0.001	0.275	0.990	4.14E-05	B-46	
				(selection)	(LK)	(success)	(no conseq.)		
						0.010	4.18E-07	B-47	

Figure V - BWR Exceeding Criticality Loading Criteria Decision Tree

						(failure)	(no conseq.)		
					0.715	0.990	1.08E-04	B-48	
					(MK)	(success)	(no conseq.)		
						0.010	1.09E-06	B-49	1.16E-12
						(failure)	(criticality)		
					0.010	0.990	1.51E-06	B-50	
					(HK)	(success)	(no conseq.)		
						0.010	1.52E-08	B-51	2.26E-16
						(failure)	(criticality)		
			0.035	1.000	0.990	1.24E-04		B-52	
			(thick plate)	(any FA)	(success)	(no conseq.)			
					0.010	1.26E-06		B-53	
					(failure)	(no conseq.)			
	0.010	0.995	0.994		0.990	9.79E-03		B-54	
	(thick plate)	(intended WP)	(any FA)		(success)	(no conseq.)			
					0.010	9.89E-05		B-55	
					(failure)	(no conseq.)			
		0.005	0.278	0.994	0.999	1.38E-05		B-56	
		(wrong WP)	(no absorber)	(intended FA)	(success)	(no conseq.)			
					0.001	1.38E-08		B-57	
					(failure)	(criticality)			
				0.005	0.278	0.999	1.93E-08	B-58	
				(concept)	(LK)	(success)	(no conseq.)		
						0.001	1.93E-11	B-59	
						(failure)	(no conseq.)		
					0.722	0.999	5.02E-08	B-60	
					(MK)	(success)	(no conseq.)		
						0.001	5.03E-11	B-61	
						(failure)	(criticality)		
				0.001	0.275	0.990	1.67E-07	B-62	
				(selection)	(LK)	(success)	(no conseq.)		
						0.010	1.68E-09	B-63	
						(failure)	(no conseq.)		
					0.715	0.990	4.33E-07	B-64	
					(MK)	(success)	(no conseq.)		
						0.010	4.38E-09	B-65	1.87E-17
						(failure)	(criticality)		
					0.010	0.990	6.06E-09	B-66	
					(HK)	(success)	(no conseq.)		
						0.010	6.12E-11	B-67	3.66E-21
						(failure)	(criticality)		
			0.722	0.994	0.999	3.59E-05		B-68	
			(plate)	(intended FA)	(success)	(no conseq.)			
					0.001	3.60E-08		B-69	
					(failure)	(criticality)			

Figure V - BWR Exceeding Criticality Loading Criteria Decision Tree

				0.005	0.278	0.999	5.02E-08	B-70	
				(concept)	LK	(success)	(no conseq.)		
						0.001	5.03E-11	B-71	
						(failure)	(no conseq.)		
					0.722	0.999	1.31E-07	B-72	
					MK	(success)	(no conseq.)		
						0.001	1.31E-10	B-73	
						(failure)	(no conseq.)		
				0.001	0.275	0.990	4.33E-07	B-74	
				(selection)	LK	(success)	(no conseq.)		
						0.010	4.38E-09	B-75	
						(failure)	(no conseq.)		
					0.715	0.990	1.13E-06	B-76	
					MK	(success)	(no conseq.)		
						0.010	1.14E-08	B-77	
						(failure)	(no conseq.)		
					0.010	0.990	1.58E-08	B-78	
					HK	(success)	(no conseq.)		
						0.010	1.59E-10	B-79	2.48E-20
						(failure)	(criticality)		
		No Absorber		Plates		Thick Plates		(Total)	
	Concept	4.82E-06		1.61E-07		0.00E+00		4.98E-06	
	Selection	8.84E-05		3.14E-06		0.00E+00		9.15E-05	
	Selection (2)	7.24E-09		9.58E-12		0.00E+00		7.25E-09	
	Total	**9.32E-05**		**3.30E-06**		**0.00E+00**		**9.65E-05**	
	Probability of Misload Leading					Probability of Misload Leading			
	to Exceeding Criticality Loading Criteria					to Exceeding Criticality Loading Criteria			
	due to **Concept** Error per Waste					a **No Absorber** package			9.32E-05
	Package			4.98E-06					
						Probability of Misload Leading			
	Probability of Misload Leading					to Exceeding Criticality Loading Criteria			
	to Exceeding Criticality Loading Criteria					an **Absorber Plate** package			3.30E-06
	due to **Selection** Error per Waste								
	Package			9.15E-05		Probability of Misload Leading			
						to Exceeding Criticality Loading Criteria			
	Probability of Misload Leading					a **Thick Absorber Plate** package			0.00E+00
	to Exceeding Criticality Loading Criteria								
	due to **Selection (2)** Error per Waste								
	Package			7.25E-09					

ATTACHMENT VI

DATA "TAB" FOR PWR AND BWR CASES

TableVI-1 - Input Data Used to Quantify the PWR Decision Trees

							MK & HK Only		LK & HK Only		LK & MK Only	
							Fraction	Percent	Fraction	Percent	Fraction	Percent
Fraction of PWR fuel assemblies with low-range criticality					(LK)	0.39			0.39	92.86%	0.39	40.21%
Fraction of PWR fuel assemblies with mid-range criticality					(MK)	0.58	0.58	95.08%			0.58	59.79%
Fraction of PWR fuel assemblies with with high-range criticality					(HK)	0.03	0.03	4.92%	0.03	7.14%		
						1.00	0.61		0.42		0.97	
Fraction of PWR fuel assemblies with low- and mid-range criticality						0.97						
Fraction of PWR fuel assemblies with high-range criticality						0.03						
HEPs												
	HEP	Recovery	HEP w/rec.			HEP	Recovery	HEP w/rec.				
WP-correct	0.9950	—	0.9950		FA-concept	0.005	0	0.005				
WP-incorrect	0.0050	0	0.0050		FA-select	0.001	0	0.001				
					Total Wrong FA	0.006		0.006				
					Verification/Match	0.01						
					Verification/Match following *Concept* error	0.001						
Average Coverage for Scenario C1												
							Input to Spreadsheets					
		Fraction		Comments								
21 PWR (no absorber)		0.355		LK			0.350					
21 PWR (absorber plate)		0.555		MK			0.560					
21 PWR (absorber rods)		0.035		HK			0.030					
12 PWR (no absorbers)		0.035		LK			0.040					
12 PWR (ST, absorber plates)		0.020		MK			0.020					

Table VI-2 - Input Data Used to Quantify the BWR Decision Tree

							MK & HK Only		LK & HK Only		LK & MK Only	
							Fraction	Percent	Fraction	Percent	Fraction	Percent
Fraction of BWR fuel assemblies with low-range criticality					(LK)	0.28			0.28	96.49%	0.28	27.78%
Fraction of BWR fuel assemblies with mid-range criticality					(MK)	0.72	0.72	98.62%			0.72	72.22%
Fraction of BWR fuel assemblies with high range criticality					(HK)	0.01	0.01	1.38%	0.01	3.51%		
						1.00	0.73		0.29		0.99	
Fraction of BWR fuel assemblies with low- and mid-range criticality						0.99						
Fraction of BWR fuel assemblies with high-range criticality						0.01						
HEPs												
	HEP	Recovery	HEP w/rec.			HEP	Recovery	HEP w/rec.				
WP-correct	0.9950	—	0.9950		FA-concept	0.005	0	0.005				
WP-incorrect	0.0050	0.000	0.0050		FA-select	0.001	0	0.001				
					Total Wrong FA	0.006		0.006				
					Verification/Match	0.01						
					Verification/Match following *Concept* error	0.001						
Average Coverage for Scenario C1												
		Fraction		Comments			Input to spreadsheet					
44 BWR (no absorber)		0.275		LK			0.275					
44 BWR (absorber plates)		0.715		MK			0.715					
24 BWR (thick absorber plates)		0.010		HK			0.010					

ATTACHMENT VII

SELECT WP HUMAN RELIABILITY ANALYSIS

Figure VII - Human Reliability Analysis for Incorrect WP

HEP Tree to determine the probability					
that the incorrect WP is selected					
(and place below the transport port).					
	Human Error Probabilities				
		HEP			
	WP-concept	0.005			
	WP-select	0.001			
	Verfication/Match	0.01			
	(Recovery)				
					Endstate
		0.999		9.940E-01	HEP-1
		DC operator loads requested WP			Success
	0.995				
	Requested correct Wp		0.990	9.851E-04	HEP-2
			Recovery by Line operator		Success
		0.001			
Line operator		DC operator loads incorrect WP			
requests WP		(selection error)	0.010	9.950E-06	HEP-3
			No recovery		Failure
	0.005	1.000		5.000E-03	HEP-4
	Requested incorrect WP	DC operator loads requested WP			Failure
	(concept error)	(No recovery)			
				1.000000	
	Success Endstates	0.994990			
	Failure Endstates	0.005010			

ATTACHMENT VIII

SUMMARY OF PWR/BWR REGRESSION ANALYSIS RESULTS

Regression Analysis Summary

PWR-A					
SUMMARY OUTPUT (PWR-A No Absorber)					
Regression Statistics					
Multiple R	0.999650205				
R Square	0.999300532				
Adjusted R Square	0.999166019				
Standard Error	5.10145E-07				
Observations	32				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	9.66696E-09	1.93339E-09	7429.02623	3.87681E-40
Residual	26	6.76645E-12	2.60248E-13		
Total	31	9.67372E-09			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	1.0639E-06	4.6163E-07	2.304655213	0.029426914	
LK^2	-0.00019831	1.88599E-06	-105.148964	1.01208E-35	
MK^2	7.90505E-06	1.6361E-06	4.831627975	5.24115E-05	
LK*MK	2.68078E-05	2.89161E-06	9.270895388	1.00104E-09	
LK	0.000201046	2.02907E-06	99.08300338	4.72666E-35	
MK	-5.8763E-06	1.76733E-06	-3.324958057	0.002638449	
SUMMARY OUTPUT (PWR-A Absorber Plate)					
Regression Statistics					
Multiple R	0.99930686				
R Square	0.9986142				
Adjusted R Square	0.998465721				
Standard Error	6.35133E-07				
Observations	32				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	8.13924E-09	2.71308E-09	6725.64327	4.17264E-40
Residual	28	1.1295E-11	4.03393E-13		
Total	31	8.15053E-09			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	5.96767E-08	2.57934E-07	0.231364406	0.818714149	
MK^2	-0.00020824	1.75793E-06	-118.4562231	2.30866E-39	
LK*MK	-0.0002103	1.84061E-06	-114.2530158	6.3359E-39	
MK	0.000208447	1.5945E-06	130.7286647	1.46788E-40	

Regression Analysis Summary

PWR-B					
SUMMARY OUTPUT (PWR-B No Absorber)					
Regression Statistics					
Multiple R	0.999418363				
R Square	0.998837064				
Adjusted R Square	0.998712463				
Standard Error	1.59918E-06				
Observations	32				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	6.15025E-08	2.05008E-08	8016.327364	3.58451E-41
Residual	28	7.16068E-11	2.55738E-12		
Total	31	6.15741E-08			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	0.000209131	8.42967E-07	248.089198	2.41548E-48	
LK*MK	0.000209584	5.27075E-06	39.76365323	3.51486E-26	
LK	-0.00020638	1.62944E-06	-126.6563106	3.55546E-40	
MK	-0.00020371	1.62043E-06	-125.7131137	4.38164E-40	
SUMMARY OUTPUT (PWR-B Absorber Plates)					
Regression Statistics					
Multiple R	0.999261587				
R Square	0.998523718				
Adjusted R Square	0.998365545				
Standard Error	3.1418E-08				
Observations	32				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	1.86941E-11	6.23136E-12	6312.856505	1.01147E-39
Residual	28	2.76385E-14	9.8709E-16		
Total	31	1.87217E-11			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	5.96135E-09	1.27592E-08	0.467221202	0.643957274	
MK^2	-9.9905E-06	8.69595E-08	-114.8867762	5.42851E-39	
LK*MK	-1.0087E-05	9.10492E-08	-110.7818183	1.50032E-38	
MK	9.9895E-06	7.8875E-08	126.6496532	3.56069E-40	

Regression Analysis Summary

PWR-C					
SUMMARY OUTPUT (PWR-C No Absorber)					
Regression Statistics					
Multiple R	0.999772074				
R Square	0.999544201				
Adjusted R Square	0.999456547				
Standard Error	4.2079E-07				
Observations	32				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	5	1.00956E-08	2.01912E-09	11403.32856	1.4815E-42
Residual	26	4.60366E-12	1.77064E-13		
Total	31	1.01002E-08			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	4.23477E-06	3.80772E-07	11.12152987	2.21671E-11	
LK^2	-0.00021378	1.55564E-06	-137.4216173	9.7277E-39	
MK^2	1.91724E-05	1.34953E-06	14.20670992	9.12663E-14	
LK*MK	1.72634E-05	2.38512E-06	7.237959439	1.09594E-07	
LK	0.000214066	1.67366E-06	127.903008	6.27172E-38	
MK	-1.8396E-05	1.45777E-06	-12.61915378	1.36342E-12	
SUMMARY OUTPUT (PWR-C Absorber Plates)					
Regression Statistics					
Multiple R	0.998935469				
R Square	0.997872071				
Adjusted R Square	0.997644078				
Standard Error	8.65941E-07				
Observations	32				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	9.84583E-09	3.28194E-09	4376.777038	1.68986E-37
Residual	28	2.09959E-11	7.49854E-13		
Total	31	9.86683E-09			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	4.35403E-07	3.51667E-07	1.238111409	0.225955783	
MK^2	-0.00022734	2.39677E-06	-94.85225996	1.14577E-36	
LK*MK	-0.00023353	2.50949E-06	-93.05982373	1.95156E-36	
MK	0.000227933	2.17395E-06	104.847212	6.98478E-38	

Regression Analysis Summary

PWR-D					
SUMMARY OUTPUT (PWR-D No Absorber)					
Regression Statistics					
Multiple R	0.999907494				
R Square	0.999814996				
Adjusted R Square	0.999802237				
Standard Error	2.54898E-07				
Observations	32				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	1.01828E-08	5.09142E-09	78362.01871	7.4841E-55
Residual	29	1.88422E-12	6.49731E-14		
Total	31	1.01847E-08			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	4.85696E-06	1.03517E-07	46.91959818	6.64873E-29	
MK^2	-0.00021173	6.31349E-07	-335.3557422	1.35061E-53	
MK	0.000210616	5.46987E-07	385.0466977	2.4586E-55	
BWR					
SUMMARY OUTPUT (BWR - No Absorber)					
Regression Statistics					
Multiple R	0.99968725				
R Square	0.999374599				
Adjusted R Square	0.999308767				
Standard Error	1.20542E-06				
Observations	22				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	4.41162E-08	2.20581E-08	15180.74307	3.66024E-31
Residual	19	2.76076E-11	1.45303E-12		
Total	21	4.41438E-08			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	4.69836E-07	4.61902E-07	1.017178727	0.321846881	
LK^2	-0.000453153	3.00219E-06	-150.9406855	1.01022E-30	
LK	0.00045624	2.66362E-06	171.2854307	9.15754E-32	

Regression Analysis Summary

SUMMARY OUTPUT (BWR - Absorber Plate)					
Regression Statistics					
Multiple R	0.966217217				
R Square	0.93357571				
Adjusted R Square	0.922504995				
Standard Error	1.0773E-05				
Observations	22				
ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	3	2.93608E-08	9.78695E-09	84.32840247	8.60167E-11
Residual	18	2.08904E-09	1.16058E-10		
Total	21	3.14499E-08			
	Coefficients	*Standard Error*	*t Stat*	*P-value*	
Intercept	5.17856E-06	4.16906E-06	1.242141436	0.230125339	
MK^2	-0.000350922	3.21615E-05	-10.91126168	2.29615E-09	
MK	0.000393047	2.99991E-05	13.1019297	1.21154E-10	
LK*MK	-0.000475537	3.44806E-05	-13.79144363	5.21109E-11	