

**Spent Fuel Pool Criticality Management  
Spreadsheet: A compilation of the means used  
to meet subcriticality requirements for all  
operating domestic spent fuel pools, public  
version**

**Technical Letter Report**

April Pulvirenti and Matthew Hiser

Nuclear Regulatory Commission  
Office of Nuclear Regulatory Research

December 21, 2011

Contents

Summary..... 1

Background ..... 2

Spent Fuel Pool Criticality Management Spreadsheet ..... 2

Pools in the Spent Fuel Pool Criticality Management Spreadsheet..... 2

Organization of subcriticality credit data for a Pool ..... 3

    Current means used to meet subcriticality requirements: ..... 3

    Reference License Amendment and Confirmation ..... 4

    Citations for the references: ..... 4

    Date Updated:..... 5

Decommissioned Reactors..... 5

Conclusion..... 5

## Summary

In spent fuel in pools, Nuclear Regulatory Commission (NRC) licensees use several means to meet subcriticality requirements specified by Title 10 of the Code of Federal Regulations Section 50.68 (10 CFR 50.68) or General Design Criteria (GDC) 62. For example, licensees may credit soluble boron in the pool water, or boron-based neutron absorber materials incorporated into the racks which support the spent fuel assemblies. Because the means used to meet subcriticality requirements are not standardized among pools and because these means may change during plant operation, it was necessary to collect this information into a single updatable reference document that can inform regulatory decisions. Information about the means used to meet subcriticality requirements for each spent fuel pool was taken from public documents found in the NRC Agencywide Document Access Management System (ADAMS) and compiled into two spreadsheets.

The Spent Fuel Pool Criticality Management spreadsheet lists the means by which each operating spent fuel pool in the entire US fleet meets its subcriticality requirement of  $k_{eff} \leq 0.95$ , along with the original License Amendment reference which approved the current means. All information in the spreadsheet is obtained from publicly available documents.

## **Background**

NRC licensees use many means to meet subcriticality requirements in the spent fuel pool specified by the regulations 10 CFR 50.68 or GDC 62. Most spent fuel pools now store spent fuel assemblies in high-density racks which incorporate neutron absorber materials into the rack walls. These neutron absorber materials, especially Boraflex, can degrade enough to lose their neutron absorbing capabilities and challenge subcriticality requirements. Due to this degradation, many licensees now employ other means to meet subcriticality requirements such as spent fuel loading patterns, fuel burnup credit, control rods or other neutron poisons contained within spent fuel bundles, soluble boron [B] in the pool water, or some combination of all of these. In some cases, a licensee will credit no neutron absorber material and rely entirely on other means to meet subcriticality requirements. Since licensees use many different means to meet subcriticality requirements, and because licensees may employ new means due to neutron absorbing material degradation or spent fuel pool storage needs, it is necessary to compile this information into a single updateable reference to inform regulatory decisions.

## **Spent Fuel Pool Criticality Management Spreadsheet**

Before describing the spreadsheet, it should be noted that not each reactor is assigned to one dedicated spent fuel pool. Two reactors may share a single pool, a single reactor may store fuel in more than one pool, or two reactors at a single site may move fuel between both pools. In addition, there are three operating pools associated with decommissioned reactors. Therefore, entries in all spreadsheet will refer to individual spent fuel pools rather than to reactor licensees.

To populate the spreadsheet, staff from the Office of Nuclear Regulatory Research (RES) first obtained information on the various means used to meet subcriticality requirements for each spent fuel pool using the licensees' Updated Final Safety Analysis Reports (UFSARs). UFSARs, while not publicly available, provide a broad description of spent fuel storage, including rack design, neutron absorbing materials and other means used to meet subcriticality requirements. To confirm the means used to meet subcriticality requirements employed by each spent fuel pool as stated in the UFSAR, RES staff searched the ADAMS document database the definitive documents which clearly defined these means.

## **Pools in the Spent Fuel Pool Criticality Management Spreadsheet**

Spent Fuel Pool Criticality Management spreadsheet is a Microsoft Excel Workbook comprising three worksheets. One worksheet lists pressurized water reactor (PWR) pools, a second worksheet lists boiling water reactor (BWR) pools, and the third worksheet lists pools at decommissioned reactors. In general, each pool is entered on one line. If two reactors at a plant site share a pool, the entry is listed as one pool and is indicated as a shared pool, for example: "North Anna Units 1+2 (shared pool)." The Calvert Cliffs pool shares one large pool

divided by a wall. However, because the two halves employ a different strategy for meeting subcriticality requirements, each half of the Calvert Cliffs pool is listed separately. Three Mile Island Unit 1 operates two pools: Pools A and B. Each pool employs different means to meet subcriticality requirements, and so they are listed separately. Shearon Harris is a one-reactor unit, but employs four interconnected pools. To be consistent with the Shearon Harris UFSAR, Pools A and B are grouped as one pool and Pools C and D are grouped as a second pool. In several plants, an additional spent fuel rack was installed in other sections of the fuel handling system such as the cask pool or refueling channel.

### **Organization of subcriticality credit data for a Pool**

For each pool, the spreadsheet lists the most current means to meet subcriticality requirements, as of December 16, 2011, along with the reference for the License Amendment which describes the current means(s). The last column of the spreadsheet is a time stamp to facilitate further updates. The information in the spreadsheet was confirmed by both public and non-public sources, such as Technical Specifications, Safety Evaluation Reports (SERs), and the pool's most recent UFSAR. Columns are described separately:

#### **Current means used to meet subcriticality requirements:**

This column lists all means used to meet subcriticality requirements in the spent fuel pool. In general, the subcriticality requirements are met by a combination of neutron absorber materials, storage patterns/burnup, and, in PWR's only, soluble boron [B]. The means used to meet subcriticality requirements is the most current as of the latest applicable License Amendment reference found in ADAMS, and does not include previous rack configurations or previous means used to meet subcriticality requirements.

For the PWR worksheet in the spreadsheet, the Current Means column is divided into subcolumns denoting Region 1, designed for freshly discharged fuel, and Region 2, designed for older fuel. If a PWR licensee utilizes soluble boron as a means of meeting subcriticality requirements, then the licensee will calculate the minimum ppm of soluble boron necessary to meet the subcriticality requirement under normal operations. This calculated ppm [B], as stated in the reference license amendment, is listed for each region of the pool. Furthermore, some licensees explicitly estimate the necessary operating B concentration for each region of the pool separately. Therefore, the ppm [B] listed may be different for Region 1 and Region 2.

The term "storage patterns/burnup" encompasses a variety of means to meet subcriticality requirements. These means include low-density or flux-trap racks, storage configurations which place a high-burnup assembly adjacent to a low-burnup assembly, storage configurations such as checkerboarding or administrative water holes, or storage configurations to place less reactive fuel assemblies next to degraded panels where less neutron absorption is needed. Fuel burnup credit includes credit for the net reduction in fissile isotopes and net increase in neutron absorption in the fuel bundle. Final net depletion in reactivity, for which burnup credit is taken, depends on numerous factors such as reactor operating parameters, initial enrichment,

or presence of fixed or integrated neutron absorbers. Because the types and combinations of storage patterns and burnup are numerous, varied, and often changed, no attempt was made to list the specific storage patterns or fuel burnup credit in this spreadsheet. Users are referred to the references for details of a specific pool.

#### Reference License Amendment and Confirmation

Each change in assignment of means used to meet subcriticality requirements is reviewed and approved under the NRC License Amendment process. The reference for Issuance of License Amendment is cited in the Original Reference column by License Amendment number, date, and ADAMS Accession (ML) number. The Reference License Amendment refers to the license amendment where the current means of meeting subcriticality was approved. Amendments for past configurations are not listed in the Management of Spent Fuel Pool Criticality spreadsheet, although it is planned to include historical information in a future database. If two or three license amendments are issued for a plant site, one for each pool, then the data cells in this column will cite the same reference ADAMS Accession ML number, but will denote the respective license amendment number. In several cases, a license amendment was issued, but not implemented until sometime after issuance. In a few cases, new license amendments are pending. These instances are noted in the comments. If no license amendment is found, that is also specified. For several pools, no License Amendment was found for the pool's current method to manage subcriticality; for example if the pool adopted a new subcriticality method under 10 CFR 50.59. These cases are specified in the Reference License Amendment Columns and are described further in the Comment column.

In order to confirm that the means used to meet subcriticality requirements specified in the Reference License Amendment are still valid, RES staff identified a recent confirmatory reference, e.g., Technical Specifications, Safety Evaluation Reports, or the pool's most recent UFSAR. Where Technical Specifications or UFSARS did not confirm the information from the Reference License Amendment, a recent corroborating reference, such as a Safety Evaluation Report (SER), Technical Specification Bases, or a response to a Request for Additional Information (RAI) was used for confirmation.

#### Citations for the references:

For most spent fuel pools, the reference License Amendment is cited as the source of each pool's means to meet criticality requirements. Documents are cited by date, and, when available, by ADAMS Accession ML number. References may also include a page number; for example: "ML052720276 p243." The page number refers to the page number of the .PDF file as entered into ADAMS, not the page number within the actual document. Citing the .PDF page

number allows the user to quickly jump to the page where the information can be found. All page number references in the Management of Spent Fuel Pool Criticality spreadsheet refer to the PDF page number.

#### Date Updated:

Each entry on all worksheets is time-stamped with a "Date Updated." This date refers to the last date when ADAMS was searched, *not* the date when the spreadsheet itself was updated. For example, in the current version of Spent Fuel Pool Criticality Management, ADAMS was searched for documents as late as December 16, 2011. Thus, if a user were to update the spreadsheet, the user would search ADAMS for documents dated after December 16, 2011.

#### Decommissioned Reactors

The last worksheet in the Spent Fuel Pool Criticality Management spreadsheet compiles information about decommissioned reactors. Reactors are only listed if they possess fuel in wet storage. Of the decommissioned reactor sites, three wet pools are still actively storing spent fuel: LaCrosse, Millstone 1, and Zion Units 1+2 (shared pool). Only one source is cited for means used to meet criticality requirements. Millstone 1 and Zion Units 1+2 cite a Decommissioned Safety Analysis Report (DSAR), and LaCrosse cites a document related to a recent license amendment. Citations and ADAMS Data are similar to the PWR and BWR worksheets.

#### Conclusion

The means used to meet subcriticality requirements for all US domestic active spent fuel pools was compiled from publicly available documents for PWR pools, BWR pools, and active pools for decommissioned plants. For each pool, the current means used to meet subcriticality requirements is described and referenced by the original License Amendment. All information was confirmed by a recent definitive source. Relevant comments are also included and referenced. The database contains a date stamp to facilitate future searching and updates. The spreadsheet gathers the relevant public information concerning means used to meet subcriticality requirements for all spent fuel pools into one reference document.