Duke Energy

H. B. Barron
Vice President

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August 1, 2000

U.S. Nuclear Regulatory Commission
ATTENTION: Document Control Desk
Washington, DC 20555-0001

SUBJECT: Duke Energy Corporation (DEC)
McGuire Nuclear Station Units 1 and 2
Docket Nos. 50-369/50-370
Proposed Technical Specification (TS) Amendments
TS 3.7.15 - Spent Fuel Assembly Storage
TS 4.3 - Fuel Storage

Pursuant to 10 CFR 50.90 and 10 CFR 50.4, this letter submits a license amendment request (LAR) for the McGuire Nuclear Station Facility Operating Licenses (FOL) and TS's. This amendment request modifies a LAR previously submitted by a letter dated April 5, 1999 and supplemented by a letter dated January 14, 2000. Due to possible non-conservative calculations in the criticality analysis used to support the original LAR, that amendment request was subsequently retracted by letter dated March 23, 2000. The non-conservative nature of these calculations arose from assumptions in the analyses originally used to model the McGuire Spent Fuel Pools. They were discovered during re-analysis to support the original LAR (reference McGuire LER 369/00-03). The attached LAR incorporates changes resulting from DEC's revision of the supporting criticality analysis calculations.

This LAR will change the McGuire TS's to provide revised spent fuel pool storage configurations, revised spent fuel pool storage criteria, and revised fuel enrichment and burnup requirements which take credit for soluble boron in maintaining acceptable margins of subcriticality in the spent fuel storage pools. In addition, this LAR will change the McGuire TS's to provide revised criteria for acceptable levels of subcriticality in the McGuire spent fuel storage pools. These changes are necessary to offset the loss of some boron in the spent fuel storage cell Boraflex panels at McGuire. This proposed amendment is applicable to Facility Operating Licenses NPF-9 and NPF-17 for the McGuire Nuclear Station. It is similar to a LAR for Turkey Point Units 3 and 4 which was approved by the NRC via an SER issued on July 19, 2000 (TAC No.s MA7262 and MA7263)

Attachment 1 provides marked up pages of the existing McGuire TS's showing the proposed changes. Attachment 2 contains the new

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McGuire TS pages. The Description of Proposed Changes and Technical Justification is provided in Attachment 3. Pursuant to 10CFR50.92, Attachment 4 documents the determination that this proposed amendment contains no significant hazards considerations. Pursuant to 10CFR51.22 (c)(9), Attachment 5 provides the basis for the categorical exclusion from performing an Environmental Assessment or Impact Statement. The McGuire Spent Fuel Pool Criticality Analysis, McGuire Spent Fuel Pool Dilution Analysis Summary, and the McGuire Boraflex Degradation Analysis used to support this LAR are shown on Attachments 6, 7, and 8 respectively. Attachments 10 and 11 show the proposed and revised BASES for TS 3.7.14 and 3.7.15. The differences between the original LAR submitted on April 5, 1999 as supplemented on January 14, 2000 and the modified LAR submitted with this letter are summarized in Attachment 12.

Implementation of this amendment to the McGuire FOL's and TS's will impact the stations UFSAR. Consequently, upon approval of this LAR, the applicable revisions will be included in a McGuire UFSAR update. These revisions will include a proposed addition to Chapter 16 of the UFSAR, "Selected Licensee Commitments" as shown in Attachment 9. This commitment will provide for periodic monitoring of future Boraflex degradation. If this monitoring determines that the Boraflex in a spent fuel storage pool has degraded to levels that would not support the conclusions of the McGuire Criticality Analysis that provides a basis for this LAR, then a future LAR would be submitted proposing additional changes to the McGuire TS's as needed to maintain acceptable levels of subcriticality in the McGuire spent fuel storage pools. Note that an evaluation by DEC determined that this Boraflex panel monitoring did not meet the TS criteria specified in 10 CFR 50.36 (c)(2)(ii) and as such a new TS is not proposed for this feature. This is consistent with the previously mentioned Turkey Point LAR which did not propose any new TS for Boraflex panel monitoring.

In accordance with Duke internal procedures and the Quality Assurance Program Topical Report, this proposed amendment has been previously reviewed and approved by the McGuire Station's Plant Operations Review Committee and the Duke Corporate Nuclear Safety Review Board. Pursuant to 10CFR50.91, a copy of this LAR is being forwarded to the appropriate North Carolina state officials.

Due to the loss of some boron in the spent fuel pool Boraflex panels at McGuire and the discovery of the non-conservative criticality analysis calculations, McGuire is currently operating under administrative controls to maintain acceptable margins of subcriticality in the storage pools. DEC understands that the NRC staff had completed their review of a significant portion of the original LAR. To expedite the review of this LAR submittal, a detailed list of the changes made to the original LAR submitted on April 5, 1999 is included in Attachment 12. Consequently, it is requested that the NRC expedite review of the attached LAR. DEC requests approval of this LAR by December 1, 2000 to support the next Unit 1 refueling outage (1EOC14).

Please contact Julius Bryant at 704-875-4162 with any questions regarding this LAR.

Very truly yours,

H. B. Barron
Site Vice President
McGuire Nuclear Station

Attachments

xc: (w/attachments)

L.A. Reyes
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U.S. Nuclear Regulatory Commission
Atlanta Federal Center
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V.R. Autry, Director
Division of Radioactive Waste Management
Bureau of Land and Waste Management
Department of Health and Environmental Control
2600 Bull Street
Columbia, S.C. 29201

H. B. Barron, being duly sworn, states that he is Vice President of McGuire Nuclear Station; that he is authorized on the part of Duke Energy Corporation to sign and file with the U.S. Nuclear Regulatory Commission these revisions to the McGuire Nuclear Station Facility Operating Licenses Nos. NPF-9 and NPF-17; and, that all statements and matters set forth therein are true and correct to the best of his knowledge.

H B Barron

H. B. Barron, Vice President
McGuire Nuclear Station
Duke Energy Corporation

Subscribed and sworn to before me this 1st day of August, 2000.

Deborah G. Thrap
Notary Public
Deborah G. Thrap

My Commission Expires: 4/6/2002

bxc: (w. attachments)

T. C. Geer (MG05EE)
K. L. Crane (MG01RC)
G. D. Gilbert (CN01RC)
L. J. Rudy (CN01RC)
G. B. Swindlehurst (EC08H)
L. E. Nicholson (ON03RC)
J. I. Glenn (MG05EE)
S. C. Ballard (MG05EE)
K. P. Waldrop (EC08F)
D. C. Jones (EC08F)
C. J. Thomas (EC05O)
ELL (EC05O)
NSRB Support Staff (EC05N)
Masterfile

ATTACHMENT 1

PROPOSED REVISIONS TO THE
MCGUIRE TECHNICAL SPECIFICATIONS

, burnup and number of Integral Fuel Burnable Absorber (IFBA) rods

3.7 PLANT SYSTEMS

3.7.15 Spent Fuel Assembly Storage

LCO 3.7.15 The combination of initial enrichment ~~and burnup~~ of each new or spent fuel assembly stored in the spent fuel pool storage racks shall be within the following configurations:

a. New or irradiated fuel may be stored in Region 1A of the spent fuel pool in accordance with these limits:

SEE NEXT PAGE FOR INSERT

1. Unrestricted storage of new fuel meeting the criteria of Table 3.7.15-1; or

3 2. Restricted storage in accordance with Figure 3.7.15-1, of fuel which does not meet the criteria of Table 3.7.15-1 or Table 3.7.15-2.

b. New or irradiated fuel may be stored in Region 1B of the spent fuel pool in accordance with these limits:

1. Unrestricted storage of fuel meeting the criteria of Table 3.7.15-~~3~~ 4; or

2. Restricted storage in accordance with Figure 3.7.15-2, of fuel which meets the criteria of Table 3.7.15-~~4~~ 5; or

3. Checkerboard storage in accordance with Figure 3.7.15-3 of fuel which does not meet the criteria of Table 3.7.15-~~4~~ 5.

ADD

c. New or irradiated fuel which has decayed at least 16 days may be stored in Region 2A of the spent fuel pool in accordance with these limits:

1. Unrestricted storage of fuel meeting the criteria of Table 3.7.15-7; or

2. Restricted storage in accordance with Figure 3.7.15-4, of fuel which meets the criteria of Table 3.7.15-8; or

3. Checkerboard storage in accordance with Figure 3.7.15-5 of fuel which does not meet the criteria of Table 3.7.15-8.

INSERT FOR PAGE 3.7.15-1

2. Unrestricted storage of fuel meeting the criteria of Table 3.7.15-2; or

ADD

d. New or irradiated fuel which has decayed at least 16 days may be stored in Region 2B of the spent fuel pool in accordance with these limits:

1. Unrestricted storage of fuel meeting the criteria of Table 3.7.15-10; or

2. Restricted storage in accordance with Figure 3.7.15-6, of fuel which meets the criteria of Table 3.7.15-11; or

3. Checkerboard storage in accordance with Figure 3.7.15-7 of fuel which does not meet the criteria of Table 3.7.15-11.

APPLICABILITY: Whenever any fuel assembly is stored in the spent fuel pool.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Requirements of the LCO not met.	A.1 -------------NOTE-------------- LCO 3.0.3 is not applicable. ----------------------------------- Initiate action to move the noncomplying fuel assembly to the correct location.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.7.15.1 ~~Verify by administrative means the initial enrichment and burnup of the fuel assembly is in accordance with the specified configurations.~~	Prior to storing the fuel assembly in the spent fuel pool

Verify by administrative means the planned spent fuel pool location is acceptable for the fuel assembly being stored.

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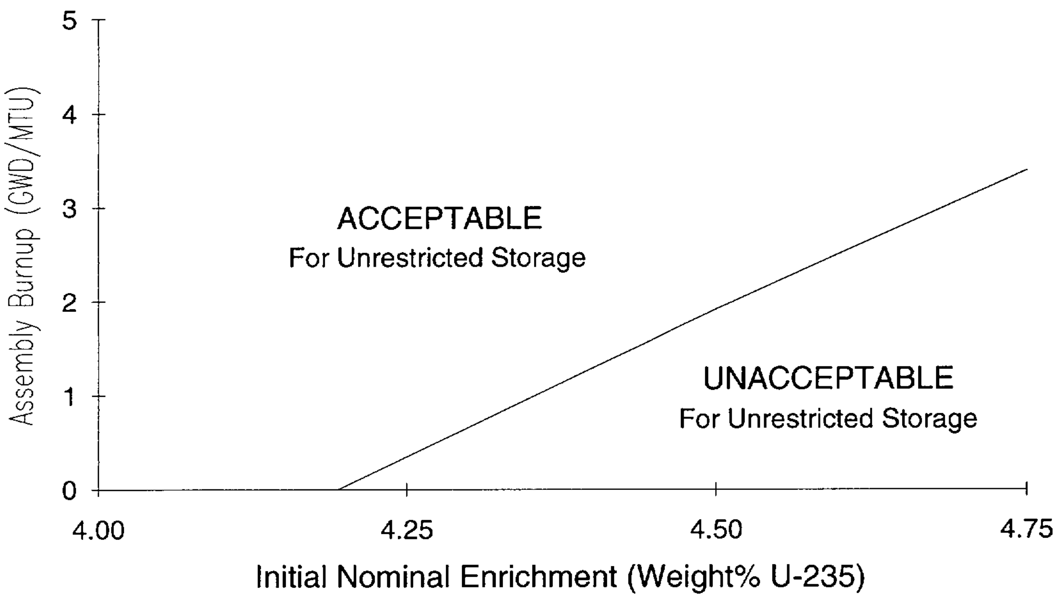
Table 3.7.15-1 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Unrestricted Region 1 Storage

Initial Nominal Enrichment (Weight% U-235)	Assembly Burnup (GWD/MTU)
4.19(or less)	0
4.20	0.04
4.50	1.92
4.75	3.40



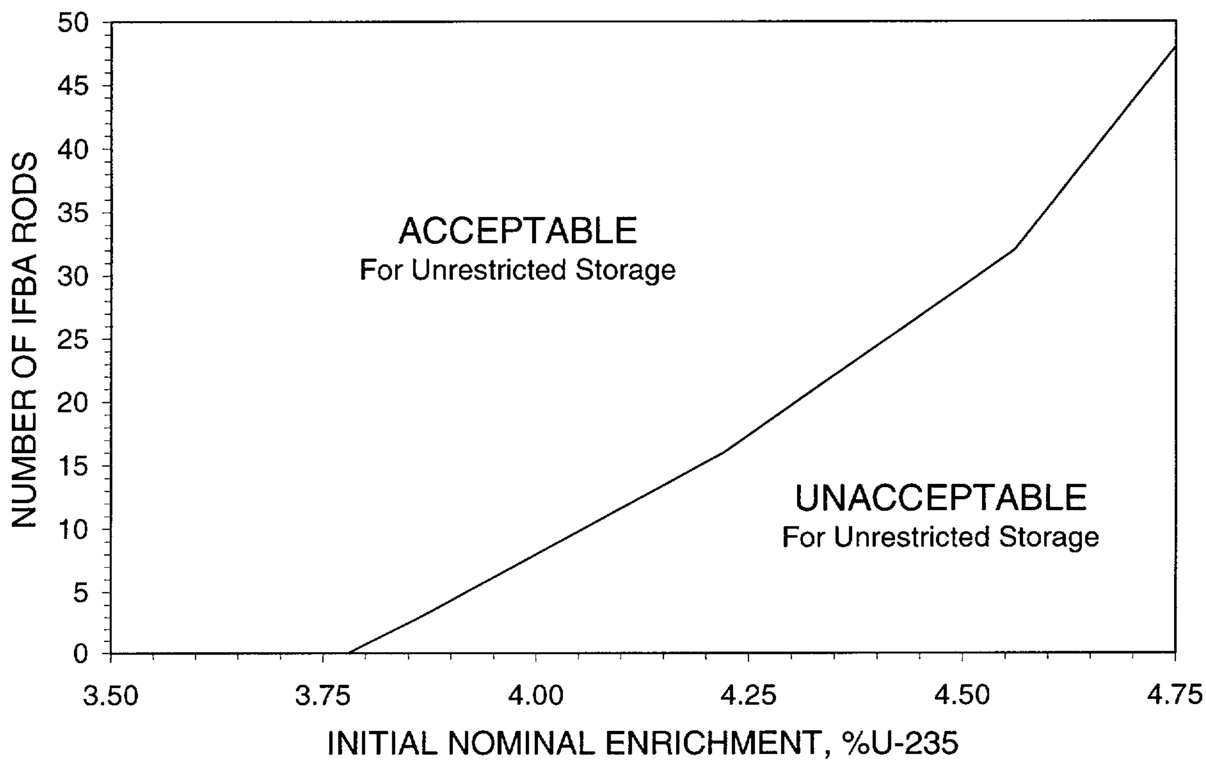
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-1 may be qualified for Unrestricted Region 1 storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than or equal to 0.95. Likewise, previously unanalyzed fuel up to a nominal 4.75 weight% U-235 may be qualified for Restricted Region 1 storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than or equal to 0.95.

NEW PAGE
3.7.15-3

Table 3.7.15-1 (page 1 of 1)
Minimum Qualifying Number of IFBA Rods Versus Initial Enrichment
for Unrestricted Region 1A Storage of New Fuel

Initial Nominal Enrichment (% U-235)	Number of IFBA Rods
3.78 (or less)	0
4.22	16
4.56	32
4.75	48



NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-1 may be qualified for Unrestricted Region 1A storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

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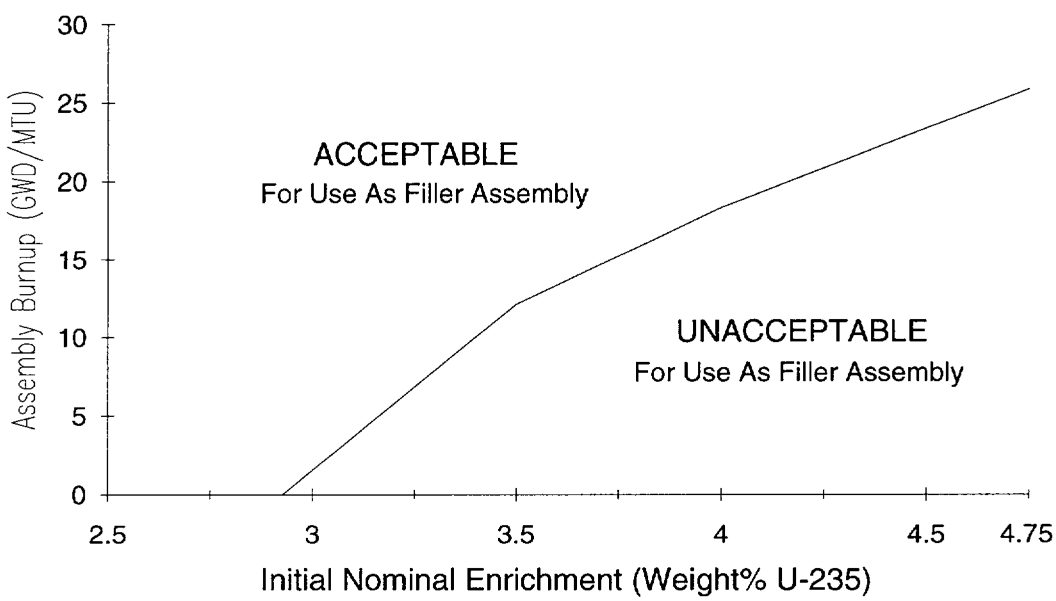
Table 3.7.15-2 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Region 1 Filler Assemblies

Initial Nominal Enrichment (Weight% U-235)	Assembly Burnup (GWD/MTU)
2.92 (or less)	0
3.00	1.57
3.50	13.30
4.00	18.32
4.50	23.36
4.75	25.84



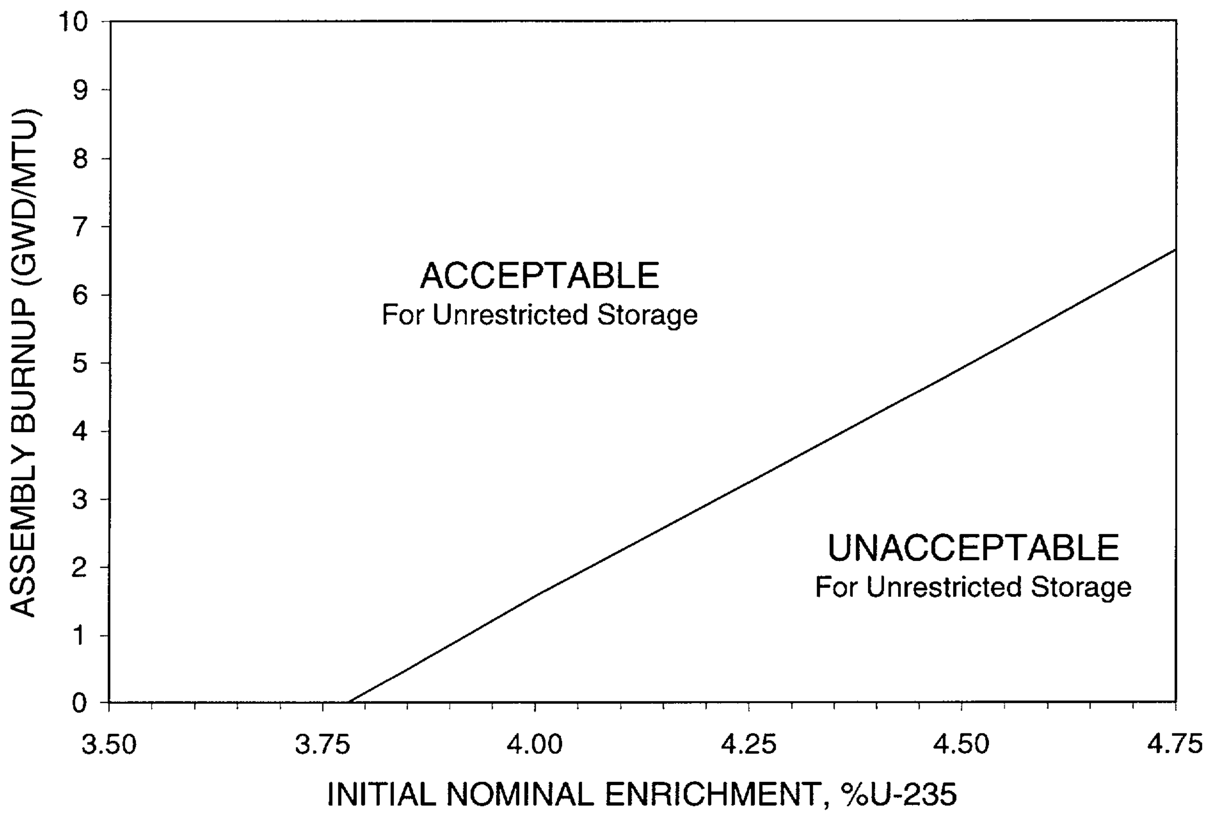
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-2 may be qualified for use as a Region 1 Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than or equal to 0.95.

NEW PAGE
3.7.15-4

Table 3.7.15-2 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Unrestricted Region 1A Storage

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
3.78 (or less)	0
4.00	1.58
4.50	4.92
4.75	6.66



NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-2 may be qualified for Unrestricted Region 1A storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron. Likewise, previously unanalyzed fuel up to a nominal 4.75 weight% U-235 may be qualified for Restricted Region 1A storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

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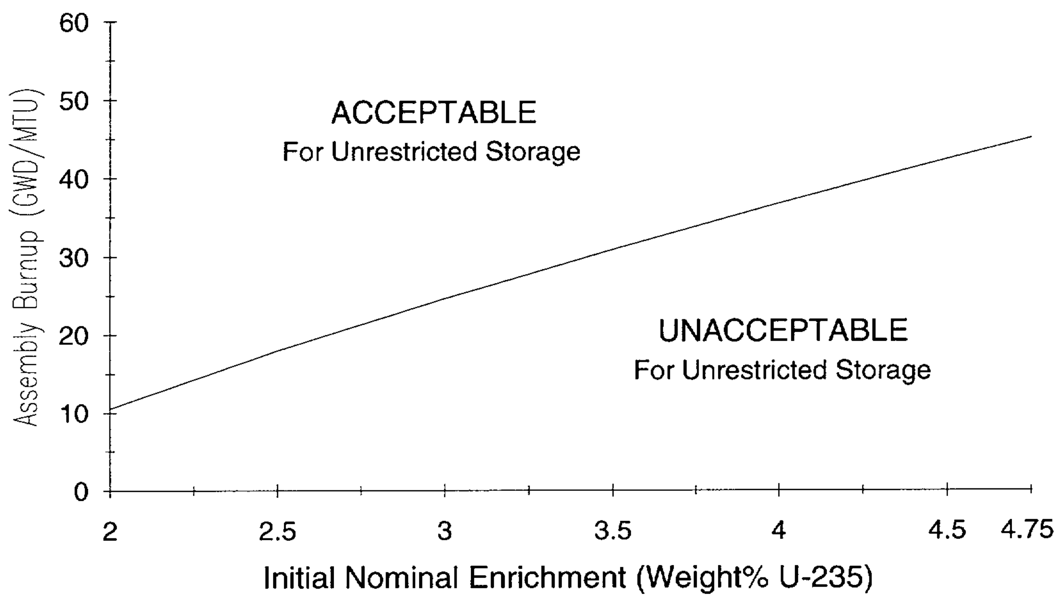
Table 3.7.15-3 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Unrestricted Region 2 Storage

Initial Nominal Enrichment (Weight% U-235)	Assembly Burnup (GWD/MTU)
2.00 (or less)	10.54
2.50	17.96
3.00	24.64
3.50	30.86
4.00	36.75
4.50	42.38
4.75	45.10



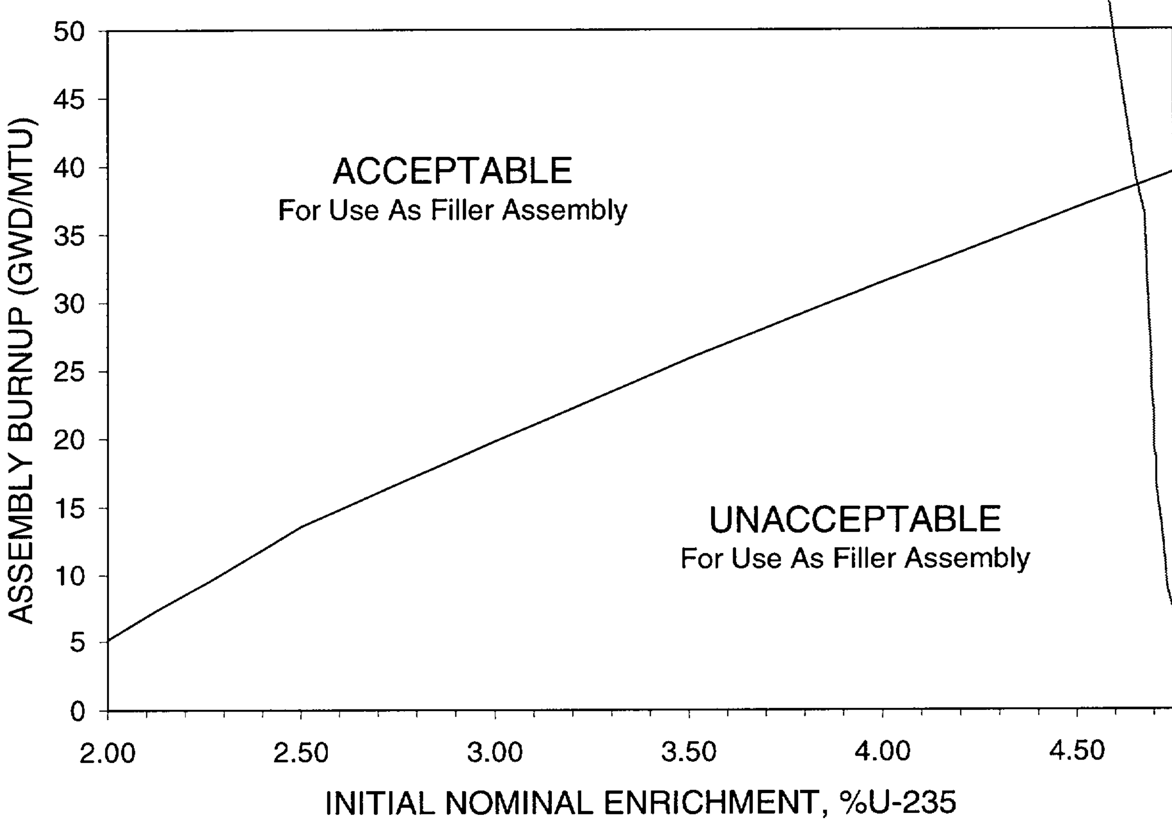
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-3 may be qualified for Unrestricted Region 2 storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than or equal to 0.95.

NEW PAGE
3.7.15-5

Table 3.7.15-3 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Region 1A Filler Assemblies

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.76 (or less)	0
2.00	5.12
2.50	13.57
3.00	19.80
3.50	25.85
4.00	31.50
4.50	36.93
4.75	39.54



NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-3 may be qualified for use as a Region 1A Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

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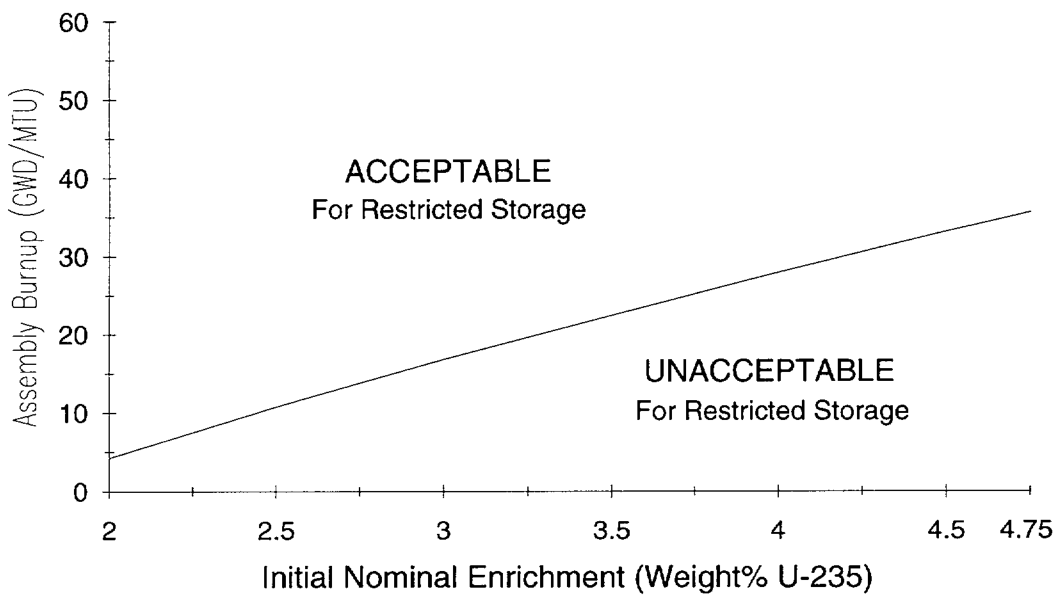
Table 3.7.15-4 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Restricted Region 2 Storage with Fillers

Initial Nominal Enrichment (Weight% U-235)	Assembly Burnup (GWD/MTU)
2.00 (or less)	4.22
2.50	10.75
3.00	16.80
3.50	22.41
4.00	27.92
4.50	33.14
4.75	35.65



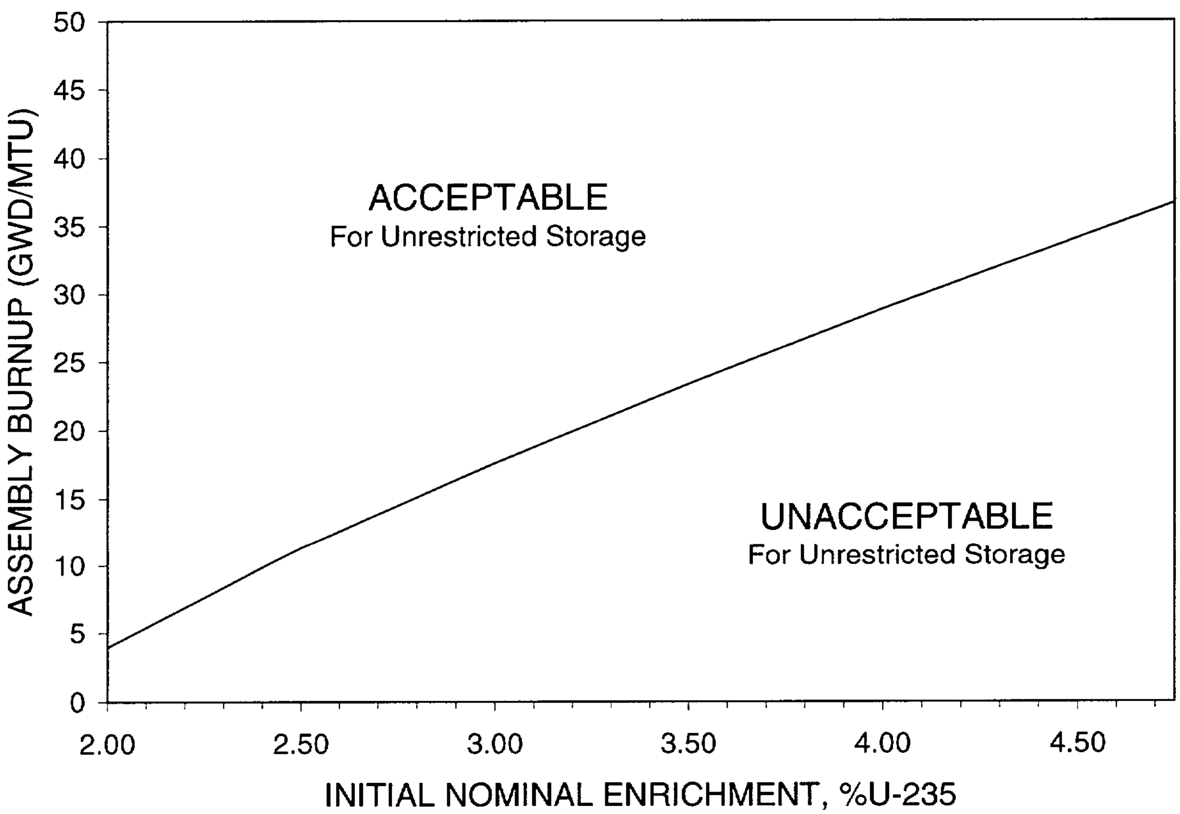
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-4 may be qualified for Restricted Region 2 Storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than or equal to 0.95.

NEW PAGE
3.7.15-6

Table 3.7.15-4 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Unrestricted Region 1B Storage

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.78 (or less)	0
2.00	3.96
2.50	11.35
3.00	17.61
3.50	23.35
4.00	28.86
4.50	34.10
4.75	36.67



NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-4 may be qualified for Unrestricted Region 1B storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

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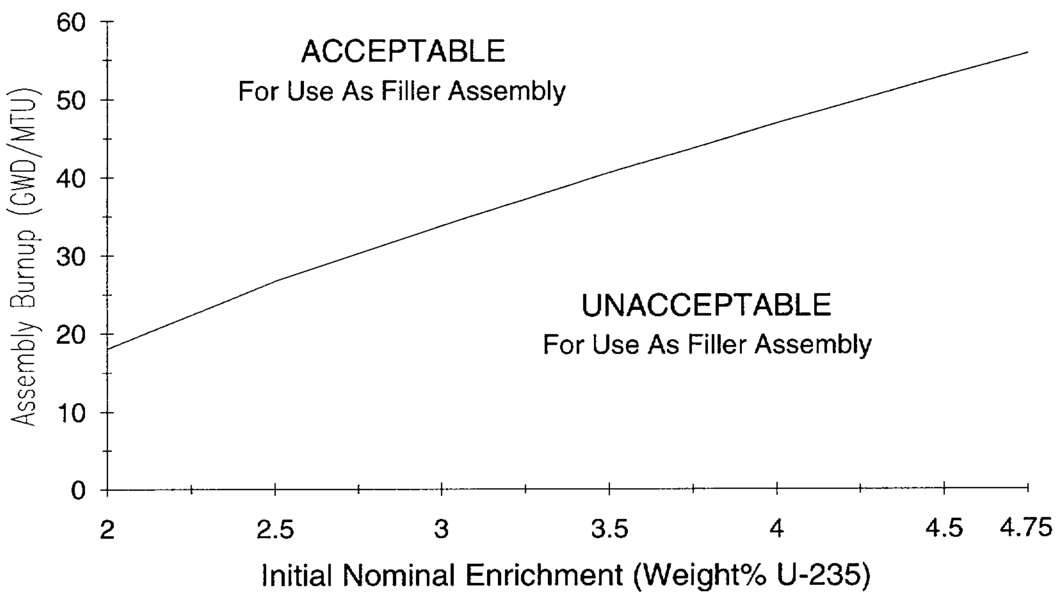
Table 3.7.15-5 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Region 2 Filler Assemblies

Initial Nominal Enrichment (Weight% U-235)	Assembly Burnup (GWD/MTU)
2.00 (or less)	18.03
2.50	26.71
3.00	33.79
3.50	40.56
4.00	46.83
4.50	52.86
4.75	55.78



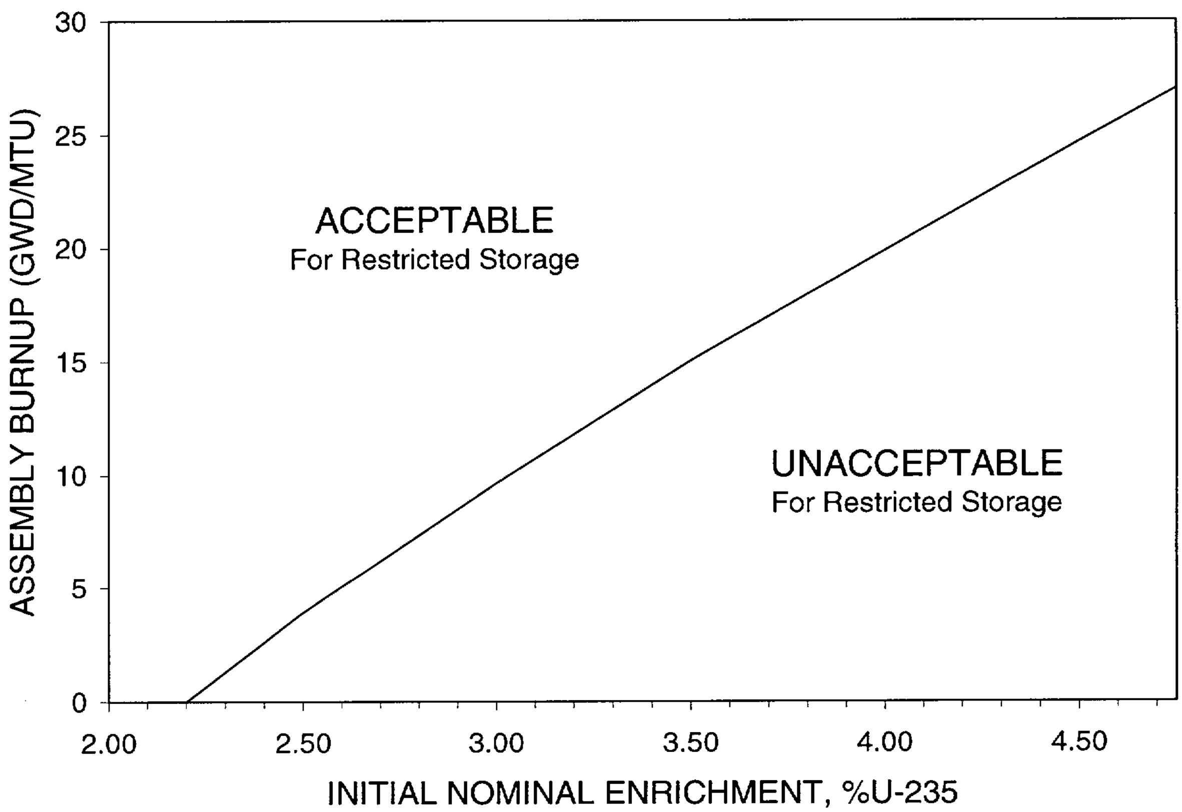
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-5 may be qualified for use as a Region 2 Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than or equal to 0.95.

NEW PAGE
3.7.15-7

Table 3.7.15-5 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Restricted Region 1B Storage with Fillers

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
2.20 (or less)	0
2.50	3.91
3.00	9.65
3.50	15.04
4.00	19.87
4.50	24.68
4.75	27.01



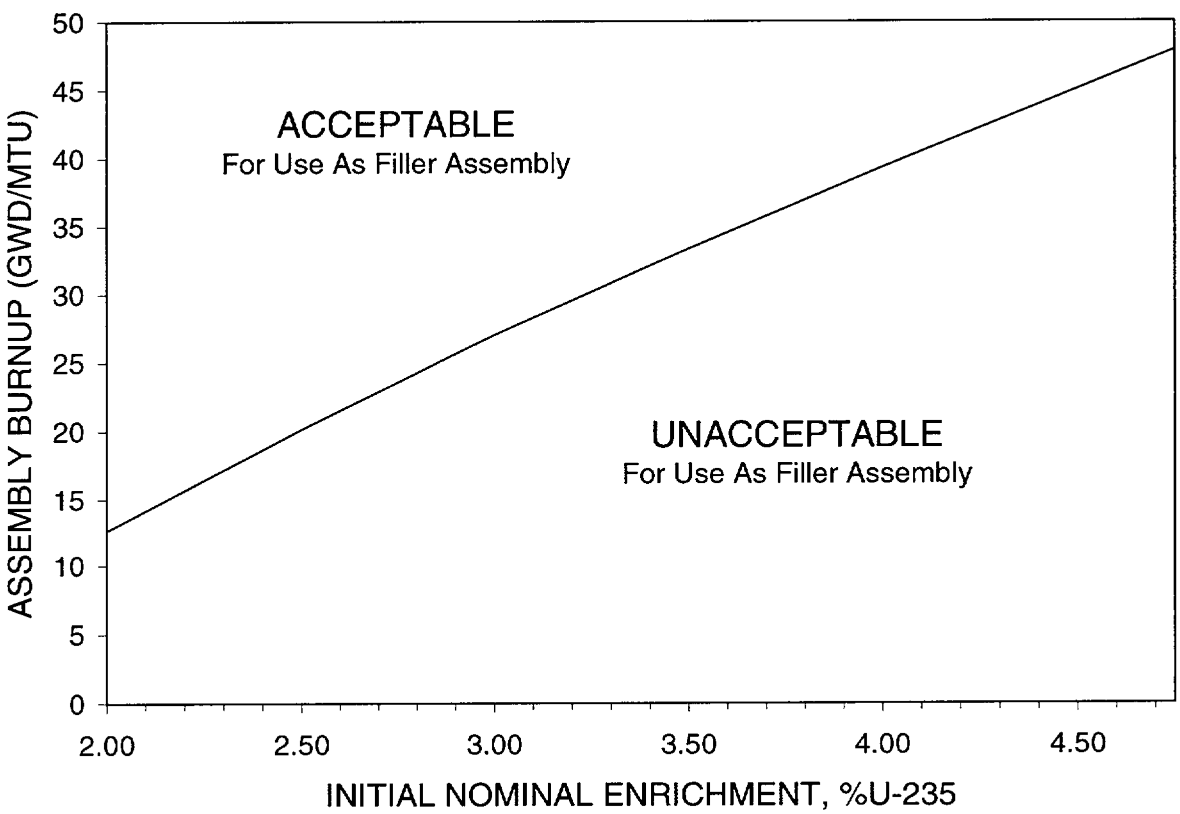
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-5 may be qualified for Restricted Region 1B Storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

NEW PAGE
3.7.15-8

Table 3.7.15-6 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Region 1B Filler Assemblies

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.44 (or less)	0
2.00	12.68
2.50	20.17
3.00	27.03
3.50	33.35
4.00	39.33
4.50	45.07
4.75	47.89



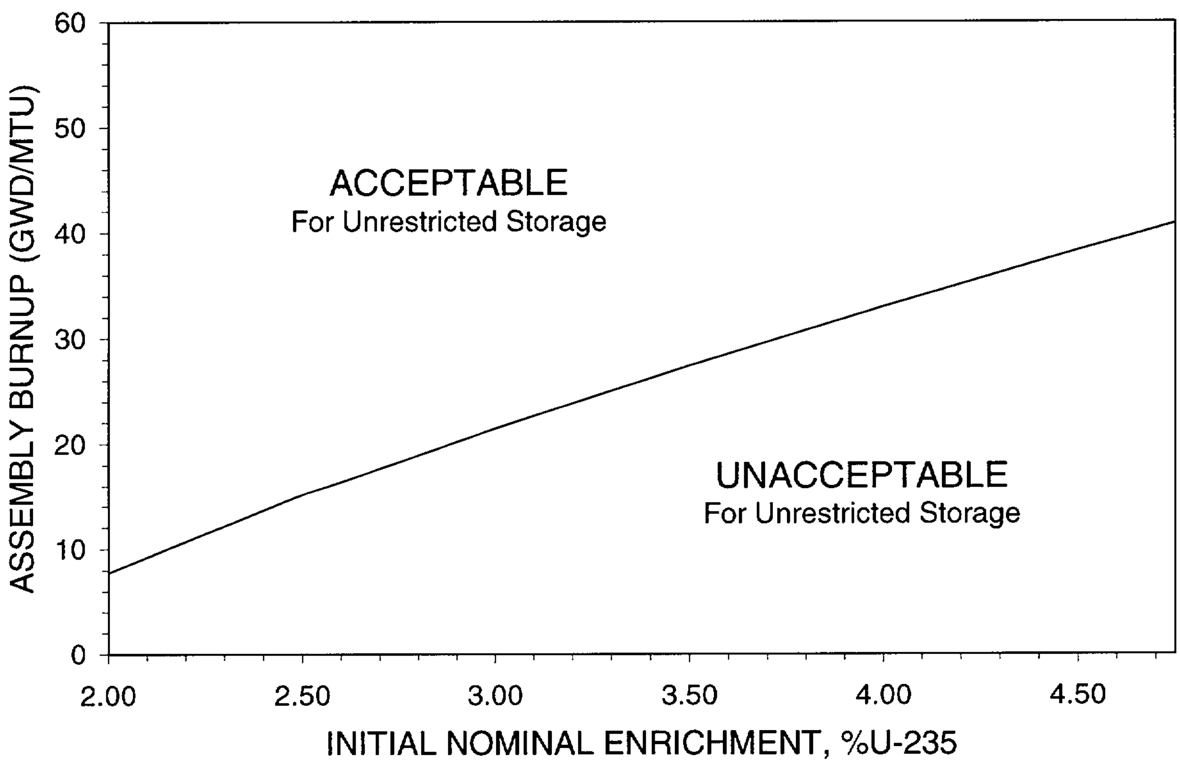
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-6 may be qualified for use as a Region 1B Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

NEW PAGE
3.7.15-9

Table 3.7.15-7 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Unrestricted Region 2A Storage

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.61 (or less)	0
2.00	7.79
2.50	15.14
3.00	21.45
3.50	27.42
4.00	33.00
4.50	38.32
4.75	40.91



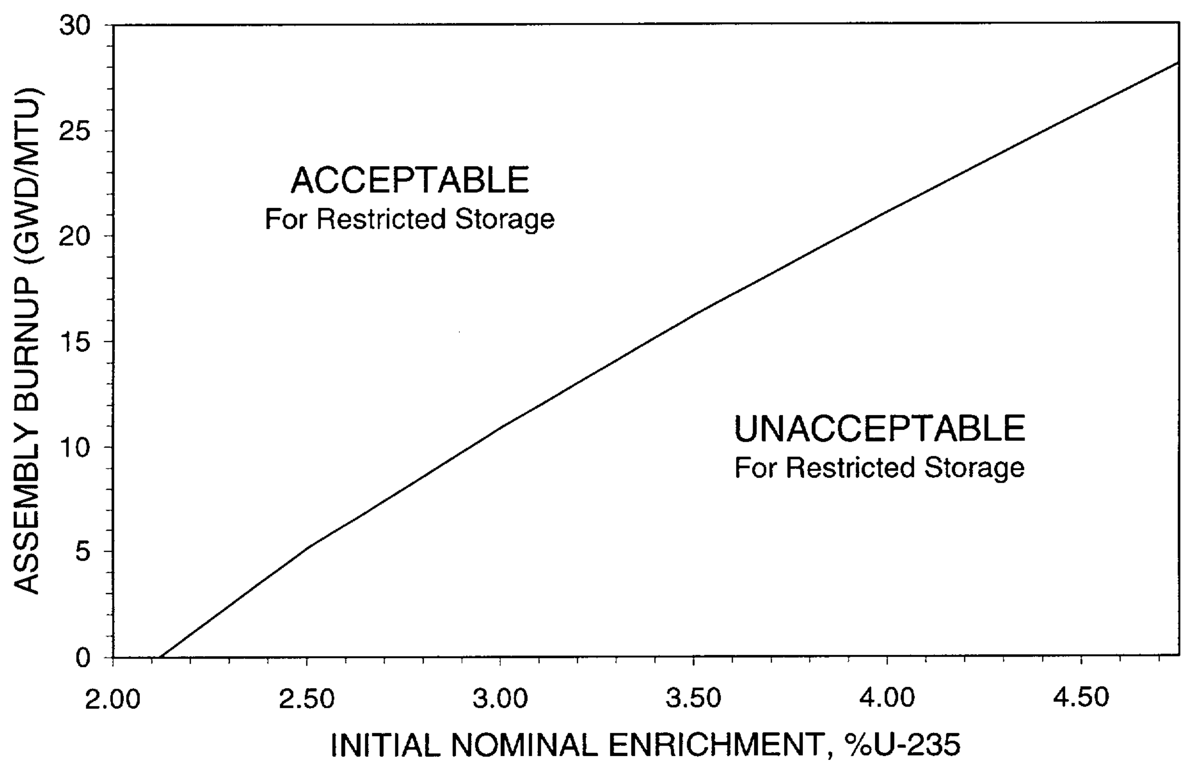
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-7 may be qualified for Unrestricted Region 2A storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

NEW PAGE
3.7.15-10

Table 3.7.15-8 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Restricted Region 2A Storage with Fillers

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
2.12 (or less)	0
2.50	5.10
3.00	10.88
3.50	16.19
4.00	21.07
4.50	25.81
4.75	28.11



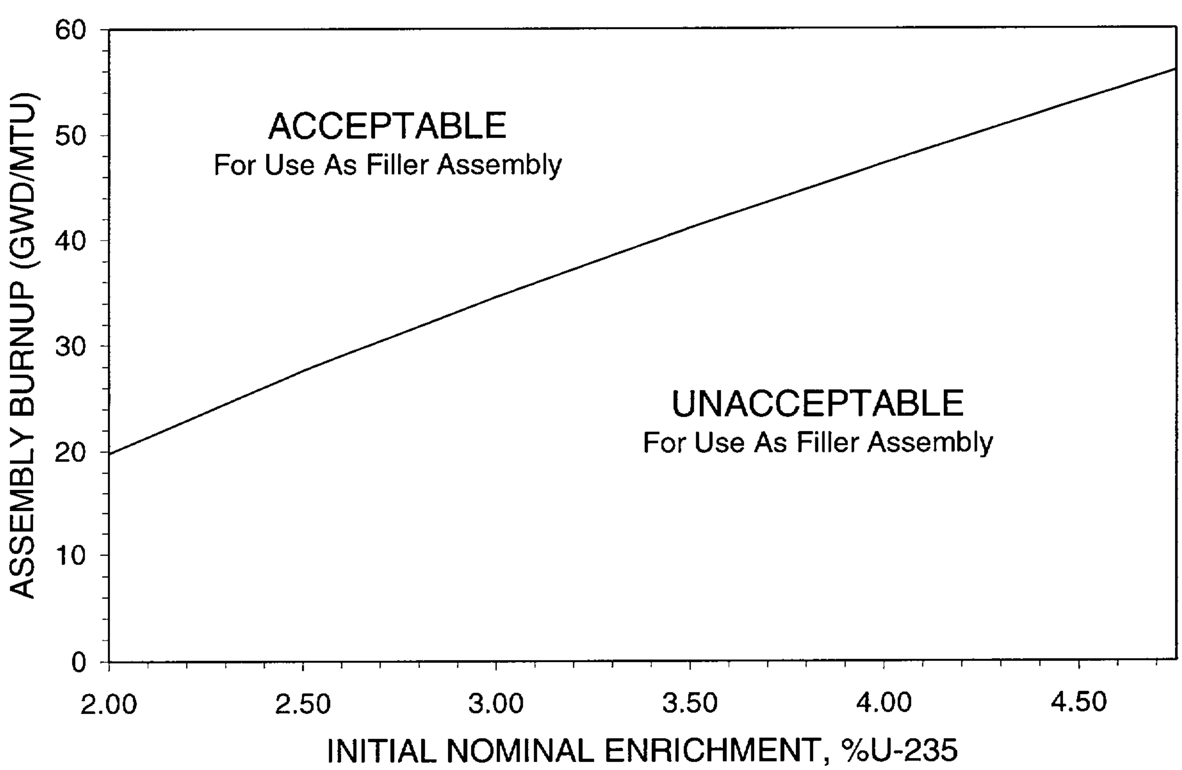
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-8 may be qualified for Restricted Region 2A Storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

NEW PAGE
3.7.15-11

Table 3.7.15-9 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Region 2A Filler Assemblies

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.20 (or less)	0
2.00	19.80
2.50	27.64
3.00	34.56
3.50	41.08
4.00	47.25
4.50	53.15
4.75	56.01



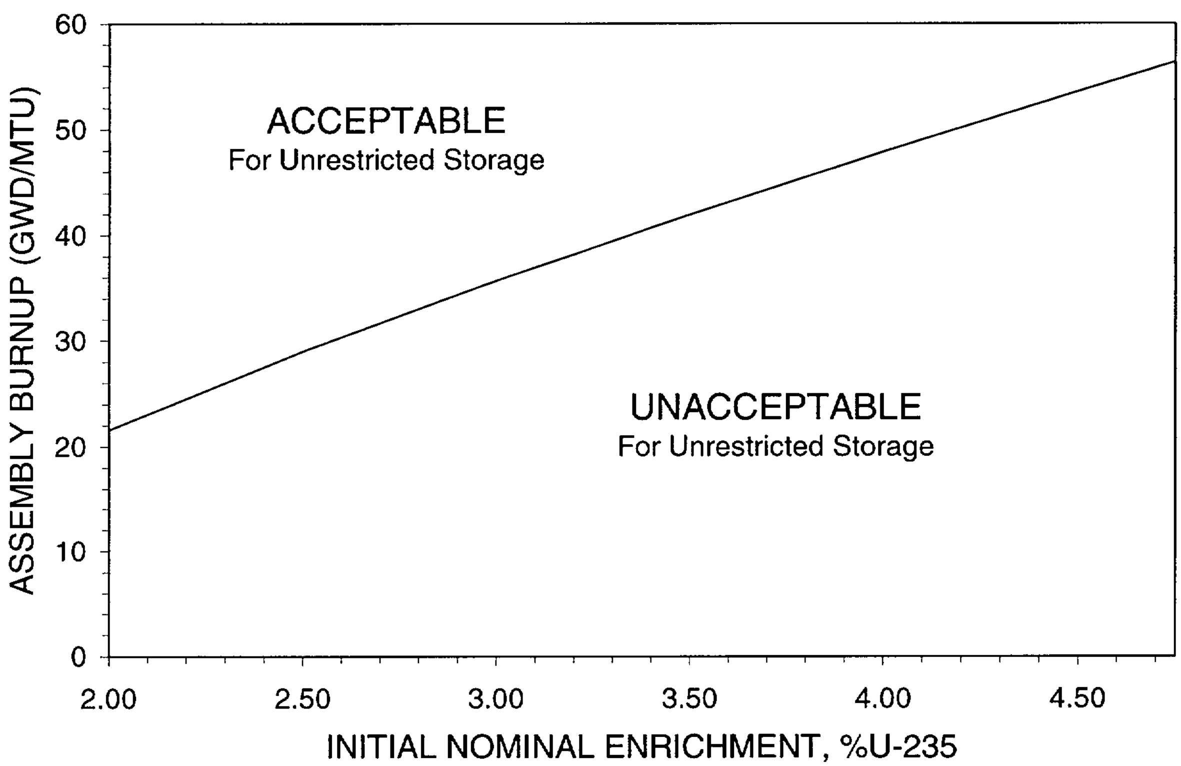
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-9 may be qualified for use as a Region 2A Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

NEW PAGE
3.7.15-12

Table 3.7.15-10 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Unrestricted Region 2B Storage

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.11 (or less)	0
2.00	21.58
2.50	29.00
3.00	35.69
3.50	41.97
4.00	47.90
4.50	53.57
4.75	56.33



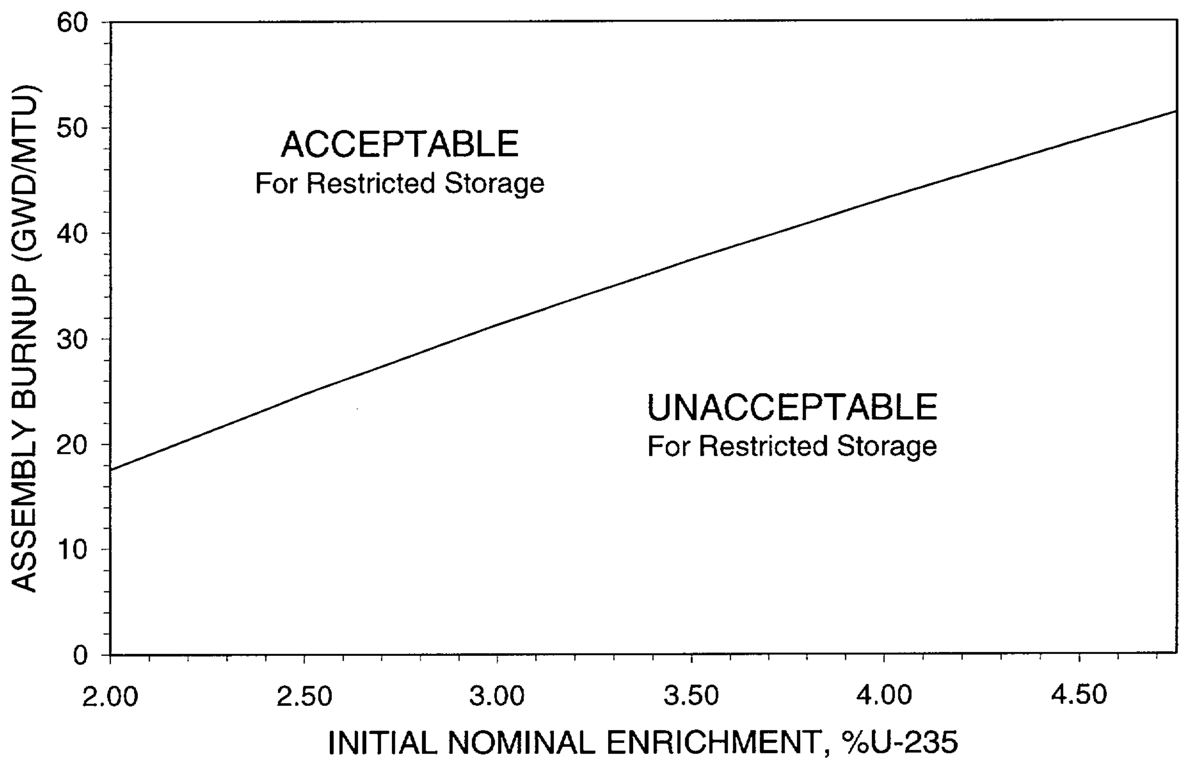
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-10 may be qualified for Unrestricted Region 2B storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

NEW PAGE
3.7.15-13

Table 3.7.15-11 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Restricted Region 2B Storage with Fillers

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.22 (or less)	0
2.00	17.55
2.50	24.73
3.00	31.31
3.50	37.40
4.00	43.15
4.50	48.65
4.75	51.33



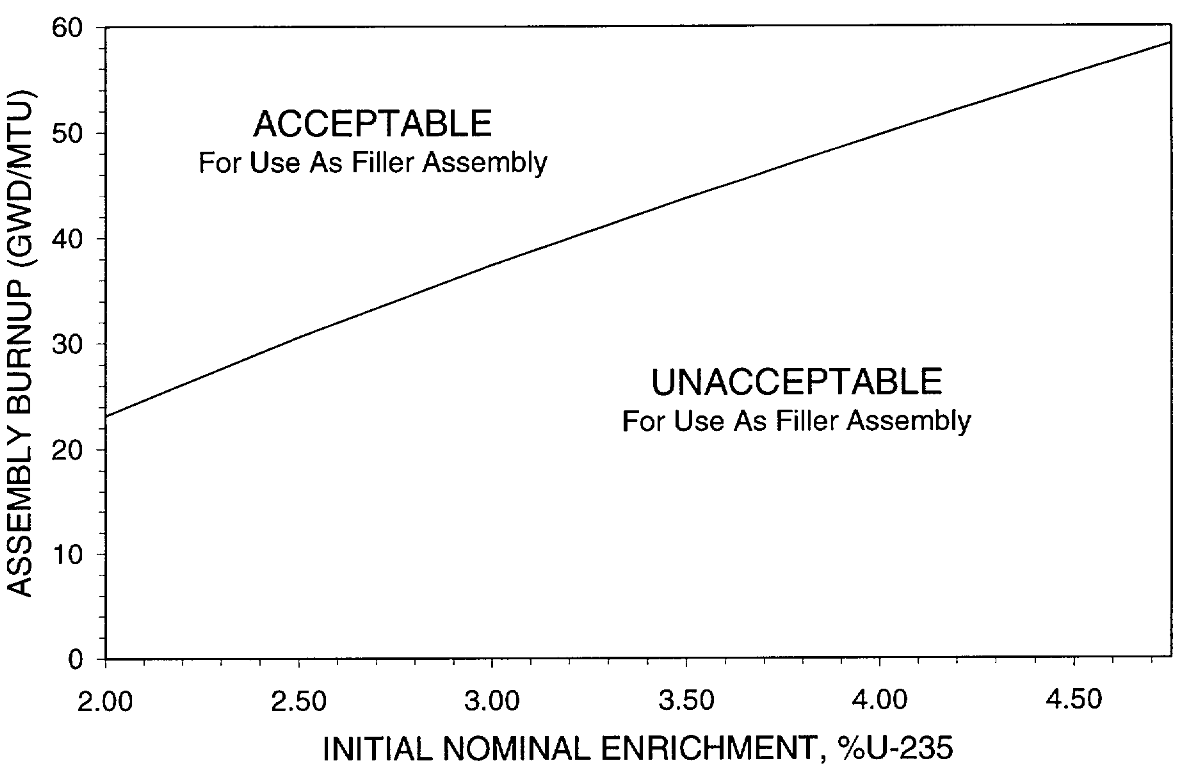
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-11 may be qualified for Restricted Region 2B Storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

NEW PAGE
3.7.15-14

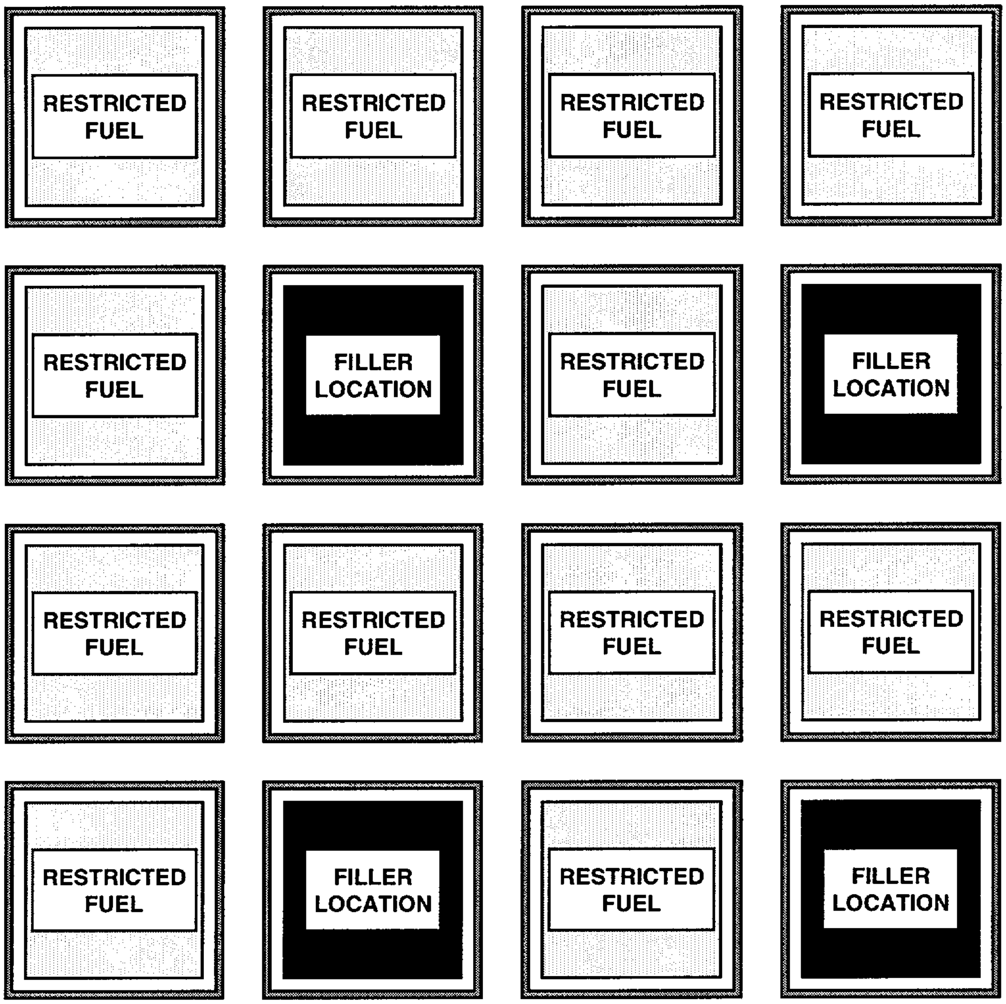
Table 3.7.15-12 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Region 2B Filler Assemblies

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.08 (or less)	0
2.00	23.14
2.50	30.59
3.00	37.42
3.50	43.74
4.00	49.72
4.50	55.49
4.75	58.33



NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-12 may be qualified for use as a Region 2B Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to ~~0.95 with credit for so~~luble boron.

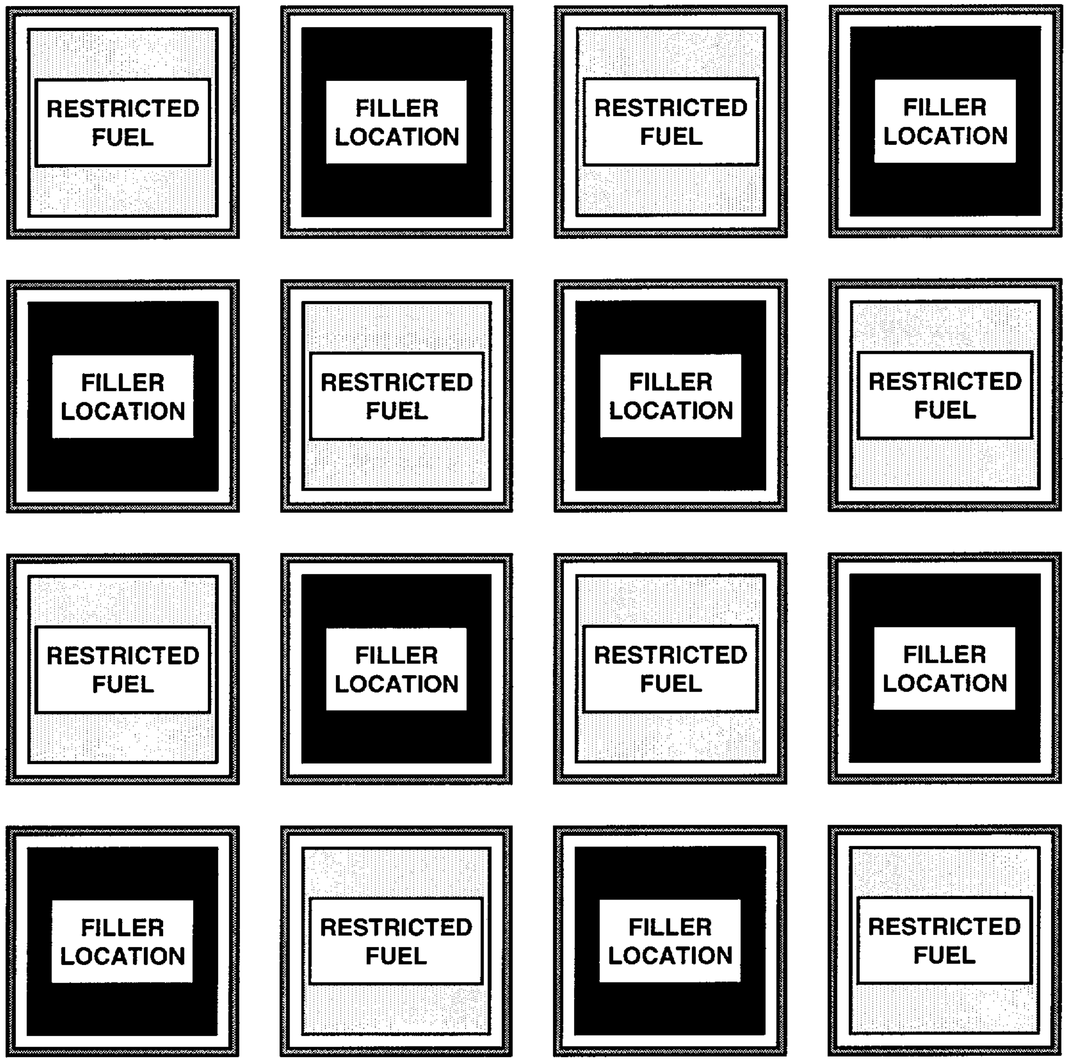


Restricted Fuel: Fuel which does not meet the minimum burnup requirements of either Table 3.7.15-1 or Table 3.7.15.2 (Fuel which does meet the requirements of Table 3.7.15-1 or Table 3.7.15.2 or non-fuel components, or an empty location may be placed in restricted fuel locations as needed).

Filler Location: Either fuel which meets the minimum burnup requirements of Table 3.7.15-~~2~~ 3 or an empty cell.

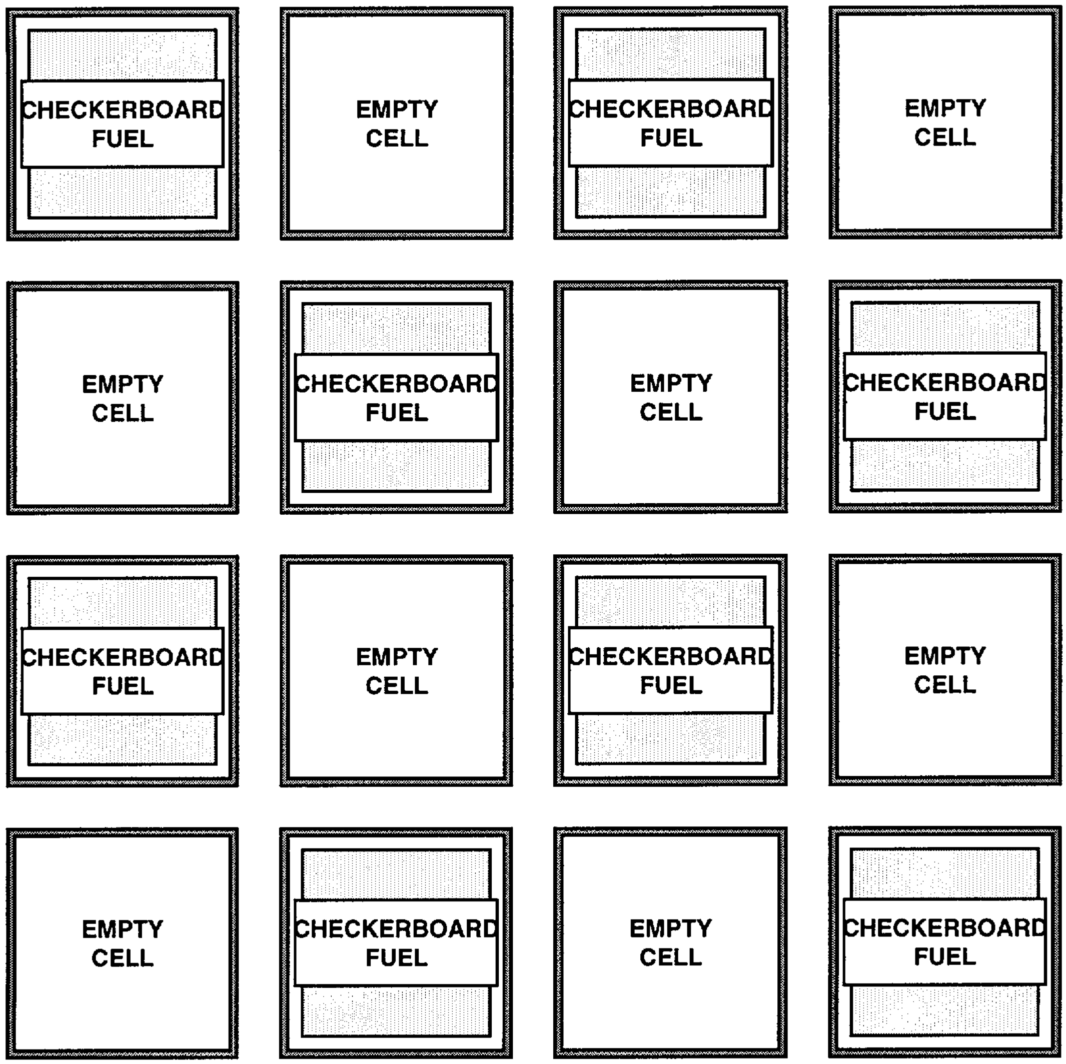
Boundary Condition: Any Restricted Region 1A Storage Area row bounded by any other storage area shall contain a combination of restricted fuel assemblies and filler locations arranged such that no restricted fuel assemblies are adjacent to each other. Example: In the figure above, row 1 or column 1 can not be adjacent to another storage area, but row 4 or column 4 can be.

Figure 3.7.15-1 (page 1 of 1)
Required 3 out of 4 Loading Pattern for Restricted Region 1A Storage



Restricted Fuel:	Fuel which meets the minimum burnup requirements of Table 3.7.15-4 5 or non-fuel components, or an empty location.
Filler Location:	Either fuel which meets the minimum burnup requirements of Table 3.7.15-5 6 or an empty cell.
Boundary Condition:	No restrictions on boundary assemblies.

Figure 3.7.15-2 (page 1 of 1)
Required 2 out of 4 Loading Pattern for Restricted Region 1B Storage



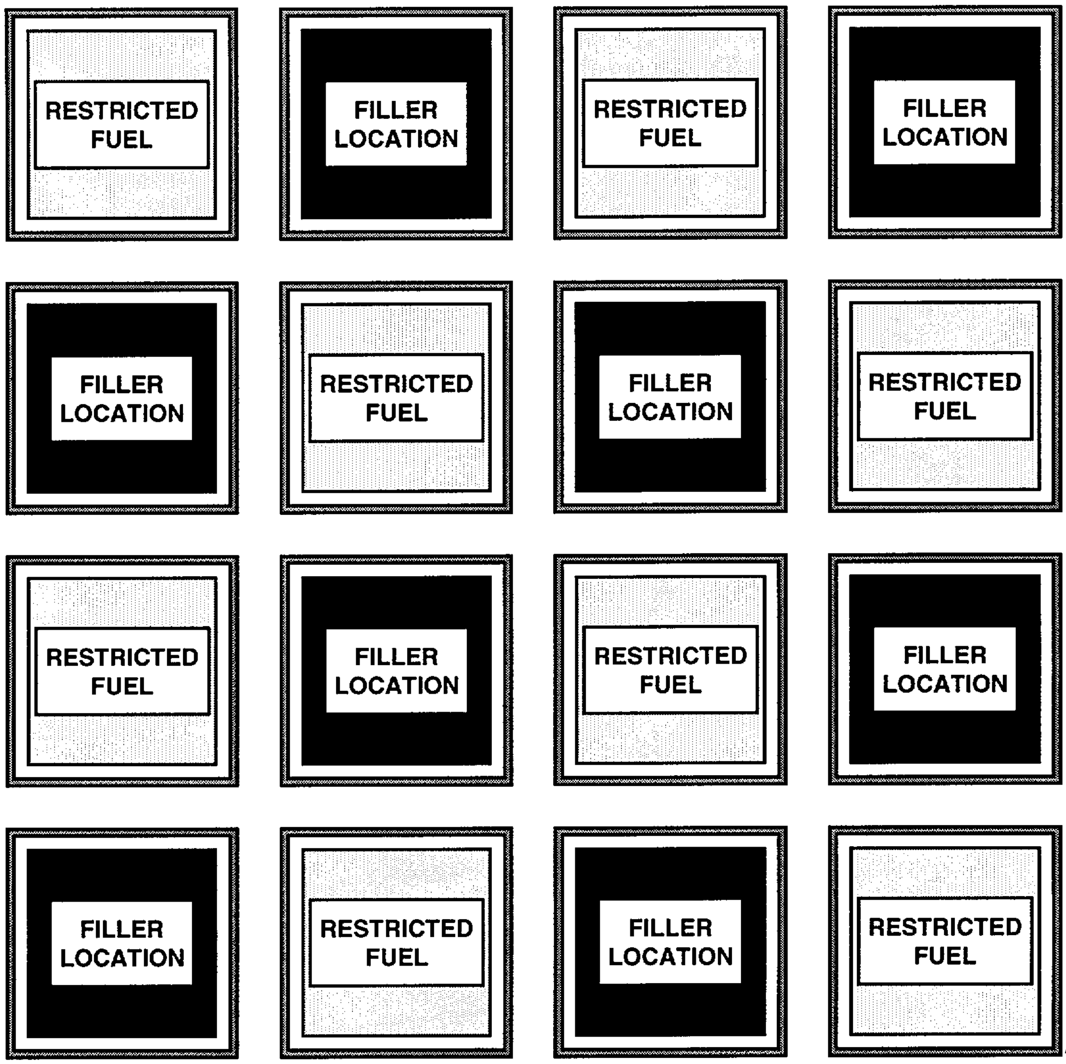
Checkerboard Fuel: Fuel which does not meet the minimum burnup requirements of Table 3.7.15-~~4~~ 5 (Fuel which does meet the requirements of Table 3.7.15-~~4~~5 or non-fuel components, or an empty location may be placed in checkerboard fuel locations as needed)

Boundary Condition: ~~At least two opposite sides shall be bounded by either an empty row of cells, or a spent fuel pool wall.~~

No restrictions on boundary assemblies.

Figure 3.7.15-3 (page 1 of 1)
Required 2 out of 4 Loading Pattern for Checkerboard Region 1B Storage

NEW PAGE
3.7.15-18



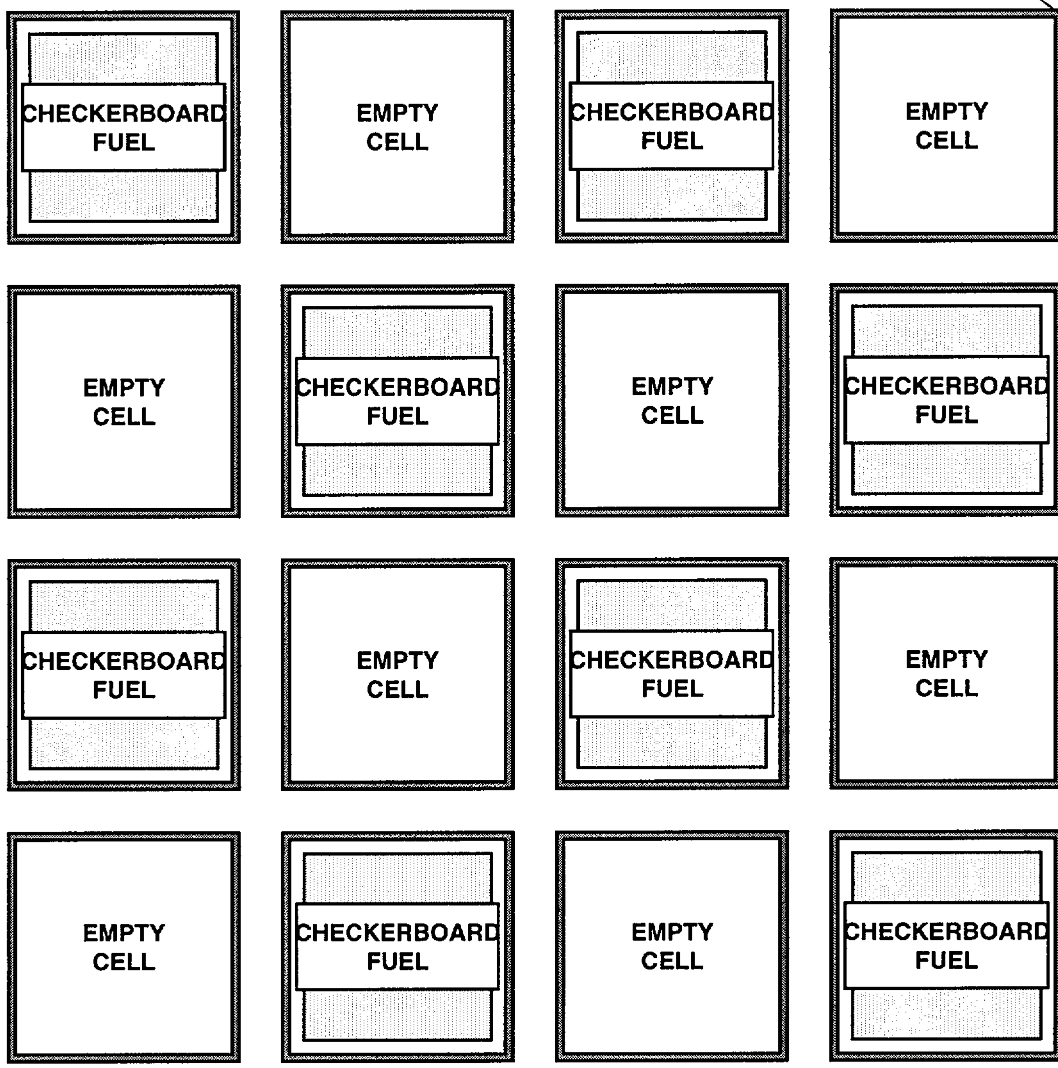
Restricted Fuel: Fuel which meets the minimum burnup requirements of Table 3.7.15-8, or non-fuel components, or an empty location.

Filler Location: Either fuel which meets the minimum burnup requirements of Table 3.7.15-9, or an empty cell.

Boundary Condition: No restrictions on boundary assemblies.

Figure 3.7.15-4 (page 1 of 1)
Required 2 out of 4 Loading Pattern for Restricted Region 2A Storage

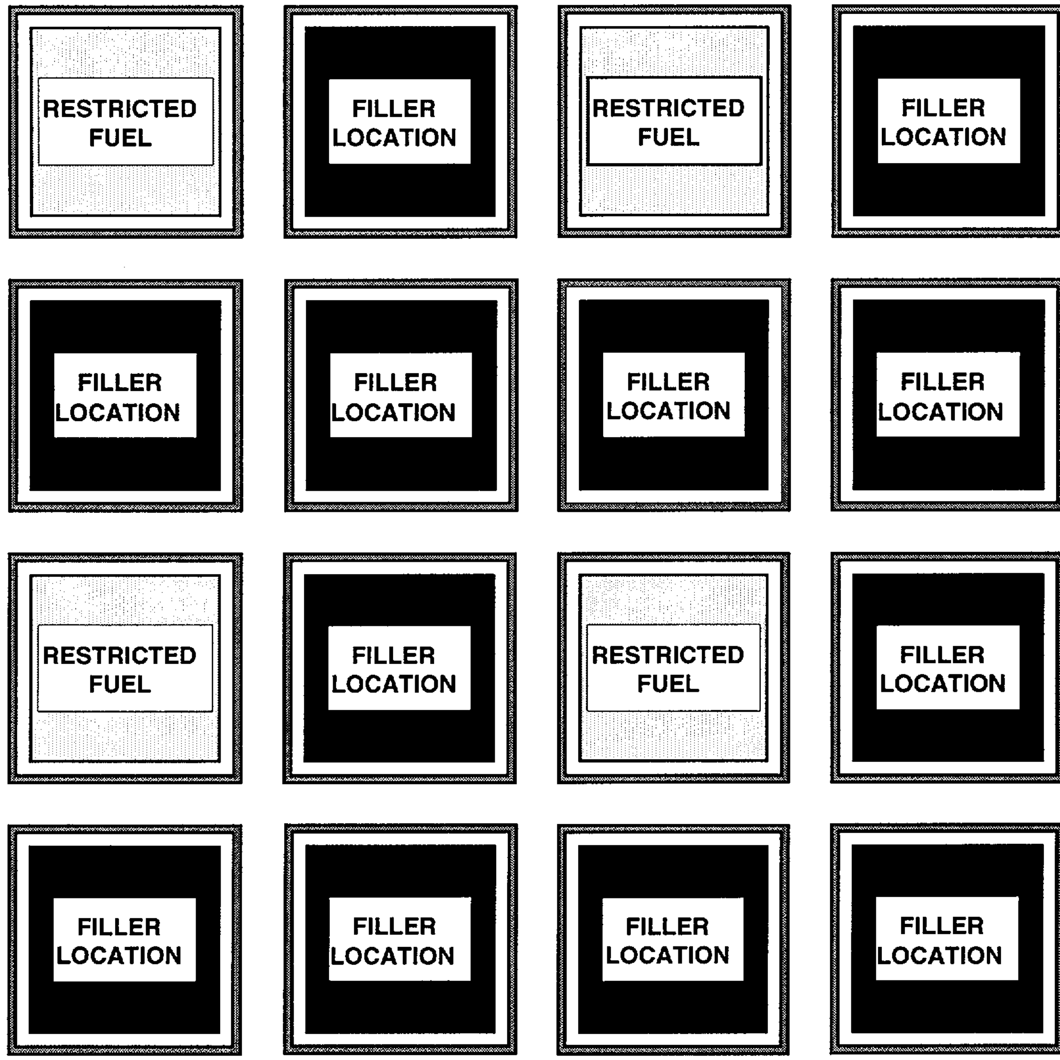
NEW PAGE
3.7.15-19



Checkerboard Fuel:	Fuel which does not meet the minimum burnup requirements of Table 3.7.15-8. (Fuel which does meet the requirements of Table 3.7.15-8, or non-fuel components, or an empty location may be placed in checkerboard fuel locations as needed)
Boundary Condition:	No restrictions on boundary assemblies.

Figure 3.7.15-5 (page 1 of 1)
Required 2 out of 4 Loading Pattern for Checkerboard Region 2A Storage

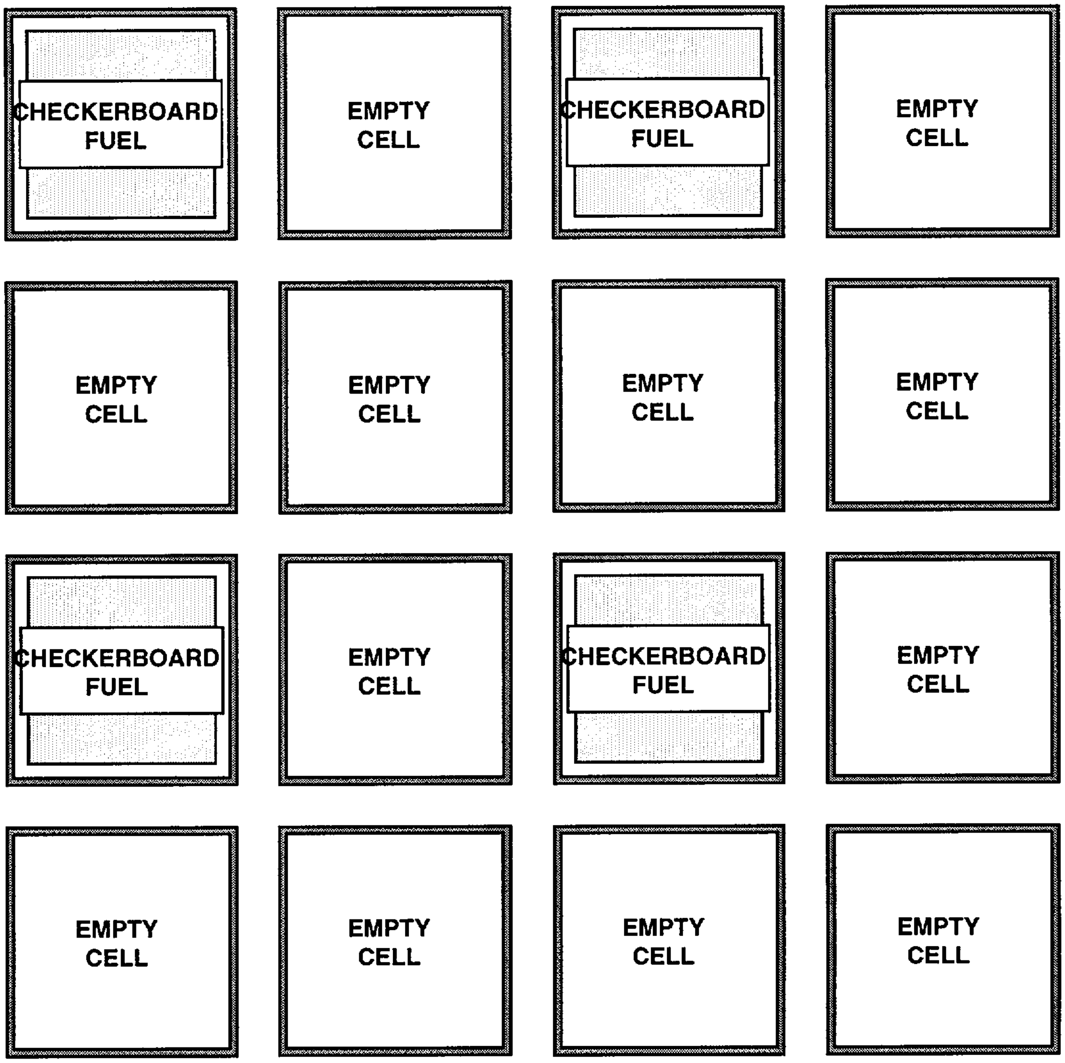
NEW PAGE
3.7.15-20



Restricted Fuel:	Fuel which meets the minimum burnup requirements of Table 3.7.15-11, or non-fuel components, or an empty location.
Filler Location:	Either fuel which meets the minimum burnup requirements of Table 3.7.15-12, or an empty cell.
Boundary Condition:	Any Restricted Region 2B Storage Area row bounded by any other storage area shall contain only filler locations arranged such that no Restricted Fuel assemblies are adjacent to any other fuel except Region 2B Filler Locations. Example: In the figure above, row 1 or column 1 can not be adjacent to another storage area, but row 4 or column 4 can be.

Figure 3.7.15-6 (page 1 of 1)
Required 1 out of 4 Loading Pattern for Restricted Region 2B Storage

NEW PAGE
3.7.15-21



Checkerboard Fuel: Fuel which does not meet the minimum burnup requirements of Table 3.7.15-11. (Fuel which does meet the requirements of Table 3.7.15-11, or non-fuel components, or an empty location may be placed in checkerboard fuel locations as needed)

Boundary Condition: Any Checkerboard Region 2B Storage Area row bounded by any other storage area shall contain only empty cells arranged such that no Checkerboard Fuel assemblies are adjacent to any fuel. Example: In the figure above, row 1 or column 1 can not be adjacent to another storage area, but row 4 or column 4 can be.

Figure 3.7.15-7 (page 1 of 1)
Required 1 out of 4 Loading Pattern for Checkerboard Region 2B Storage

4.0 DESIGN FEATURES

4.1 Site Location

The McGuire Nuclear Station site is located at latitude 35 degrees, 25 minutes, 59 seconds north and longitude 80 degrees, 56 minutes, 55 seconds west. The Universal Transverse Mercator Grid Coordinates are E 504, 669, 256, and N 3, 920, 870, 471. The site is in northwestern Mecklenburg County, North Carolina, 17 miles north-northwest of Charlotte, North Carolina.

4.2 Reactor Core

4.2.1 Fuel Assemblies

The reactor shall contain 193 fuel assemblies. Each assembly shall consist of a matrix of Zircalloy fuel rods with an initial composition of natural or slightly enriched uranium dioxide (UO_2) as fuel material. Limited substitutions of zirconium alloy or stainless steel filler rods for fuel rods, in accordance with approved applications of fuel rod configurations, may be used. Fuel assemblies shall be limited to those fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all fuel safety design bases. A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions.

4.2.2 Control Rod Assemblies

The reactor core shall contain 53 control rod assemblies. The control material shall be silver indium cadmium (Unit 1) silver indium cadmium and boron carbide (Unit 2) as approved by the NRC.

4.3 Fuel Storage

4.3.1 Criticality

4.3.1.1 The spent fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having a maximum nominal U-235 enrichment of 4.75 weight percent;

b. $k_{eff} < 1.0$ if fully flooded with unborated water, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR;

ADD

c. $k_{eff} \leq 0.95$ if fully flooded with water borated to 730 ppm, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR;

4.0 DESIGN FEATURES

4.3 Fuel Storage (continued)

c. A nominal 10.4 inch center to center distance between fuel assemblies placed in Regions 1A and 1B; and

d. A nominal 9.125 inch center to center distance between fuel assemblies placed in Regions 2A and 2B.

4.3.1.2 The new fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having a maximum nominal U-235 enrichment of 4.75 weight percent;

b. $k_{eff} \leq 0.95$ if fully flooded with unborated water, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR;

c. $k_{eff} \leq 0.98$ if moderated by aqueous foam, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR; and

d. A nominal 21 inch center to center distance between fuel assemblies placed in the storage racks.

4.3.2 Drainage

The spent fuel storage pool is designed and shall be maintained to prevent inadvertent draining of the pool below elevation 745 ft.-7 in.

4.3.3 Capacity

The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 1463 fuel assemblies (286 total spaces in Regions 1A and 1B and 1177 total spaces in Regions 2A and 2B).

ATTACHMENT 2

REVISED MCGUIRE TECHNICAL SPECIFICATIONS

3.7 PLANT SYSTEMS

3.7.15 Spent Fuel Assembly Storage

LCO 3.7.15 The combination of initial enrichment, burnup and number of Integral Fuel Burnable Absorber (IFBA) rods of each new or spent fuel assembly stored in the spent fuel pool storage racks shall be within the following configurations:

a. New or irradiated fuel may be stored in Region 1A of the spent fuel pool in accordance with these limits:

1. Unrestricted storage of new fuel meeting the criteria of Table 3.7.15-1; or

2. Unrestricted storage of fuel meeting the criteria of Table 3.7.15-2; or

3. Restricted storage in accordance with Figure 3.7.15-1, of fuel which does not meet the criteria of Table 3.7.15-1 or Table 3.7.15-2.

b. New or irradiated fuel may be stored in Region 1B of the spent fuel pool in accordance with these limits:

1. Unrestricted storage of fuel meeting the criteria of Table 3.7.15-4; or

2. Restricted storage in accordance with Figure 3.7.15-2, of fuel which meets the criteria of Table 3.7.15-5; or

3. Checkerboard storage in accordance with Figure 3.7.15-3 of fuel which does not meet the criteria of Table 3.7.15-5.

c. New or irradiated fuel which has decayed at least 16 days may be stored in Region 2A of the spent fuel pool in accordance with these limits:

1. Unrestricted storage of fuel meeting the criteria of Table 3.7.15-7; or

2. Restricted storage in accordance with Figure 3.7.15-4, of fuel which meets the criteria of Table 3.7.15-8; or

3. Checkerboard storage in accordance with Figure 3.7.15-5 of fuel which does not meet the criteria of Table 3.7.15-8.

d. New or irradiated fuel which has decayed at least 16 days may be stored in Region 2B of the spent fuel pool in accordance with these limits:

1. Unrestricted storage of fuel meeting the criteria of Table 3.7.15-10; or

2. Restricted storage in accordance with Figure 3.7.15-6, of fuel which meets the criteria of Table 3.7.15-11; or

3. Checkerboard storage in accordance with Figure 3.7.15-7 of fuel which does not meet the criteria of Table 3.7.15-11.

APPLICABILITY: Whenever any fuel assembly is stored in the spent fuel pool.

ACTIONS

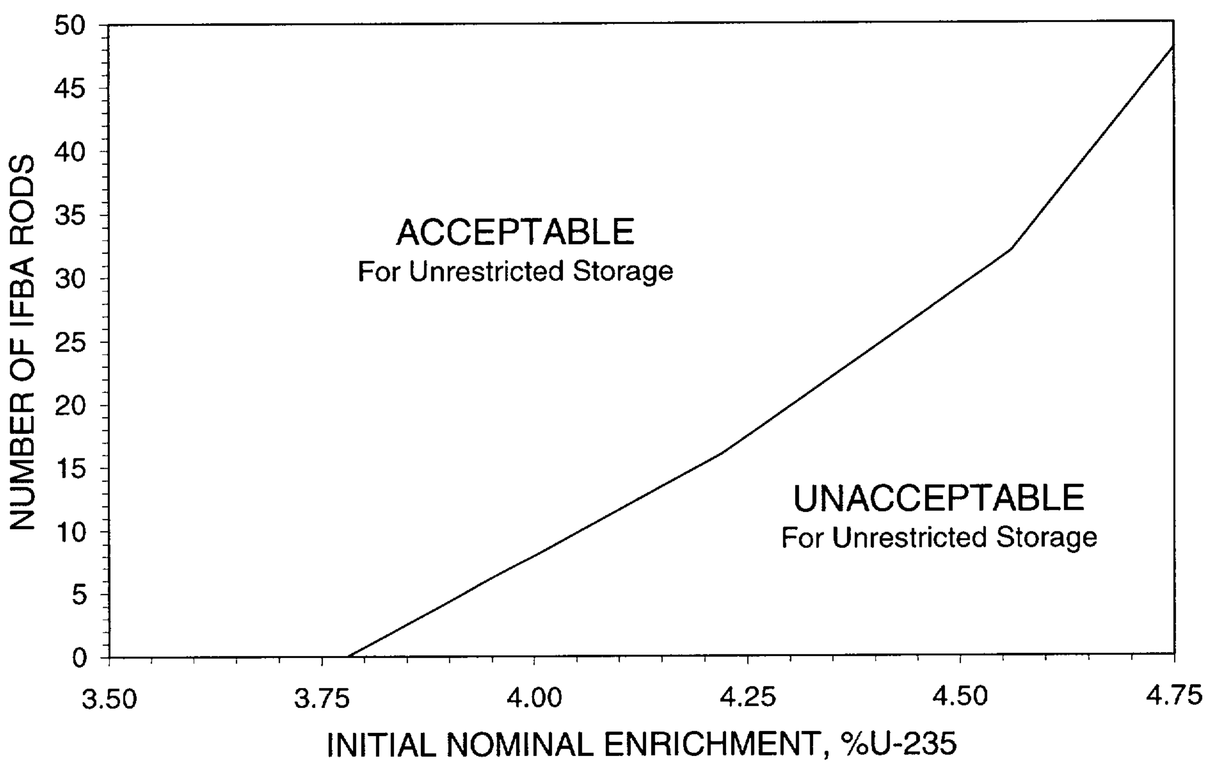
CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Requirements of the LCO not met.	A.1 -------------NOTE------------- LCO 3.0.3 is not applicable. ----------------------------------	
	Initiate action to move the noncomplying fuel assembly to the correct location.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.7.15.1	Verify by administrative means the planned spent fuel pool location is acceptable for the fuel assembly being stored.	Prior to storing the fuel assembly in the spent fuel pool

Table 3.7.15-1 (page 1 of 1)
Minimum Qualifying Number of IFBA Rods Versus Initial Enrichment
for Unrestricted Region 1A Storage of New Fuel

Initial Nominal Enrichment (% U-235)	Number of IFBA Rods
3.78 (or less)	0
4.22	16
4.56	32
4.75	48

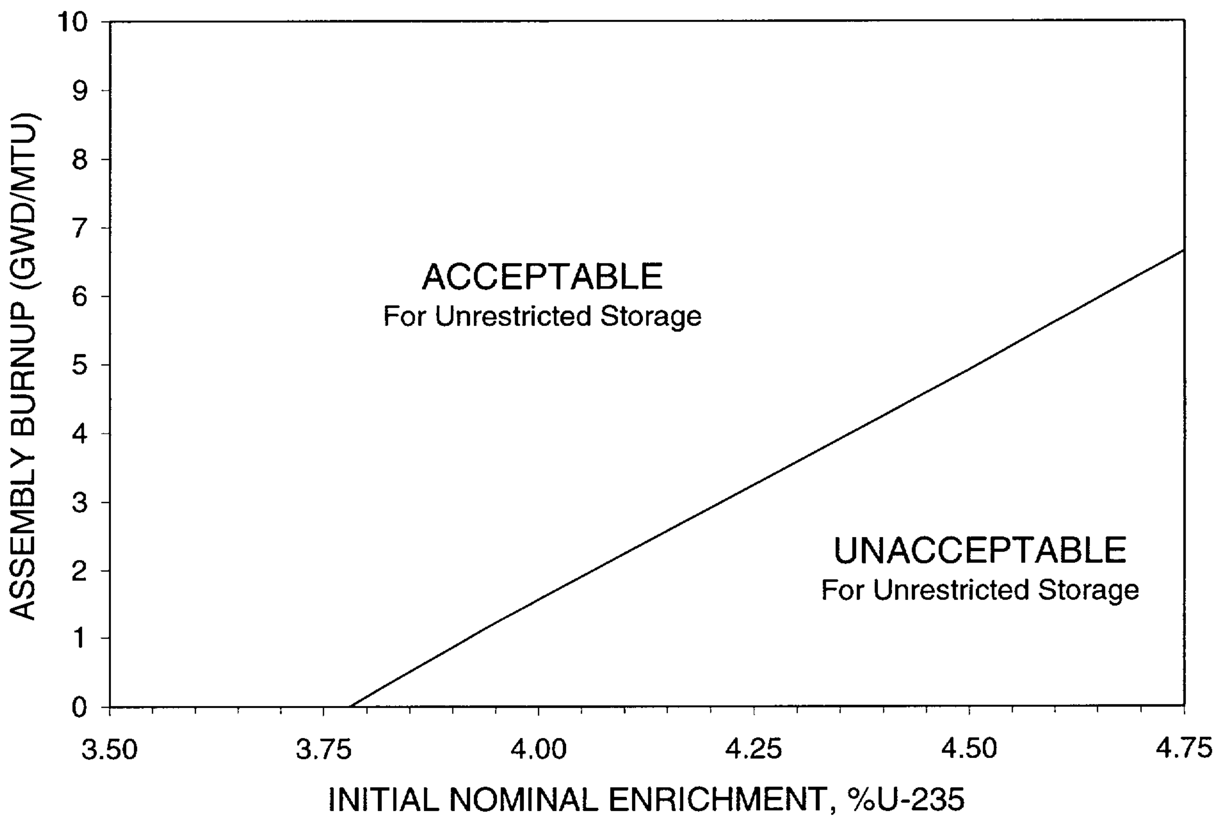


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-1 may be qualified for Unrestricted Region 1A storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

Table 3.7.15-2 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Unrestricted Region 1A Storage

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
3.78 (or less)	0
4.00	1.58
4.50	4.92
4.75	6.66

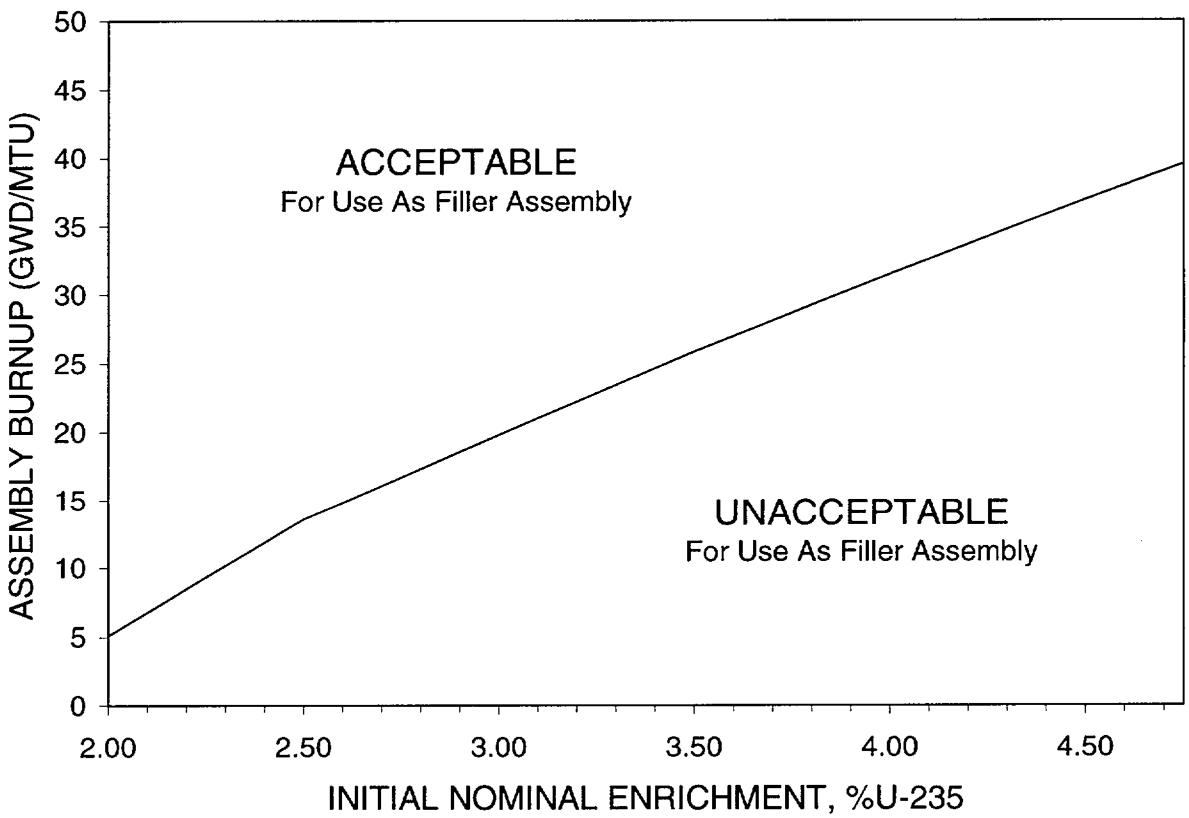


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-2 may be qualified for Unrestricted Region 1A storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron. Likewise, previously unanalyzed fuel up to a nominal 4.75 weight% U-235 may be qualified for Restricted Region 1A storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

Table 3.7.15-3 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Region 1A Filler Assemblies

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.76 (or less)	0
2.00	5.12
2.50	13.57
3.00	19.80
3.50	25.85
4.00	31.50
4.50	36.93
4.75	39.54

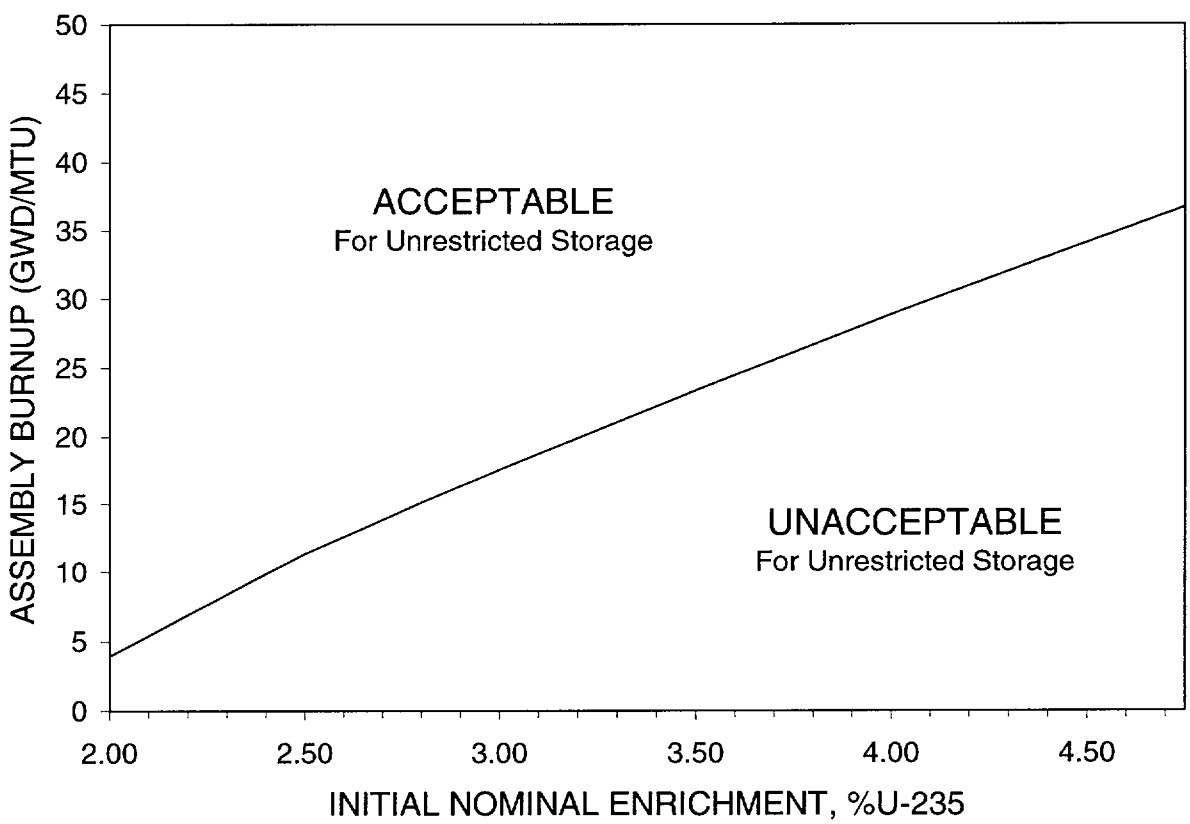


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-3 may be qualified for use as a Region 1A Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

Table 3.7.15-4 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Unrestricted Region 1B Storage

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.78 (or less)	0
2.00	3.96
2.50	11.35
3.00	17.61
3.50	23.35
4.00	28.86
4.50	34.10
4.75	36.67

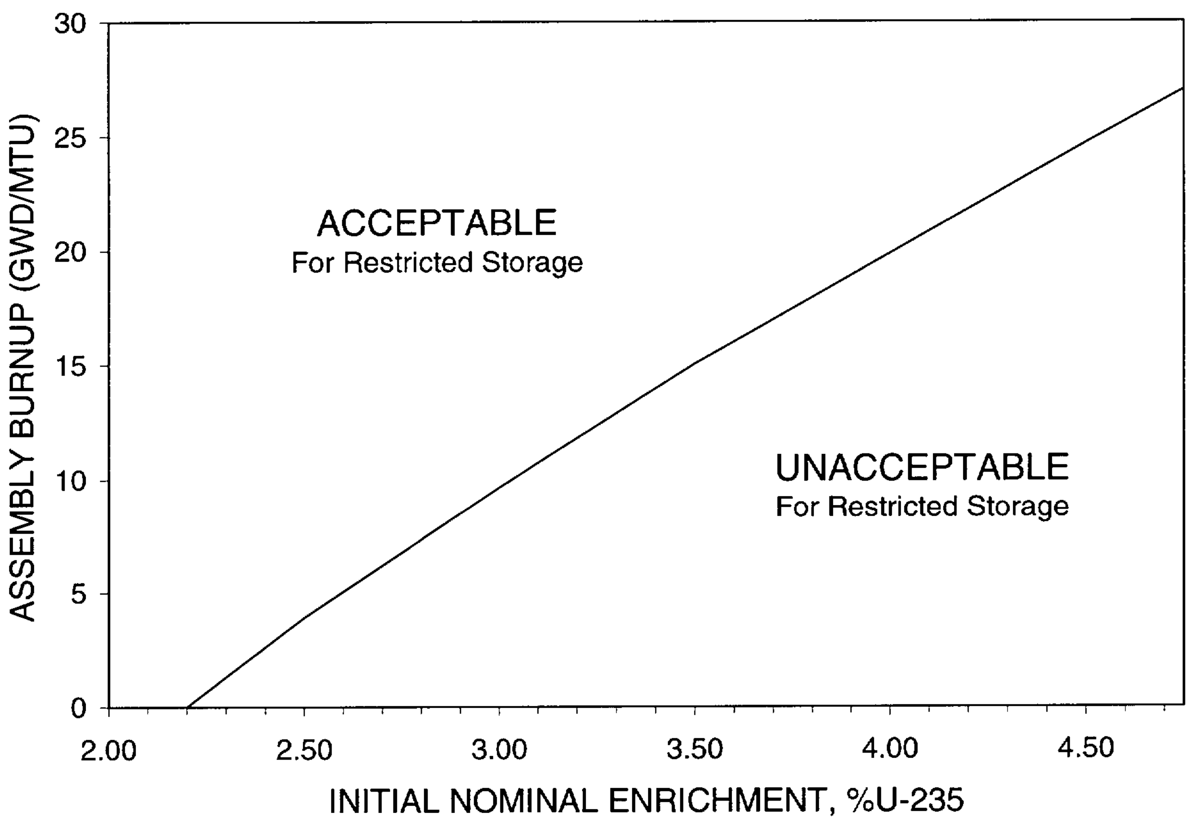


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-4 may be qualified for Unrestricted Region 1B storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

Table 3.7.15-5 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Restricted Region 1B Storage with Fillers

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
2.20 (or less)	0
2.50	3.91
3.00	9.65
3.50	15.04
4.00	19.87
4.50	24.68
4.75	27.01

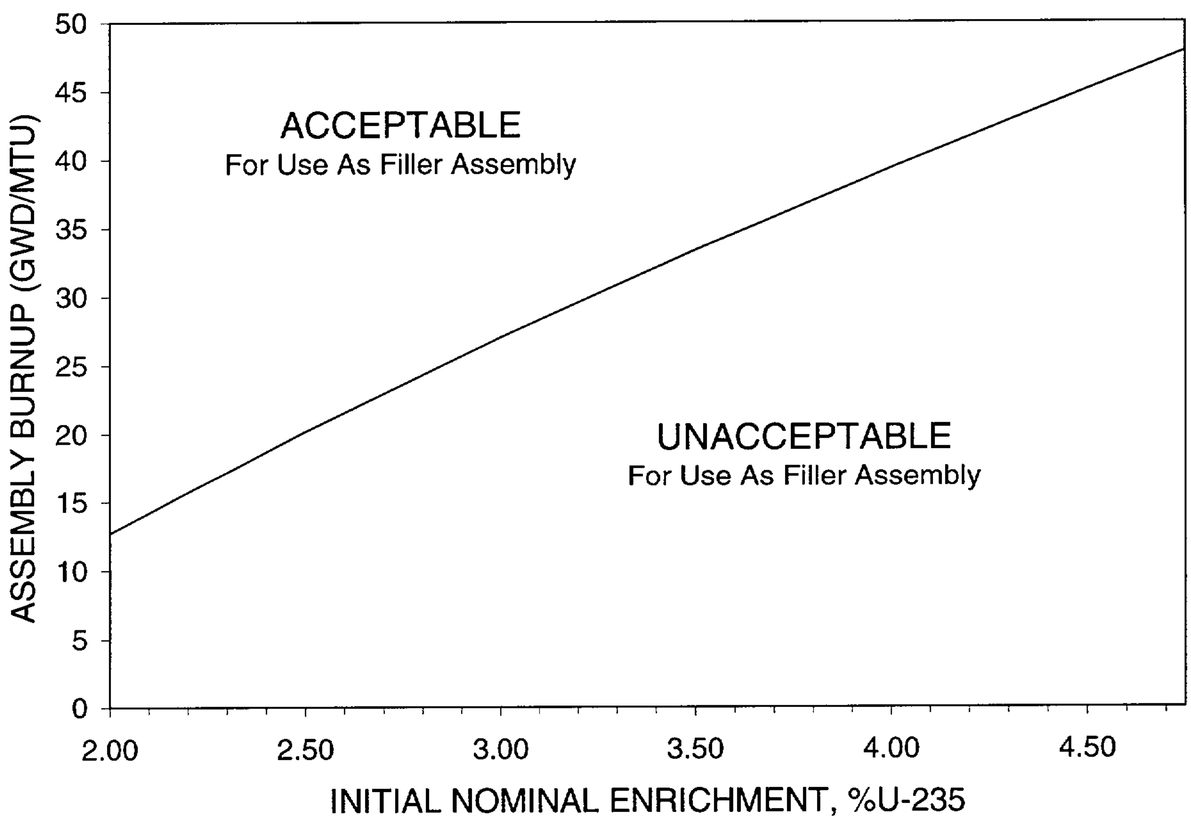


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-5 may be qualified for Restricted Region 1B Storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

Table 3.7.15-6 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Region 1B Filler Assemblies

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.44 (or less)	0
2.00	12.68
2.50	20.17
3.00	27.03
3.50	33.35
4.00	39.33
4.50	45.07
4.75	47.89

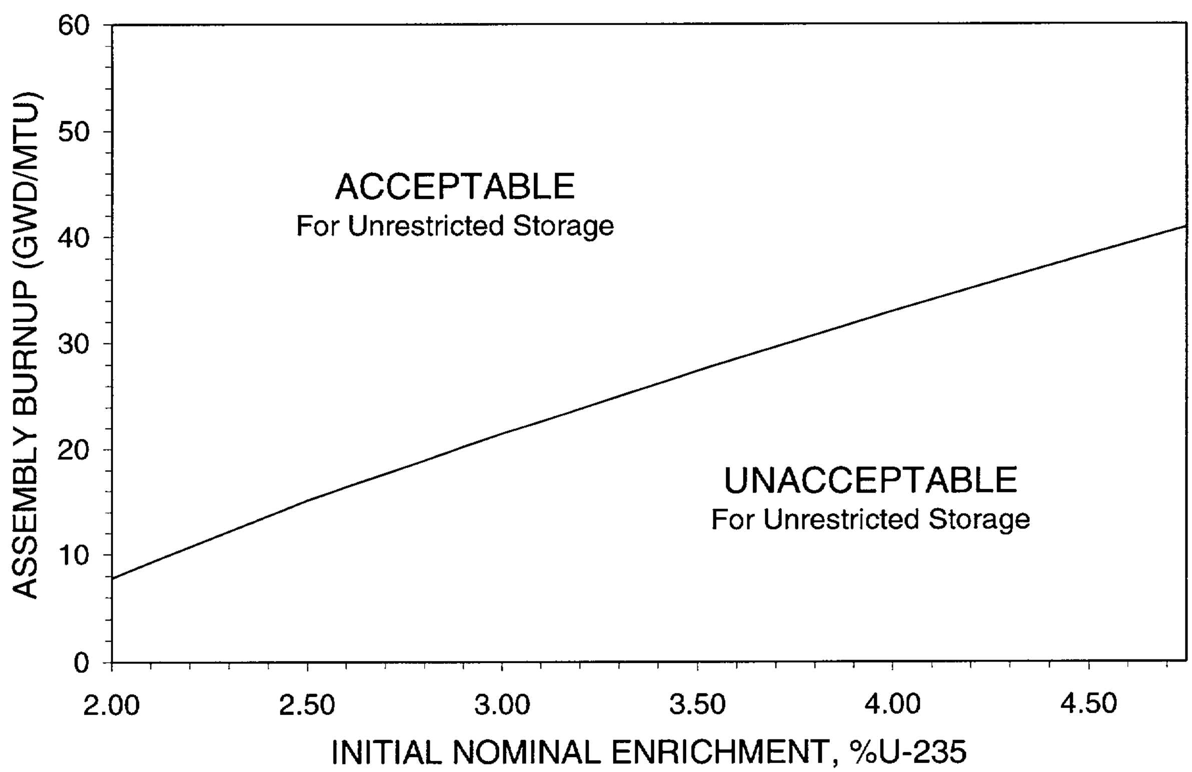


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-6 may be qualified for use as a Region 1B Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

Table 3.7.15-7 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Unrestricted Region 2A Storage

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.61 (or less)	0
2.00	7.79
2.50	15.14
3.00	21.45
3.50	27.42
4.00	33.00
4.50	38.32
4.75	40.91

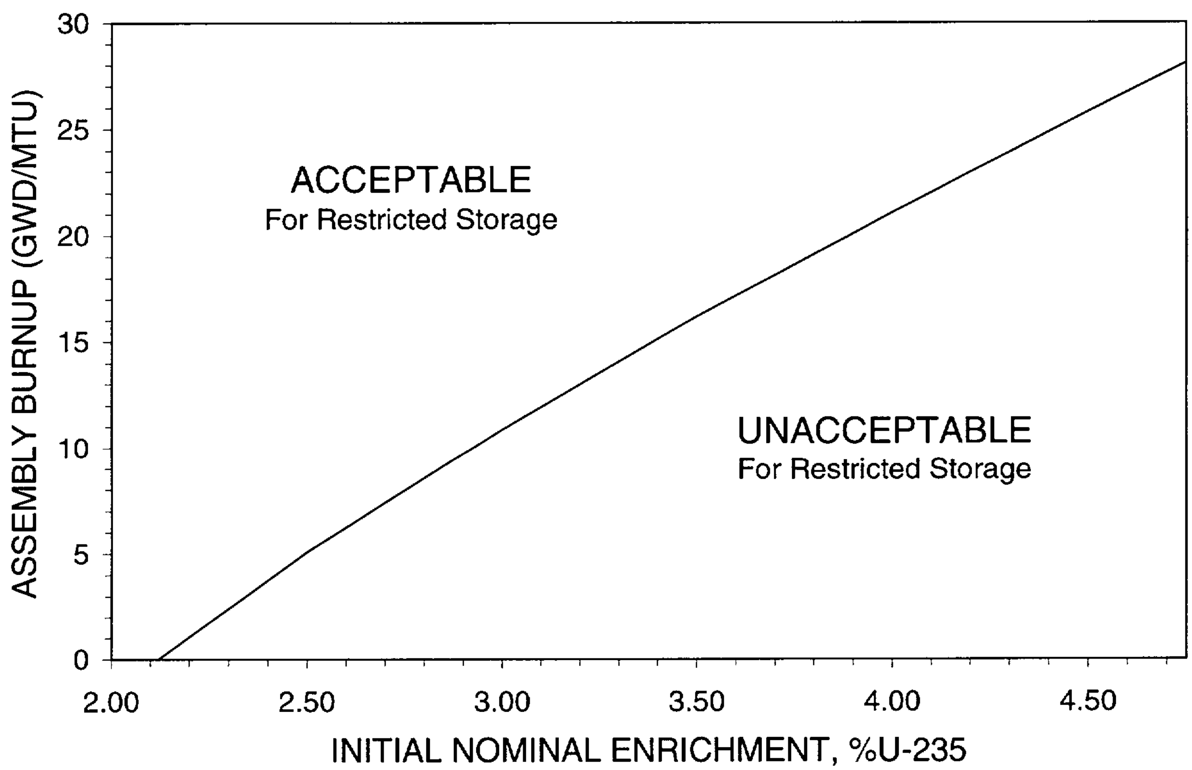


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-7 may be qualified for Unrestricted Region 2A storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

Table 3.7.15-8 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Restricted Region 2A Storage with Fillers

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
2.12 (or less)	0
2.50	5.10
3.00	10.88
3.50	16.19
4.00	21.07
4.50	25.81
4.75	28.11

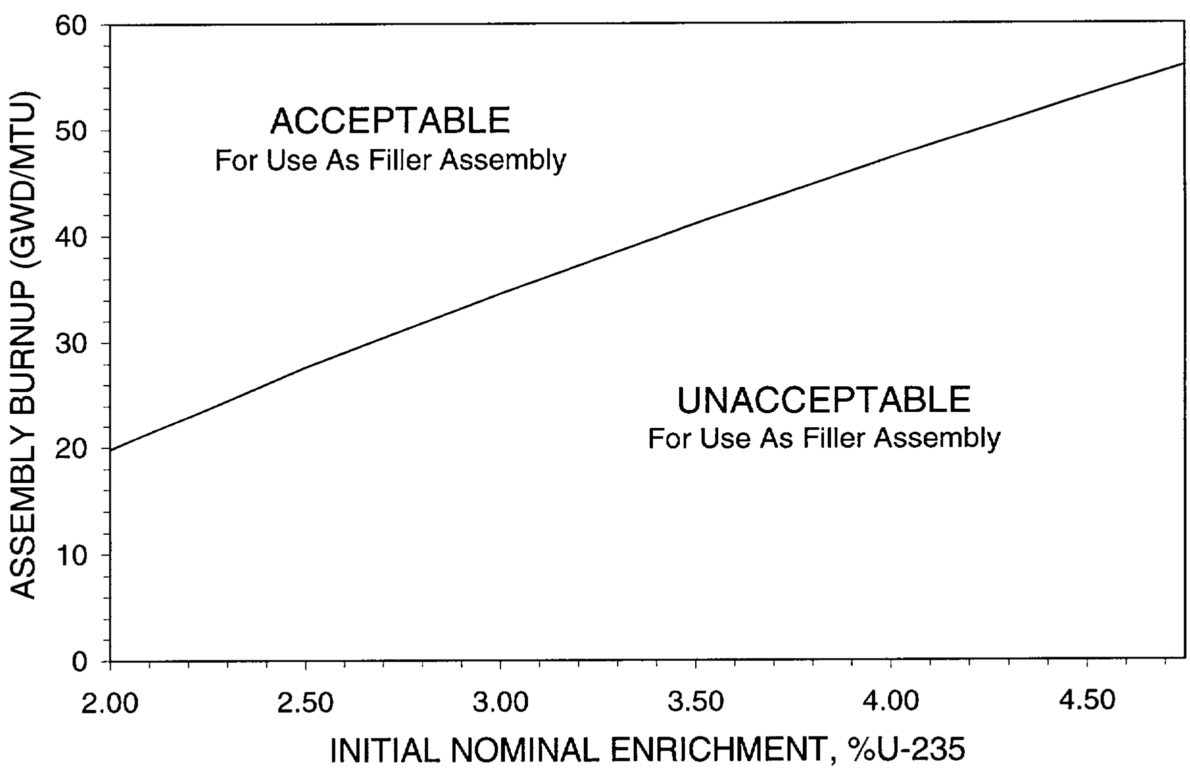


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-8 may be qualified for Restricted Region 2A Storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

Table 3.7.15-9 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Region 2A Filler Assemblies

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.20 (or less)	0
2.00	19.80
2.50	27.64
3.00	34.56
3.50	41.08
4.00	47.25
4.50	53.15
4.75	56.01

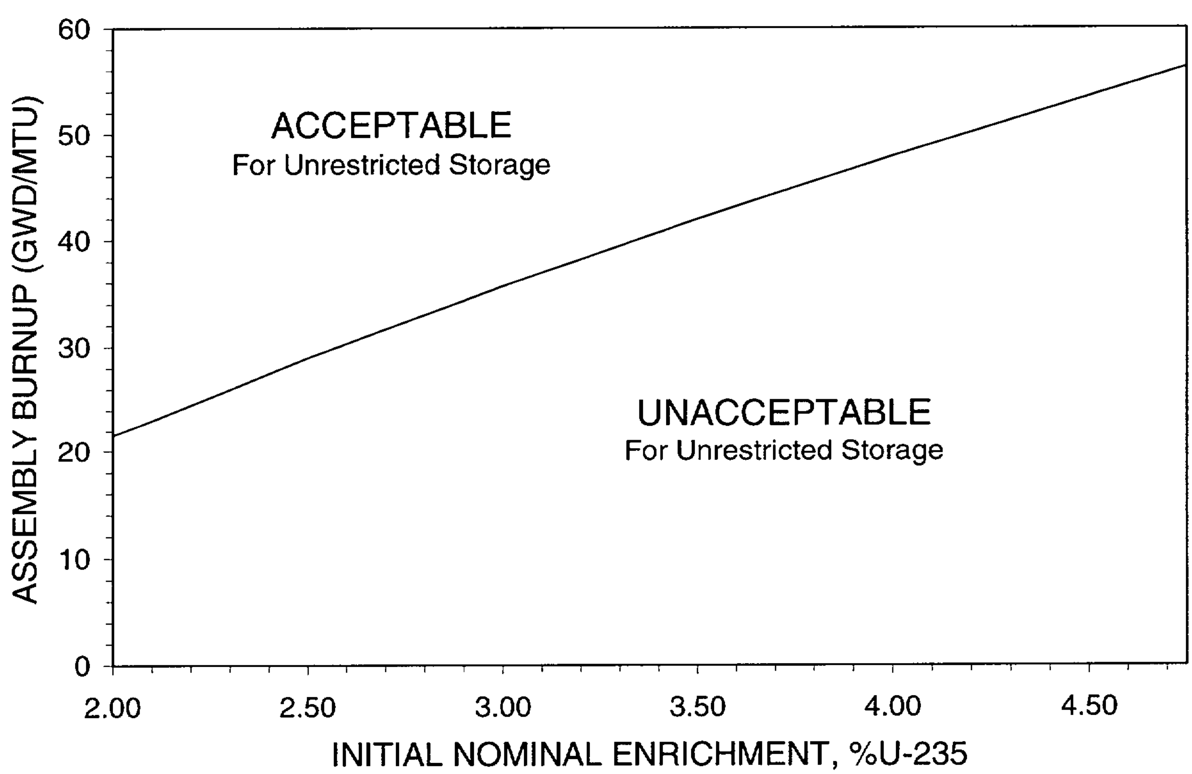


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-9 may be qualified for use as a Region 2A Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

Table 3.7.15-10 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Unrestricted Region 2B Storage

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.11 (or less)	0
2.00	21.58
2.50	29.00
3.00	35.69
3.50	41.97
4.00	47.90
4.50	53.57
4.75	56.33

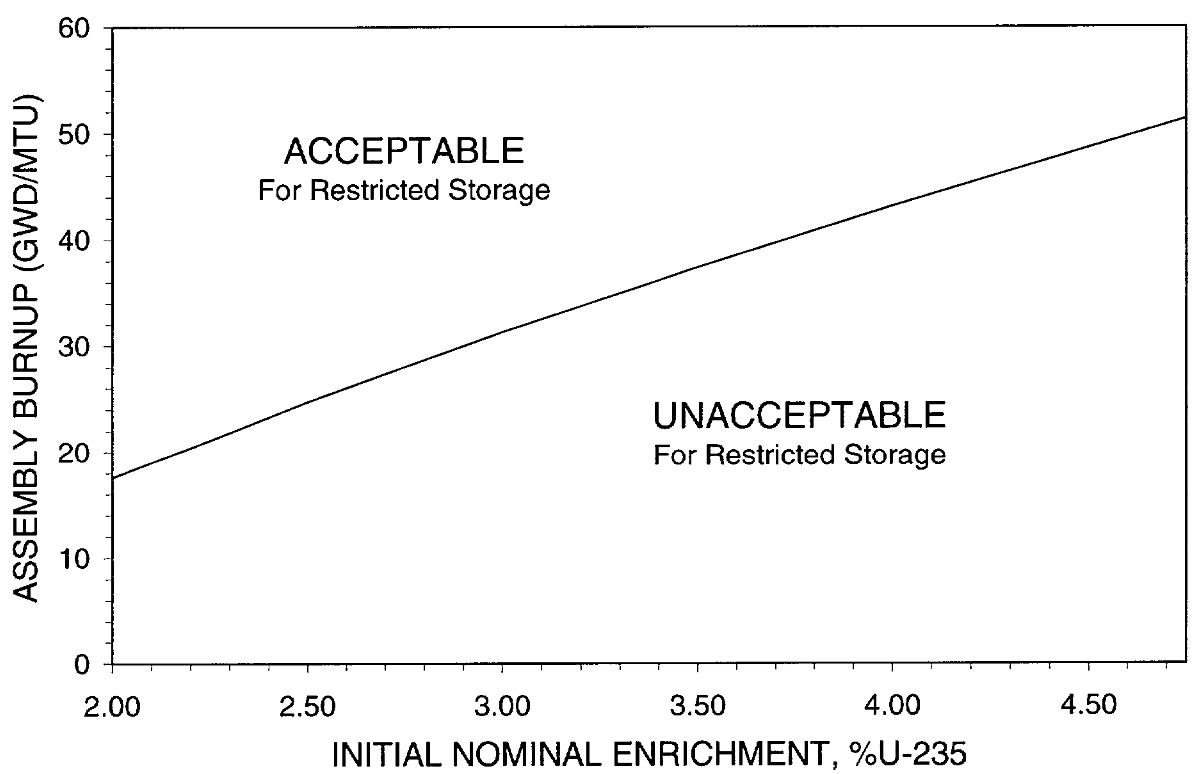


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-10 may be qualified for Unrestricted Region 2B storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

Table 3.7.15-11 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Restricted Region 2B Storage with Fillers

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.22 (or less)	0
2.00	17.55
2.50	24.73
3.00	31.31
3.50	37.40
4.00	43.15
4.50	48.65
4.75	51.33

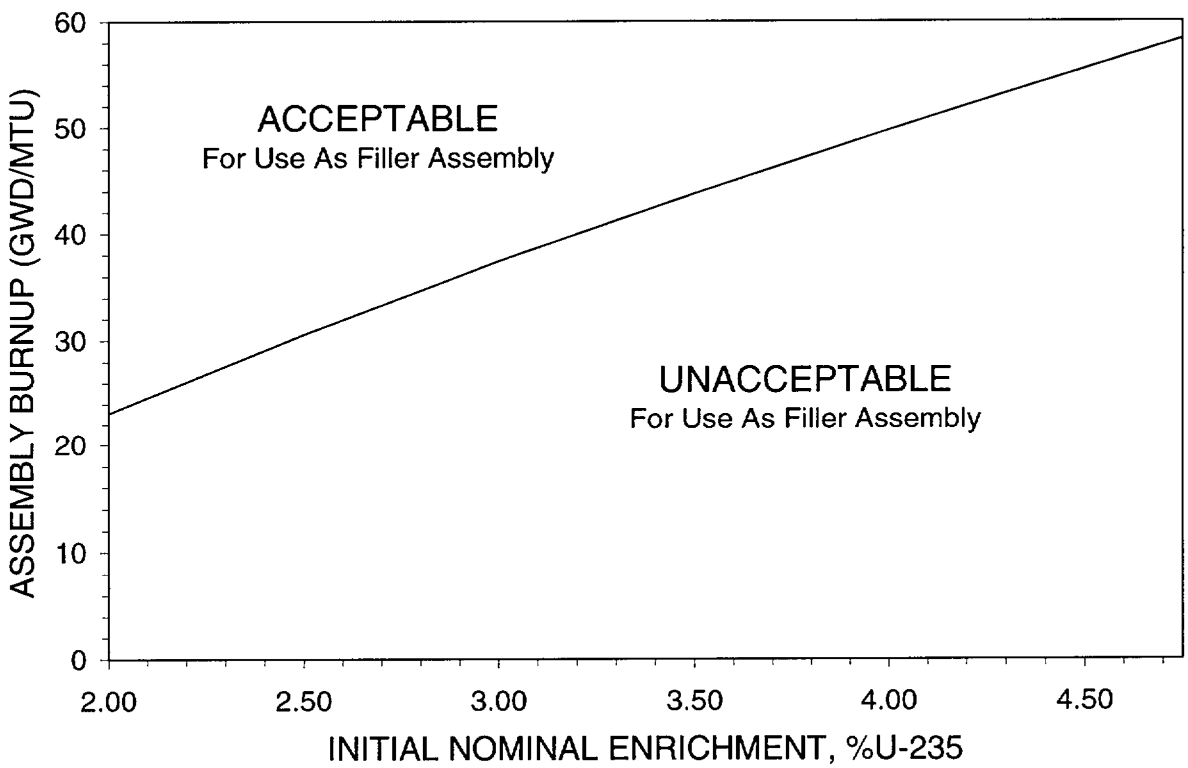


NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-11 may be qualified for Restricted Region 2B Storage by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.

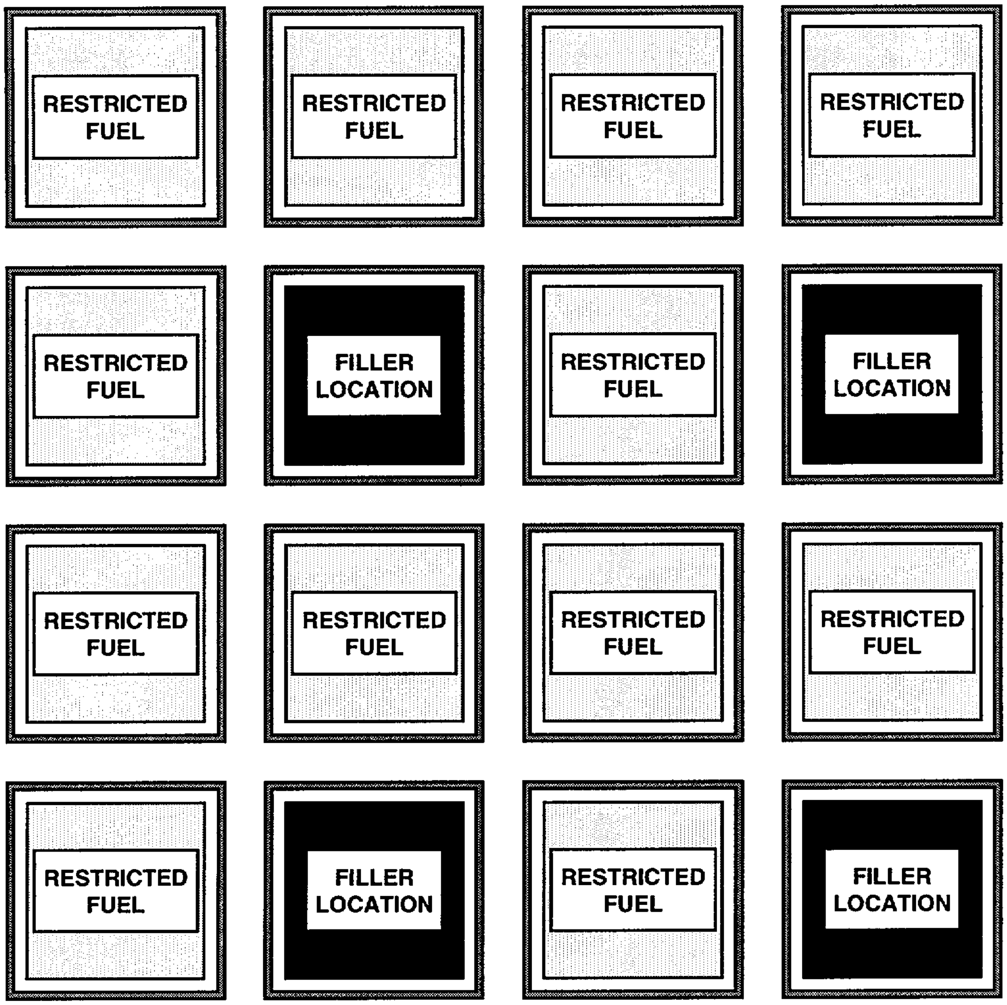
Table 3.7.15-12 (page 1 of 1)
Minimum Qualifying Burnup Versus Initial Enrichment
for Region 2B Filler Assemblies

Initial Nominal Enrichment (% U-235)	Assembly Burnup (GWD/MTU)
1.08 (or less)	0
2.00	23.14
2.50	30.59
3.00	37.42
3.50	43.74
4.00	49.72
4.50	55.49
4.75	58.33



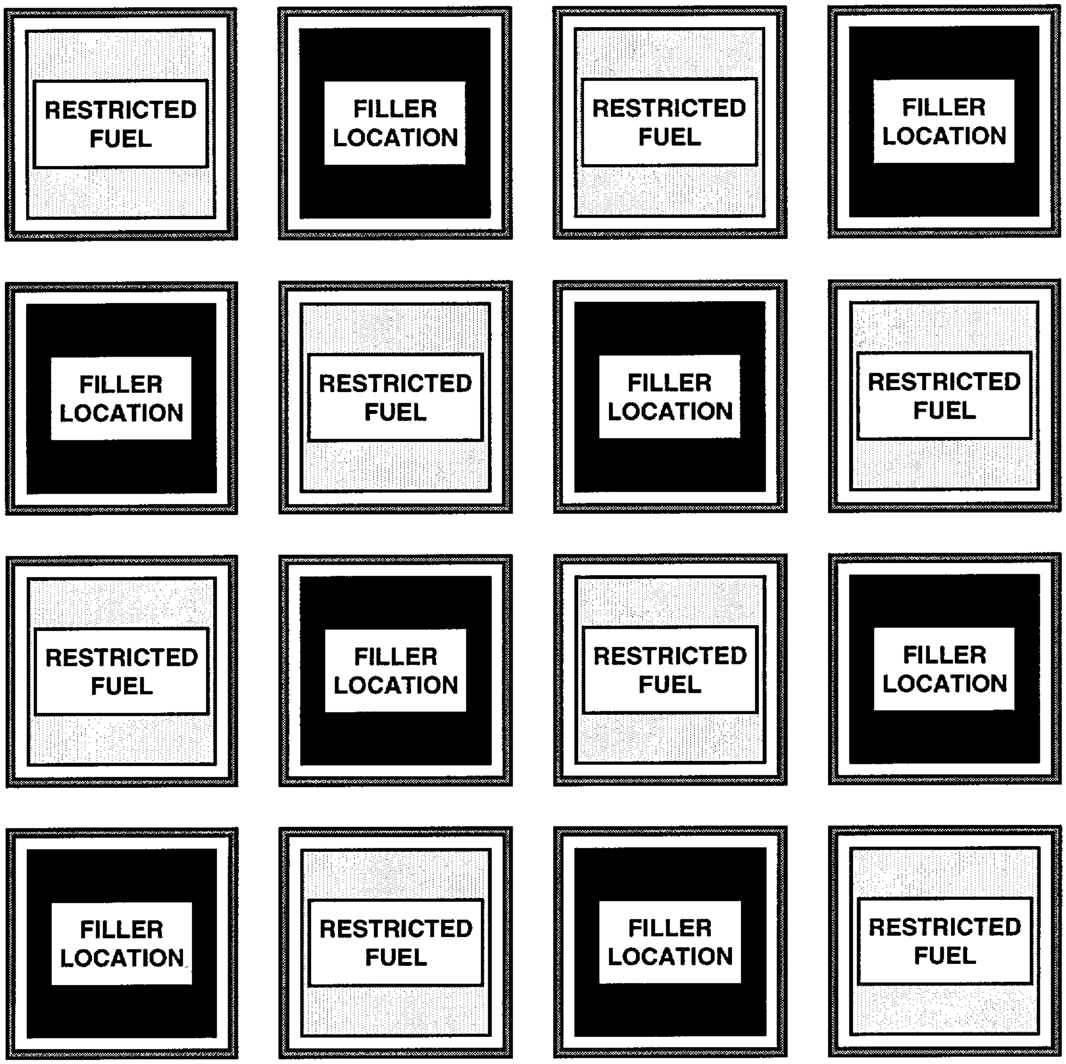
NOTES:

Fuel which differs from those designs used to determine the requirements of Table 3.7.15-12 may be qualified for use as a Region 2B Filler Assembly by means of an analysis using NRC approved methodology to assure that k_{eff} is less than 1.0 with no boron and less than or equal to 0.95 with credit for soluble boron.



Restricted Fuel:	Fuel which does <u>not</u> meet the minimum burnup requirements of either Table 3.7.15-1 or Table 3.7.15. 2. (Fuel which does meet the requirements of Table 3.7.15-1 or Table 3.7.15. 2, or non-fuel components, or an empty location may be placed in restricted fuel locations as needed).
Filler Location:	Either fuel which meets the minimum burnup requirements of Table 3.7.15-3, or an empty cell.
Boundary Condition:	Any Restricted Region 1A Storage Area row bounded by any other storage area shall contain a combination of restricted fuel assemblies and filler locations arranged such that no restricted fuel assemblies are adjacent to each other. Example: In the figure above, row 1 or column 1 can <u>not</u> be adjacent to another storage area, but row 4 or column 4 can be.

Figure 3.7.15-1 (page 1 of 1)
Required 3 out of 4 Loading Pattern for Restricted Region 1A Storage

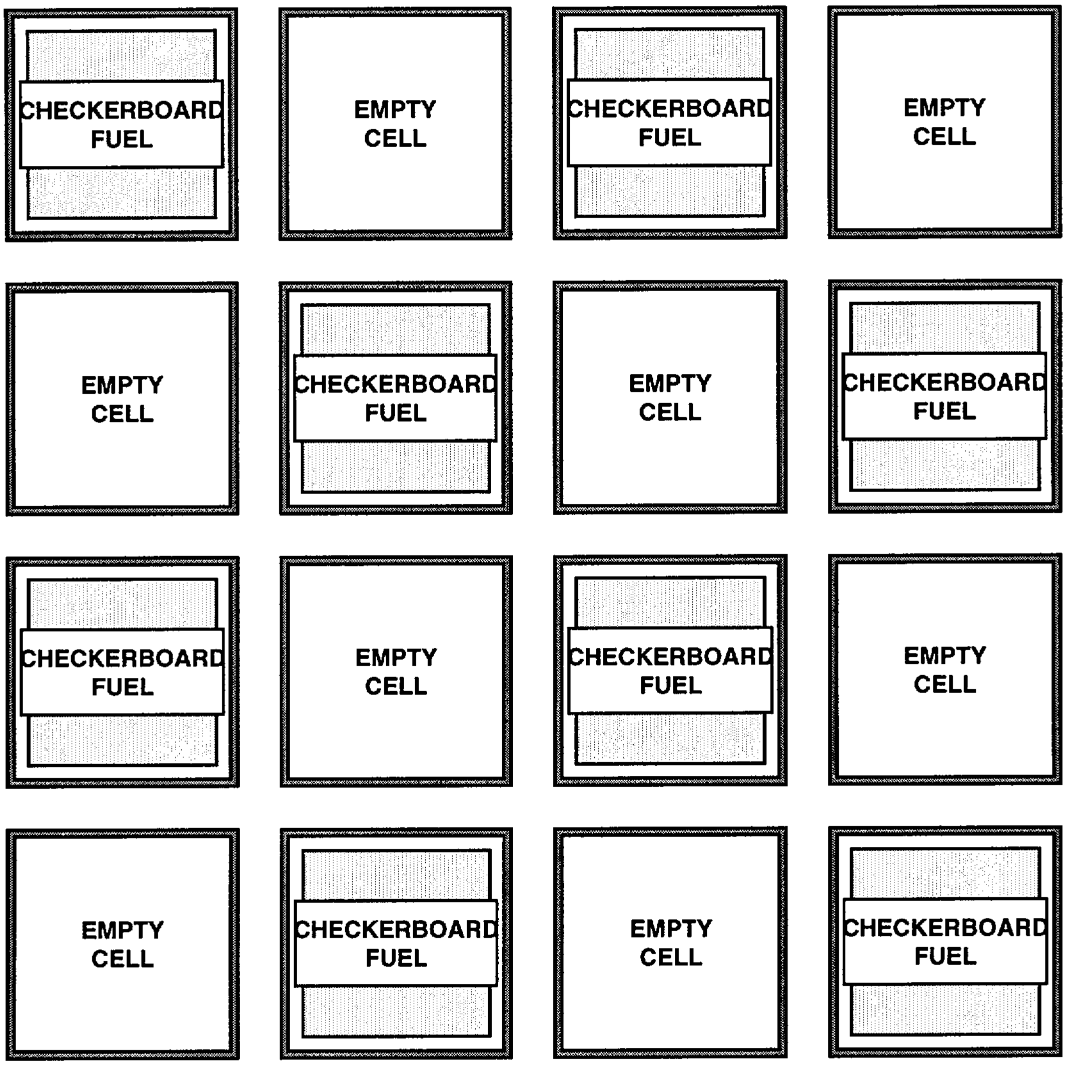


Restricted Fuel: Fuel which meets the minimum burnup requirements of Table 3.7.15-5, or non-fuel components, or an empty location.

Filler Location: Either fuel which meets the minimum burnup requirements of Table 3.7.15-6, or an empty cell.

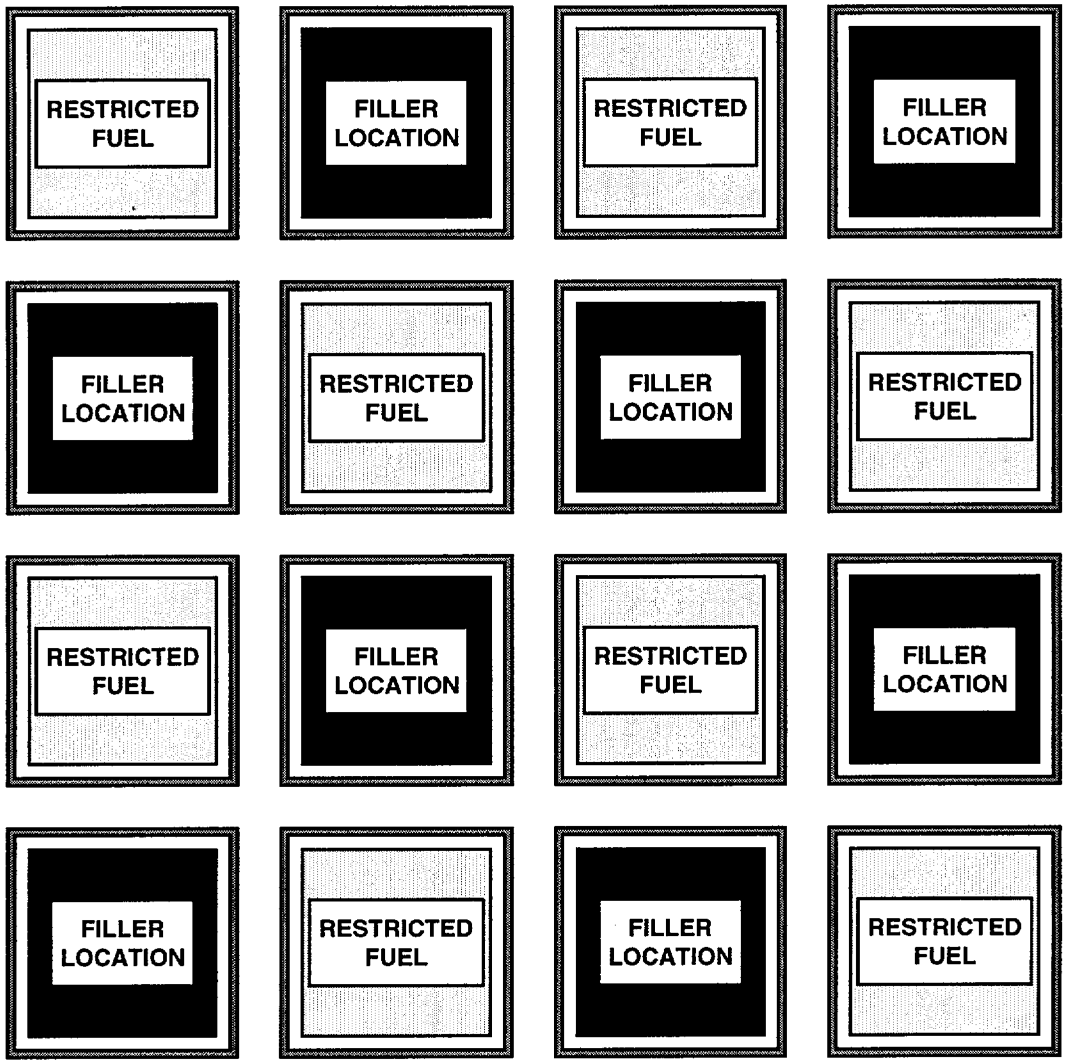
Boundary Condition: No restrictions on boundary assemblies.

Figure 3.7.15-2 (page 1 of 1)
Required 2 out of 4 Loading Pattern for Restricted Region 1B Storage



Checkerboard Fuel:	Fuel which does <u>not</u> meet the minimum burnup requirements of Table 3.7.15-5. (Fuel which does meet the requirements of Table 3.7.15-5, or non-fuel components, or an empty location may be placed in checkerboard fuel locations as needed)
Boundary Condition:	No restrictions on boundary assemblies.

Figure 3.7.15-3 (page 1 of 1)
Required 2 out of 4 Loading Pattern for Checkerboard Region 1B Storage

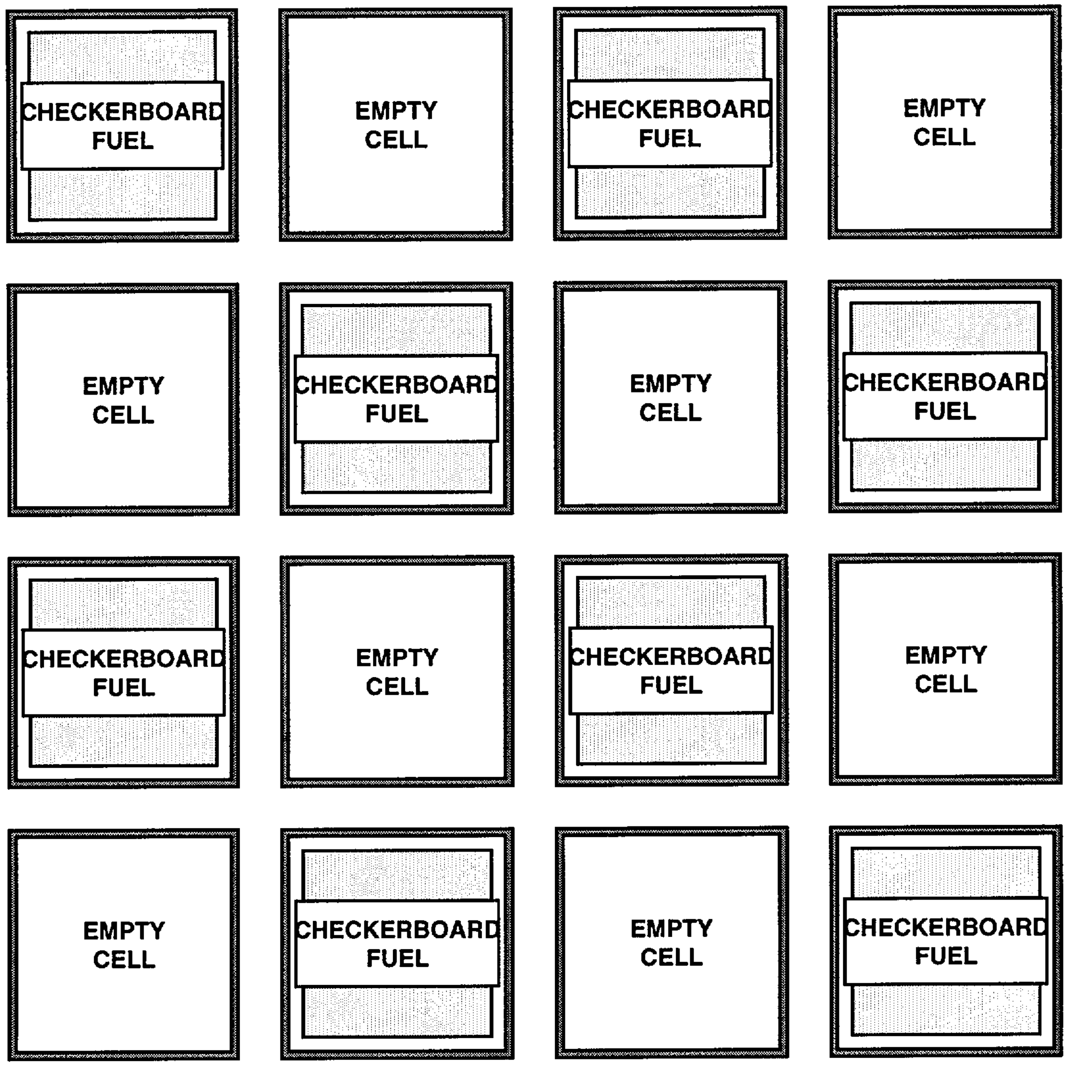


Restricted Fuel: Fuel which meets the minimum burnup requirements of Table 3.7.15-8, or non-fuel components, or an empty location.

Filler Location: Either fuel which meets the minimum burnup requirements of Table 3.7.15-9, or an empty cell.

Boundary Condition: No restrictions on boundary assemblies.

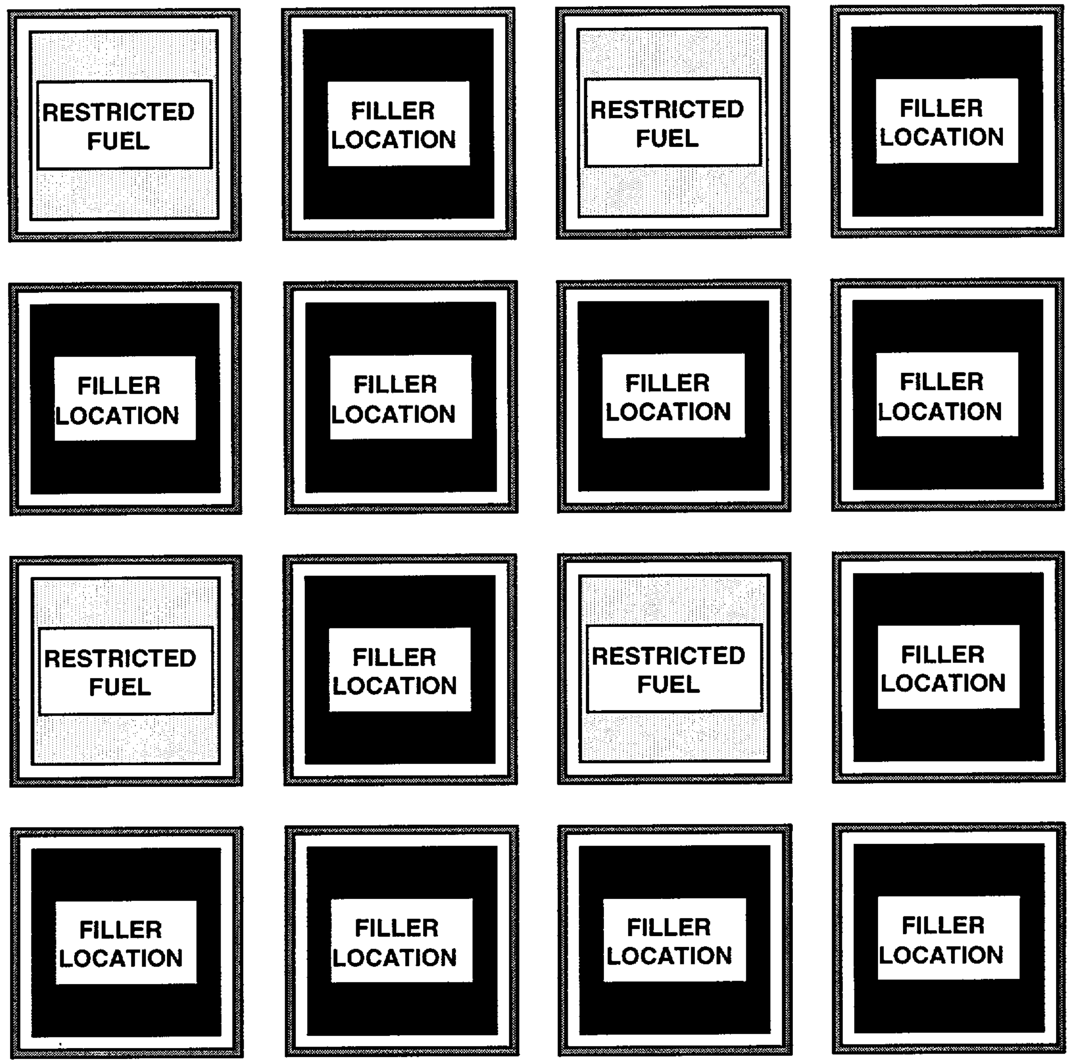
Figure 3.7.15-4 (page 1 of 1)
Required 2 out of 4 Loading Pattern for Restricted Region 2A Storage



Checkerboard Fuel: Fuel which does <u>not</u> meet the minimum burnup requirements of Table 3.7.15-8. (Fuel which does meet the requirements of Table 3.7.15-8, or non-fuel components, or an empty location may be placed in checkerboard fuel locations as needed)

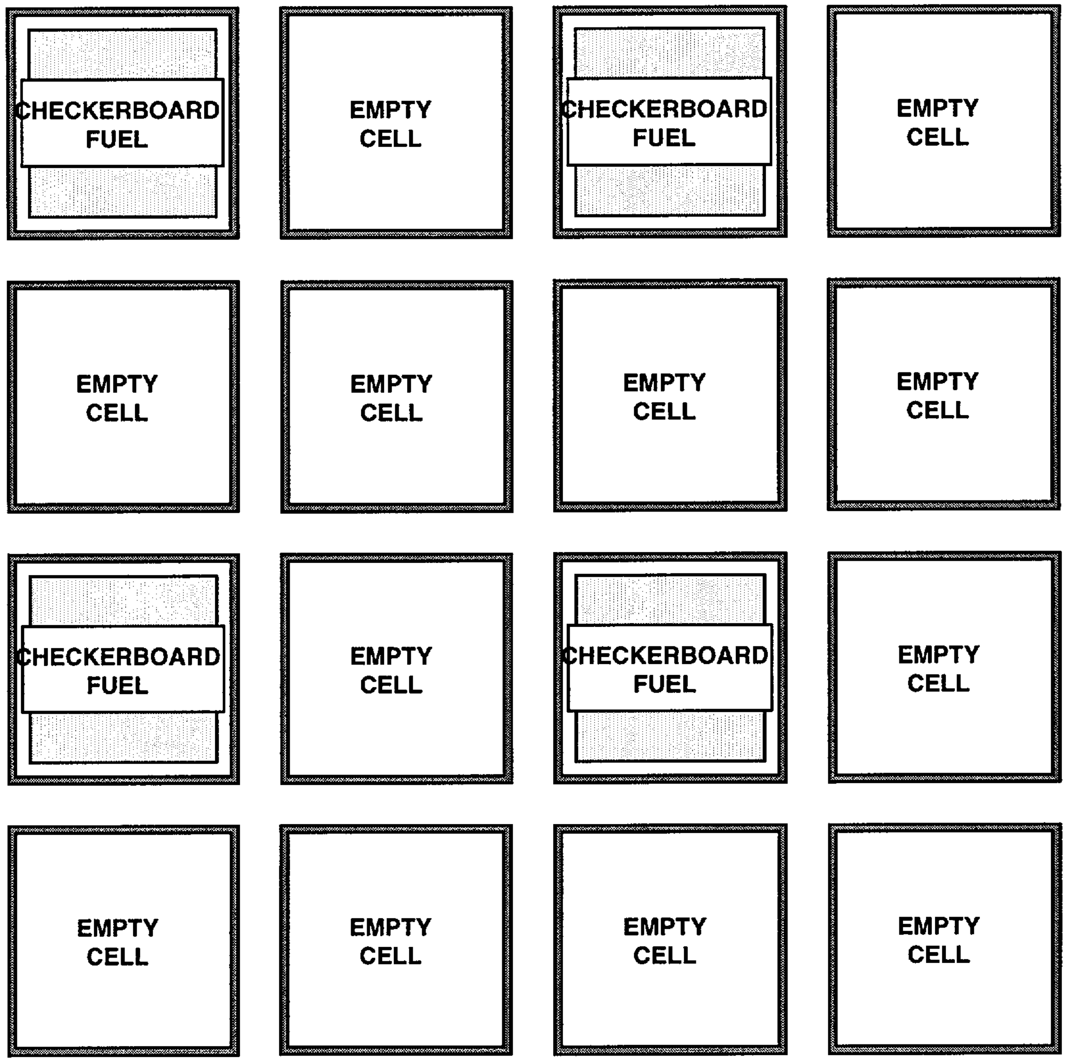
Boundary Condition: No restrictions on boundary assemblies.

Figure 3.7.15-5 (page 1 of 1)
Required 2 out of 4 Loading Pattern for Checkerboard Region 2A Storage



Restricted Fuel:	Fuel which meets the minimum burnup requirements of Table 3.7.15-11, or non-fuel components, or an empty location.
Filler Location:	Either fuel which meets the minimum burnup requirements of Table 3.7.15-12, or an empty cell.
Boundary Condition:	Any Restricted Region 2B Storage Area row bounded by any other storage area shall contain only filler locations arranged such that no Restricted Fuel assemblies are adjacent to any other fuel except Region 2B Filler Locations. Example: In the figure above, row 1 or column 1 can not be adjacent to another storage area, but row 4 or column 4 can be.

Figure 3.7.15-6 (page 1 of 1)
Required 1 out of 4 Loading Pattern for Restricted Region 2B Storage



Checkerboard Fuel: Fuel which does not meet the minimum burnup requirements of Table 3.7.15-11. (Fuel which does meet the requirements of Table 3.7.15-11, or non-fuel components, or an empty location may be placed in checkerboard fuel locations as needed)

Boundary Condition: Any Checkerboard Region 2B Storage Area row bounded by any other storage area shall contain only empty cells arranged such that no Checkerboard Fuel assemblies are adjacent to any fuel. Example: In the figure above, row 1 or column 1 can not be adjacent to another storage area, but row 4 or column 4 can be.

Figure 3.7.15-7 (page 1 of 1)
Required 1 out of 4 Loading Pattern for Checkerboard Region 2B Storage

4.0 DESIGN FEATURES

4.1 Site Location

The McGuire Nuclear Station site is located at latitude 35 degrees, 25 minutes, 59 seconds north and longitude 80 degrees, 56 minutes, 55 seconds west. The Universal Transverse Mercator Grid Coordinates are E 504, 669, 256, and N 3, 920, 870, 471. The site is in northwestern Mecklenburg County, North Carolina, 17 miles north-northwest of Charlotte, North Carolina.

4.2 Reactor Core

4.2.1 Fuel Assemblies

The reactor shall contain 193 fuel assemblies. Each assembly shall consist of a matrix of Zircalloy fuel rods with an initial composition of natural or slightly enriched uranium dioxide (UO_2) as fuel material. Limited substitutions of zirconium alloy or stainless steel filler rods for fuel rods, in accordance with approved applications of fuel rod configurations, may be used. Fuel assemblies shall be limited to those fuel designs that have been analyzed with applicable NRC staff approved codes and methods and shown by tests or analyses to comply with all fuel safety design bases. A limited number of lead test assemblies that have not completed representative testing may be placed in nonlimiting core regions.

4.2.2 Control Rod Assemblies

The reactor core shall contain 53 control rod assemblies. The control material shall be silver indium cadmium (Unit 1) silver indium cadmium and boron carbide (Unit 2) as approved by the NRC.

4.3 Fuel Storage

4.3.1 Criticality

4.3.1.1 The spent fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having a maximum nominal U-235 enrichment of 4.75 weight percent;

b. $k_{eff} < 1.0$ if fully flooded with unborated water, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR;

c. $k_{eff} \leq 0.95$ if fully flooded with water borated to 730 ppm, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR;

4.0 DESIGN FEATURES

4.3 Fuel Storage (continued)

d. A nominal 10.4 inch center to center distance between fuel assemblies placed in Regions 1A and 1B; and

e. A nominal 9.125 inch center to center distance between fuel assemblies placed in Regions 2A and 2B.

4.3.1.2 The new fuel storage racks are designed and shall be maintained with:

a. Fuel assemblies having a maximum nominal U-235 enrichment of 4.75 weight percent;

b. $k_{eff} \leq 0.95$ if fully flooded with unborated water, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR;

c. $k_{eff} \leq 0.98$ if moderated by aqueous foam, which includes an allowance for uncertainties as described in Section 9.1 of the UFSAR; and

d. A nominal 21 inch center to center distance between fuel assemblies placed in the storage racks.

4.3.2 Drainage

The spent fuel storage pool is designed and shall be maintained to prevent inadvertent draining of the pool below elevation 745 ft.-7 in.

4.3.3 Capacity

The spent fuel storage pool is designed and shall be maintained with a storage capacity limited to no more than 1463 fuel assemblies (286 total spaces in Regions 1A and 1B and 1177 total spaces in Regions 2A and 2B).

ATTACHMENT 3

DESCRIPTION OF PROPOSED CHANGES AND TECHNICAL JUSTIFICATION

Description of Proposed Changes

The existing design basis for preventing criticality in the McGuire spent fuel storage pools is that, including uncertainties, there is a 95% probability at a 95% confidence level that k_{eff} of the fuel storage assembly array will be less than or equal to 0.95 with full density moderation under both accident and non-accident conditions. A design basis standard condition states that the spent fuel pool water is assumed to be unborated. This LAR proposes an exception to this standard condition and a revision to the existing McGuire TS's and spent fuel storage pool design bases. The proposed changes are described below and are based upon the assumptions of the amount of Boraflex remaining in the pools as described in the new McGuire Spent Fuel Pool Criticality Analysis (Attachment 6):

1. McGuire TS 4.3 will be revised to provide new acceptable levels of subcriticality for spent fuel storage. Upon incorporation of the proposed changes to TS 3.7.15, these acceptable levels of subcriticality are an effective neutron multiplication factor (k_{eff}) less than 1.0 if fully flooded with unborated water, including an allowance for uncertainties as described in Section 9.1 of the McGuire UFSAR and $k_{eff} \leq$ 0.95 if fully flooded with water borated to 730 ppm, including an allowance for uncertainties as described in Section 9.1 of the UFSAR. TS 4.3 is also revised to reflect the new sub-regions within Regions 1 and 2.

2. McGuire TS 3.7.15 will be revised to provide revised spent fuel pool storage configurations, revised spent fuel pool storage criteria and revised fuel enrichment and burnup requirements. With the applicable minimum concentration of soluble boron present in the spent fuel storage pool, credit for the presence of IFBA rods where applicable, and reduced credit for the degraded spent fuel rack Boraflex neutron absorber panels, these changes will ensure that the pool storage rack k_{eff} is $\leq$ 0.95 under non-accident conditions (including the unlikely occurrence of a worst case spent fuel storage pool dilution event with thorough mixing) and accident conditions. The applicable minimum concentration of soluble boron would be ensured by existing McGuire TS 3.7.14. Note that credit for soluble boron is currently used at McGuire for Mode 6 reactivity control in the reactor vessel, to compensate for a misloaded fuel assembly in the spent fuel storage pools and will be used for control of reactivity during the loading of spent fuel storage casks.

   In the unlikely event of a worst case spent fuel storage pool dilution event without thorough mixing, the proposed changes will ensure that the pool storage rack k_{eff} is < 1.0 under non-accident conditions with no credit for soluble boron, credit for the presence of IFBA rods where applicable, and reduced credit for the degraded spent fuel rack Boraflex neutron absorber panels.

As stated above, the proposed changes are based upon the assumptions of the amount of Boraflex remaining in the pools as described in the new McGuire Spent Fuel Pool Criticality Analysis. A proposed addition to Chapter 16 of the McGuire UFSAR, "Selected Licensee Commitments", would provide for periodic monitoring of future Boraflex degradation. If this monitoring determined that the Boraflex in a spent fuel storage pool degraded to levels that would not support the conclusions of the McGuire Spent Fuel Pool Criticality Analysis, then a future LAR would be submitted proposing additional changes to the McGuire TS's and spent fuel storage pool design bases as needed to maintain acceptable levels of subcriticality in the McGuire fuel pools. Note that a review of the TS criteria specified in 10 CFR 50.36(c)(2)(ii) determined that incorporation of this Boraflex panel monitoring into a TS was not required for the following reasons:

- Boraflex monitoring and inadequate Boraflex levels are not associated with plant instrumentation used to detect or indicate a degradation of the reactor coolant pressure boundary.

- Boraflex monitoring and inadequate Boraflex levels do not represent or affect a process variable, design feature, or operating restriction that is the initial condition of a design basis accident or transient analysis. A review of non-spent fuel pool storage related accidents described in the McGuire UFSAR determined that neither Boraflex monitoring nor inadequate Boraflex levels represent or affect a process variable, design feature, or operating restriction that is the initial condition of any of these accidents or transients. The only spent fuel pool storage related design basis accidents or transients analyzed in Chapter 15 of the McGuire UFSAR are a fuel assembly drop and a weir gate drop. Neither Boraflex monitoring nor inadequate Boraflex levels are a process variable, design feature, or operating restriction that represents an initial condition of either of these events. In addition, Boraflex levels do not represent an active design feature or operating restriction that is needed to preclude a risk or safety significant unanalyzed accident or transient. This position is based upon risk analysis which indicates that inadequate Boraflex levels is not a high probability occurrence and not risk significant given the presence of soluble boron in the spent fuel storage pools.

- Boraflex monitoring and inadequate Boraflex levels do not represent or affect a structure, system, or component which functions or actuates to mitigate a design basis accident or transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier. A review of non-spent fuel pool storage related accidents described in the McGuire UFSAR determined that neither Boraflex monitoring nor inadequate Boraflex levels represent or affect a structure, system, or component which functions or actuates to mitigate these analyzed design basis accidents or transients. The only spent fuel pool storage related design basis accidents or transients analyzed in Chapter 15 of the McGuire UFSAR are a fuel assembly drop and a weir gate drop. The consequences of both of these accidents is ruptured fuel assembly cladding and the resulting release of radioactivity. Neither Boraflex monitoring nor inadequate Boraflex levels represent or affect a structure, system, or component which functions or actuates to mitigate these consequences.

- Boraflex monitoring or inadequate Boraflex levels do not represent or affect a structure, system, or component which operating experience or a probabilistic risk assessment has shown to be significant to public health and safety.

Technical Justification

Normal Conditions:

The McGuire spent fuel storage racks were analyzed taking credit for soluble boron as allowed in the NRC approved "Westinghouse Spent Fuel Rack Criticality Analysis Methodology" described in WCAP-14416-NP-A (Reference 1).

Utilizing the spent fuel pool storage configurations, spent fuel pool storage criteria, and the fuel enrichment and burnup requirements described in the new McGuire Spent Fuel Pool Criticality Analysis, that analysis demonstrates that under non-accident conditions a spent fuel storage pool boron concentration of 730 ppm would be adequate to maintain the spent fuel storage rack $k_{eff} \leq 0.95$ with credit for the presence of IFBA rods where applicable, and reduced credit for the degraded spent fuel rack Boraflex neutron absorber panels. Existing McGuire TS 3.7.14 states that the spent fuel pool storage boron concentrations shall be maintained within the limits specified in the McGuire Core Operating Limits Report (COLR). The spent fuel pool boron concentration limit currently specified in the COLR is 2675 ppm which is well above the minimum required boron credit of 730 ppm for non-accident conditions.

It is possible that the boron concentration in the spent fuel storage pool could be lowered below the COLR limit by a pool dilution event. Consequently, an analysis of dilution event spent fuel storage pool boron concentrations is necessary to ensure that acceptable levels of subcriticality are maintained during and following the event (Attachment 7). Note that based upon the double contingency principle, this dilution event is assumed to occur under non-accident conditions. As part of this spent fuel storage pool dilution event analysis, calculations were performed to define the dilution time and volumes for the spent fuel pool. The dilution sources available at McGuire were compiled and evaluated against the calculated dilution volume to identify the bounding dilution event. The McGuire dilution analysis concluded that the bounding event was dilution from the McGuire Recycle Holdup Tanks (RHT's) while they are in "piggy-back" alignment with the Reactor Makeup Water Storage Tank (RMWST) and the spent fuel storage pool cask loading pit is isolated and drained. Given the volume of water in these tanks and the capacity of the pumps in the flowpath to a spent fuel storage pool, the dilution analysis determined that it would take over 2-½ days for all the water in these tanks to be added to a fuel pool. It is likely that such a worst case dilution event would be detected by a spent fuel storage pool level alarm or by plant operations personnel walking through the area before the entire volume of the RHT's and the RMWST was added to the fuel pool. Note that in the unlikely event this worst case dilution event was not detected and the entire volume of the three tanks was transferred to a fuel pool, the dilution analysis indicates that the boron concentration of a pool would be reduced to approximately 937 ppm assuming a conservative starting boron concentration of 2475 ppm and thorough mixing of the non-borated water added to a pool. This post-dilution boron concentration is well above the minimum required boron credit of 730 ppm for non-accident conditions. Note that the above post-dilution event boron concentrations are based upon the assumption that all of the non-borated water added to a spent fuel pool is thoroughly mixed with the water in the pool. Given the spent fuel storage pool cooling water flow and convection from the spent fuel decay heat, it is likely that this thorough mixing would occur. However, if mixing was not adequate, it is possible that a localized pocket of non-borated water could form somewhere in the spent fuel pool. This possibility is addressed by the calculation in Attachment 6 which shows that a spent fuel storage pool k_{eff} will still be less than 1.0 on a 95/95 basis with the spent fuel pool filled with non-borated water. Thus, in the unlikely event that the worst case dilution event occurred and then a pocket of non-borated water formed in the spent fuel pool due to inadequate mixing, acceptable subcritical conditions would still be maintained in the McGuire spent fuel storage pools.

Accident Conditions:

Many of the postulated spent fuel pool accidents at McGuire will not result in an increase in k_{eff} of the spent fuel racks. Such accidents are the drop of a fuel assembly on top of a rack, the drop of a fuel assembly between rack modules, and the drop of a fuel assembly between rack modules and the pool wall. At McGuire, the spent fuel assembly rack configuration is such that it precludes the insertion of a fuel assembly between rack modules. The placement of an assembly between the rack and the pool wall would result in a lower k_{eff} relative to the criticality analysis due to the increased neutron leakage at the spent fuel pool wall because the criticality analysis assumes an infinite array of fuel assemblies. In the case where a dropped fuel assembly in its most reactive condition is dropped onto the spent fuel racks, it is assumed that the rack structure pertinent for criticality is not excessively deformed. For this event, previous accident analysis with unborated water showed that a dropped fuel assembly resting horizontally on top of the spent fuel rack has sufficient water separating it from the active fuel height of stored fuel assemblies to preclude neutronic interaction.

However, three accidents can be postulated which could result in an increase in reactivity in the spent fuel storage pools. The first is a drop or placement of a fuel assembly into the cask loading area. If a fuel assembly were to be dropped or placed into the cask loading area of a pool, any reactivity increase would be bounded by the fuel assembly misload accident described below. The other two postulated accidents which need to be addressed are a significant change in the spent fuel pool water temperature and the misloading of a fuel assembly. A fuel assembly misload accident relates to the use of restricted storage locations based on fuel assembly type, initial enrichment, burnup and IFBA rod loading requirements. The misloading of a fuel assembly constitutes not meeting the enrichment, burnup or IFBA rod requirements of that restricted location. The result of the misloading is to add positive reactivity, increasing k_{eff} toward 0.95. Note that special administrative controls are placed on the patterning and region loading of assemblies into these restricted locations. A significant change in the spent fuel pool water temperature can be caused by either the loss of normal cooling to the spent fuel pool water which causes an increase in the temperature of the water passing through the stored fuel assemblies or a large makeup to the pool with cold water which could happen if the spent fuel pool were used an as emergency source of borated water. The loss of spent fuel pool cooling causes a decrease in water density which would result in a decrease in reactivity when Boraflex neutron absorber panels are present in the racks. However, since Boraflex is not considered to be present for some regions and the spent fuel pool water has a high concentration of boron, a density decrease results in a decrease in boron density which causes a positive reactivity addition. The decrease in pool temperature causes an increase in water density which would normally result in an increase in reactivity.

For each storage configuration proposed in the revised TS 3.7.15, a McGuire spent fuel rack criticality analysis was performed as described in the McGuire Spent Fuel Pool Criticality Analysis (Attachment 6). This new McGuire Criticality Analysis evaluated the amount of soluble boron necessary to ensure that the spent fuel rack k_{eff} will be maintained less than or equal to 0.95 following a significant change in spent fuel pool temperature or the misloading of a fuel assembly. For each of these accidents, that evaluation established that a minimum boron concentration of 1470 ppm is required to maintain k_{eff} less than or equal to 0.95. A separate McGuire TS states that the spent fuel pool storage boron concentrations shall be maintained within the limits specified in the McGuire Core Operating Limits Report (COLR). The spent fuel pool boron concentration limit currently specified in the COLR is 2675 ppm. Consequently, under the applicable accident conditions, maintaining spent fuel pool boron concentrations within the COLR limit in the presence of IFBA rods where applicable will ensure that the spent fuel storage rack k_{eff} is $\leq$ 0.95 when fuel is stored in accordance with the revised spent fuel pool storage configurations, revised spent fuel pool storage criteria and revised fuel enrichment and burnup requirements specified in the proposed change to TS 3.7.15. Note that, based on the double contingency principle, the margin for accident conditions included in the boron concentration limit does not have to account for both a loss of cooling accident, a misload accident, or a spent fuel pool dilution event occurring at the same time.

Conclusion

Revision of the McGuire TS's and design bases as proposed in this LAR will provide a level of safety comparable to the conservative criticality analysis methodology required by References 1, 2, and 3 of this attachment. Consequently, the health and safety of the public will not be adversely affected by the proposed Technical Specification changes. The bases for these conclusions are as follows:

1. Utilizing the revised spent fuel pool storage configurations, revised spent fuel pool storage criteria and revised fuel enrichment and burnup requirements specified in the proposed change to TS 3.7.15, the new McGuire Spent Fuel Pool Criticality Analysis demonstrates that, under <u>non-accident conditions (including thorough mixing of pool water following the unlikely occurrence of a worst case spent fuel storage pool dilution event)</u>, a minimum spent fuel storage pool boron credit of 730 ppm would be adequate to maintain the spent fuel storage rack k_{eff} $\leq$ 0.95 with credit for the presence of IFBA rods where applicable and reduced credit for the degraded spent fuel rack Boraflex neutron absorber panels. This minimum boron concentration would be ensured by existing

McGuire TS 3.7.14.

2. Utilizing the revised spent fuel pool storage configurations, revised spent fuel pool storage criteria and revised fuel enrichment and burnup requirements specified in the proposed change to TS 3.7.15, the new McGuire Spent Fuel Pool Criticality Analysis demonstrates that, under non-accident conditions and non-thorough mixing of pool water following the unlikely occurrence of a worst case spent fuel storage pool dilution event, spent fuel storage rack k_{eff} would remain < 1.0 with credit for the presence of IFBA rods where applicable and reduced credit for the degraded spent fuel rack Boraflex neutron absorber panels.

3. Utilizing the revised spent fuel pool storage configurations, revised spent fuel pool storage criteria, revised fuel enrichment and burnup requirements specified in the proposed change to TS 3.7.15, the new McGuire Spent Fuel Pool Criticality Analysis demonstrates that under accident conditions a minimum spent fuel storage pool boron credit of 1470 ppm would be adequate to maintain the spent fuel storage rack $k_{eff} \leq 0.95$ with credit for the presence of IFBA rods where applicable,and reduced credit for the degraded spent fuel rack Boraflex neutron absorber panels. This minimum boron concentration would be ensured by existing McGuire TS 3.7.14.

Note that the existing TS 3.7.15 specifies the requirements for spent fuel pool storage configurations, fuel pool storage criteria, fuel enrichment, and fuel burnup. Consequently, plant operating procedures already include controls to ensure these existing requirements are satisfied These procedural controls will be revised and maintained as needed under the revised TS 3.7.15. In addition, new controls necessary to ensure that independent administrative confirmation of the number of IFBA rods will be incorporated into plant operating procedures prior to implementation of the proposed TS changes. Finally, current administrative controls on spent fuel pool boron concentration and water inventory will be evaluated and procedures will be upgraded as necessary to ensure that the spent fuel pool boron concentration and water inventory are controlled during both normal and accident situations. Note that existing McGuire spent fuel pool storage systems, supporting systems, and instrumentation are not modified as a result of this proposed LAR.

References

1. WCAP-14416-NP-A, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology", Revision 1, November 1996.

2. USNRC Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, NUREG-0800, June 1987.

3. USNRC Spent Fuel Storage Facility Design Bases (for Comment) Proposed Revision 2, 1981, Regulatory Guide 1.13.

ATTACHMENT 4

NO SIGNIFICANT HAZARDS CONSIDERATION EVALUATION

No Significant Hazards Consideration Evaluation

In accordance with the criteria set forth in 10 CFR 50.91 and 50.92, McGuire Nuclear Station has evaluated the proposed Technical Specification change and determined it does not represent a significant hazards consideration. The following is provided in support of this conclusion.

The radiological consequences of a fuel handling accident in the spent fuel pool do not change by taking credit for soluble boron in the pool because the current spent fuel pool boron concentration limit is not being changed.

1. Will the change involve a significant increase in the probability or consequence of an accident previously evaluated?

   No, based upon the following:

   Dropped Fuel Assembly

   There is no significant increase in the probability of a fuel assembly drop accident in the spent fuel pools when considering the degradation of the Boraflex panels in the spent fuel pool racks coupled with the presence of soluble boron in the spent fuel pool water for criticality control. The handling of the fuel assemblies in the spent fuel pool has always been performed in borated water, and the quantity of Boraflex remaining in the racks has no affect on the probability of such a drop accident.

   The criticality analysis showed that the consequences of a fuel assembly drop accident in the spent fuel pools are not affected when considering the degradation of the Boraflex in the spent fuel pool racks and the presence of soluble boron.

   Fuel Misloading

   There is no significant increase in the probability of the accidental misloading of spent fuel assemblies into the spent fuel pool racks when considering the degradation of the Boraflex in the spent fuel pool racks and the presence of soluble boron in the pool water for criticality control. Fuel assembly placement and storage will continue to be controlled pursuant to approved fuel handling procedures to ensure compliance with the Technical Specification requirements. These procedures will be revised as needed to comply with the revised requirements which would be imposed by the proposed Technical Specification changes. Note that the proposed amendment would increase the number of different storage limits in Technical Specification 3.7.15. However, these revised storage limits were developed with input from station personnel. Their awareness, in conjunction with any procedure changes as described above, will provide additional assurance that an accidental misloading of a spent fuel assembly will not occur.

There is no increase in the consequences of the accidental misloading of spent fuel assemblies into the spent fuel pool racks because criticality analyses demonstrate that the pool will remain subcritical following an accidental misloading if the pool contains an adequate soluble boron concentration. Current Technical Specification 3.7.14 will ensure that an adequate spent fuel pool boron concentration is maintained in the McGuire spent fuel storage pools. A McGuire Station UFSAR change will revise Chapter 16, "Selected Licensee Commitments", to provide for adequate monitoring of the remaining Boraflex in the spent fuel pool racks. If that monitoring identifies further reductions in the Boraflex panels which would not support the conclusions of the McGuire Criticality Analysis, then the McGuire TS's and design bases would be revised as needed to ensure that acceptable subcriticality are maintained in the McGuire spent fuel storage pools.

Significant Change in Spent Fuel Pool Temperature

There is no significant increase in the probability of either the loss of normal cooling to the spent fuel pool water or a decrease in pool water temperature from a large emergency makeup when considering the degradation of the Boraflex in the spent fuel pool racks and the presence of soluble boron in the pool water for subcriticality control since a high concentration of soluble boron has always been maintained in the spent fuel pool water. Current Technical Specification 3.7.14 will ensure that an adequate spent fuel pool boron concentration is maintained in the McGuire spent fuel storage pools

A loss of normal cooling to the spent fuel pool water causes an increase in the temperature of the water passing through the stored fuel assemblies. This causes a decrease in water density that would result in a decrease in reactivity when Boraflex neutron absorber panels are present in the racks. However, since a reduction in the amount of Boraflex present in the racks is considered, and the spent fuel pool water has a high concentration of boron, a density decrease causes a positive reactivity addition. However, the additional negative reactivity provided by the current boron concentration limit, above that provided by the concentration required to maintain k_{eff} less than or equal to 0.95 (1470 ppm), will compensate for the increased reactivity which could result from a loss of spent fuel pool cooling event. Because adequate soluble boron will be maintained in the spent fuel pool water, the consequences of a loss of normal cooling to the spent fuel pool will not be increased. Current Technical Specification 3.7.14 will ensure that an adequate spent fuel pool boron concentration is maintained in the McGuire spent fuel storage pools.

A decrease in pool water temperature from a large emergency makeup causes an increase in water density that would result in an increase in reactivity when Boraflex neutron absorber panels are present in the racks. However, the additional negative reactivity provided by the current boron concentration limit, above that provided by the concentration required to maintain k_{eff} less than or equal to 0.95 (1470 ppm), will compensate for the increased reactivity which could result from a decrease in spent fuel pool water temperature. Because adequate soluble boron will be maintained in the spent fuel pool water, the consequences of a decrease in pool water temperature will not be increased. Current Technical Specification 3.7.14 will ensure that an adequate spent fuel pool boron concentration is maintained in the McGuire spent fuel storage pools.

2. Will the change create the possibility of a new or different kind of accident from any previously evaluated?

No. Criticality accidents in the spent fuel pool are not new or different types of accidents. They have been analyzed in Section 9.1.2.3 of the Updated Final Safety Analysis Report and in Criticality Analysis reports associated with specific licensing amendments for fuel enrichments up to 4.75 weight percent U-235. Specific accidents considered and evaluated include fuel assembly drop, accidental misloading of spent fuel assemblies into the spent fuel pool racks, and significant changes in spent fuel pool water temperature. The accident analysis in the Updated Final Safety Analysis Report remains bounding.

The possibility for creating a new or different kind of accident is not credible. The amendment proposes to take credit for the soluble boron in the spent fuel pool water for reactivity control in the spent fuel pool while maintaining the necessary margin of safety. Because soluble boron has always been present in the spent fuel pool, a dilution of the spent fuel pool soluble boron has always been a possibility, however a criticality accident resulting from a dilution accident was not considered credible. For the proposed amendment, the spent fuel pool dilution evaluation (Attachment 7) demonstrates that a dilution of the boron concentration in the spent fuel pool water which could increase the rack k_{eff} to greater than 0.95

(constituting a reduction of the required margin to criticality) is not a credible event. The requirement to maintain boron concentration in the spent fuel pool water for reactivity control will have no effect on normal pool operations and maintenance. There are no changes in equipment design or in plant configuration. This new requirement will not result in the installation of any new equipment or modification of any existing equipment. Therefore, the proposed amendment will not result in the possibility of a new or different kind of accident.

3. Will the change involve a significant reduction in a margin of safety?

No. The proposed Technical Specification changes and the resulting spent fuel storage operating limits will provide adequate safety margin to ensure that the stored fuel assembly array will always remain subcritical. Those limits are based on a plant specific criticality analysis (Attachment 6) based on the "Westinghouse Spent Fuel Rack Criticality Analysis Methodology" described in Reference 1. The Westinghouse methodology for taking credit for soluble boron in the spent fuel pool has been reviewed and approved by the NRC (Reference 6). This methodology takes partial credit for soluble boron in the spent fuel pool and requires conformance with the following NRC Acceptance criteria for preventing criticality outside the reactor:

1) k_{eff} shall be less than 1.0 if fully flooded with unborated water which includes an allowance for uncertainties at a 95% probability, 95% confidence (95/95) level; and

2) k_{eff} shall be less than or equal to 0.95 if fully flooded with borated water, which includes an allowance for uncertainties at a 95/95 level.

The criticality analysis utilized credit for soluble boron to ensure k_{eff} will be less than or equal to 0.95 under normal circumstances, and storage configurations have been defined using a 95/95 k_{eff} calculation to ensure that the spent fuel rack k_{eff} will be less than 1.0 with no soluble boron. Soluble boron credit is used to provide safety margin by maintaining k_{eff} less than or equal to 0.95 including uncertainties, tolerances and accident conditions in the presence of spent fuel pool soluble boron. The loss of substantial amounts of soluble boron from the spent fuel pool which could lead to exceeding a k_{eff} of 0.95 has been evaluated (Attachment 7) and shown to be not credible. Accordingly, the required margin to criticality is not reduced.

The evaluations in Attachment 7, which show that the dilution of the spent fuel pool boron concentration from the conservative assumed initial boron concentration (2475 ppm) to the minimum boron concentration required to maintain $k_{eff} \leq 0.95$ (730 ppm) is not credible, combined with the 95/95 calculation which shows that the spent fuel rack k_{eff} will remain less than 1.0 when flooded with unborated water, provide a level of safety comparable to the conservative criticality analysis methodology required by References 2, 3 and 4.

Therefore the proposed changes in this license amendment will not result in a significant reduction in the facility's margin of safety.

References

1. WCAP-14416-NP-A, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology", Revision 1, November 1996.

2. USNRC Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, LWR Edition, NUREG-0800, June 1987.

3. USNRC Spent Fuel Storage Facility Design Bases (for Comment) Proposed Revision 2, 1981, Regulatory Guide 1.13.

4. ANS, Design Requirements for Light Water Reactor Spent Fuel Storage Facilities at Nuclear Power Stations, ANSI/ANS-57.2-1983.

5. Attached McGuire Criticality Analysis and other attached documentation (including references therein) forming the basis for this license amendment request.

6. Letter from TE Collins (NRC) to T Greene (WOG), Acceptance for Referencing of Licensing Topical Report WCAP-14416-P, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology." (TAC No. M93254), Dated October 15, 1996

ATTACHMENT 5

ENVIRONMENTAL IMPACT ASSESSMENT

Environmental Impact Assessment:

The proposed Technical Specification amendment has been reviewed against the criteria of 10 CFR 51.22 for environmental considerations. The proposed amendment will allow credit to be taken for soluble boron in the spent fuel storage pool water to maintain an acceptable margin of subcriticality. Appropriate controls are in place or they will be implemented to monitor the soluble boron concentration in the spent fuel pool water and to monitor for future degradation of the Boraflex panels in the spent fuel storage cells. Consequently, the proposed amendment does not involve a significant hazards consideration, nor increase the types and amounts of effluents that may be released offsite, nor increase individual or cumulative occupational radiation exposures. Therefore, the proposed amendment meets the criteria given in 10 CFR 51.22(c)(9) for a categorical exclusion from the requirement for an Environmental Impact Assessment.

ATTACHMENT 6

MCGUIRE SPENT FUEL POOL CRITICALITY ANALYSIS

MCGUIRE SPENT FUEL POOL CRITICALITY ANALYSIS

Table of Contents

1.0 INTRODUCTION

This attachment describes the criticality analysis of the McGuire Nuclear Station spent fuel storage racks. This analysis takes credit for soluble boron in the spent fuel pool water as allowed in Reference 8.1 of this attachment.

It should be noted that the Westinghouse methodology in Reference 8.1 was used as the basis for the methodology used in this analysis. However, since this analysis was performed by Duke Energy, some minor differences in the application of the methodology exist. For example, this analysis used a different set of computer codes to perform the calculations (as described in Section 2.0) instead of those described in Reference 8.1. So, while the process and criteria defined in the "Westinghouse Spent Fuel Rack Criticality Analysis Methodology" were followed, the methodology used for this submittal, which is based on the Westinghouse methodology, is described in this attachment.

The storage rack design for the McGuire spent fuel pools is a two region design. Each region utilizes the poison material Boraflex. Due to the degradation of the Boraflex poison material and the need to establish acceptable spent fuel storage limits, each region has been divided into two sub-regions; with and without credit for Boraflex. For the regions taking credit for Boraflex, a minimum amount of Boraflex was assumed that is less than the original design minimum B_{10} areal density. The sub-regions are defined as follows:

- Region 1A takes credit for 25% of the original Boraflex material
- Region 1B takes no credit for Boraflex
- Region 2A takes credit for 50% of the original Boraflex material
- Region 2B takes no credit for Boraflex

Within each sub-region, the criticality analysis takes credit for burnup and storage configuration restrictions to achieve acceptable spent fuel storage limits. Two storage configurations are defined for each of the four regions: Unrestricted and Restricted storage. A third loading pattern, Checkerboard storage, was defined for Regions 1B, 2A and 2B. Unrestricted storage allows storage in all cells without restriction on the storage configuration. Restricted storage allows storage of higher reactivity fuel when restricted to a certain storage configuration with lower reactivity fuel. Checkerboard storage allows storage of the highest reactivity fuel in each region when checkerboarded with empty storage cells.

In addition, credit is also taken for Integrated Fuel Burnable Absorbers (IFBAs). IFBA credit is only taken for Region 1A since this is the region where the new fuel will be stored prior to refueling the reactor.

The main design criteria for the McGuire spent fuel storage rack criticality analysis is that $k_{eff} < 1.0$ with no boron (including tolerances and uncertainties) and $k_{eff} \leq 0.95$ with credit for soluble boron. The soluble boron credit required for the storage configurations in all regions is 730 ppm for normal conditions and 1470 ppm for accident conditions.

1.1 Spent Fuel Storage Rack Design

McGuire has two independent identical spent fuel pools for Units 1 and 2. The spent fuel storage rack in each pool consists of a two-region design.

The Region 1 area of the spent fuel pools is designed and generally reserved for temporary storage of new or partially irradiated fuel which would not qualify for storage in the Region 2 area. The storage cell configuration in this region represents a less reactive array than that of Region 2. The stainless steel cells are spaced at 10.4 inches and were constructed with a minimum 0.02 gm/cm^2 loading of B_{10} neutron absorbing material attached to the exterior cell wall wrapper plate. Region 1 has a capacity which is just sufficient to accommodate both a complete off load of the reactor core and storage of a reload fuel batch. With the larger fuel batch sizes to accommodate McGuire's 18-month cycle lengths, there are very few unused cells in Region 1 during an outage.

The basic spent fuel storage pool rack arrangement for Units 1 and 2 is shown in Figure 1. The Region 1 area of the pool is highlighted and a schematic of the Region 1 cell configuration is also provided.

The Region 2 area of the spent fuel pools is designed and generally used for normal, long term storage of permanently discharged fuel that has achieved qualifying burnup levels. The storage cell configuration in this region represents a more reactive array than that of Region 1. The stainless steel cells are assembled in a checkerboard pattern, producing a honeycomb structure of "cell" and "non-cell" locations. This configuration has a much tighter center-to-center pitch of 9.125 inches. These cells also utilize a neutron absorbing material with a slightly lower minimum B_{10} areal density (0.006 gm/cm^2) than that used in Region 1. This region has a nominal capacity of 1177 locations.

The basic spent fuel storage pool rack arrangement for Units 1 and 2 is shown again in Figure 2 with the Region 2 area of the pool highlighted and a schematic of the Region 2 cell configuration provided.

1.2 New Fuel Storage Vault Design

The new fuel storage vaults which are used for temporary dry storage of unirradiated reload fuel are built on 21 inch centers and are currently licensed for maximum nominal fuel enrichments of 4.75 %U-235. To accommodate a new Westinghouse Performance Plus fuel design, previously approved analytical methods were used to demonstrate that this new fuel containing up to 4.75 %U-235 can be safely stored in these fuel racks. No other restrictions beyond this enrichment limit are applicable to storage in the new fuel vaults. Discussion of the methods used to justify this increased limit can be found in Section 3.3. No technical specification changes are applicable to the new fuel storage vaults.

2.0 COMPUTER CODES AND METHODOLOGY

The methodology employed in this analysis is based on the "Westinghouse Spent Fuel Rack Criticality Analysis Methodology" (Reference 8.1). While, the process and criteria defined in the Westinghouse methodology were followed, the methodology used for this submittal, which is based on the Westinghouse methodology, is described in this attachment.

The methodology employed in this analysis uses both the CASMO-3/TABLES-3/SIMULATE-3 and SCALE system of codes for criticality analysis. CASMO-3/TABLES-3/SIMULATE-3 is used primarily and SCALE with KENO-Va is used for limited applications.

The burnup credit approach to fuel rack criticality analysis requires calculation and comparison of reactivity values over a range of burnup and initial enrichment conditions. In order to accurately model characteristics of irradiated fuel which impact reactivity, a criticality analysis method capable of evaluating arrays of these irradiated assemblies is needed. In this license submittal, the advanced nodal methodology combining CASMO-3/TABLES-3/SIMULATE-3 is used for this purpose. CASMO-3 is an integral transport theory code, SIMULATE-3 is a nodal diffusion theory code, and TABLES-3 is a linking code which reformats CASMO-3 data for use in SIMULATE-3. This methodology permits direct coupling of incore depletion calculations and resulting fuel isotopics with out-of-core storage array criticality analyses. The CASMO-3/TABLES-3/SIMULATE-3 methodology has been previously approved for use in criticality analysis of the McGuire spent fuel storage racks (Reference 8.2).

The CASMO-3/TABLES-3/SIMULATE-3 methodology is validated by comparison to measured results of fuel storage critical experiments. The criticality experiments used to benchmark the methodology were the Babcock and Wilcox close proximity storage critical experiments performed at the CX-10 facility (Reference 8.3). The B&W critical experiments used are specifically designed for benchmarking reactivity calculation techniques. The criticality experiments examined have similar nuclear characteristics to spent fuel storage and are applicable to conditions encountered during the handling of LWR fuel outside reactors.

The results of the CASMO-3/TABLES-3/SIMULATE-3 benchmark calculations are shown in Table 1. There are no significant trends in the results with respect to moderator soluble boron concentration, array spacing, or boron level in the isolation sheets.

The SCALE system of computer codes was used to model the Checkerboard storage configurations, new fuel storage vault and various biases and uncertainties related to the Boraflex material (self shielding, shrinkage and gaps). This methodology utilizes three dimensional Monte Carlo theory. Specifically, this analysis method used the CSAS25 sequence contained in Criticality Analysis Sequence No. 4 (CSAS4). CSAS4 is a control module contained in the SCALE-4.2 system of codes. The CSAS25 sequence utilizes two cross section processing codes (NITAWL and BONAMI) and a 3-D Monte Carlo code (KENO-Va) for calculating the effective multiplication factor for the system. The 27 Group NDF4 cross section library was used exclusively for this analysis.

The KENO-Va methodology is also benchmarked to measured results of fuel storage critical experiments. The criticality experiments used to benchmark the KENO-Va methodology were from the PNL reports PNL-3314 (Reference 8.4), PNL-2438 (Reference 8.5) and PNL-6205 (Reference 8.6). The criticality experiments examined have similar nuclear characteristics to spent fuel storage and are applicable to conditions encountered during the handling of LWR fuel outside reactors.

The results of the KENO-Va benchmark calculations are shown in Table 2. There are no significant trends in the results with respect to fuel pin spacing, array spacing, poison loading and material or fuel enrichment.

For additional verification that the models used in the McGuire criticality analysis are accurate, calculated k_{eff}s from CASMO-3, SIMULATE-3 and KENO-Va are compared in Table 3. The results listed in Table 3 show very good agreement between the transport theory, diffusion theory and Monte Carlo codes, with CASMO-3 and SIMULATE-3 being slightly conservative compared to KENO-Va.

3.0 CRITICALITY ANALYSIS

This section describes the criticality analysis performed to determine the spent fuel storage limits for the McGuire spent fuel storage racks.

The following assumptions are used in the spent fuel pool criticality analysis.

1. All fuel designs stored, or planned for storage, at McGuire were analyzed. This included Westinghouse Standard (STD), Optimized (OFA) and Robust Fuel (RFA, also referred to as Performance Plus or PF+) and Framatome Mark BW (MkBW) fuel designs. Also included were the Oconee fuel assemblies currently stored at McGuire. All fuel designs are analyzed for all cases and only the most reactive fuel design is used to set the storage requirements.

2. All conditions are modeled at both 68 and 150 °F. Only the most reactive temperature is used to set the storage requirements.

3. Most calculations are 2-D; i.e. no axial effects are modeled. A reactivity bias is included in the 2-D calculations to account for differences between 2-D and 3-D modeling.

4. No xenon conditions are assumed in the storage racks.

5. No credit is taken for the spacer grid material.

6. McGuire Region 1A contains 25% of its original thickness and areal density.

7. McGuire Region 1B contains no Boraflex.

8. McGuire Region 2A Boraflex contains 50% of its original thickness and areal density.

9. McGuire Region 2B contains no Boraflex.

10. The Boraflex panels are reduced in the width direction to account for 0.25 inches assumed shrinkage.

11. The Boraflex panels are reduced in the axial direction to account for measured shrinkage.

12. No reactivity penalty is included for gaps in the Boraflex panels (see Section 3.1).

13. The nominal coating on IFBA rods is assumed to be 1.0X which

is the minimum standard loading offered by the vendor. The IFBA coating is reduced to 75% of this value to account for the IFBA coating not being applied for the full length of the fuel rod.

3.1 No Boron 95/95 k_{eff}

This section describes the methodology used to determine the limits for the k_{eff} calculation with no boron including all biases and uncertainties (95/95 k_{eff}).

The 95/95 k_{eff} must be less than 1.0 with no boron. The calculation of the 95/95 k_{eff} must consider various biases and uncertainties related to the materials and construction of the racks. Specifically, the biases and uncertainties accounted for in the McGuire spent fuel pool criticality analysis are the bias and uncertainty associated with the benchmarking of the methodology, biases and uncertainties associated with the affect of Boraflex shrinkage, a bias to account for the underprediction of reactivity due to self shielding, a bias to account for 3-dimensional effects not captured by the 2-dimensional model and the uncertainty due to mechanical tolerances from the manufacturing process. The mechanical tolerance uncertainty is comprised of the following components: cell ID, CTC spacing, cell thickness, Boraflex width, plenum thickness, enrichment, fuel pellet dish volume, fuel pellet theoretical density, fuel pellet OD, clad OD and assembly position within the storage cell. For the no boron 95/95 k_{eff}, these biases and uncertainties are generated at no boron conditions. Additional uncertainties related to burned fuel are discussed with the burnup credit methodology. Table 4 lists the biases and uncertainties for each region.

The uncertainties associated with the effect of Boraflex shrinkage include the following. A reactivity bias is included to account for an assumed 0.25 inches of shrinkage in the width of the Boraflex panels. A reactivity uncertainty is included to account for the 95/95 worst case shrinkage in the axial direction (end pullback of the top and bottom). No reactivity penalty is included to account for gaps in the middle of the Boraflex panels, nor are any gaps included in the models. However, an analysis was performed to determine the maximum gap size before an increase in reactivity occurs. This analysis looked at a gap in one out of four panels, two out of four and four out of four panels. The results of this analysis indicate that the size gap required before an increase in reactivity is observed is less than the size of gaps observed in recent measured data. Hence, no reactivity penalty is necessary to account for gaps in the

Boraflex panels.

A no boron 95/95 maximum design k_{eff} is defined to be 1.0 less the combination of all the biases and uncertainties. For the final k_{eff} to remain less than 1.0, the calculated k_{eff} must remain less than the no boron maximum design k_{eff}. Since the combined biases and uncertainties are dependent on the fuel storage rack, four no boron 95/95 maximum design k_{eff}s are defined, one for each region of the pool. These maximum design k_{eff}s are listed in Table 4.

To determine the maximum enrichment for Unrestricted storage, CASMO-3 is used to iterate on enrichment until the calculated k_{eff} from CASMO-3 meets the no boron 95/95 maximum design k_{eff}. Since CASMO-3 is a lattice code, its calculations are for single assemblies in an infinite array, which is representative of the Unrestricted 100% storage option. The results of the fresh fuel limits for Unrestricted storage are summarized in Table 6.

Assemblies which do not qualify for unrestricted storage must be stored in a restricted storage configuration. Two restricted storage configurations are employed; Restricted storage with low reactivity 'filler' assemblies in a specified storage pattern and Checkerboard storage with empty cells in a specified storage pattern.

For Restricted storage to be effective, the storage requirements must be carefully selected to optimize the use of the spent fuel storage cells for the current and expected inventory of fuel for each region. For this reason, a different Restricted storage pattern is defined for each region of the McGuire spent fuel pools. For Region 1A, a 3 out of 4 storage pattern is defined which allows assemblies not qualified for Unrestricted storage to be stored in 3 out of every 4 locations with the 4^{th} being a qualified low reactivity 'filler' assembly. This storage pattern is shown in Figure 3. For Regions 1B and 2A, two different checkerboard storage patterns are defined which allow assemblies not qualified for Unrestricted storage to be stored in 2 out of every 4 locations with the other 2 being qualified low reactivity 'filler' assemblies. This storage pattern is shown in Figure 4. For Region 2B, a 1 out of 4 storage pattern is defined which allows assemblies not qualified for Unrestricted storage to be stored in 1 out of every 4 locations with the other 3 being qualified low reactivity 'filler' assemblies. This storage pattern is shown in Figure 5. By storing the more reactive assemblies not qualified for Unrestricted storage with less reactive fuel, the overall reactivity of the array is able to stay beneath the no boron 95/95 maximum design k_{eff}. The Unrestricted and Restricted storage patterns for each region will allow optimum usage of all the storage cells in the McGuire racks for a wide range of fuel assemblies.

Prior to performing any reactivity calculations, the requirements of either the filler or restricted assemblies must be selected. In this analysis, the requirements for the restricted assemblies were selected first and the filler requirements were then calculated for the restricted assembly requirements chosen. The fresh fuel limits defined for Restricted storage are summarized in Table 6.

The maximum enrichment for the Filler fuel in the Restricted storage configurations is calculated using SIMULATE-3. To model the Restricted storage patterns, the model must have the ability to analyze different assemblies in the same problem. This required the nodal code. SIMULATE-3 was executed to calculate k_{eff} of the Restricted storage array containing dissimilar fuel. The maximum enrichment for the filler fuel is determined by iterating on enrichment until the calculated k_{eff} from SIMULATE-3 meets the no boron 95/95 maximum design k_{eff}. The results of the fresh fuel limits for Filler fuel in the Restricted storage configuration are summarized in Table 6.

Assemblies which do not qualify for Unrestricted or Restricted storage must be stored in a checkerboard storage pattern with empty storage locations. Checkerboard storage will allow storage of all fuel in each region.

The goal of Checkerboard storage is to be able to store the most reactive fuel assembly in each region. This is accomplished by storing the most reactive assembly with empty storage locations to keep the overall reactivity of the array beneath the required reactivity limit. To determine the storage pattern for Checkerboard storage, the calculated k_{eff} is varied by varying the number of empty cells until the calculated k_{eff} is less than or equal to the maximum design k_{eff}. The calculated k_{eff}s are taken from KENO-Va. A different Checkerboard storage pattern is defined for each region of the McGuire spent fuel pools. Since restricted storage for Region 1A includes fuel up to the maximum allowed enrichment, Checkerboard storage is not necessary for this region. The Checkerboard storage patterns are shown in Figures 6 and 7.

While it is intended to use the Unrestricted and Restricted storage patterns for optimum usage of all the storage cells, Checkerboard storage allows storage of the most reactive fuel in all regions if it becomes necessary.

3.1.1 No Boron 95/95 k_{eff} -Burnup Credit

In order to store fuel with enrichments higher than the maximum enrichment limits for fresh fuel, the concept of reactivity equivalencing is employed. Reactivity equivalencing determines an equivalent reactivity by introducing a reactivity effect that was not previously considered. In this case, the negative reactivity from fuel burnup is used to offset the positive reactivity from higher enrichments until the reactivity is equivalent to that of the fresh fuel maximum enrichment case (i.e. the no boron 95/95 maximum design k_{eff}).

To use burnup credit, additional uncertainties related to depleted fuel must also be accounted for. The only burnup related uncertainty included in the no boron 95/95 maximum design k_{eff} calculation is the reactivity increase associated with the removal of Burnable Poison assemblies (BP-pull). All other burnup related uncertainties, namely the uncertainty on the calculated reactivity versus burnup, the uncertainty on the measured burnup and the bias related to the axial distribution of burnup will be accounted for with boron credit as discussed in Section 3.2.

A bias is applied in the burnup credit calculations to account for a reactivity increase due to the shadowing effect of a BP. For burnup credit calculations, the standard criticality assumption was made that no removable poisons are in the assembly. However, an assembly which has a BP removed after its first cycle of operation is more reactive than an assembly that never contained a BP. A BP-pull bias is applied to account for this affect. A study of a database of BP-pull data for McGuire determined a maximum BP-pull reactivity increase of 0.01 Δk at 14 GWD/MTU. The bias is assumed to be linear from 0 GWD/MTU to the maximum bias at 14 GWD/MTU and is constant beyond 14 GWD/MTU. This is conservative because the reactivity of the BP-pulled assembly tends to approach the reactivity of the never BP'd assembly by EOL. For burnup credit calculations, the bias only needs to be applied for assemblies with burnup. Hence, for Unrestricted storage burnup credit calculations, CASMO-3 is used and hence, the entire bias is applied, since every assembly has burnup. For the SIMULATE-3 model used for the Restricted storage calculations, only the Filler fuel has burnup. The Restricted fuel is modeled as fresh fuel with the maximum enrichments from Table 6. Therefore, an appropriate ratio of the BP-pull bias is applied for the Restricted storage array since only part of the array has burnup.

Summarizing, the BP-pull bias for each region is as follows.

Unrestricted Storage All Regions BP-pull bias $= \dfrac{0.01 \times BU}{14}$

Restricted Storage Region 1A BP-pull bias $= \dfrac{0.0025 \times BU}{14}$

Restricted Storage Region 1B BP-pull bias $= \dfrac{0.005 \times BU}{14}$

Restricted Storage Region 2A BP-pull bias $= \dfrac{0.005 \times BU}{14}$

Restricted Storage Region 2B BP-pull bias $= \dfrac{0.0075 \times BU}{14}$

Where: BU = Assembly burnup in GWD/MTU up to a maximum of 14

To model fuel burnup, CASMO-3 was used to deplete the fuel under hot full power reactor conditions. CASMO-3 restarts were then performed to model the depleted assemblies in the storage racks. This ensures the reactivity of the depleted assembly is explicitly determined in the storage rack conditions. CASMO-3 restarts are performed at 5 GWD/MTU intervals from 0 to 60 GWD/MTU and at 0.5 w/o enrichment intervals from 2.0 to 4.5 w/o and the maximum enrichment of 4.75 w/o. A TABLES-3 library was also created from the CASMO-3 storage rack restart data to allow modeling the burned fuel in SIMULATE-3.

The burnup credit calculations are performed similar to the calculations that determined the maximum fresh fuel enrichments except that instead of varying the enrichment, the burnup is varied. As with the maximum fresh fuel enrichment calculations, for Unrestricted storage, the calculated k_{eff}s come from CASMO-3, specifically, the storage rack restart cases with burned fuel. For Restricted storage, the calculated k_{eff}s come from SIMULATE-3. The calculated k_{eff}s are used to determine minimum burnup limits for each enrichment to ensure that the 95/95 storage rack k_{eff} is < 1.0. The burnup limit is the burnup where the calculated k_{eff} equals the no boron maximum design k_{eff} from Table 4 minus the appropriate BP-pull bias discussed above. The minimum burnup requirements for each enrichment are determined by linearly interpolating between the calculated burnups. This linear interpolation assumes that the calculated k_{eff} vs. burnup curve is linear. This is a very good assumption over small ranges of burnup.

The minimum burnup requirements for each enrichment are then plotted versus burnup and enrichment to yield a storage curve. A separate storage curve is generated for each type of storage and each region. A fuel assembly qualifies for storage if its burnup and enrichment fall above the storage curve.

The results of the burnup credit calculations are summarized in Tables 7 through 9. The storage curves are shown in Figures 8 and 9.

3.1.2 No Boron 95/95 k_{eff} -IFBA Credit

This section describes the methodology for reactivity equivalencing taking credit for integrated fuel burnable absorber (IFBA) rods. IFBA rods are fuel rods with a thin layer of ZrB_2 sprayed on the fuel pellet. This coating provides a reactivity holddown at beginning of cycle. For the criticality analysis, this coating provides an integral poison in the fuel that may be taken credit for in the analysis. Credit for normal burnable poison rods is not allowed since these poison components can be removed from the fuel assembly.

In order to store fresh fuel more efficiently, the concept of reactivity equivalencing is employed. Reactivity equivalencing determines an equivalent reactivity by introducing a reactivity effect that was not previously considered. In this case, IFBA rods are introduced into the calculation and the enrichment is varied until the calculated k_{eff} is equivalent to that of the fresh fuel maximum enrichment case (i.e. the no boron 95/95 maximum design k_{eff}).

Credit for IFBA is only utilized in Region 1A, where the fresh fuel is to be stored. The reactivity of Regions 1B, 2A and 2B are such that there is no real benefit for IFBA credit since these regions will not typically store fresh fuel. The use of IFBA credit for fresh fuel in Region 1A will permit most of the fresh fuel to be stored within the limited number of locations available in this region.

The calculated k_{eff}s come from the infinite lattice code CASMO-3. The calculated k_{eff}s are used to determine maximum enrichment for each discrete number of IFBA rods to ensure that the 95/95 storage rack k_{eff} is < 1.0. The maximum enrichment requirements for each number of IFBA rods are determined by iterating on enrichment until the calculated k_{eff} is less than the no boron 95/95 maximum design k_{eff}.

The maximum enrichment requirements for each number of IFBA rods are then plotted versus enrichment and number of IFBA rods to yield an Unrestricted storage curve. A fuel assembly qualifies for Unrestricted storage if its enrichment and number of IFBA rods fall above the Unrestricted storage curve. Assemblies which fall below the Unrestricted storage curve must be stored in a Restricted loading pattern.

The results of the IFBA credit calculations are summarized in Table 10.

3.2 Boron Credit 95/95 k_{eff}

This section describes the methodology used to determine the amount of soluble boron required to maintain the 95/95 $k_{eff} \leq 0.95$. The soluble boron required consists of two components; the boron required to reduce the no boron 95/95 k_{eff} from 1.0 to 0.95 and the boron required to account for uncertainties in the reactivity equivalencing methods. The sum of these two components of required boron represent the amount of soluble boron credit needed. This required boron concentration must be less than the amount of boron available for normal conditions. The amount of boron available for normal conditions is determined from an appropriate boron dilution analysis. Additional boron requirements are needed to compensate for reactivity increases as a result of postulated accidents. These are discussed in the Section 4.

Just as with the no boron 95/95 k_{eff} calculation, the calculation of the soluble boron credit 95/95 k_{eff} must consider various biases and uncertainties related to the materials and construction of the racks. The same biases and uncertainties for the no boron 95 percent probability at a 95 percent confidence level k_{eff} are determined for the soluble boron credit 95/95 k_{eff} calculation. The only difference in the calculation of the uncertainties is that the calculations are now performed with the boron concentration required to maintain k_{eff} less than 0.95. Only the mechanical tolerance uncertainty was explicitly calculated with boron. Given the extremely small change in the uncertainty between no boron and boron conditions, and the significant amount of margin available in the amount of boron available, the Boraflex related uncertainties were not recalculated at boron conditions. Table 5 lists the boron credit biases and uncertainties for each region.

The soluble boron credit 95/95 maximum design k_{eff} is then 0.95 less these biases and uncertainties. For the final k_{eff} to remain less than 0.95, the calculated k_{eff} must remain less than the boron credit maximum design k_{eff}. Since the combined biases and uncertainties are dependent on the fuel storage rack, four boron credit 95/95 maximum design k_{eff}s are defined, one for each region of the pool. These maximum design k_{eff}s are listed in Table 5.

To determine the boron concentration required for $k_{eff} \leq 0.95$, SIMULATE-3 is used to iterate on the boron concentration using the appropriate fresh fuel enrichment for each region until the calculated k_{eff} from SIMULATE-3 is less than the soluble boron credit 95/95 maximum design k_{eff}. Two sets of cases are run for each region for Unrestricted and Restricted storage. The appropriate fresh fuel enrichments for each case are the maximum fresh fuel enrichments for Unrestricted and Restricted storage in each region shown in Table 6. This establishes the first part of the total soluble boron credit required without accidents.

In addition to the boron credit required to maintain $k_{eff} \leq 0.95$, boron credit is also used to compensate for uncertainties associated with the reactivity equivalencing methods. Two reactivity equivalencing methods are used in this analysis; burnup credit and IFBA credit.

For burnup credit, the uncertainties associated with this reactivity equivalencing method are as follows:

Burnup Credit Uncertainties
Calculated reactivity and depletion versus burnup
Measured burnup
Axial burnup distribution

The BP-pull reactivity increase is not included in the boron credit determination since it is already accounted for in the burnup limits.

Previous analysis for McGuire fuel determined an exposure reactivity bias of 0.0048 Δk at 50 GWD/MTU to be applied linearly versus burnup. However, a more conservative value will be used which is consistent with other boron credit analyses. A value of 0.01 Δk at 30 GWD/MTU applied linearly versus burnup will be used for the calculated reactivity uncertainty.

To determine the amount of boron credit required for the uncertainty in the calculation of burnup, the burnup credit reactivity bias is determined for the highest burnup requirement from the fuel storage curves for each region. SIMULATE-3 is then run to iterate on the boron concentration until the k_{eff} is equal to the k_{eff} with no boron, less the burnup credit reactivity bias.

The uncertainty on measured burnup is 4%. This is the measurement uncertainty applied to the 2-D power distribution (F_{DH}). This is conservative because the burnup is simply the power distribution integrated over time. Thus, to assume a burnup uncertainty of 4% is to assume the measured power distribution was low by 4% for its entire depletion history, when in reality it is low at times and high at other times.

To determine the amount of boron credit required for the measurement uncertainty on burnup, the highest burnup requirement from the fuel storage curves for each region is determined. The highest burnup requirement is then reduced by 4%. SIMULATE-3 is then run to iterate on the boron concentration until the k_{eff} with 4% reduced burnup is equal to the k_{eff} with the highest burnup (i.e. not reduced) and no boron.

Since the criticality calculations used to define the spent fuel storage limits are performed in 2-dimensions, a flat axial burnup distribution is inherent in the 2-D modeling. An analysis performed to study the effect of a 3-D burnup distribution determined that ignoring the effect of the axial variation in burnup on the criticality calculation becomes non-conservative as burnup increases. This analysis determined biases for each sub-region as a function of enrichment and burnup to be applied to account for the potential non-conservatism from not modeling the axial burnup distribution. The axial burnup distribution bias is then interpolated to the appropriate burnups of the assemblies in the specific problem.

To determine the amount of boron credit required to properly account for the axial burnup distribution, the axial burnup distribution bias is determined for the highest burnup requirements from the fuel storage curves for each region. SIMULATE is then run to iterate on the boron concentration until the k_{eff} is equal to the k_{eff} with no boron, less the axial burnup distribution bias.

For IFBA credit, the uncertainties associated with this reactivity equivalencing method are as follows:

IFBA Credit Uncertainties
Manufacturing uncertainty
Calculational uncertainty

The manufacturing uncertainty applied is a 5% decrease in the B_{10} loading on the IFBA rods. To determine the amount of boron credit needed for the manufacturing uncertainty on IFBA rods, the highest number of IFBA rods required for storage is determined. CASMO-3 is then run to calculate the k_{eff} with B_{10} loading reduced by 5%. The boron concentration is iterated on until the k_{eff} with the reduced B_{10} loading is equal to the k_{eff} with the normal loading and no boron.

The calculational uncertainty applied is a 10% decrease in the number of IFBA rods. To determine the amount of boron credit needed for the calculational uncertainty on IFBA rods, the highest number of IFBA rods required for storage is determined.

In this case, the IFBA requirements for 4.75 w/o fuel are interpolated from the previous IFBA results to determine a specific number of IFBA rods required, instead of one of the discrete number of IFBA rod configurations available. This specific number of IFBA rods is reduced by 10% and then rounded down to the nearest number of IFBA rods available. CASMO-3 is then run to calculate the k_{eff} with this number of IFBA rods. The boron concentration is iterated on until the k_{eff} with the reduced number of IFBA rods is equal to the no boron 95/95 maximum design k_{eff}.

Note that the IFBA credit uncertainties are only calculated for restricted storage in Region 1A since IFBA credit is not used for any other storage limits.

The boron credit requirements are summarized in Table 11.

3.3 New Fuel Storage Vault Analysis

The new fuel vaults at the McGuire Nuclear Station are designed exclusively for temporary storage of fresh unirradiated fuel. The ANSI/ANS-57.3 Design Standard simply requires that k_{eff} be maintained at less than or equal to 0.95 under fully flooded conditions and less than or equal to 0.98 assuming optimum moderation. Analysis used to determine k_{eff} in these storage racks must therefore assume maximum allowable fuel enrichments. Criticality control relies strictly on the wide spacing between individual storage locations and a specified upper limit for as-built fuel enrichment. The absence of other factors such as soluble boron, fixed poisons, burnup effects and fission products makes for a relatively straightforward analysis. The normally dry condition of the fuel vaults introduces the possibility of water intrusion. Consequently, full density water flooding was conservatively modeled as a base condition in this analysis. Other less likely events which could create low density moderator conditions (i.e. foaming, misting, etc.) dictated analysis of optimum moderator conditions as an accident condition. Vault criticality analysis is therefore performed as a function of both enrichment and moderator density.

KENO-Va was used to calculate the k_{eff} for 4.75 %U-235 nominal enrichment for vault storage. The analysis assumed a 100% cell loading pattern and consequently, no loading pattern restrictions are needed or applicable in the new fuel storage vault.

The following assumptions are used in the new fuel storage vault criticality analysis.

1. All fuel designs used, or planned for use, at McGuire were

analyzed. This included Westinghouse Standard (STD), Optimized (OFA) and Performance Plus (PF+) and Framatome Mark BW (MkBW) fuel designs.

2. All calculations are 3-D. The upper and lower fuel assembly nozzles are ignored.

3. All fuel is fresh unirradiated.

4. No credit is taken for the spacer grid material.

The calculated worst-case k_{eff}s for fully flooded and optimum moderation conditions for a fuel assembly with the maximum nominal enrichment of 4.75 %U-235 are:

Fully Flooded Maximum k_{eff} = 0.9433
Optimum Moderation Maximum k_{eff} = 0.9759

These values were for the Westinghouse Performance Plus fuel design which was the most reactive of all fuel types analyzed. This value also includes geometrical and material uncertainties and biases at a 95 percent probability and a 95 percent confidence level as required to demonstrate criticality safety. The uncertainties considered include:

Embedded concrete tolerances
Fuel Cage tolerances

As specified in ANSI/ANS 57.3, the maximum k_{eff} value in a LWR new fuel storage vault shall be less than or equal to 0.98 under optimum moderator conditions and less than or equal to 0.95 under fully flooded conditions. The analytical results shown above indicate that these criteria have been met.

3.4 Conditions Outside the Storage Rack

This section briefly describes the evaluation of the reactivity conditions of fuel located anywhere outside of the storage rack.

Fuel is first received in shipping containers approved for use under 10CFR Part 71 and need not be considered any further.

After the fuel is received it may be loaded into the new fuel storage vault which is discussed in Section 3.3.

The fuel is transferred from the new fuel vault into a new fuel elevator where it is lowered into the spent fuel pool such that the fuel handling crane can access it to place it in a storage cell. The most limiting condition from a criticality standpoint during this process is the fuel assembly in water with no poison. As discussed in Section 3.1, k_{eff} must be less than 1.0 with no boron. This condition has been analyzed and it was determined that it would require a fresh fuel enrichment much greater than 5.0 w/o to approach a k_{eff} of 1.0 for a single assembly surrounded by water. As discussed in Section 3.2, k_{eff} must be less than or equal to 0.95 with credit for soluble boron. KENO is run to iterate on the boron concentration to determine the required boron to maintain $k_{eff} \leq 0.95$. To simplify this calculation, the calculation is performed at 4.80 w/o, instead of 4.75 w/o and all other fuel parameter uncertainties are neglected except the method bias and uncertainty determined in Table 2. The boron credit requirements for a single assembly in water are compared to the boron requirements determined as described in Section 3.2 and the more restrictive of the two will is used. This is because the boron requirements for the single assembly in water are independent of the boron requirements in Section 3.2. As can be seen from the results in Table 11, the single assembly in water case is well bounded by the boron credit required from Section 3.2.

The fuel is stored in the spent fuel storage cell until it is ready to be loaded into the reactor. At that point, the fuel handling crane moves the assembly into the upender, where it is then lowered to a horizontal position for transfer into the reactor building via the fuel transfer tubes. While the upender and fuel handling crane contain some amount of steel, and hence poison material, these conditions are bounded by the single assembly in water case.

Another possible location of fuel is in any reconstitution or inspection equipment. Criticality considerations for these scenarios are addressed by a 50.59 evaluation covering the use of the equipment for the intended purpose. Also included in this would be storage of failed fuel in special canisters or racks.

The only other possible places to have a fuel assembly would be as a result of an accident, i.e. dropping an assembly where it is not supposed to be. These conditions are covered by either the single assembly in water condition described in this section, or in Section 4.0.

Therefore, all possible locations of a fuel assembly inside the McGuire Nuclear Station are acceptable for up to and including 4.75 w/o for all analyzed fuel designs.

4.0 ACCIDENT CONDITIONS

As part of the criticality analysis for the McGuire spent fuel pools, abnormal and accident conditions are considered to verify that acceptable criticality margin is maintained for all conditions. Most accident conditions will not result in an increase in k_{eff} of the rack. However, accidents can be postulated which would increase the reactivity of the spent fuel pool. These accidents must be analyzed to verify acceptable criticality safety margin exists. Since boron is used to compensate for reactivity increases as a result of postulated accidents, acceptable criticality safety margin exists if the total boron requirements are less than the normal concentration in the storage pool water.

The most severe accident in terms of criticality would be the misloading of an assembly; in particular, misloading the highest reactive assembly allowed in the pool in place of the lowest reactive assembly. This accident would be the substitution of a fresh 4.75 w/o assembly for a required filler assembly.

Since the SIMULATE-3 models for the McGuire storage racks consist of a 2x2 array reflected with periodic boundary conditions, the substitution of a fresh 4.75 w/o assembly for a required filler assembly will be extremely conservative since this accident condition will be infinitely reflected. A more realistic representation of this accident would be to model a larger array, and misloading a single assembly near the center of this array. However, since substantial criticality margin exists, the overly conservative 2x2 array will be sufficient.

Other accidents which could have an impact on reactivity in the spent fuel pool are those that affect the water temperature of the spent fuel pool. Accidents could be postulated which would either increase or decrease the temperature of the spent fuel pool. Therefore, to bound the range of temperatures of the spent fuel pool water, the accident analysis considers water temperatures of 32 and 212 ^{o}F.

The above accident conditions are analyzed and the boron concentration is iterated upon until the calculated k_{eff} is less than the no boron 95/95 maximum design k_{eff}. This boron concentration, combined with the boron concentration for boron credit 95/95 k_{eff} from Section 3.2 represents the total credit for boron that is required for accident conditions. This total boron requirement must be less than the normal spent fuel pool boron concentration.

Note that by combining the boron required for accidents with the boron required to maintain $k_{eff} \leq 0.95$ (i.e. the boron credit 95/95 maximum design k_{eff}), the accident conditions are imposed on top of the dilution accident for the total boron requirements. However, accident conditions are not assumed with no boron conditions. This is consistent with previous criticality analysis methodology where the double contingency principle is applied for accidents. The double contingency principle allows credit for soluble boron under other abnormal or accident conditions, since only a single accident need be considered at one time and to not assume the presence of some boron would be a second unlikely event. The difference with the boron credit methodology is that, for added assurance that sufficient criticality safety margin exists, the dilution of the pool with perfect mixing to 937 ppm is assumed to be a credible event.

The additional boron credit requirements for accident conditions are summarized in Table 11.

5.0 BORON CREDIT SUMMARY

This analysis takes partial credit for soluble boron in the spent fuel pool for both normal and accident conditions. Boron credit is used to compensate for uncertainties related to reactivity equivalencing and accident conditions. The total boron credit requirements for each region are shown in Table 11. The total boron credit requirements for the entire McGuire spent fuel pool are then the highest values from all regions as follows:

	Boron Credit Required	Boron Available
Normal Conditions	730	937[1]
Accident Conditions	1470	2675[2]

[1] - From dilution analysis
[2] - current limit specified in the Core Operating Limits Report

6.0 REGION INTERFACE RESTRICTIONS

Fuel will be stored in four regions of the spent fuel pool according to three different loading configurations. The boundary conditions between these configurations are analyzed to assure that the storage configurations at the boundary do not cause an increase in the nominal k_{eff} above the design criteria limit on k_{eff} for the individual regions. This analysis is performed to determine if there is a need for new administrative restrictions at the boundaries. The results of this analysis yield the following region interface restrictions.

Region Interface Restrictions

Region 1A	Unrestricted Storage	No restrictions
Region 1A	Restricted Storage	The boundary between Region 1A Restricted Storage and any other region shall be a row of restricted and filler assemblies. That is, the row of all restricted assemblies may be adjacent to a wall, but may not be adjacent to another storage configuration.
Region 1B	Unrestricted Storage	No restrictions
Region 1B	Restricted Storage	No restrictions
Region 1B	Checkerboard Storage	No restrictions
Region 2A	Unrestricted Storage	No restrictions
Region 2A	Restricted Storage	No restrictions
Region 2A	Checkerboard Storage	No restrictions
Region 2B	Unrestricted Storage	No restrictions
Region 2B	Restricted Storage	The boundary between Region 2B Restricted Storage and any other region shall be a row of only filler assemblies. That is, Region 2B Restricted Storage fuel may be adjacent to a wall, but may not be adjacent to another storage configuration.
Region 2B	Checkerboard Storage	The boundary between Region 2B Checkerboard Storage and any other region shall be a row of only filler assemblies. That is, Region 2B Checkerboard Storage fuel may be adjacent to a wall, but may not be adjacent to any other storage configuration.

7.0 SUMMARY OF RESULTS

The results of the criticality analysis for the McGuire spent fuel storage racks indicate that the acceptance criteria for criticality is met; that is $k_{eff} \leq 0.95$ including uncertainties. The two region rack design is subdivided within each region for cells with credit for Boraflex and cells without credit for Boraflex. This analysis takes credit for soluble boron, partial credit for Boraflex in Regions 1A and 2A, no credit for Boraflex in Regions 1B and 2B, credit for burnup and credit for IFBA rods. Each of the four regions has two storage configurations, Unrestricted and Restricted storage. Three regions (Regions 1B, 2A and 2B) have an additional Checkerboard configuration that allows the most reactive fuel to be stored.

The spent fuel storage limits are summarized in Tables 6 through 10 and Figures 3 through 9.

The total boron credit requirements for these configurations in all regions are 730 ppm for normal conditions and 1470 ppm for accident conditions.

Also, the acceptability of storing the new Westinghouse Performance Plus fuel design in the new fuel storage vaults is verified.

8.0 REFERENCES

8.1 "Westinghouse Spent Fuel Rack Criticality Analysis Methodology," WCAP-14416-NP-A, Westinghouse Commercial Nuclear Fuel Division, Revision 1, November, 1996.

8.2 "Issuance of Amendments - McGuire Nuclear Station, Units 1 and 2," Amendment Nos. 159 and 141 to Facility Operating Licenses NPF-9 and NPF-17, U.S. Nuclear Regulatory Commission, November 6, 1995.

8.3 Baldwin, Hoovler, Eng, and Welfare, "Critical Experiments Supporting Close Proximity Water Storage of Power Reactor Fuel", B&W-1484-7, 7/79.

8.4 Beirman, S.R., Clayton, E.D., "Criticality Experiments with Subcritical Clusters of 2.35 and 4.31 wt% 235U Enriched UO2 Rods in Water at a Water to Fuel Volume Ratio of 1.6" PNL-3314, July 1980.

8.5 Beirman, S.R. , et al, "Critical Separation Between Subcritical Clusters of 2.35 wt% 235U Enriched UO2 Rods in Water with Fixed Neutron Poisons" PNL-2438, October 1977.

8.6 Beirman, S.R., "Criticality Experiments to Provide Benchmark Data on Neutron Flux Traps" PNL-6205, June 1988.

Table 1

CASMO-3/TABLES-3/SIMULATE-3

Benchmarking Results

Core	Soluble Boron	Moderator Temp	Separation Spacing (cm)	Poison Sheet (%B)	k_{eff} calc	k_{eff} meas	Bias
2	1037	18.5	0	n/a	1.00271	1.0001	-0.00261
3	764	18	1.636	n/a	1.00319	1.0000	-0.00319
9	0	17.5	6.544	n/a	.99908	1.0030	0.00392
10	143	24.5	4.908	n/a	.99795	1.0001	0.00215
11	514	26	1.636	SS	1.00493	1.0000	-0.00493
13	15	20	1.636	1.614	1.00914	1.0000	-0.00914
14	92	18	1.636	1.257	1.00451	1.0001	-0.00441
15	395	18	1.636	0.401	.99608	0.9988	0.00272
17	487	17.5	1.636	0.242	.99889	1.0000	0.00111
19	634	17.5	1.636	0.1	1.00003	1.0002	0.00017
				avg k_{eff}calc	1.00165	st.dev calc	0.00412
				avg k_{eff} meas	1.00023	avg bias	-0.00142

CASMO-3/TABLES-3/SIMULATE-3 Methodology Bias = -0.00142

CASMO-3/TABLES-3/SIMULATE-3 Methodology Uncertainty = 0.01199

Table 2

KENO-Va

Benchmarking Results

Report	Exp. Number	Calculated k_{eff}	std dev	Report	Exp. Number	Calculated k_{eff}	std dev
PNL-3314	043	0.99991	0.00295	PNL-3314	085	0.98979	0.00354
PNL-3314	045	0.9984	0.00335	PNL-3314	094	0.99568	0.00383
PNL-3314	046	0.9999	0.0033	PNL-3314	095	0.99914	0.004
PNL-3314	047	1.00532	0.00346	PNL-3314	096	0.99908	0.00349
PNL-3314	048	1.00083	0.00326	PNL-3314	097	0.99731	0.00342
PNL-3314	04c	0.99727	0.00317	PNL-3314	098	0.99494	0.00353
PNL-3314	051	1.00114	0.00392	PNL-3314	100	0.99621	0.00378
PNL-3314	053	0.99105	0.0035	PNL-3314	101	0.99799	0.00391
PNL-3314	055	0.99502	0.00409	PNL-3314	105	0.99911	0.00339
PNL-3314	056	0.99249	0.0038	PNL-3314	106	0.99323	0.00353
PNL-3314	057	0.99603	0.00317	PNL-3314	107	0.99812	0.00302
PNL-3314	058	0.99613	0.00321	PNL-3314	131	0.99708	0.00379
PNL-3314	059	0.99233	0.00377	PNL-3314	996	1.0115	0.00304
PNL-3314	060	0.99657	0.00362	PNL-3314	997	1.00775	0.00305
PNL-3314	061	0.99331	0.00371	PNL-2438	005	0.9923	0.00348
PNL-3314	062	0.9954	0.00418	PNL-2438	014	0.99212	0.00321
PNL-3314	064	0.98736	0.00351	PNL-2438	015	0.99207	0.00301
PNL-3314	065	0.99728	0.00392	PNL-2438	021	0.99119	0.00302
PNL-3314	066	0.9942	0.00374	PNL-2438	026	0.99218	0.00314
PNL-3314	067	0.99153	0.00374	PNL-2438	027	0.99396	0.00312
PNL-3314	068	0.99169	0.00333	PNL-2438	028	0.99092	0.00322
PNL-3314	069	0.99684	0.00396	PNL-2438	029	0.99366	0.00319
PNL-3314	06d	1.00645	0.004	PNL-2438	034	0.99596	0.00323
PNL-3314	070	0.98921	0.00369	PNL-2438	035	0.98911	0.00317
PNL-3314	071	0.99405	0.00342	PNL-6205	214	0.99117	0.00353
PNL-3314	072	0.98865	0.00356	PNL-6205	223	0.99726	0.0038
PNL-3314	073	0.98801	0.00343	PNL-6205	224	0.99329	0.00388
PNL-3314	083	0.99043	0.00341	PNL-6205	229	1.00119	0.00355
PNL-3314	084	0.99366	0.00364	PNL-6205	230	1.00031	0.00406

Average k_{eff} = 0.99559

KENO-Va Methodology Bias = 0.00441

KENO-Va Methodology Uncertainty = 0.00739

Table 3
CASNO-3 / SIMULATE-3 / KENO Va Comparisons

Rack Region	Fuel Enrichment	Fuel Type	CASMO k_{eff}	Simulate k_{eff}	KENO k_{eff}
MNS Region 1A (25% of original Boraflex)	4.0	mbw	.97661	.976666	.96827
MNS Region 1B (No Boraflex)	4.0	mbw	1.18568	1.185535	1.17930
MNS Region 2A (50% of original Boraflex)	1.4	mbw	.93033	.930428	.92877
MNS Region 2B (No Boraflex)	1.4	mbw	1.06701	1.06701	1.06233

Table 4
CASMO / SIMULATE
No Boron Biases and Uncertainties for Fresh Fuel

Bias or Uncertainty	Region 1A	Region 1B	Region 2A	Region 2B
Methodology Bias*	-0.00142	-0.00142	-0.00142	-0.00142
Boraflex Width Shrinkage Bias	0.005405	0	0.00202	0
Self-Shielding Bias	0.002141	0	0.000712	0
3 Dimensional Bias*	-0.00158	-0.00252	-0.00202	-0.00295
95/95 Methodology Uncertainty	0.01199	0.01199	0.01199	0.01199
Boraflex Axial Shrinkage Uncertainty	0.002595	0	0.00010	0
Mechanical Uncertainty	0.015923	0.018729	0.007877	0.010993
Combined Bias and Uncertainty	0.027647	0.022238	0.017178	0.016267

No Boron 95/95 Maximum Design k_{eff}	0.972353	0.977762	0.982822	0.983733

Combined Bias and Uncertainty:

$$\Delta k = \Delta k_{MethBias} + \Delta k_{Width} + \Delta k_{SelfShielding} + \Delta k_{3\ Dimensional} + \sqrt{\Delta k^2_{MethUnc} + \Delta k^2_{Axial} + \Delta k^2_{MechUnc}}$$

* Negative bias conservatively ignored

For KENO-Va calculations, the above methodology bias and uncertainty are replaced with the KENO-Va methodology bias and uncertainty (Table 2) and the KENO-Va calculated uncertainty is included under the radical.

Table 5
CASMO / SIMULATE
Boron Credit Biases and Uncertainties for Fresh Fuel

Bias or Uncertainty	Region 1A	Region 1B	Region 2A	Region 2B
Methodology Bias*	-0.00142	-0.00142	-0.00142	-0.00142
Boraflex Width Shrinkage Bias	0.005405	0	0.00202	0
Self-Shielding Bias	0.002141	0	0.000712	0
3 Dimensional Bias*	-0.00158	-0.00252	-0.00202	-0.00295
95/95 Methodology Uncertainty	0.01199	0.01199	0.01199	0.01199
Boraflex Axial Shrinkage Uncertainty	0.002595	0	0.00010	0
Mechanical Uncertainty	0.015912	0.019684	0.008545	0.010922
Combined Bias and Uncertainty	0.027638	0.023049	0.017556	0.016266

No Boron 95/95 Maximum Design k_{eff}	0.922362	0.926951	0.932444	0.933734

Combined Bias and Uncertainty:

$$\Delta k = \Delta k_{MethBias} + \Delta k_{Width} + \Delta k_{SelfShielding} + \Delta k_{3\ Dimensional} + \sqrt{\Delta k^2_{MethUnc} + \Delta k^2_{Axial} + \Delta k^2_{MechUnc}}$$

* Negative bias conservatively ignored

Table 6
Summary of Maximum Fresh Fuel Enrichment Limits (w/o U-235)

Type of Storage	Region 1A	Region 1B	Region 2A	Region 2B
Unrestricted	3.78	1.78	1.61	1.11
Restricted	4.75	2.20	2.12	1.22
Filler	1.76	1.44	1.20	1.08
Checkerboard	N/A	4.75	4.75	4.75

Table 7
Minimum Qualifying Burnup versus Initial Enrichment
For Unrestricted Storage

Region 1A		Region 1B		Region 2A		Region 2B	
Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)	Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)	Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)	Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)
3.78	0.00	1.78	0.00	1.61	0.00	1.11	0.00
4.00	1.58	2.00	3.96	2.00	7.79	2.00	21.58
4.50	4.92	2.50	11.35	2.50	15.14	2.50	29.00
4.75	6.66	3.00	17.61	3.00	21.45	3.00	35.69
		3.50	23.35	3.50	27.42	3.50	41.97
		4.00	28.86	4.00	33.00	4.00	47.90
		4.50	34.10	4.50	38.32	4.50	53.57
		4.75	36.67	4.75	40.91	4.75	56.33

Table 8
Minimum Qualifying Burnup versus Initial Enrichment
For Restricted Storage

Region 1A		Region 1B		Region 2A		Region 2B	
Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)	Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)	Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)	Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)
4.75	0.00	2.20	0.00	2.12	0.00	1.22	0.00
		2.50	3.91	2.50	5.10	2.00	17.55
		3.00	9.65	3.00	10.88	2.50	24.73
		3.50	15.04	3.50	16.19	3.00	31.31
		4.00	19.87	4.00	21.07	3.50	37.40
		4.50	24.68	4.50	25.81	4.00	43.15
		4.75	27.01	4.75	28.11	4.50	48.65
						4.75	51.33

Table 9
Minimum Qualifying Burnup versus Initial Enrichment
For Filler Assemblies

Region 1A		Region 1B		Region 2A		Region 2B	
Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)	Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)	Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)	Initial Enrichment (w/o U-235))	Minimum Burnup (GWD/MTU)
1.76	0.00	1.44	0.00	1.20	0.00	1.08	0.00
2.00	5.12	2.00	12.68	2.00	19.80	2.00	23.14
2.50	13.57	2.50	20.17	2.50	27.64	2.50	30.59
3.00	19.80	3.00	27.03	3.00	34.56	3.00	37.42
3.50	25.85	3.50	33.35	3.50	41.08	3.50	43.74
4.00	31.50	4.00	39.33	4.00	47.25	4.00	49.72
4.50	36.93	4.50	45.07	4.50	53.15	4.50	55.49
4.75	39.54	4.75	47.89	4.75	56.01	4.75	58.33

Table 10
Summary of IFBA Credit Requirements

Number of IFBA Rods	Maximum Fresh Fuel Enrichment For Unrestricted Storage
0	3.78
16	4.22
32	4.56
48	4.89

Table 11
Summary of Boron Credit Requirements

	Unrestricted				Restricted w/ Filler			
	1A	1B	2A	2B	1A	1B	2A	2B
k-eff ≤ 0.95								
Boron required for k-eff ≤ 0.95	310	160	230	160	330	160	240	160
Reactivity Equivalencing								
Boron required for bu unc	20	50	120	120	30	50	120	120
Boron required for measured burnup	20	40	90	100	10	40	90	100
Boron required for axial burnup	0	70	230	350	70	90	240	350
Boron required for IFBA manuf unc	20	0	0	0	0	0	0	0
Boron required for IFBA calc unc	70	0	0	0	0	0	0	0
Accident conditions								
Boron required for misload	300	360	710	740	300	360	710	740
Boron required for abnormal heat load	0	20	0	0	0	20	0	0
Boron required for emergency makeup	10	0	20	0	10	0	20	0
Boron required for single assy in water	170	170	170	170	170	170	170	170
Total Boron Credit Required w/o Accidents	440	320	670	**730**	440	340	690	**730**
Total Boron Credit Required with Accidents	740	680	1380	**1470**	740	700	1400	**1470**

Figure 1
McGuire Fuel Pool Layout with Region 1 Detail

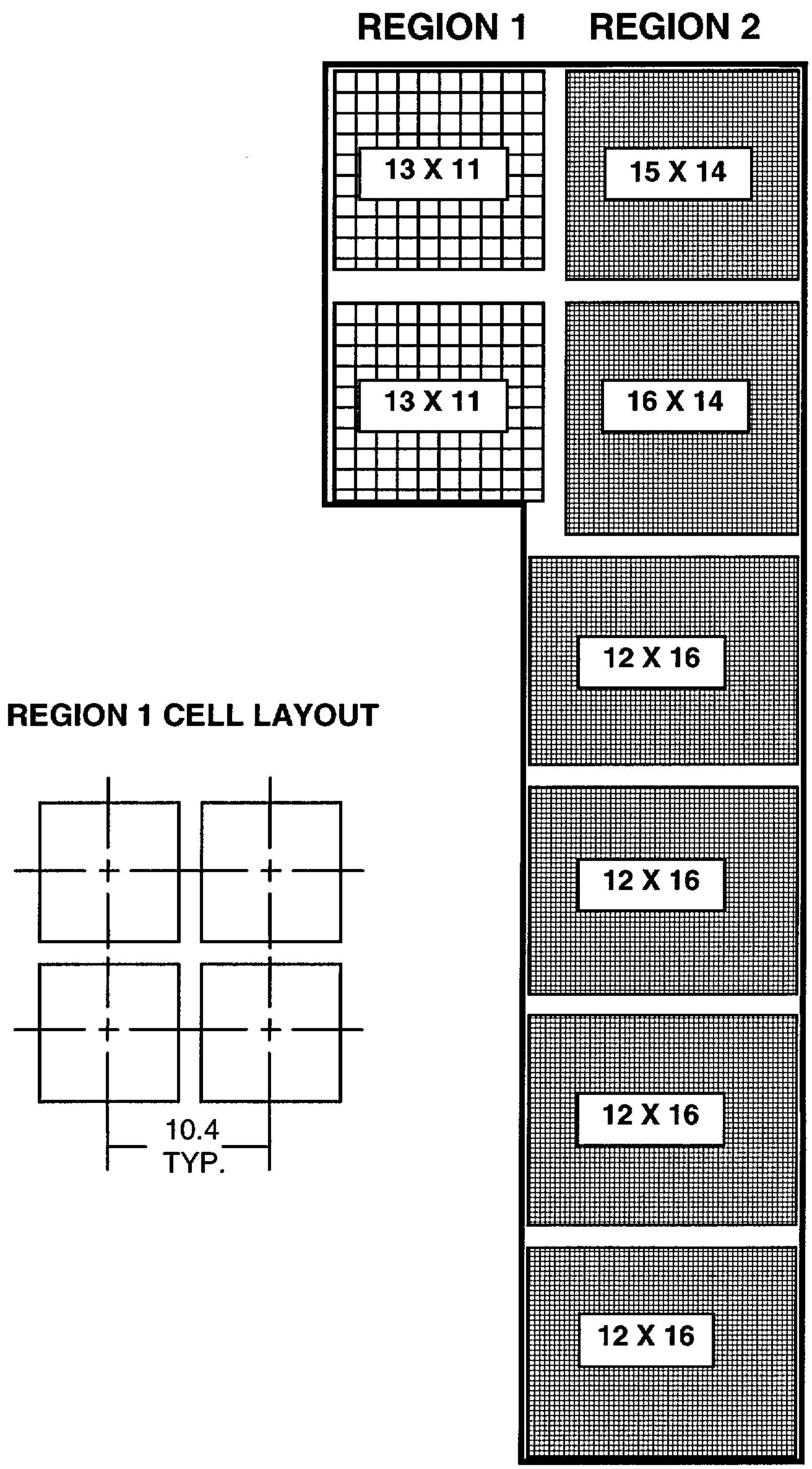


Figure 2
McGuire Fuel Pool Layout with Region 2 Detail

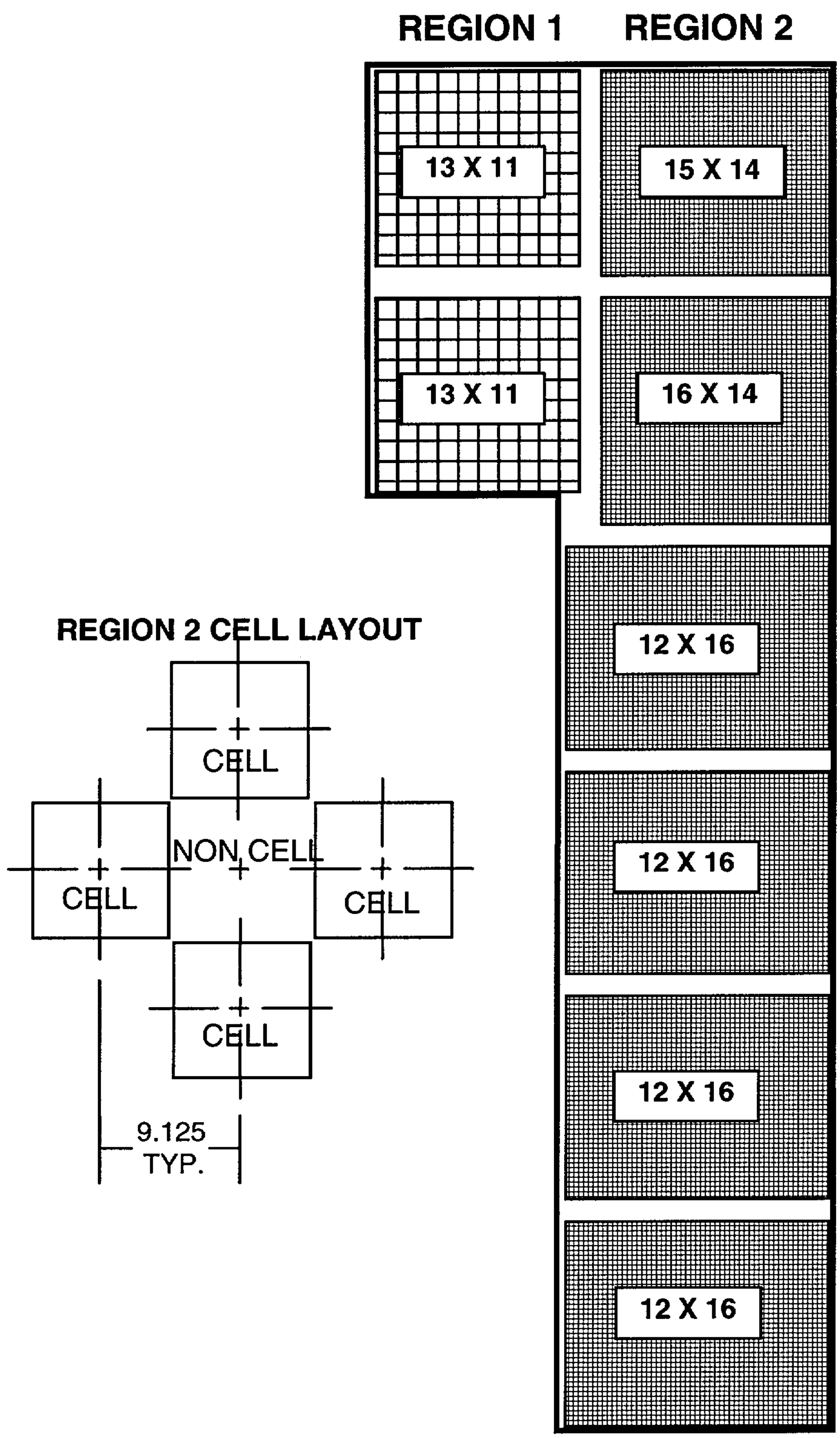


Figure 3
3 out of 4 Restricted Storage Pattern for Region 1A

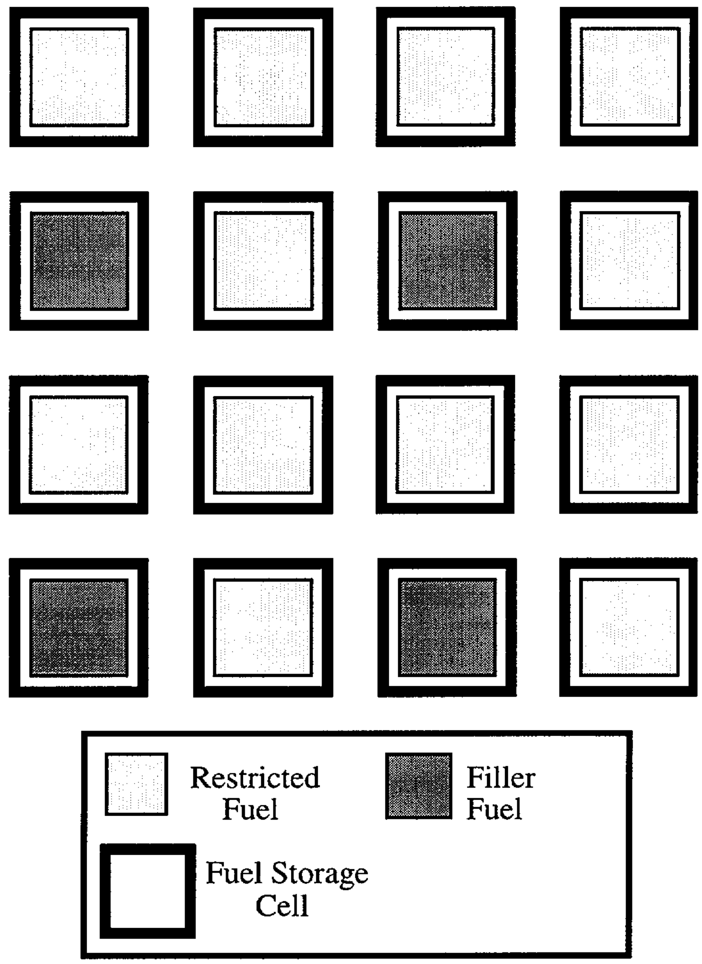


Figure 4
2 out of 4 Restricted Storage Pattern for Regions 1B and 2A

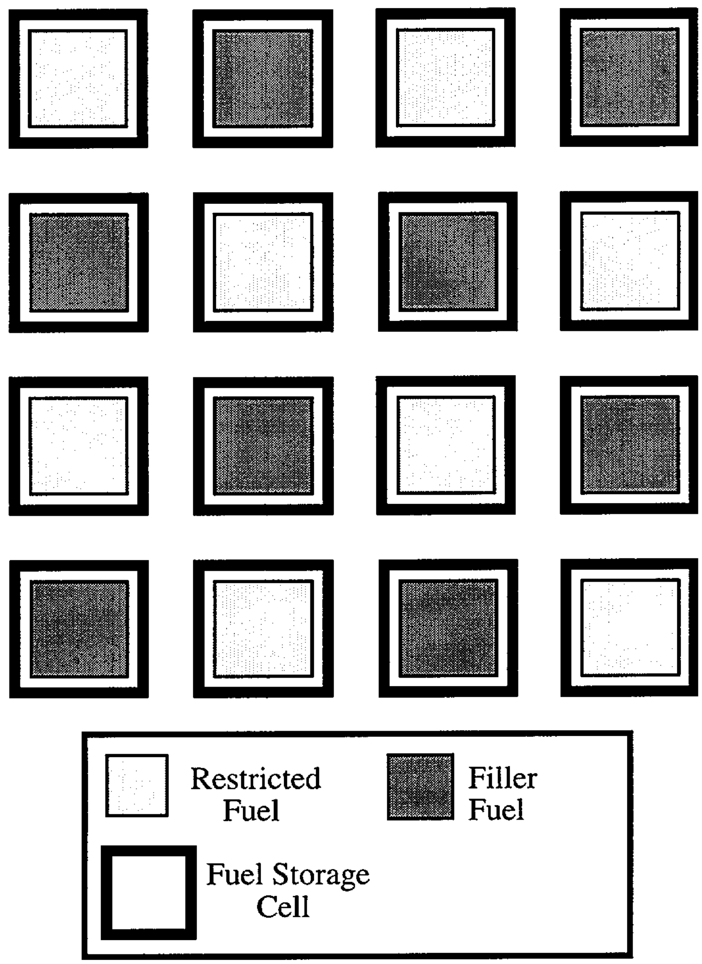


Figure 5
1 out of 4 Restricted Storage Pattern for Region 2B

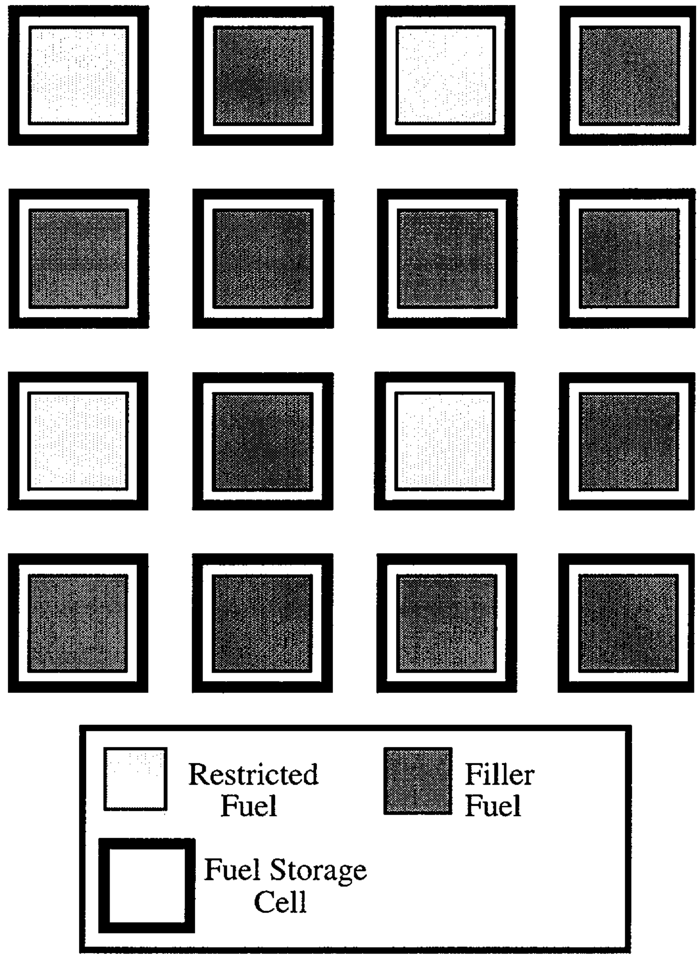


Figure 6
2 out of 4 Checkerboard Storage Pattern for Regions 1B and 2A

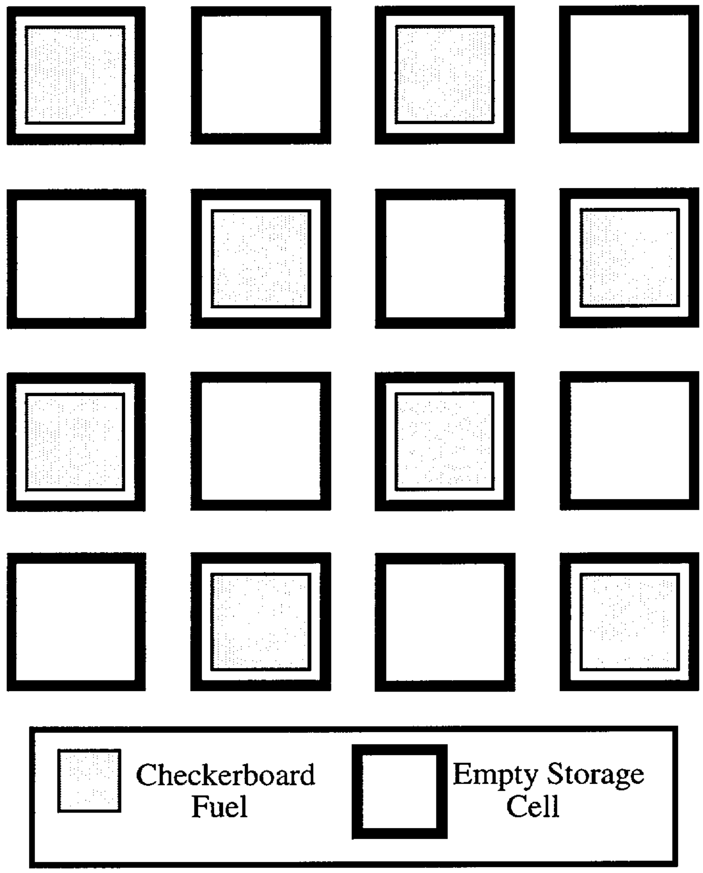


Figure 7
1 out of 4 Checkerboard Storage Pattern for Region 2B

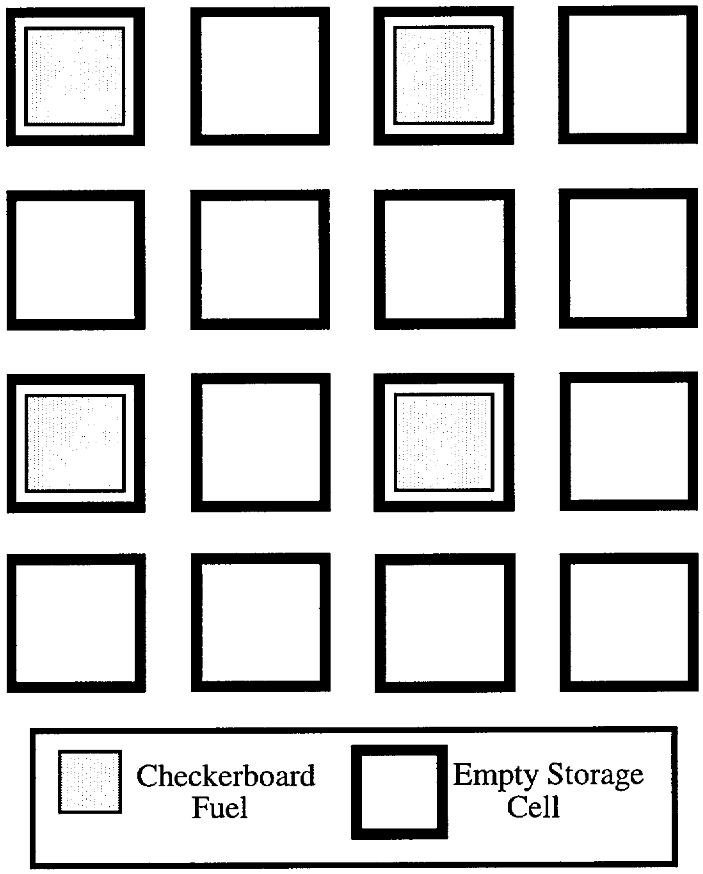


Figure 8
McGuire Region 1A and 1B
Burnup versus Enrichment Limits

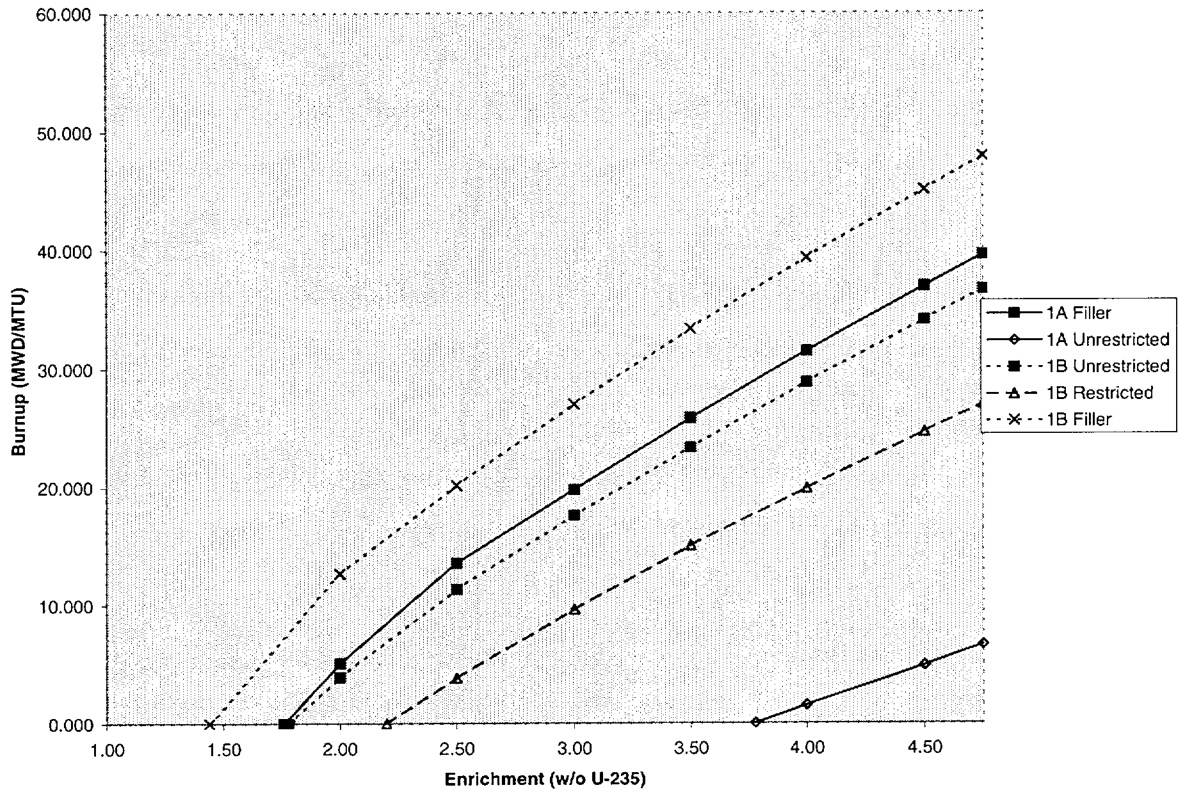
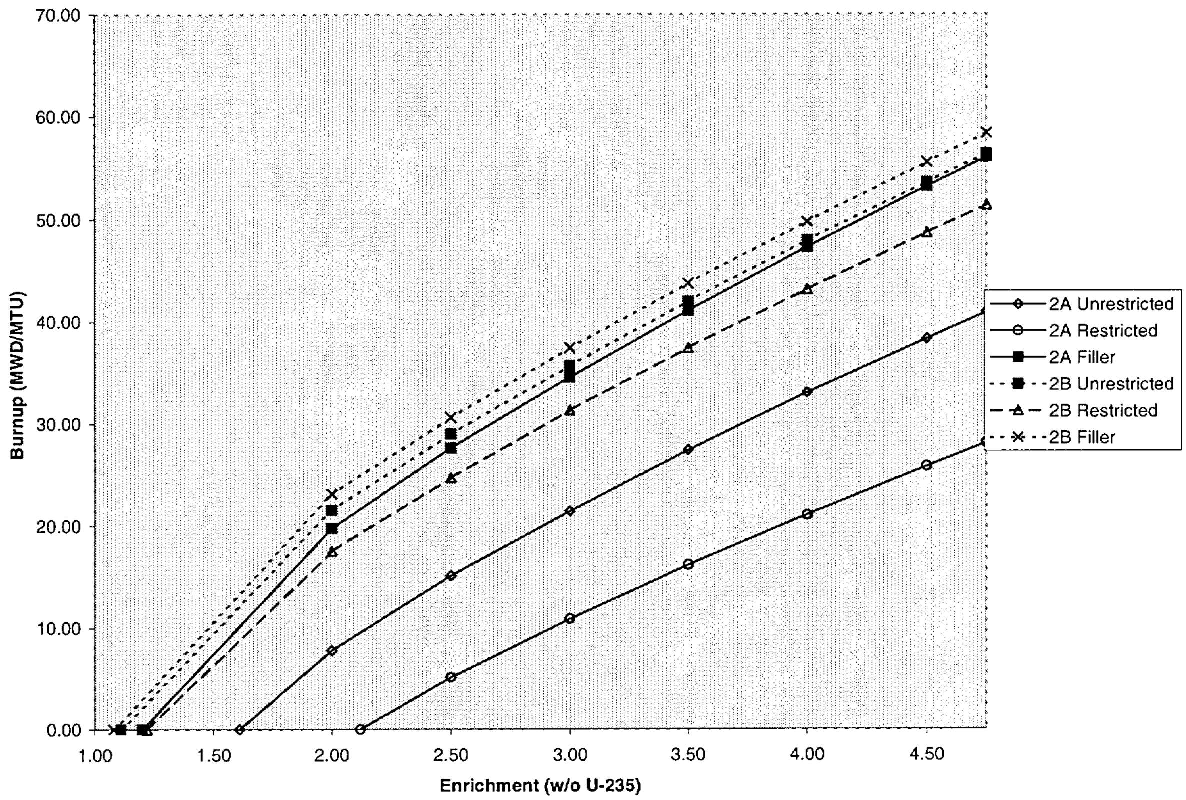


Figure 9
McGuire Region 2A and 2B
Burnup versus Enrichment Limits



ATTACHMENT 7

MCGUIRE NUCLEAR STATION
SPENT FUEL POOL SOLUBLE BORON
CREDIT BORON DILUTION ANALYSIS
(SUMMARY OF APPLICABLE PORTIONS)

Evaluation Of Potential Boron Dilution Accidents For The McGuire Spent Fuel Pools

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Evaluation Of Potential Boron Dilution Accidents

For The McGuire Spent Fuel Pools

1.0 INTRODUCTION/BACKGROUND

The current criticality analysis for the McGuire Spent Fuel Pool (SFP) takes credit for a solid boron material in the fuel racks known as Boraflex. This material has unexpectedly degraded over time and has lead to a loss of boron in the material. As this degradation has continued, it has become necessary to reduce or eliminate credit for the solid boron in the racks in the criticality analysis. In order to continue meeting criticality design criteria, it is necessary to take credit for soluble boron contained in the SFP water. This calculation will evaluate potential accidents that could add significant amounts of unborated water to the Spent Fuel Pool causing dilution of the pool boron concentration. This calculation will evaluate the minimum possible boron concentration which could result from a credible boron dilution accident event. The results will also provide timing estimates of boron concentrations resulting from these accidents.

The overall governing methodology for crediting soluble boron is described in WCAP-14416-NP-A (Reference 1). This approach requires that a boron dilution analysis be performed to ensure that sufficient time is available to detect and mitigate the dilution before the 0.95 k_{eff} design basis criterion is exceeded. This approach further states that the dilution analysis should include an evaluation of the following plant-specific features:

1. Spent Fuel Pool and Related System Features
   - Dilution Sources

- Dilution Flow Rates
- Boration sources
- Instrumentation
- Administrative Procedures
- Piping
- Loss of Off-Site Power Impact

2. Boron Dilution Initiating Events (including operator error)
3. Boron Dilution Times and Volumes

The staff has concluded that the new methodology in WCAP-14416 can be used in licensing actions. All licensees proposing to use the new method for soluble boron credit should identify potential events which could dilute the spent fuel pool boron to the concentration required to maintain the 0.95 k_{eff} limit and should quantify the time span of these dilution events to show that sufficient time is available to enable adequate detection and suppression of any dilution event. The effects of incomplete boron mixing should be considered.

The methodology employed uses four basic steps:

1. Develop Preliminary List of Potential Events
2. Screen Events that are not Credible or are Irrelevant
3. Evaluate Events for Dilution Times and Volumes
4. Summarize Results and Conclusions

A preliminary list of events for review was developed through the review of several industry studies and review of the design of the McGuire Spent Fuel Pool and related systems. A plant walkdown was conducted to examine SFP structural features and the spatial relationships between the SFP and related plant systems. Furthermore, a review of industry operating experience was conducted to check for possible failures modes not previously considered. Many types of postulated events were screened out because they lead to consequences different than deboration, and others were screened out because they are not credible with the McGuire pool design.

Events which were not initially screened out were evaluated further to determine the potential impact of those events on pool boron concentration. In some cases, the accident source of unborated water comes from a finite source that is relatively small compared to the volume of the pool. These events were evaluated to show the resulting boron concentration if the entire source were added to the pool and the length of time required to do so. On the other hand, some sources of unborated water could come from continuously flowing systems. These "infinite" water sources were evaluated for the highest flow rate as the bounding case. Events involving continuously flowing systems are also evaluated to determine the available time for operator action to show that sufficient time is available to terminate the flow into the pool.

2.0 ASSUMPTIONS

A number of important assumptions were made to perform this assessment. Most of the major assumptions are discussed below.

2.1 Unit 1 and Unit 2 Spent Fuel Pool Similarity

The layout and overall dimensions of the Unit 1 and Unit 2 Spent Fuel Pools are the same except that each is a "mirror image" of the other. As a result, the estimated volumes are also the same. No significant differences were found in design parameters between the interfacing systems for each unit. Although there were some differences in piping layout around the pool areas, no differences in the piping system were found that would have any obvious effect on the rate or magnitude of dilution in either pool. Therefore, only one set of calculations is made and the results are applicable to both McGuire Spent Fuel Pools.

2.2 Boron Concentration

The initial pool boron concentration is conservatively assumed to be 2475 ppm. This corresponds to the COLR limit for McGuire Unit 1 Cycle 12 which is the lowest limit currently in use at McGuire. However, the Unit 1 Cycle 13 limit is scheduled to be raised to 2675 ppm matching the current limit for McGuire Unit 2. Choosing the lower value provides some additional safety margin as well as allows the COLR limit to be lowered for future reactor designs (if needed or desired) without impacting this analysis. Based on the double contingency principle, it is not necessary to postulate that the pool boron concentration is below its TS minimum concentration concurrently with a second event that puts a large volume of unborated water into the pool (Reference 1).

2.3 Spent Fuel Pool Water Level

The initial pool water level is assumed to be at the normal level at elevation 771' + 4.75". The volume of water in the Spent Fuel Pool at this water level is 43,108 cubic feet, which corresponds to approximately 322,450 gallons. This value will be used for the initial water volume in dilution calculations. This volume includes the cask loading pit and the fuel transfer canal, but excludes the volume of water within the fuel pin area. It also excludes the volume in the gate openings between the main pool and the transfer canal and between the main pool and the cask loading pit. The Tech Spec minimum level is 23 feet above the fuel, which corresponds to an elevation of 769'. Again due to the double contingency principle, it is not necessary to postulate that the spent fuel pool level is below its normal level concurrently with a second event that puts a large volume of unborated water into the pool. Furthermore, the additional volume of water in the fuel pin area should more than account for any slight level variations that might occur prior to a postulated boron dilution event. Thus it is concluded that the assumption of normal pool level with 322,450 gallons of water volume is acceptable.

Note that SFP level is not measured using the control room instrument but rather by a physical marking on the pool wall for the purposes of normal routine surveillance and normal makeup to the SFP for evaporation. The control room SFP level instrument instead serves to provide a high and low level alarm function. Given that such a physical marking is not subject to "instrument drift" and that the water volume estimate is conservative, it is unnecessary to account for "instrument error" in the water volume estimation.

This analysis is only addressing dilution events where there is the potential to add large amounts of unborated water to the SFP. Events involving a large loss of SFP coolant inventory are not evaluated for boron dilution from emergency makeup used to restore SFP level. Certain catastrophic failures of the pool could result in a large loss of SFP inventory that could cause a zircaloy cladding fire. However, it is assumed that plant procedures will address boron addition as a part of the emergency makeup response. In addition, the SFP criticality analysis examines the case where there is no soluble boron in the SFP. Emergency makeup without boration could lead to a loss of all boron and thus a loss of the 5% safety margin; however, the "no boron" case shows that k_{eff} will remain still less than 1.0.

2.4 Mixing Factors

It is conservatively assumed that any unborated water that enters the pool will mix completely with the existing water in the pool. Complete mixing generally maximizes the rate of boron dilution. This assumption is consistent with the approach used in Reference 2 and in similar licensing submittals made by other licensees.

Good mixing is expected for the dilution events of interest. Operation of the KF system in conjunction with thermal mixing of warmer water rising from the fuel help ensure good mixing in the pool. Specifically, the KF pumps continuously recirculate approximately 1000 gpm from the South end of the main pool to the North end. Also the Spent Fuel Pool Skimmer Pump provides an additional 100 gpm of flow from the South end of the pool back to the opposite ends of the main pool, fuel transfer canal and cask loading pit. Partial mixing may occur in cases where a pipe breaks in the pool area and causes the pool to overflow. In this case, the water entering the pool may not fully mix with the rest of the pool inventory before exiting the pool. Partial mixing in this case would serve only to slow-down the dilution of the rest of the pool. The potential for "pockets" of lower boron concentration are bounded by the "no boron" criticality case and do not need to be considered further.

2.5 Piping Break Sizes

For random piping breaks, the break size is determined using the method in FSAR Section 3.6.2.2. While high-energy systems must consider double-ended pipe breaks, moderate energy systems are only required to assume through-wall cracks. The through-wall crack break area considered for this event is based on a length equal to one-half the nominal inside diameter and a width equal to one-half the minimum wall thickness of the system piping material.

For this assessment, piping breaks caused by seismic or tornado events are also considered for non-seismic piping or piping not protected from tornado winds or missiles. For these breaks a larger through-wall crack size was assumed than for random break events. The through-wall crack break area assumed for these events is based on a length equal to the circumference of the pipe at its inside diameter and a width equal to one-half the minimum wall thickness of the system piping material.

3.0 Identification of Dilution Initiating Events

A preliminary list of events for review was developed through the review of several industry studies (References 2 and 3) and review of the McGuire Spent Fuel Pool and related systems. Table 1 provides a listing of the types of events considered and how these events were dispositioned. Many types of postulated events were screened out because they lead to consequences different than boron dilution, and others were screened out because they are not credible with the McGuire pool design.

4.0 Evaluation of Boron Dilution Times and Volumes

In order to determine the boron concentration for various flow rates and volumes it is necessary to examine the dimensions and configuration of the spent fuel pool. A sketch of the Unit 1 SFP is provided in Figure 1. The pool consists of three connected compartments: the main pool area where fuel is stored, the cask loading area, and the transfer canal area. Normally all three areas are connected, but gates can be installed for infrequent activities such as maintenance on the "upender" in the Transfer Canal, or the loading or unloading of a cask in the cask loading area. For the base case analysis, the initial pool volume is 322,450 gallons which includes all three areas (i.e., gates removed). Other modes are evaluated separately.

All of the events to be evaluated involve the addition of unborated water to the existing water volume. It is important to note that the normal water level (771' + 4.75") is well below the top of Spent Fuel Pool operating floor (Elevation 778'+10"). Since no water is assumed to flow out of the pool at the initiation of a dilution event, unborated water enters the pool and fills the pool continuously until it reaches the top of the pool and overflows. Figure 1 provides an illustration of the various water and pool elevations.

Three stages of boron dilution flow are examined. The first stage involves filling up the pool to the top of the Transfer Canal wall at elevation 773' + 6". The second stage involves filling the pool from the top of the Transfer Canal wall up to the top of the pool operational deck at elevation 778' + 10". The third stage involves the flow of unborated water into the pool with an equal amount of the diluted mixture flowing out of the pool into the lower areas of the Spent Fuel Pool Building.

The volume of water required to fill the pool up to the top of the Transfer Canal wall is 23,995 gallons. The volume of water required to fill the pool from the top of the Transfer Canal wall up to the top of the pool is 68,029 gallons.

The pool boron concentration at the end of stage 1 (C_1) is found using:

$$C_1 = \frac{C_o * V_o}{V_o + V_c}$$

where C_o = Initial Pool Boron Concentration (2475 ppm),
V_o = Initial Pool Water Volume (322,450 gallons), and
V_c = Volume of water to fill to top of Transfer Canal Wall (23,995 gallons)

This yields a value for C_1 of 2304 ppm. The length of time to reach this concentration is dependent on the dilution flow rate into the pool. This length of time can be found by dividing V_c by the flow rate. Table 2 provides a listing of times required to fill the pool to the top of the Transfer Canal Wall for various flow rates. To find the pool concentration at any specific time during stage 1, the following equation is used:

$$C = \frac{C_o * V_o}{V_o + (Q*60*t)}$$

where C_o = Initial Pool Boron Concentration (2475 ppm),
V_o = Initial Pool Water Volume (322,450 gallons),
Q = Flow rate into Pool (gpm),
t = Length of time after initiation of dilution flow (hours), and
60 = Conversion factor for converting hours to minutes.

The pool boron concentration at the end of stage 2 (C_2) is found using:

$$C_2 = \frac{C_o * V_o}{V_o + V_c + V_T}$$

where C_o = Initial Pool Boron Concentration (2475 ppm),
V_o = Initial Pool Water Volume (322,450 gallons),
V_c = Volume of water to fill to top of Transfer Canal Wall (23,995 gallons)

V_T = Volume to fill from Canal Wall to Top of Pool (68,029 gallons)

This yields a value for C_2 of 1925 ppm. The length of time to reach this concentration is dependent on the dilution flow rate into the pool. This length of time can be found by dividing the sum of V_c and V_T by the flow rate. Table 1 provides a listing of times required to fill the pool to the top for various flow rates. To find the pool concentration at any specific time during stage 2, the following equation is used:

$$C = \frac{C_o * V_o}{V_o + V_c + \left(Q*60*\left(t - t_c\right)\right)}$$

where Q = Flow rate into Pool (gpm),

t_c = Length of time to fill to top of Transfer Canal Wall (hours),

t = Length of time after initiation of dilution flow (hours), and

60 = Conversion factor for converting hours to minutes.

*By definition, t must be greater than t_c and less than t_T. Values of t_c and t_T are provided in Table 2.

After the pool reaches stage 3 where the pool is overflowing, the boron concentration is found using:

$$C = C_2\, e^{(-Q*60/V_M)(t-t_T)}$$

where C_2 = equals the pool concentration at the end of stage 2 (1925 ppm)

Q = Flow rate into Pool (gpm),

V_M = Total SFP Mixing Volume (V_o+V_c+V_T=414,474 gal)

t_T = Length of time to fill to top of pool (hours),

t = Length of time after initiation of dilution flow (hours), and

Using the equations above, the pool boron concentration was estimated for a range of flow rates for various times from 1 to 72 hours with the results presented in Table 2.

The dilution equation can also be rearranged and solved for time t in order to find how much time it takes at a given flow rate to dilute the SFP down to a specific boron concentration. The following equation is used to calculate the amount of time required to dilute the SFP down to the minimum boron limit (730 ppm) credited in the SFP criticality analysis in Attachment 6.

$$t = t_T + \left(\frac{V_M}{Q \times 60}\right) \cdot \ln\left(\frac{C_2}{730}\right)$$

In some of the events evaluated, the source of dilution flow is defined by a fixed volume instead of a continuous dilution flow. If the total volume added to the pool does not overflow the pool (less than 92,024 gallons), the pool boron concentration is found using:

$$C = \frac{C_o * V_o}{V_o + V}$$

where C_o = Initial Pool Boron Concentration (2475 ppm),
V = Water Volume added to the pool (gallons), and
V_o = Initial Pool Water Volume (322,450 gallons).

If the total volume added to the pool does overflow the top of the pool (greater than 92,024 gallons), then the pool boron concentration is found using:

$$C = C_2 e^{-\left(\frac{V-92024}{Vo+92024}\right)}$$

where C_2 = equals the pool concentration at the end of stage 2 (1925 ppm),

V_o = Initial Pool Water Volume (322,450 gallons),

V = Water Volume added to pool (gallons), and

92024 = number of gallons to fill pool to overflowing (V_C+V_T).

5.0 Evaluation of SFP Dilution Events

5.1 Pipe Breaks

Both McGuire Spent Fuel Pools are located at an elevation above all adjacent buildings. Pipe breaks in adjacent buildings or areas can not flow into the pool and are excluded. Through the review of plant drawings and a plant walkdown, piping for the following systems was identified in the SFP area that, if broken, could flow into the SFP:

System	Largest Pipe	System Pressure
RF - Fire Protection Supply	4 inch	150 psig
YM - Demineralized Water Supply	2.5 inch	120 psig
YD - Drinking Water Supply	1 inch	100 psig
WE - High Pressure Decon Water	* System Abandon In Place *	

Note: KF system piping in the SFP area is excluded because it contains borated water.

Besides being the largest and highest pressure line in the SFP area, the RF header is supplied by the RF pumps taking suction from Lake Norman (an "infinite" source). For this reason, the RF line is taken to be the worst line break.

The RF system is classified as a moderate energy system (UFSAR Table 3-19). For random piping breaks of moderate energy systems, the size of the break is determined per the criteria provided in UFSAR Section 3.6. For the 4" RF line, the piping material is Schedule 40 Carbon Steel which has a thickness of 0.237" and an inside diameter of 4.026".

This results in a break size of 0.239 square inches or 0.551 inches equivalent diameter for the random pipe break. At a maximum system pressure of 150 psig, this results in a maximum break flowrate of 111.1 gallons per minute.

Since the RF line is not seismically qualified, it is also evaluated for a larger through-wall crack size. Using a pipe thickness 0.237" and an inside diameter of 4.026", the break area is 1.50 square inches. This yields an equivalent diameter of 1.382 inches. At a maximum system pressure of 150 psig, this results in a maximum break flowrate of approximately 700 gallons per minute.

Table 2 provides a tabulation of the resulting boron concentration over time from a 700 gpm dilution flow rate. The amount of time required (at 700 gpm) to dilute the SFP down to the 730 ppm boron credit limit is calculated using the following equation.

$$t = (2.19) + \left(\frac{414,474}{700 \times 60}\right) \cdot \ln\left(\frac{1925}{730}\right) = (2.19) + (9.57) = 11.76 \text{ hrs}$$

5.2 Misalignment of Systems Interfacing with KF System

The potential exists for systems that interface (directly or indirectly) with the KF system to become misaligned due to operator errors or component malfunction or failure causing unborated water to be added to the Spent Fuel Pool. These interfacing systems are the Refueling Water (FW) System, Boron Recycle (NB) System, Liquid Waste Recycle (WL) System, Chemical and Volume Control (NV) System, Makeup Demineralized Water (YM) System, Filtered Water (YF) System, Drinking Water (YD) System, Fire Protection (RF) System, Nuclear Service Water (RN) System, and Component Cooling Water (KC) System. The potential impact of these systems is evaluated below. The SSF Standby Makeup Pump also connects to the SFP through the Fuel Transfer Tube; however, the impact of SSF operation will be examine later (Loss of Off-site Power discussion).

5.2.1 Dilution From Reactor Makeup Water Storage Tank

While normal makeup to the Spent Fuel Pool is provided by the Refueling Water Storage Tank, an alternate makeup source is provided by the Boron Recycle (NB) System. This is accomplished by aligning the Reactor Makeup Water (RMW) Pumps from the Reactor Makeup Water Storage Tank (RMWST) to discharge directly into the pool. The RMWST has a usable volume of 112,000 gallons and the RMW pumps have a capacity of 150 gpm each.

If an error occurred that inadvertently caused the entire volume of unborated water in the RMWST to be pumped into the SFP, the resulting boron concentration is 1834 ppm. At the maximum assumed piping capacity of 300 gpm, it would require 6.22 hours to reach this concentration.

5.2.2 Dilution From The Recycle Holdup Tanks

Another portion of the Boron Recycle (NB) System contains the Recycle Evaporator Feed Pumps and the Recycle Holdup Tanks (RHT). There are two pumps (30 gpm each) and two tanks with a usable volume of 112,000 gallons each. There is not a direct connection between this source and the KF system or the SFP; however, it is possible to pump this water into the pool indirectly by misaligning the Refueling Water (FW) system makeup line to the SFP through manual valves KF-81 and KF-83.

However, another path from the RHTs to the SFP would be to align the Recycle Evaporator Feed Pumps to the RMWST and to "piggy-back" the RMW pumps into the SFP. This path is potentially worse because of the greater combined volume of both Recycle Holdup Tanks and the RMWST. The total volume of these tanks is 336,000 gallons (112,000+112,000+112,000). Transfering the entire volume of coolant into the SFP would result in a boron concentration of 1068 ppm.

The amount of time required to dilute to this concentration, however, is constrained by the amount of time to transfer the RHT water to the RMWST (224,000 gallons at 60 gpm = 62.2 hrs), as opposed to the RMW pumps transferring 336,000 gallons at 300 gpm for 18.67 hours. Thus, the average net flowrate would be 336,000 gallons divided by 62.2 hours or 90 gpm.

5.2.3 Dilution From Demineralized Water (YM) System

While the normal makeup to the pool comes from the FWST, makeup water can also be added to the pool from the Demineralized Water (YM) System. There is not a direct connection between this source and the KF system or SFP; however, there are two indirect paths which could be used to add YM to the SFP.

First, it is possible to attach a hose to a YM connection in the pool area and run the hose a few feet over into the pool. However, the flow rate is somewhat limited due to the smaller piping size. The second path is considered to be the worst case event in which the YM system is aligned through the RMWST. This event conservatively assumes that a misalignment occurs in which YM is "piggy-backed" on the RMW pumps putting water into the pool. The volume of water is assumed to be the sum of all the water available in the YM system plus the volume of the RMWST. The volume of water available in the YM system is assumed to include both Demineralized Water Storage Tanks (1000 gallons each) and both Filtered Water Tanks (42,500 gallons each). The total volume of the all these tanks is 199,000 gallons (2,000+85,000+112,000). The maximum pool dilution resulting from this event is 1489 ppm. At an assumed maximum flowrate of 300 gpm for both of the RMW pumps, it will require 11.06 hours to pump 199,000 gallons into the SFP to reach this concentration.

5.2.4 Dilution From The Recycle Monitor Tank

Another source of makeup water to the RMWST comes from the Liquid Waste Recycle (WL) System. There are two Recycle Monitor Tank Pumps (100 gpm each) that can be connected to transfer the Recycle Monitor Tank (RMT) inventory into the RMWST. Since there is not a direct connection between this source and the KF system or SFP, it is assumed to be misaligned where both RMT Pumps are "piggy-backed" on the RMW pumps putting water into the pool. For this event the volume of water is assumed to be the sum of both RMTs (5,000 gallons each) and the volume of the RMWST (112,000). The total volume of the all these tanks is 122,000 gallons (10,000+112,000). The maximum pool dilution resulting from this event is 1791 ppm. At an assumed maximum flowrate of 300 gpm for both of the

RMW pumps, it will require 6.78 hours to pump 122,000 gallons into the SFP to reach this concentration.

5.2.5 Dilution From Nuclear Service Water System

The KF System is designed with a connection to the RN System "A" Header and a separate connection to the RN "B" Header. This is considered to be the safety-related "assured" makeup source to the Spent Fuel Pool which would only be used if no other demineralized water were available. Each connection is designed to provide 500 gallons per minute of makeup flow. Each line is isolated from the SFP by two "locked-closed" manual valves in series. The postulated dilution event is the unintentional opening of one of these lines resulting in an assumed dilution flow rate of 500 gpm. Table 2 provides a tabulation of the resulting boron concentration over time from a 500 gpm flowrate. The amount of time required (at 500 gpm) to dilute the SFP down to the 730 ppm boron credit limit is 16.5 hours.

5.2.6 KC/KF Heat Exchanger Leak

The Component Cooling Water (KC) System provides cooling water to the KF heat exchangers for decay heat removal. There is no direct connection between the KC system and KF system. However, a connection would occur if a leak were to develop in a KF heat exchanger that is in service. In case of a leak, KC water would be expected to flow into the KF system since KC is at a slightly higher pressure. It is expected that the flow rate from such leakage would be very small due to the very small difference in system operating pressures.

Even if a significant flow rate resulted from a leak, the impact on the SFP boron concentration would be very small due to the limited volume of water available in the KC system. The total volume of water in the KC system is 31,214 gallons. Operator response to a loss of KC inventory includes manually aligning a demineralized water makeup source (YM) or using the "assured" makeup source from the RN system. The alarms from the KC surge tank and the SFP high level alarm would alert control room operators of the lost inventory and the source of the leak.

The boron concentration resulting from a dilution volume of 31,214 gallons is found to equal 2257 ppm, a change of only 218 ppm.

Because of the limited amount of water available for the KC system and the mechanisms available to operators to identify such leakage, a KF heat exchanger leak can not result in any significant dilution of the SFP and is not considered further.

5.2.7 Dilution From Drinking Water System

There is a Drinking Water (YD) System supply line located in the SFP area to dispense potable water for various cleaning and decontamination activities that take place in this area. Water for this system is supplied from the local Charlotte/Mecklenburg County water system. It is postulated that this source could be misaligned or inappropriately used causing unborated water to enter the pool. It is assumed that this source could not produce more than 50 gpm of flow from this connection. However, this dilution source is not a concern due to the much greater flow rates estimated for piping breaks for the RF System.

Table 2 provides a tabulation of the resulting boron concentration over time from 50 gpm of dilution flow. The amount of time required (at 50 gpm) to dilute the SFP down to the 730 ppm boron credit limit is 165 hours.

5.2.8 Boron Removal By Spent Fuel Pool Demineralizer

When the spent fuel pool demineralizer is first placed in service after being recharged with fresh resin it can initially remove boron from the water passing through it. The demineralizer normally utilizes a mixed bed of anion and cation resin which would remove only a small amount of boron before saturating. Because of the small amount of boron removed by the demineralizer, it is not considered a limiting dilution event for the purposes of this evaluation.

5.2.9 Dilution From Fire Protection System

The Fire Protection (RF) System is not directly connected to the pool. However, two fire protection hose stations located in the SFP area could be used to manually add water to the SFP. Each hose station has the capacity to deliver approximately 100 gpm of unborated water. Use of RF for this purpose would be as a last resort to restore pool inventory following the failure or depletion of all normal makeup sources to the pool as well as both trains of the RN "assured" makeup source. The impact of this dilution source is bounded by the consideration of a pipe break in the 4" RF supply header which feeds both hose stations. In addition, station procedures for emergency makeup to the SFP are assumed to address the addition of boron to the pool regardless of which makeup source is used. Therefore, this source will be addressed under "Pipe Breaks" in Section 5.1 and will not be considered further in the context of "Interfacing System".

5.3 Loss of Off-Site Power

Of the dilution sources considered, only the RN assured makeup, fire protection system, and drinking water system are capable of providing non-borated water to the spent fuel pool during a loss of off-site power. Each fuel pool cooling (KF) pump is supplied backup power by its corresponding emergency diesel generator at one hour after the loss of normal station power, however, the pumps must be manually started. The Fire Protection (RF) pumps are also supplied with emergency diesel power which must be manually connected. The Fuel Pool Skimmer Pump is not provided with a backup source of power. The spent fuel pool level instrumentation is powered from a battery-backed source which can be manually aligned to receive emergency diesel generator backed power if normal power can not be promptly restored.

Due to the low probability of a loss of power event concurrently with a pipe break or a misalignment of the RN, RF, or YD water sources, an accidental dilution of the spent fuel pool water is not considered credible. However, there is a scenario involving operation of the Standby Shutdown Facility (SSF) where the pool boron concentration may be intentionally lowered. The SSF includes an independent diesel generator ac power source and the Standby Makeup Pump which takes suction from the spent fuel pool to provide seal injection flow for the Reactor Coolant (NC) Pumps. The SSF was designed to respond to security events or Appendix R fire events, but is also credited for responding to station blackout scenarios if emergency diesel power fails.

Operation of the SSF is postulated for up to 72 hours. During this 72 hours, the Standby Makeup Pump draws approximately 26 gpm of flow from the pool. Plant procedures have provisions to provide makeup to the pool during SSF operation. The maximum volume of borated water taken from the pool is estimated to be (26 gpm x 60 min/hr x 72 hr) 112,320 gallons. If this water volume is replaced with non-borated water, the maximum dilution is calculated to be 1613 ppm. If operators were to accidentally refill the pool to the maximum level (overflow) instead of the normal level, the maximum dilution is calculated to be 1255 ppm.

5.4 Evaluation of Infrequent Spent Fuel Pool Configurations

Two configurations were identified that are significantly different than the normal SFP configuration. These would be if either the fuel transfer canal or cask loading pit were isolated from the main pool.

The purpose for isolating the transfer canal would be to drain the canal to gain access to the fuel handling equipment used to transport fuel assemblies between the SFP and the Refueling Canal. Under current policies and practices, the transfer canal is not drained unless the fuel handling equipment can not be repaired by using diving equipment. The use of high-quality underwater color television cameras at McGuire has also eliminated the need to drain the transfer canal to perform visual inspections of this equipment. Pool high-level alarms and plant personnel involved in the equipment repair would ensure very prompt detection prior to a significant amount of unborated water being added to the SFP. In fact, the pool would actually spill over into the fuel transfer canal and stop any work taking place there. Piping breaks in the pool area would also be obvious to crews working there. Also, the borated water drained from the transfer canal would be stored in the Recycle Holdup Tanks, effectively eliminating one of the more significant dilution sources. Because of the very low frequency of this configuration, the enormous volume of water required to significantly dilute the pool, and the effective means of early detection of an event, this configuration is not considered to be a part of a credible boron dilution accident scenario and is not considered further in this analysis.

The purpose of isolating and draining the cask loading pit is to prepare for the loading of fuel into a cask or for the actual movement of a cask into or out of the pit. While this activity has been very rare in recent past experience, some cask loading activities are planned for the future. Isolation of the cask loading pit removes approximately 46,423 gallons from the total volume of borated water available in the pool. For this special case, a new set of parameters is derived that exclude water volume in the cask loading area.

Using these new parameters, the previous dilution calculations for the worst case bounding events (the 700 gpm RF line break and the RHT/RMWST misalignment event) were performed again. For the 700 gpm RF line break, the results for this alternate configuration are provided in Table 3 which shows that it would take more than 10 hours for this dilution event to lower pool boron concentrations below the non-accident conditions minimum boron credit of 730 ppm. For the RHT/RMWST misalignment event, the final pool boron concentration is 937 ppm and would require this dilution event continue unnoticed for more than 2.5 days. Neither of these events are likely since they would be detected by a spent fuel storage pool level alarm or by plant operations personnel walking through the area before the required volumes of water were added to a fuel pool.

6.0 Results

A summary of dilution event results is provided in the table below.

Summary of Dilution Event Results

Event Scenario	Dilution Volume & Dilution Flow Rate	Final Boron Conc.(ppm) & Dilution Time	Time to Reach 730 ppm
Pipe Break (4" RF Header)	"infinite source" at 700 gpm	Time Dependent (See Table 2)	11.76 hrs
Dilution From RMWST	112,000 gallons at 300 gpm	1834 ppm at 6.22 hrs	-
Dilution From RHT & RMWST	336,000 gallons at 90 gpm (avg.)	1068 ppm at 62.2 hrs	-
Dilution From YM & RMWST	199,000 gallons at 300 gpm	1489 ppm at 11.06 hrs	-
Dilution From RMT &RMWST	122,000 gallons at 300 gpm	1791 ppm at 6.78 hrs	-
Dilution From RN System	500 gpm	Time Dependent (See Table 2)	16.47 hrs
Dilution From YD System	50 gpm	Time Dependent (See Table 2)	164.63 hrs
SSF Operation (Refill to Normal)	112,320 gallons removed and 112,320 added back	1613 ppm at >72 hrs	-
SSF Operation (Refill to Overflow)	112,320 gallons removed and 204,344 added back	1255 ppm at >72 hrs	-
Infrequent Configuration (Cask Loading Pit Isolated) (4" RF Pipe Break)	"infinite source" at 700 gpm	Time Dependent (See Table 3)	10.12 hrs
Infrequent Configuration (Cask Loading Pit Isolated) (RHT & RMWST Misaligned)	336,000 gallons at 90 gpm (avg.)	937 ppm at 62.2 hrs	-

Table 2 also provides an estimate of the length of time required for various flow rates to fill the pool to the high level alarm setpoint and to reach the pool overflow level.

7.0 Conclusions

Potential deboration accident scenarios in the SFP have been evaluated over a range of possible conditions. These postulated events involve combinations of multiple human errors, medium to large pipe breaks, or infrequent SFP configurations that make a significant loss of boron in the SFP very unlikely. In the unlikely event that any of these worst case unplanned or inadvertent dilution events occurred, they would be detected by plant personnel walking through the spent fuel pool areas, or indicated by level or flow alarms before sufficient water could be added to a pool to significantly lower its soluble boron concentration. The impact of these accidents result in a range of values of boron concentration depending on dilution flow rates and pool volumes. The results also show that the dilution process requires many hours to significantly reduce pool boron concentration even under the most limiting conditions and provides sufficient time for operator actions to terminate the accident. Based on the analysis presented above, it is concluded that there are no credible events that would result in the dilution of the spent fuel pool boron concentration from 2475 ppm to less than the the minimum boron credit of 730 ppm.

This conclusion is supported by the following:

1. A substantial amount of water is required to significantly dilute the spent fuel pool. In the SFP's worse case configuration with the cask loading pit isolated, no individual dilution source or combination of sources have sufficient inventory to dilute the pool from 2475 ppm to the boron credit limit of 730 ppm. Conservative assumptions were also made that the largest tanks were all full, which is in itself considered an infrequent condition. At the maximum postulated pipe

break flow of 700 gpm and with the cask pit isolated, it requires greater than 10 hours to pump a volume of water sufficient to reach the boron credit limit of 730 ppm.

2. Since such a large volume of water is required, a spent fuel pool dilution event would be readily detected by plant personnel by level alarms, flooding in the auxiliary building, or by normal operator rounds through the spent fuel pool area. In the case of the RF line break accident, control room alarms would provide indication that one or more RF pumps had started. In addition, flow alarms on the RF headers would also indicate to operators that the flow was going into the Auxiliary Building. These indications would initiate an immediate investigation into the location of the pipe break and the cause of the RF pump start.

3. Sensitivity analysis indicates that even if substantially higher flow rates of unborated water into the SFP are assumed, there is still sufficient time available to detect and respond to such an event (See Table 2).

4. The analysis conservatively assumes that the initial SFP water volume is 322,450 gallons which does not account for a significant volume of water contained within the fuel pin area.

8.0 References

1. WCAP-14416-NP-A, Revision 1, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology, Westinghouse Electric Corporation, November 1996.
2. NUREG-1353, "Beyond Design Basis Accidents in Spent Fuel Pools", U.S. Nuclear Regulatory Commission, April 1989.

3. WCAP-14181, "Westinghouse Owners Group Evaluation of the Potential For Diluting PWR Spent Fuel Pools," Westinghouse Electric Corporation, July, 1995.

Table 1 - Preliminary List of Dilution Initiating Events

Initiating Event	Disposition	Screening Notes
Structural Failure - Missiles	Screened	Postulated missiles causing damage to the pool structure could lead to a loss of inventory and zircaloy cladding fire but can not cause a dilution event.
Structural Failure - Aircraft Crashes	Screened	Postulated damage to the pool structure from an aircraft crash could lead to a loss of inventory and zircaloy cladding fire but can not cause a dilution event. (See also below - "Piping Damage caused by Airplane Crashes")
Structural Failure - Heavy Load Drops	Screened	Postulated heavy load drop events causing damage to the pool structure could lead to a loss of inventory and zircaloy cladding fire but can not cause a dilution event.
Seismic Structural Failure	Screened	Seismic structural failure is postulated to cause an unrecoverable loss of water in the SFP, and leads to a zircaloy cladding fire and cannot cause a dilution event.

Table 1 - Preliminary List of Dilution Initiating Events

Initiating Event	Disposition	Screening Notes
Reactor Cavity Seal Failure and/or Nozzle Dam Failure	Screened	The design of the McGuire Reactor Cavity Seals makes a catastrophic failure of the seals extremely unlikely. Such failures would be quickly isolated by procedure by closing valve KF122 (Fuel Transfer Tube Isolation Valve). In addition, a catastrophic failure would result in a loss of SFP inventory that could cause a zircaloy cladding fire and is not a boron dilution initiating event. The same conclusion applies to other failures of the reactor coolant system piping during refueling operation (including nozzle dams).
Loss of Cooling/Makeup	Screened	Loss of cooling/normal makeup is not considered a deboration event since the loss of inventory through evaporation and/or boil off does not remove boron from the pool.

Table 1 - Preliminary List of Dilution Initiating Events

Initiating Event	Disposition	Screening Notes
Inadvertent Drainage/Loss of Inventory	Screened	Most loss of inventory events are expected to be small. Design features of the KF system (e.g., siphon breaks) purposely limit the amount of water that could be removed from the pool due to KF system pipe breaks, system malfunctions, or operator errors. A boron dilution event could occur if unborated water is used to refill the pool. However, these events are not generally expected to remove enough water to deborate the pool significantly. Plant procedures will address the addition of boron to the pool in response to a significant loss of inventory which requires emergency makeup water.
Fires (at or near the pool)	Screened	Typically, combustible loadings around the pool area are relatively small. If the fire hose stations were used to extinguish a fire, the volume of water required to extinguish a local fire is not expected to be of sufficient magnitude to cause a significant change in pool boron concentration.

Table 1 - Preliminary List of Dilution Initiating Events

Initiating Event	Disposition	Screening Notes
External Floods	Screened	This type of event is not credible for McGuire Nuclear Station. FSAR analysis of potential external flood sources showed that the station embankment will protect the plant from worst case flooding scenarios. In addition, the elevation of the top of the pool is an additional 18 feet above grade.

Table 1 - Preliminary List of Dilution Initiating Events

Initiating Event	Disposition	Screening Notes
Storms Causing Runoff into the Spent Fuel Pool	Screened	The location of the spent fuel pool is high enough to preclude storm water from entering the pool due to flooding of the site. However, the roof drains for the Spent Fuel Pool Building are located directly above the pool. This piping is Class B (QA-1) seismically designed, although the portion of this piping over the railroad bay is not tornado wind or missile protected. However, wind or missile damage to this piping is considered very unlikely in a tornado strike event on the plant site and is not considered further. The McGuire UFSAR does not postulate piping breaks in lines fed by gravity such as this line. Also, with a probable maximum precipitation (PMP) event (30" rain in 6 hours), the 8825 sq. ft area on the roof would only generate 165,000 gallons. Even with a significant crack in the piping, most of the water flow would go down the drain (path of least resistance). Thus even a PMP event could not produce a dilution event greater than other postulated events. This event is screened.

Table 1 - Preliminary List of Dilution Initiating Events

Initiating Event	Disposition	Screening Notes
Pipe Breaks caused by seismic events, or tornadoes	Evaluate	Some piping in the SFP area (RF, YM, YD, etc.) is not seismically qualified and is not specifically protected from tornadoes. Realistically the probabilities of these failure events is lower than from random pipe breaks. In particular, the probability of tornado wind or missile damage is judged to be extremely low and do not need to be considered further. Since non-seismically qualified piping has been identified in the SFP area, this type of piping damage will be evaluated in Section 5.1.
Random Pipe Breaks	Evaluate	Piping in the vicinity of the pool will be evaluated for dilution accidents.
Other Damage caused by Airplane Crashes	Screened	The likelihood of an aircraft crash on either of the McGuire Spent Fuel Pools is extremely remote and is dismissed as a credible boron dilution initiating event
Tank Ruptures near the SFP	Screened	Review of plant drawings and a plant walkdown determined that no tanks in or around the plant could flow into the SFP if the tank ruptured.
Dilution Events Initiated in the Reactor Coolant System	Screened	No credible pathways could be identified for this type of event.
Misalignment of Systems Interfacing with KF system	Evaluate	There are several interfacing systems that will be evaluated.

Table 1 - Preliminary List of Dilution Initiating Events

Initiating Event	Disposition	Screening Notes
Loss of Off-site Power	Evaluate	The impact of loss of ac power events will be reviewed and evaluated including possible SSF scenarios.
Loss of Boron Due To Demineralizers or other Purification Equipment	Evaluate	The potential impact of the purification system will be evaluated.
Infrequent SFP Configurations	Evaluate	Potential alternative configurations will be evaluated.

Table Two
SFP Boron Concentration (ppm)

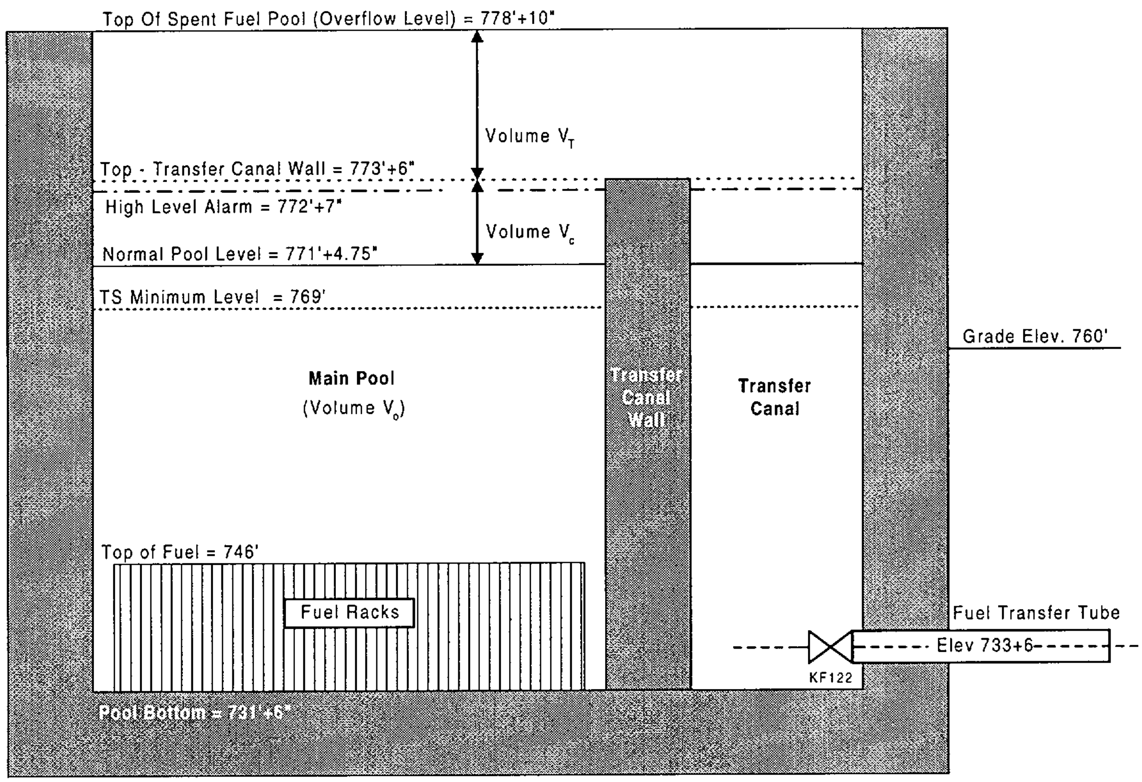
Initial Pool Boron Conc. =	C_o	2475	ppm
Initial Pool Level =	L_o	771.396	feet
Initial Spent Fuel Pool Volume =	V_o	322,450	gallons
Volume to fill SFP to Top of Transfer Canal =	V_c	23,995	gallons
Volume to fill SFP from Canal Wall to Overflow =	V_T	68,029	gallons

			Flow Rate Into SFP (gpm)							
			50	*100*	*200*	*300*	*500*	*700*	*1000*	*1500*
Fill To Top of Canal Wall	T_c (hrs)		*8.0*	*4.0*	*2.0*	*1.3*	*0.8*	*0.6*	*0.4*	*0.3*
(Stage 1)	Concentration		*2304*	*2304*	*2304*	*2304*	*2304*	*2304*	*2304*	*2304*
Fill To Pool Overflow Level	T_T (hrs)		*30.7*	*15.3*	*7.7*	*5.1*	*3.1*	*2.2*	*1.5*	*1.0*
(Stage 2)	Concentration		1925	1925	1925	1925	1925	1925	1925	1925
High Level Alarm (Elev. 772'+7")	Detection Time (hrs)		4.51	2.26	1.13	0.75	0.45	0.32	0.23	0.15
	Time (hrs)		*50*	*100*	*200*	*300*	*500*	*700*	*1000*	*1500*
Pool Concentration (ppm) Versus Time and Flowrate	Time (hours)	1	2452	2430	2386	2344	2264	2190	2087	1935
		2	2430	2386	2304	2226	2087	1963	1800	1557
		4	2386	2304	2154	2023	1800	1603	1347	1009
		6	2344	2226	2023	1853	1557	1309	1009	653
		8	2304	2154	1907	1699	1347	1069	755	423
		10	2264	2087	1800	1557	1166	873	565	274
		11	2245	2054	1748	1491	1084	789	489	221
		12	2226	2023	1699	1428	1009	713	423	178
		16	2154	1907	1513	1200	755	475	237	74
		24	2023	1699	1200	848	423	211	74	13
		36	1853	1428	848	503	178	63	13	1
		48	1699	1200	599	299	74	19	2	0
		56	1603	1069	475	211	42	8	1	0
		64	1513	952	377	149	23	4	0	0
		72	1428	848	299	105	13	2	0	0

Table 3 - RF Line Break With Cask Loading Pit Isolated

Time (hrs)	Base Case Concentration (ppm)	Alternate Configuration Case Conc.	Difference
1	2190	2148	-42
2	1963	1897	-66
4	1603	1500	-103
6	1309	1186	-123
8	1069	937	-132
10	873	741	-132
11	789	659	-130
12	713	586	-127
10.12	862	730	-132
16	475	366	-109
24	211	143	-68
36	63	35	-28
48	19	9	-10
56	8	3	5
64	4	1	-3
72	2	1	-1

Figure 1 - McGuire Spent Fuel Pool Elevations



Drawing Not To Scale

ATTACHMENT 8

MCGUIRE NUCLEAR STATION
BORAFLEX DEGRADATION ANALYSIS

MCGUIRE BORAFLEX DEGRADATION ASSESSMENT

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1.0 BACKGROUND

The McGuire spent fuel storage racks contain Boraflex neutron-absorbing panels. The Unit 1 racks were installed in January 1986, and the Unit 2 racks were installed in December 1984. The function of the Boraflex panels is ensuring that reactivity of the stored fuel assemblies is maintained within required limits.

Boraflex, as manufactured, is a silicon rubber material that retains a powder of boron carbide neutron absorbing material. The Boraflex panels are enclosed in a formed stainless steel wrapper sheet that is spot-welded to the storage tube. The wrapper sheet is bent at each end to complete the enclosure of the Boraflex panel. The Boraflex panel is contained in the plenum area between the storage tube and the wrapper plate. Since the wrapper plate enclosure is not sealed, spent fuel pool water fills the enclosure.

It has been observed that after Boraflex receives a high gamma dose from the stored irradiated fuel ($>10^{10}$ rads) it can begin to degrade and dissolve in the wet environment. Thus, the boron carbide poison material can be removed, thereby reducing the poison worth of the Boraflex sheets. This phenomenon is documented in NRC Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks" (Reference 6.1).

2.0 PURPOSE

One of the key assumptions in the criticality calculation for the spent fuel storage racks is the boron-10 (B_{10}) loading of the Boraflex. (B_{10} is the neutron-absorbing isotope of boron in boron carbide.) This attachment provides an assessment of the Boraflex in the McGuire spent fuel racks with consideration given to the degradation mechanism discussed above.

3.0 APPROACH

Duke's approach to verifying McGuire's Boraflex is to periodically obtain results from quantitative in-situ measurements. The first in-situ testing was performed in the McGuire Unit 2 spent fuel storage racks in January 1997 (see discussion below).

Additionally, Duke has used the RACKLIFE computer code, developed for the Electric Power Research Institute (EPRI), for estimating the condition of the Boraflex through 2003. While Duke considers in-situ testing as its method of Boraflex verification, RACKLIFE is useful for an overall assessment of degradation. A RACKLIFE model can be used to estimate degradation of each Boraflex panel for some future date of interest. These results can be used for defining the fuel storage sub-regions of the pool and for determining which Boraflex panels should be in-situ tested.

The following is a description of in-situ testing and RACKLIFE modeling for the McGuire spent fuel storage racks.

3.1 IN-SITU TESTING

3.1.1 METHOD

Northeast Technology Corporation (NETCO), under contract for the Electric Power Research Institute (EPRI), has developed the Boron-10 Areal Density Gage for Evaluating Racks (BADGER). This system is used to measure the B_{10} areal density (expressed as grams of B_{10} per cm^2) in spent fuel storage racks.

The BADGER system consists of a source head containing a Cf_{252} source and a detector head containing BF-3 detectors that are lowered simultaneously into adjacent spent fuel storage cells. A stepper motor and winch attached to the fuel bridge auxiliary hoist allow the detector/source heads to be remotely located at desired elevations in the storage racks. The detector signals are fed into four pre-amplifiers and then to an electronics console that is positioned beside the pool. The signals are recorded on a computer that also controls the stepper motor for positioning of the detector/source heads.

The principle of BADGER is measurement of thermal neutron attenuation by the Boraflex panel(s) between the source and detectors. The number of neutrons emitted by the Cf_{252} source that reach the BF-3 detectors, is a function of the B_{10} areal density in the Boraflex. The detector signal is low for Boraflex panels with high B_{10} areal density. Conversely, the detector signal is high for Boraflex panels with low B_{10} areal density.

The BADGER equipment is calibrated by means of a calibration cell that is similar in construction to the spent fuel storage cells and that contains Boraflex panels of known B_{10} areal density. (Additional information regarding BADGER may be found in Reference 6.2)

3.1.2 In-Situ Test Results for McGuire Unit 2

In a BADGER demonstration campaign in January 1997, 33 McGuire Unit 2 Boraflex panels were evaluated. Panels were selected to include those with the greatest gamma exposures. The results, excluding measurement uncertainties, are as follows:

Boraflex Loss:

Reference 6.2 reports Boraflex loss for Region 1 and Region 2 in Tables 4.4 and 4.3, respectively. These findings are summarized below:

In Region 1, fifteen panels were evaluated. Boraflex loss ranged from zero (for an unirradiated panel) to 33.33 percent (as compared to the original as built areal density). There was a clear trend for greater loss with increasing gamma exposure.

In Region 2, eighteen panels were evaluated. Boraflex loss ranged from zero (for an unirradiated panel) to 15.85 percent (as compared to the original as built areal density). There was no clear association between loss and gamma exposure.

Generally, the loss of boron carbide from the panels was relatively uniform. Gaps had formed in some of the panels (see discussion below) and some limited thinning had occurred in some of Region 2 panels at the location of a 0.5 inch diameter inspection port.

Gaps in Boraflex Panels:

While gap measurements are not the primary function of the BADGER test equipment, an assessment is made of gaps in the Boraflex panels based on the BADGER testing performed at McGuire in January 1997. The results of the gap measurements are presented in Tables 4-5 and 4-6 of Reference 6.2. Generally, the Region 1 panels were found to have one or two gaps per panel, and the Region 2 panels were found to have three or four gaps per panel. None of the gaps exceeded four inches. The gaps appeared to be somewhat randomly distributed with no preferential elevation for gap formation.

3.2 Computer Modeling (RACKLIFE)

The McGuire Unit 2 Boraflex performance was modeled using the RACKLIFE computer code. RACKLIFE is a computer software package developed by NETCO under contract for EPRI. It is a stand-alone PC/DOS executable program that computes the loss of boron carbide from Boraflex panels in fuel storage racks.

The RACKLIFE code is based on the following principles verified through extensive laboratory testing of irradiated Boraflex specimens as discussed in Reference 6.3:

a. Boraflex is manufactured as a polydimethyl siloxane (silicon rubber) containing a powder of boron carbide, and a filler material of crystalline silica.

b. As Boraflex ages in the spent fuel pool environment, the polymer matrix is gradually broken down and converted into amorphous silica. This is a function of gamma radiation and exposure to the pool water.

c. Amorphous silica is somewhat soluble in the spent fuel pool water at increasing rates with absorbed gamma dose, pool temperature, and time. This solubilization is the physical mechanism that leads to removal of silica and boron carbide from the storage racks.

d. The amorphous silica and boron carbide from the Boraflex panels is transported into the spent fuel pool in a constant proportion. While the boron released from the spent fuel racks is indistinguishable from the boron in the boron acid added to PWR pools for criticality control (normally greater than 2000 ppm), silica concentrations in the pool are attributable almost exclusively to the Boraflex since it is the only significant source of silica. Thus, the amount of boron carbide that is lost from the Boraflex can be calculated since the ratio of boron carbide to silica leaving the Boraflex is constant.

e. Silica concentration in the spent fuel pool water is a function of rack design, temperature, and operation of the pool clean-up system.

RACKLIFE performs a mass balance of SiO_2 in the pool and within the wrapper plate plenum that encapsulates the Boraflex panels. A simple explanation of the mass balance is that the total SiO_2 released by the Boraflex panels, in aggregate, is affected by the amount of SiO_2 in solution in the pool water and the amount removed over time by the clean-up system. The contribution of each panel to the bulk SiO_2 quantity is determined, based on the irradiation-time history of the panel. All other factors being equal, panels with higher gamma exposures have higher SiO_2 releases, and for those with equal gamma exposures, the ones that received the dose early in life have SiO_2 releases. Having calculated the SiO_2 released by each panel, RACKLIFE then calculates the boron carbide released, based on the fixed ratio of boron carbide to SiO_2. A detailed discussion of the RACKLIFE code may be found in Reference 6.3.

It is important to note that Duke will not use the RACKLIFE code for Boraflex verification. RACKLIFE will be used to identify lead panels for in-situ testing and to provide an estimate of future condition. In-situ testing will be used to verify the Boraflex.

3.2.1 MCGUIRE UNIT 2 MODEL

A RACKLIFE model was developed for the Unit 2 spent fuel pool with the following input (Note: a detailed description of the RACKLIFE inputs may be found in Reference 6.3.):

1. Dimensional data for the pool, storage racks, and Boraflex.
2. Spent fuel pool water data including temperature and silica concentration.
3. Data for the irradiated fuel assemblies stored in the racks, including enrichment, burnup, discharge date, end of cycle power fraction, reactor cycles in which the assembly operated.
4. Dates and locations where each of the irradiated fuel assemblies was stored in the spent fuel racks.

One of the key RACKLIFE inputs is the escape coefficient assumed for the storage racks. This coefficient is associated with the rate at which the spent fuel pool water moves through the stainless steel wrapper that encapsulates the Boraflex panel. The more "open" the wrapper is to the pool, the greater the resulting degradation rate. A higher escape coefficient is used for a more open wrapper.

The approach used for McGuire Unit 2 was to vary the Region 1 and Region 2 escape coefficients to obtain the best match between the RACKLIFE results and the BADGER results for the tested panels. The escape coefficients thus determined were 1.25 for Region 1 and 0.05 for Region 2.

The RACKLIFE results are adjusted based on a 95/95 worst case statistical evaluation of RACKLIFE error for the panels tested by BADGER.

A comparison of the BADGER results and worst-case RACKLIFE results, expressed as a percentage of the minimum as-built B_{10} areal density for each region (0.0216 g/cm^2 and 0.0075 g/cm^2 for Region 1 and Region 2, respectively) is shown below:

Unit 2 January 1997			Percent Boraflex Loss	
Region 1 Panels			BADGER (nominal)	RACKLIFE (worst case)
A	23	South	0%	4%
C	13	East	19%	28%
C	13	North	30%	29%
D	13	East	29%	26%
E	2	West	11%	18%
E	13	East	25%	38%
E	13	North	37%	38%
E	13	West	34%	41%
F	2	East	17%	21%
F	12	West	22%	36%
F	13	East	29%	41%
F	13	North	31%	40%
F	14	East	29%	40%
G	12	East	28%	34%
H	13	West	25%	30%

Unit 2 January 1997			Percent Boraflex Loss	
Region 2 Panels			BADGER (nominal)	RACKLIFE (worst case)
BB	78	South	0%	19%
DD	78	East	17%	19%
DD	78	North	11%	19%
DD	78	South	-3%	19%
FF	78	East	5%	19%
FF	78	North	19%	19%
HH	78	East	-3%	19%
HH	78	North	15%	19%
KK	3	South	0%	18%
KK	78	North	0%	19%
KK	78	South	3%	19%
KK	78	West	13%	19%
MM	78	East	0%	19%
MM	78	North	4%	19%
MM	78	South	4%	19%
MM	78	West	19%	19%
PP	78	East	1%	19%
PP	78	South	3%	19%

3.2.2 McGuire Unit 1 Model

BADGER testing was only performed in the Unit 2 spent fuel pool. Thus, no Unit 1 in-situ test results are available for comparison to RACKLIFE. However, the design and construction of the Unit 1 storage racks are identical to Unit 2. Therefore, the escape coefficients and adjustments determined for the Unit 2 model are applicable to the Unit 1 model.

4.0 RACKLIFE ASSESSMENT

To provide flexibility in fuel storage, the criticality analysis subdivides Region 1 and Region 2, as follows:

Region 1A is assumed to have Boraflex degraded 75 % from the original design minimum (25% remaining) and Region 1B is assumed to have Boraflex degraded 100% (0% remaining).

Region 2A is assumed to have Boraflex degraded 50 % from the original design minimum (50% remaining) and Region 2B is assumed to have Boraflex degraded 100% (0% remaining).

In the Unit 1 spent fuel racks, only the Region 1A and Region 2A designations are assigned. In the Unit 2 spent fuel racks, Region 1A, Region 1B and Region 2A designations are assigned.

Worst-case RACKLIFE assessments for the sub-Regions are presented below for various in-service dates.

4.1 January 8, 1997

Unit 2

The worst panel losses, expressed as percentage of the minimum as-built B_{10} areal density for the sub-Regions, are as follows:

Region 1A- 34%
Region 1B- 41%
Region 2A- 19%

Unit 1

No specific RACKLIFE computations were performed for Unit 1 for January 8, 1997. Calculations for later in-service dates demonstrate that degradation in Unit 1 is enveloped by Unit 2.

4.2 December 31, 1999

Unit 2

The worst-case RACKLIFE results were computed for December 31, 1999. The worst panel losses, expressed as percentage of the minimum as-built B_{10} areal density for the sub-Regions, are as follows:

Region 1A- 50%
Region 1B- 60%
Region 2A- 21%

Unit 1

No specific RACKLIFE computations were performed for Unit 1 for December 31, 1999. Calculations for later end dates demonstrate that degradation in Unit 1 is enveloped by Unit 2.

4.3 December 31, 2003

Unit 2

The worst-case RACKLIFE results were computed for December 31, 2003. The worst panel losses, expressed as percentage of the minimum as-built B_{10} areal density for the sub-Regions, are as follows:

Region 1A- 81%
Region 1B- 97%
Region 2A- 22%

Unit 1

A worst-case RACKLIFE model was developed for Unit 1 with the escape coefficients and error corrections used for the Unit 2 model. This approach is justified since the storage racks are of identical design.

The worst panel losses, expressed as percentage of the minimum as-built B_{10} areal density for the sub-Regions, are as follows:

Region 1A- 64%
Region 2A- 21%

5.0 CONCLUSIONS

The initial in-situ verification for the McGuire Unit 2 spent fuel racks in January 1997 showed the Boraflex has degraded in both Region 1 and Region 2. Additional in-situ testing will be performed at a frequency of three years, starting in 2000, to confirm the Boraflex levels assumed in the revised criticality analysis.

The Unit 2 RACKLIFE model produced results consistent with the January 1997 in-situ test results. Using the rack escape coefficients determined for the Unit 2 model, a Unit 1 RACKLIFE model was developed, and it shows Unit 1 Boraflex is less degraded than Unit 2 Boraflex. RACKLIFE assessments for the Unit 1 and Unit 2 pools for December 31, 2003 show the Boraflex is not expected to degrade to less than the values assumed in the criticality calculation. In-situ testing will be employed to verify the actual Boraflex condition.

In the near term, Duke will continue investigations into options to address degrading Boraflex at McGuire. These options include replacement of the storage racks, insertion of additional neutron poison (rack or fuel assembly inserts), more stringent controls on fuel reactivity and storage patterns, and chemical inhibitors currently under investigation by EPRI.

6.0 REFERENCES

6.1 "Boraflex Degradation in Spent Fuel Pool Storage Racks," NRC Generic Letter 96-04, June 26, 1996.

6.2 "BADGER, a Probe for Nondestructive Testing of Residual Boron-10 Absorber Density in Spent-Fuel Storage Racks: Development and Demonstration, EPRI TR-107335, October 1997".

6.3 "The RACKLIFE Boraflex Rack Life Extension Computer Code: Theory and Numerics", DRAFT, NETCO, May 1997.

ATTACHMENT 9

MCGUIRE NUCLEAR STATION
PROPOSED REVISION TO UFSAR
CHAPTER 16, "SELECTED LICENSEE
COMMITMENTS"

16.9 AUXILIARY SYSTEMS

16.9.24 SPENT FUEL POOL STORAGE RACK POISON MATERIAL

COMMITMENT

a. The Region 1 panel average storage rack poison material Boron 10 areal density shall be greater than or equal to:

0.005 gm B_{10}/cm^2 for Region 1A
0 gm B_{10}/cm^2 for Region 1B

b. The Region 2 panel average storage rack poison material Boron 10 areal density shall be greater than or equal to:

0.003 gm B_{10}/cm^2 for Region 2A
0 gm B_{10}/cm^2 for Region 2B

APPLICABILITY When a fuel assembly is stored in a spent fuel rack cell location.

REMEDIAL ACTION: For Units 1 and 2

a. With a panel average spent fuel pool storage rack cell poison material not within limits:

   1. Perform SR 3.7.14.1. within 1 hour and once per 24 hours thereafter until the affected fuel assembly is moved, and;

   2. Verify that the fuel assembly in the affected location meets LCO 3.7.15(b) for Region 1 or LCO 3.7.15(d) for Region 2 within 1 hour.

b. If Remedial Action a. 2 is not met, immediately initiate action to move the affected fuel assembly to an acceptable location.

TESTING REQUIREMENTS:

a. Verify that the panel average spent fuel pool storage rack poison material is within limits every three years.

BASES:

The McGuire spent fuel storage racks contain Boraflex neutron-absorbing panels that surround each storage cell on all four sides (except for peripheral sides). The function of these Boraflex panels is to ensure that reactivity of the stored fuel assemblies is maintained within required limits. Boraflex, as manufactured, is a silicon rubber material that retains a powder of boron carbide (B4C) neutron absorbing material. The Boraflex panels are enclosed in a formed stainless steel wrapper sheet that is spot-welded to the storage tube. The wrapper sheet is bent at each end to complete the enclosure of the Boraflex panel. The Boraflex panel is contained in the plenum area between the storage tube and the wrapper plate. Since the wrapper plate enclosure is not sealed, spent fuel pool water is free to circulate through the plenum.

It has been observed that after Boraflex receives a high gamma dose from the stored irradiated fuel ($>10^{10}$ rads) it can begin to degrade and dissolve in the wet environment. The potential degradation mechanisms with respect to boraflex in spent fuel storage racks include:

(1) gamma radiation-induced shrinkage of boraflex and the potential for developing tears or gaps in the material, and

(2) gradual long-term boraflex degradation over the intended service life of the racks as a result of gamma irradiation and exposure to the spent fuel pool environment.

Thus, the B4C poison material can be removed, thereby reducing the poison worth of the Boraflex sheets. This phenomenon is documented in NRC Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks". To address this degradation, the spent fuel racks have been analyzed taking credit for soluble boron as allowed in WCAP-14416-NP-A, "Westinghouse Spent Fuel Rack Criticality Analysis Methodology," Revision 1, November 1996. This methodology ensures that the spent fuel rack multiplication factor, k_{eff} is less than or equal to 0.95. Codes, methods and techniques used in the McGuire criticality analysis are used to satisfy this k_{eff} criterion. The spent fuel storage racks are analyzed to allow storage of fuel assemblies with enrichments up to a maximum of 4.75 weight percent Uranium-235 while maintaining $k_{eff} \leq 0.95$ including uncertainties, tolerances, bias, and credit for soluble boron. Soluble boron credit is used to offset uncertainties, tolerances, and off-normal conditions and to provide subcritical margin such that the spent fuel pool k_{eff} is maintained less than or equal to 0.95. The soluble boron concentration required to maintain k_{eff} less than or equal to 0.95 under normal conditions is 730 ppm. In addition, sub-criticality of the pool ($k_{eff} < 1.0$) is assured on a 95/95 basis without the presence of the soluble boron in the pool. Credit is taken for reactivity depletion due to fuel burnup and reduced credit for the Boraflex neutron absorber panels.

The limits specified for the panel average storage rack poison material Boron 10 areal density ensures the k_{eff} of the spent fuel pool will always remain < 1.00, assuming the pool to be flooded with unborated water. The specified limit of Boron 10 areal density in boraflex preserves the assumptions used in the analyses of the potential criticality accident scenarios. These limits are the minimum required concentration for fuel assembly storage. The criticality analysis performed shows that the acceptance criteria for criticality is met for the storage of fuel assemblies with soluble boron credit, reduced credit for the Boraflex panels and the storage configurations and enrichment limits Specified by LCO 3.7.15. The storage configuration requirements specified by LCO 3.7.15 establish four regions within the spent fuel pool storage racks. Figure 16.9-1 illustrates the four regions for the Unit 1 spent fuel pool and Figure 16.9-2 illustrates the four regions for the Unit 2 pool. The limits specified are not applicable if a storage cell location does not contain a fuel assembly.

The remedial actions associated with this SLC are designed to ensure that an unplanned criticality event cannot occur as a result of degraded boraflex conditions. Remedial Action a.1. verifies the Spent Fuel Pool boron concentration to be within Technical Specification 3.7.14 limits. These limits are based on the cycle-specific Core Operating Limits Requirements (COLR) document. The COLR Spent Fuel Pool boron concentration cannot be less than 2475 ppm soluble boron for any specific cycle. This is the initial boron concentration used in the Spent Fuel Pool boron dilution analysis. If SR 3.7.14.1 indicates boron concentrations less than the acceptable level, the associated remedial actions are to immediately suspend movement of fuel assemblies in the pool area and to immediately initiate boron additions to raise the boron concentration to acceptable levels. Remedial Action a.2. determines if the assembly can be qualified for storage in Region 1B or Region 2B. If the assembly can be stored in one of these regions, then it will not have to be moved and the Remedial Actions can be immediately exited.

If Remedial Action a.2. cannot be met, then action is to be initiated immediately to move the affected assembly to an acceptable location. There may be circumstances that will prevent the movement of the affected assembly in a reasonable time period. For example, if the pool is nearly full, there may not be enough spaces available to meet the required storage configurations of LCO 3.7.15. In this case, it is acceptable to continue Remedial Action a.1. until the affected fuel assembly can be moved to an acceptable location. The daily verification of boron concentration per SR 3.7.14.1 ensures the assumptions used in the associated criticality analyses are maintained. There is a large amount of margin between the COLR boron concentration and the boron concentration needed to maintain subcritical conditions in the Spent Fuel Pool. Daily verifications are considered to be adequate to ensure that no dilution evolution could go undetected for an extended period resulting in boron concentrations less than the minimum amounts necessary for maintaining subcritical conditions.

The testing requirements will verify that the Boron 10 areal density is within acceptable limits. The preferred method for verifying the Boron 10 areal density would be in-situ testing at least every three years. Testing may be performed more frequently based on engineering judgment, spent fuel pool water chemistry, and modeling projections of boraflex degradation.

FIGURE 16.9.24-1

UNIT 1 SPENT FUEL POOL SUB-REGION MAP

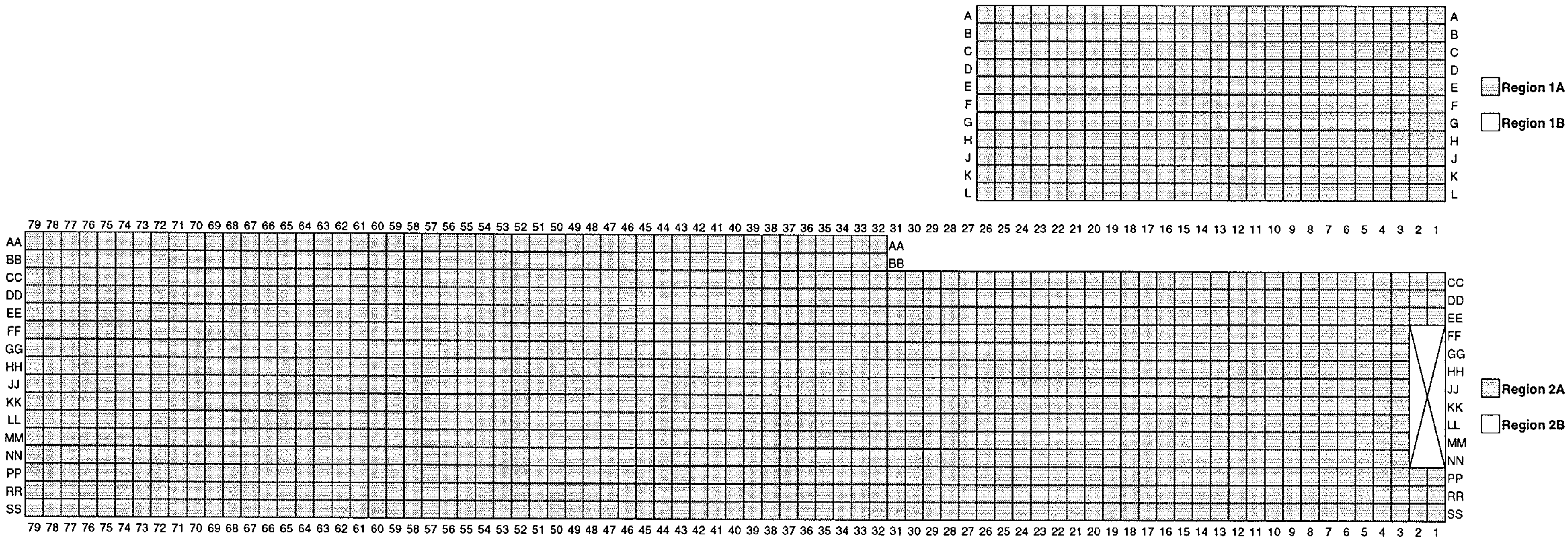
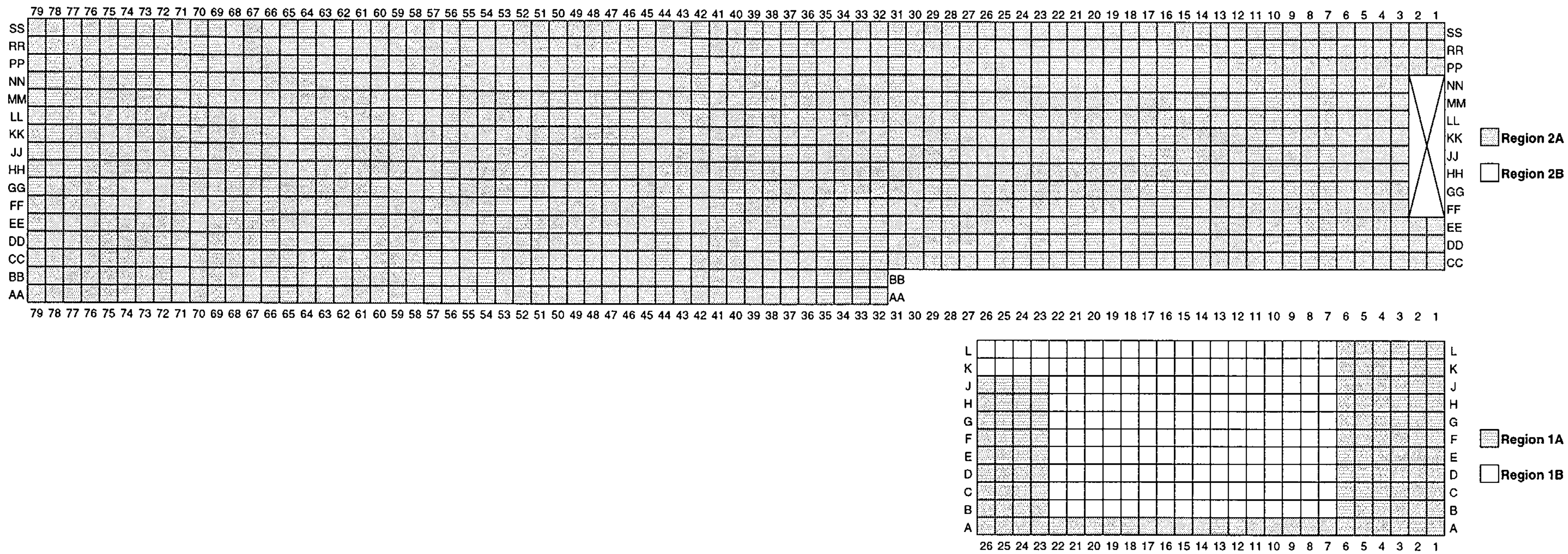


FIGURE 16.9.24-2

UNIT 2 SPENT FUEL POOL SUB-REGION MAP



REFERENCES:

1. UFSAR, Section 9.1.2.
2. Issuance of Amendments, McGuire Nuclear Station, Units 1 and 2 (TAC NOS. M89744 and M89745), November 6, 1995.
3. Double contingency principle of ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).
4. UFSAR, Section 15.7.4.
5. 10 CFR 50.36, Technical Specifications, (c)(2)(ii).
6. NRC Generic Letter 96-04: Boraflex Degradation in Spent Fuel Pool Storage Racks, June 26, 1996
7. WCAP-14416-NP-A, Westinghouse Spent Fuel Rack Criticality Analysis Methodology, Revision 1, November 1996

ATTACHMENT 10

MCGUIRE NUCLEAR STATION
PROPOSED REVISIONS TO TECHNICAL SPECIFICATION BASES

ENTIRE 3.7.14 BASES TO BE REPLACED WITH FOLLOWING PAGES.

B 3.7 PLANT SYSTEMS

B 3.7.14 Spent Fuel Pool Boron Concentration

BASES

BACKGROUND

In the two region poison fuel storage rack (Refs. 1 and 2) design, the spent fuel pool is divided into two separate and distinct regions which, for the purpose of criticality considerations, are considered as separate pools. Region 1, with 286 storage positions, is designed to accommodate new fuel with a maximum nominal enrichment of 4.75 wt% U-235 (maximum tolerance of ± 0.05 wt%), which have accumulated minimum burnup greater than or equal to the minimum qualified burnups in Table 3.7.15-1. Fuel assemblies not meeting the criteria of Table 3.7.15-1 shall be stored in accordance with Figures 3.7.15-1 through 3.7.15-3. Region 2, with 1177 storage positions, is designed to accommodate fuel of various initial enrichments which have accumulated minimum burnups in accordance with the accompanying LCO.

The water in the spent fuel pool normally contains soluble boron, which results in large subcriticality margins under actual operating conditions. However, the NRC guidelines, based upon the accident condition in which all soluble poison is assumed to have been lost, specify that the limiting k_{eff} of 0.95 be evaluated in the absence of soluble boron. Hence, the design of the spent fuel storage racks is based on the use of unborated water, which maintains each region in a subcritical condition during normal operation with the spent fuel pool fully loaded. The double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 3) allows credit for soluble boron under other abnormal or accident conditions, since only a single accident need be considered at one time. For example, the most severe accident scenario is associated with the movement of fuel from Region 1 to Region 2, and accidental misloading of a fuel assembly in Region 1 or Region 2. This could potentially increase the reactivity of the spent fuel pool. To mitigate these postulated criticality related accidents, boron is dissolved in the pool water. Safe operation of the two region poison fuel storage rack with no movement of assemblies may therefore be achieved by controlling the location of each assembly in accordance with LCO 3.7.15, "Spent Fuel Assembly Storage." Prior to movement of an assembly, it is necessary to perform SR 3.7.14.1.

APPLICABLE SAFETY ANALYSES

Most accident conditions do not result in an increase in the reactivity of either of the two regions. Examples of these accident conditions are the loss of cooling (reactivity increase with decreasing water density) and the

ENTIRE 3.7.14 BASES TO BE REPLACED WITH FOLLOWING PAGES.

APPLICABLE SAFETY ANALYSES (continued)

dropping of a fuel assembly on the top of the rack. However, accidents can be postulated that could increase the reactivity. This increase in reactivity is unacceptable with unborated water in the storage pool. Thus, for these accident occurrences, the presence of soluble boron in the storage pool prevents criticality in both regions. The postulated accidents are basically of two types. A fuel assembly could be incorrectly transferred from Region 1 to Region 2 (e.g., an unirradiated fuel assembly or an insufficiently depleted fuel assembly). The second type of postulated accidents is associated with a fuel assembly which is dropped adjacent to the fully loaded Region 2 storage rack. This could have a small positive reactivity effect on Region 2. However, the negative reactivity effect of the soluble boron compensates for the increased reactivity caused by either one of the two postulated accident scenarios. The accident analyses is provided in the UFSAR, Section 15.7.4 (Ref. 4).

The concentration of dissolved boron in the spent fuel pool satisfies Criterion 2 of 10 CFR 50.36 (Ref. 5).

LCO

The spent fuel pool boron concentration is required to be within the limits specified in the COLR. The specified concentration of dissolved boron in the spent fuel pool preserves the assumptions used in the analyses of the potential critical accident scenarios as described in Reference 4. This concentration of dissolved boron is the minimum required concentration for fuel assembly storage and movement within the spent fuel pool.

APPLICABILITY

This LCO applies whenever fuel assemblies are stored in the spent fuel pool.

ACTIONS

A.1 and A.2

The Required Actions are modified by a Note indicating that LCO 3.0.3 does not apply.

When the concentration of boron in the fuel storage pool is less than required, immediate action must be taken to preclude the occurrence of an accident or to mitigate the consequences of an accident in progress. This is most efficiently achieved by immediately suspending the movement of fuel assemblies. The concentration of boron is restored simultaneously with suspending movement of fuel assemblies. If the LCO is not met while moving irradiated fuel assemblies in MODE 5

BASES

ACTIONS (continued)

or 6, LCO 3.0.3 would not be applicable. If moving irradiated fuel assemblies while in MODE 1, 2, 3, or 4, the fuel movement is independent of reactor operation. Therefore, inability to suspend movement of fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.7.14.1

This SR verifies that the concentration of boron in the spent fuel pool is within the required limit. As long as this SR is met, the analyzed accidents are fully addressed. The 7 day Frequency is appropriate because no major replenishment of pool water is expected to take place over such a short period of time.

REFERENCES

1. UFSAR, Section 9.1.2.
2. Issuance of Amendments, McGuire Nuclear Station, Units 1 and 2 (TAC NOS. M89744 and M89745), November 6, 1995.
3. Double contingency principle of ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).
4. UFSAR, Section 15.7.4.
5. 10 CFR 50.36, Technical Specifications, (c)(2)(ii).

ENTIRE 3.7.14 BASES TO BE REPLACED WITH FOLLOWING PAGES.

NEW 3.7.14 BASES

B 3.7 PLANT SYSTEMS

B 3.7.14 Spent Fuel Pool Boron Concentration

BASES

BACKGROUND

In the two region poison fuel storage rack (Refs. 1 and 2) design, the spent fuel pool is divided into two separate and distinct regions. Region 1, with 286 storage positions, is designed and generally reserved for temporary storage of new or partially irradiated fuel. Region 2, with 1177 storage positions, is designed and generally used for normal, long term storage of permanently discharged fuel that has achieved qualifying burnup levels.

The McGuire spent fuel storage racks contain Boraflex neutron-absorbing panels that surround each storage cell on all four sides (except for peripheral sides). The function of these Boraflex panels is to ensure that the reactivity of the stored fuel assemblies is maintained within required limits. Boraflex, as manufactured, is a silicon rubber material that retains a powder of boron carbide (B4C) neutron absorbing material. The Boraflex panels are enclosed in a formed stainless steel wrapper sheet that is spot-welded to the storage tube. The wrapper sheet is bent at each end to complete the enclosure of the Boraflex panel. The Boraflex panel is contained in the plenum area between the storage tube and the wrapper plate. Since the wrapper plate enclosure is not sealed, spent fuel pool water is free to circulate through the plenum. It has been observed that after Boraflex receives a high gamma dose from the stored irradiated fuel ($>10^{10}$ rads) it can begin to degrade and dissolve in the wet environment. Thus, the B4C poison material can be removed, thereby reducing the poison worth of the Boraflex sheets. This phenomenon is documented in NRC Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks".

To address this degradation, each region of the spent fuel pool has been divided into two sub-regions; with and without credit for Boraflex. For the regions taking credit for Boraflex, a minimum amount of Boraflex was assumed that is less than the original design minimum B_{10} areal density.

The McGuire spent fuel storage racks have been analyzed taking credit for soluble boron as allowed in Reference 3. The methodology ensures that the spent fuel rack multiplication factor, k_{eff}, is less than or equal to 0.95 as recommended in ANSI/ANS-57.2-1983 (Ref. 4) and NRC guidance (Ref. 5). The spent fuel storage racks are analyzed to allow storage of fuel assemblies with enrichments up to a maximum nominal enrichment of 4.75 weight percent Uranium-235 while maintaining $k_{eff} \leq$

BASES

BACKGROUND (continued)

0.95 including uncertainties, tolerances, bias, and credit for soluble boron. Soluble boron credit is used to offset uncertainties, tolerances, and off-normal conditions and to provide subcritical margin such that the spent fuel pool k_{eff} is maintained less than or equal to 0.95. The soluble boron concentration required to maintain k_{eff} less than or equal to 0.95 under normal conditions is 730 ppm. In addition, sub-criticality of the pool ($k_{eff} < 1.0$) is assured on a 95/95 basis, without the presence of the soluble boron in the pool. The criticality analysis performed shows that the acceptance criteria for criticality is met for the storage of fuel assemblies when credit is taken for reactivity depletion due to fuel burnup, the presence of Integral Fuel Burnable Absorber (IFBA) rods, reduced credit for the Boraflex neutron absorber panels and storage configurations and enrichment limits Specified by LCO 3.7.15.

APPLICABLE SAFETY ANALYSES

Most accident conditions do not result in an increase in reactivity of the racks in the spent fuel pool. Examples of these accident conditions are the drop of a fuel assembly on top of a rack, the drop of a fuel assembly between rack modules (rack design precludes this condition), and the drop of a fuel assembly between rack modules and the pool wall. However, three accidents can be postulated which could result in an increase in reactivity in the spent fuel storage pools. The first is a drop or placement of a fuel assembly into the cask loading area. The second is a significant change in the spent fuel pool water temperature (either the loss of normal cooling to the spent fuel pool water which causes an increase in the pool water temperature or a large makeup to the pool with cold water which causes a decrease in the pool water temperature) and the third is the misloading of a fuel assembly into a location which the restrictions on location, enrichment, burnup and number of IFBA rods is not satisfied.

For an occurrence of these postulated accidents, the double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 6) can be applied. This states that one is not required to assume two unlikely, independent, concurrent events to ensure protection against a criticality accident. Thus, for these postulated accident conditions, the presence of additional soluble boron in the spent fuel pool water (above the 730 ppm required to maintain k_{eff} less than or equal to 0.95 under normal conditions) can be assumed as a realistic initial condition since not assuming its presence would be a second unlikely event.

Calculations were performed to determine the amount of soluble boron required to offset the highest reactivity increase caused by either of

BASES

APPLICABLE SAFETY ANALYSES (continued)

these postulated accidents and to maintain k_{eff} less than or equal to 0.95. It was found that a spent fuel pool boron concentration of 1470 ppm was adequate to mitigate these postulated criticality related accidents and to maintain k_{eff} less than or equal to 0.95. Specification 3.7.14 ensures the spent fuel pool contains adequate dissolved boron to compensate for the increased reactivity caused by these postulated accidents.

Specification 4.3.1.1 c. requires that the spent fuel rack k_{eff} be less than or equal to 0.95 when flooded with water borated to 730 ppm. A spent fuel pool boron dilution analysis was performed which confirmed that sufficient time is available to detect and mitigate a dilution of the spent fuel pool before the 0.95 k_{eff} design basis is exceeded. The spent fuel pool boron dilution analysis concluded that an unplanned or inadvertent event which could result in the dilution of the spent fuel pool boron concentration to 730 ppm is not a credible event.

The concentration of dissolved boron in the spent fuel pool satisfies Criterion 2 of 10 CFR 50.36 (Ref. 5).

LCO

The spent fuel pool boron concentration is required to be within the limits specified in the COLR. The specified concentration of dissolved boron in the spent fuel pool preserves the assumptions used in the analyses of the potential criticality accident scenarios as described in Reference 4. This concentration of dissolved boron is the minimum required concentration for fuel assembly storage and movement within the spent fuel pool.

APPLICABILITY

This LCO applies whenever fuel assemblies are stored in the spent fuel pool.

ACTIONS

A.1 and A.2

The Required Actions are modified by a Note indicating that LCO 3.0.3 does not apply.

When the concentration of boron in the fuel storage pool is less than required, immediate action must be taken to preclude the occurrence of an accident or to mitigate the consequences of an accident in progress. This is most efficiently achieved by immediately suspending the movement of fuel assemblies. The concentration of boron is restored simultaneously with suspending movement of fuel assemblies.

BASES

ACTIONS (continued)

If the LCO is not met while moving irradiated fuel assemblies in MODE 5 or 6, LCO 3.0.3 would not be applicable. If moving irradiated fuel assemblies while in MODE 1, 2, 3, or 4, the fuel movement is independent of reactor operation. Therefore, inability to suspend movement of fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.7.14.1

This SR verifies that the concentration of boron in the spent fuel pool is within the required limit. As long as this SR is met, the analyzed accidents are fully addressed. The 7 day Frequency is appropriate because no major replenishment of pool water is expected to take place over such a short period of time.

REFERENCES

1. UFSAR, Section 9.1.2.
2. Issuance of Amendments, McGuire Nuclear Station, Units 1 and 2 (TAC NOS. M89744 and M89745), November 6, 1995.
3. WCAP-14416-NP-A, Westinghouse Spent Fuel Rack Criticality Analysis Methodology, Revision 1, November 1996.
4. American Nuclear Society, "American National Standard Design Requirements for Light Water Reactor Fuel Storage Facilities at Nuclear Power Plants," ANSI/ANS-57.2-1983, October 7, 1983.
5. Nuclear Regulatory Commission, Memorandum to Timothy Collins from Laurence Kopp, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light Water Reactor Power Plants," August 19, 1998.
6. Double contingency principle of ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).
7. 10 CFR 50.36, Technical Specifications, (c)(2)(ii).
8. UFSAR, Section 15.7.4.

ENTIRE 3.7.15 BASES TO BE REPLACED WITH FOLLOWING PAGES.

B 3.7 PLANT SYSTEMS

B 3.7.15 Spent Fuel Assembly Storage

BASES

BACKGROUND

In the two region poison fuel storage rack (Refs. 1 and 2) design, the spent fuel pool is divided into two separate and distinct regions which, for the purpose of criticality considerations, are considered as separate pools. Region 1, with 286 storage positions, is designed to accommodate new fuel with a maximum nominal enrichment of 4.75 wt% U-235 (maximum tolerance of ± 0.05 wt%), which have accumulated minimum burnup greater than or equal to the minimum qualified burnups in Table 3.7.15-1. Fuel assemblies not meeting the criteria of Table 3.7.15-1 shall be stored in accordance with Figures 3.7.15-1 through 3.7.15-3. Region 2, with 1177 storage positions, is designed to accommodate fuel of various initial enrichments which have accumulated minimum burnups in accordance with the accompanying LCO.

The water in the spent fuel pool normally contains soluble boron, which results in large subcriticality margins under actual operating conditions. However, the NRC guidelines, based upon the accident condition in which all soluble poison is assumed to have been lost, specify that the limiting k_{eff} of 0.95 be evaluated in the absence of soluble boron. Hence, the design of the spent fuel storage racks is based on the use of unborated water, which maintains each region in a subcritical condition during normal operation with the spent fuel pool fully loaded. The double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 3) allows credit for soluble boron under other abnormal or accident conditions, since only a single accident need be considered at one time. For example, the most severe accident scenario is associated with the movement of fuel from Region 1 to Region 2, and accidental misloading of a fuel assembly in Region 1 or Region 2. This could potentially increase the reactivity of the spent fuel pool. To mitigate these postulated criticality related accidents, boron is dissolved in the pool water. Safe operation of the two region poison fuel storage rack with no movement of assemblies may therefore be achieved by controlling the location of each assembly in accordance with the accompanying LCO. Prior to movement of an assembly, it is necessary to perform SR 3.7.14.1.

APPLICABLE SAFETY ANALYSES

The hypothetical accidents can only take place during or as a result of the movement of an assembly (Ref. 4). For these accident occurrences, the presence of soluble boron in the spent fuel pool (controlled by LCO 3.7.14, "Spent Fuel Pool Boron Concentration") prevents criticality in

BASES

ENTIRE 3.7.15 BASES TO BE ~~REPLACED WITH FOLLOWING~~ PAGES.

APPLICABLE SAFETY ANALYSES (continued)

both regions. By closely controlling the movement of each assembly and by checking the location of each assembly after movement, the time period for potential accidents may be limited to a small fraction of the total operating time. During the remaining time period with no potential for accidents, the operation may be under the auspices of the accompanying LCO.

The configuration of fuel assemblies in the spent fuel pool satisfies Criterion 2 of 10 CFR 50.36 (Ref. 5).

LCO

The restrictions on the placement of fuel assemblies within the spent fuel pool, in accordance with Tables 3.7.15-1 and 3.7.15-3, in the accompanying LCO, ensures the k_{eff} of the spent fuel pool will always remain < 0.95, assuming the pool to be flooded with unborated water. Fuel assemblies not meeting the criteria of Tables 3.7.15-1 and 3.7.15-3 shall be stored in accordance with Figures 3.7.15-1, 3.7.15-2 and 3.7.15-3, and Tables 3.7.15-2 and 3.7.15-4.

APPLICABILITY

This LCO applies whenever any fuel assembly is stored in the spent fuel pool.

ACTIONS

A.1

Required Action A.1 is modified by a Note indicating that LCO 3.0.3 does not apply.

When the configuration of fuel assemblies stored in the spent fuel pool is not in accordance with the LCO, the immediate action is to initiate action to make the necessary fuel assembly movement(s) to bring the configuration into compliance.

If unable to move irradiated fuel assemblies while in MODE 5 or 6, LCO 3.0.3 would not be applicable. If unable to move irradiated fuel assemblies while in MODE 1, 2, 3, or 4, the action is independent of reactor operation. Therefore, inability to move fuel assemblies is not sufficient reason to require a reactor shutdown.

BASES

ENTIRE 3.7.15 BASES TO BE REPLACED WITH FOLLOWING PAGES.

SURVEILLANCE REQUIREMENTS

SR 3.7.15.1

This SR verifies by administrative means that the initial enrichment and burnup of the fuel assembly is in accordance with the configurations specified in the accompanying LCO.

REFERENCES

1. UFSAR, Section 9.1.2.
2. Issuance of Amendments, McGuire Nuclear Station, Units 1 and 2 (TAC NOS. M89744 and M89745), November 6, 1995.
3. Double contingency principle of ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).
4. UFSAR, Section 15.7.4.
5. 10 CFR 50.36, Technical Specifications, (c)(2)(ii).

NEW 3.7.15 BASES

B 3.7 PLANT SYSTEMS

B 3.7.15 Spent Fuel Assembly Storage

BASES

BACKGROUND

In the two region poison fuel storage rack (Refs. 1 and 2) design, the spent fuel pool is divided into two separate and distinct regions. Region 1, with 286 storage positions, is designed and generally reserved for temporary storage of new or partially irradiated fuel. Region 2, with 1177 storage positions, is designed and generally used for normal, long term storage of permanently discharged fuel that has achieved qualifying burnup levels.

The McGuire spent fuel storage racks contain Boraflex neutron-absorbing panels that surround each storage cell on all four sides (except for peripheral sides). The function of these Boraflex panels is to ensure that the reactivity of the stored fuel assemblies is maintained within required limits. Boraflex, as manufactured, is a silicon rubber material that retains a powder of boron carbide (B4C) neutron absorbing material. The Boraflex panels are enclosed in a formed stainless steel wrapper sheet that is spot-welded to the storage tube. The wrapper sheet is bent at each end to complete the enclosure of the Boraflex panel. The Boraflex panel is contained in the plenum area between the storage tube and the wrapper plate. Since the wrapper plate enclosure is not sealed, spent fuel pool water is free to circulate through the plenum. It has been observed that after Boraflex receives a high gamma dose from the stored irradiated fuel (>10^{10} rads) it can begin to degrade and dissolve in the wet environment. Thus, the B4C poison material can be removed, thereby reducing the poison worth of the Boraflex sheets. This phenomenon is documented in NRC Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks".

To address this degradation, each region of the spent fuel pool has been divided into two sub-regions; with and without credit for Boraflex. For the regions taking credit for Boraflex, a minimum amount of Boraflex was assumed that is less than the original design minimum B10 areal density.
To address this degradation, each region of the spent fuel pool has been divided into two sub-regions; with and without credit for Boraflex. For the regions taking credit for Boraflex, a minimum amount of Boraflex was assumed that is less than the original design minimum B10 areal density.

Two storage configurations are defined for each region; Unrestricted and Restricted storage. Unrestricted storage allows storage in all cells without restriction on the storage configuration. Restricted storage allows storage of higher reactivity fuel when restricted to a certain storage

NEW 3.7.15 BASES

BASES

BACKGROUND (continued)

configuration with lower reactivity fuel. A third loading pattern, Checkerboard storage, was defined for Regions 1B, 2A and 2B. Checkerboard storage allows storage of the highest reactivity fuel in each region when checkerboarded with empty storage cells.

The McGuire spent fuel storage racks have been analyzed taking credit for soluble boron as allowed in Reference 3. The methodology ensures that the spent fuel rack multiplication factor, k_{eff}, is less than or equal to 0.95 as recommended in ANSI/ANS-57.2-1983 (Ref. 4) and NRC guidance (Ref. 5). The spent fuel storage racks are analyzed to allow storage of fuel assemblies with enrichments up to a maximum nominal enrichment of 4.75 weight percent Uranium-235 while maintaining $k_{eff} \leq$ 0.95 including uncertainties, tolerances, bias, and credit for soluble boron. Soluble boron credit is used to offset uncertainties, tolerances, and off-normal conditions and to provide subcritical margin such that the spent fuel pool k_{eff} is maintained less than or equal to 0.95. The soluble boron concentration required to maintain k_{eff} less than or equal to 0.95 under normal conditions is 730 ppm. In addition, sub-criticality of the pool (k_{eff} < 1.0) is assured on a 95/95 basis, without the presence of the soluble boron in the pool. The criticality analysis performed shows that the acceptance criteria for criticality is met for the storage of fuel assemblies when credit is taken for reactivity depletion due to fuel burnup, the presence of Integral Fuel Burnable Absorber (IFBA) rods, reduced credit for the Boraflex neutron absorber panels and storage configurations and enrichment limits Specified by LCO 3.7.15.

APPLICABLE SAFETY ANALYSES

Most accident conditions do not result in an increase in reactivity of the racks in the spent fuel pool. Examples of these accident conditions are the drop of a fuel assembly on top of a rack, the drop of a fuel assembly between rack modules (rack design precludes this condition), and the drop of a fuel assembly between rack modules and the pool wall. However, three accidents can be postulated which could result in an increase in reactivity in the spent fuel storage pools. The first is a drop or placement of a fuel assembly into the cask loading area. The second is a significant change in the spent fuel pool water temperature (either the loss of normal cooling to the spent fuel pool water which causes an increase in the pool water temperature or a large makeup to the pool with cold water which causes a decrease in the pool water temperature) and the third is the misloading of a fuel assembly into a location which the restrictions on location, enrichment, burnup and number of IFBA rods is not satisfied.

For an occurrence of these postulated accidents, the double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter

NEW 3.7.15 BASES

BASES

APPLICABLE SAFETY ANALYSES (continued)

(Ref. 6) can be applied. This states that one is not required to assume two unlikely, independent, concurrent events to ensure protection against a criticality accident. Thus, for these postulated accident conditions, the presence of additional soluble boron in the spent fuel pool water (above the 730 ppm required to maintain k_{eff} less than or equal to 0.95 under normal conditions) can be assumed as a realistic initial condition since not assuming its presence would be a second unlikely event.

Calculations were performed to determine the amount of soluble boron required to offset the highest reactivity increase caused by either of these postulated accidents and to maintain k_{eff} less than or equal to 0.95. It was found that a spent fuel pool boron concentration of 1470 ppm was adequate to mitigate these postulated criticality related accidents and to maintain k_{eff} less than or equal to 0.95. Specification 3.7.14 ensures the spent fuel pool contains adequate dissolved boron to compensate for the increased reactivity caused by these postulated accidents.

Specification 4.3.1.1 c. requires that the spent fuel rack k_{eff} be less than or equal to 0.95 when flooded with water borated to 730 ppm. A spent fuel pool boron dilution analysis was performed which confirmed that sufficient time is available to detect and mitigate a dilution of the spent fuel pool before the 0.95 k_{eff} design basis is exceeded. The spent fuel pool boron dilution analysis concluded that an unplanned or inadvertent event which could result in the dilution of the spent fuel pool boron concentration to 730 ppm is not a credible event.

The configuration of fuel assemblies in the spent fuel pool satisfies Criterion 2 of 10 CFR 50.36 (Ref. 7).

LCO

a

The restrictions on the placement of fuel assemblies within the Region 1A of the spent fuel pool, which have a number of IFBA rods greater than or equal to the minimum qualifying number of IFBA rods in Table 3.7.15-1 or accumulated burnup greater than or equal to the minimum qualified burnups in Table 3.7.15-2 in the accompanying LCO, ensures the k_{eff} of the spent fuel pool will always remain $\leq$ 0.95, assuming the pool to be flooded with water borated to 730 ppm. Fuel assemblies not meeting the criteria of Tables 3.7.15-1 or 3.7.15-2 shall be stored in accordance with Figure 3.7.15-1.

BASES

NEW 3.7.15 BASES

LCO (continued)

b

The restrictions on the placement of fuel assemblies within the Region 1B of the spent fuel pool, which have accumulated burnup greater than or equal to the minimum qualified burnups in Table 3.7.15-4 in the accompanying LCO, ensures the k_{eff} of the spent fuel pool will always remain $\leq$ 0.95, assuming the pool to be flooded with water borated to 730 ppm. Fuel assemblies not meeting the criteria of Table 3.7.15-4 shall be stored in accordance with either Figure 3.7.15-2 and Table 3.7.15-5 for Restricted storage, or Figure 3.7.15-3 for Checkerboard storage.

c

The restrictions on the placement of fuel assemblies within the Region 2A of the spent fuel pool, which have accumulated burnup greater than or equal to the minimum qualified burnups in Table 3.7.15-7 in the accompanying LCO, ensures the k_{eff} of the spent fuel pool will always remain $\leq$ 0.95, assuming the pool to be flooded with water borated to 730 ppm. Fuel assemblies not meeting the criteria of Table 3.7.15-7 shall be stored in accordance with either Figure 3.7.15-4 and Table 3.7.15-8 for Restricted storage, or Figure 3.7.15-5 for Checkerboard storage.

d

The restrictions on the placement of fuel assemblies within the Region 2B of the spent fuel pool, which have accumulated burnup greater than or equal to the minimum qualified burnups in Table 3.7.15-10 in the accompanying LCO, ensures the k_{eff} of the spent fuel pool will always remain $\leq$ 0.95, assuming the pool to be flooded with water borated to 730 ppm. Fuel assemblies not meeting the criteria of Table 3.7.15-10 shall be stored in accordance with either Figure 3.7.15-6 and Table 3.7.15-11 for Restricted storage, or Figure 3.7.15-7 for Checkerboard storage.

APPLICABILITY

This LCO applies whenever any fuel assembly is stored in the spent fuel pool.

ACTIONS

A.1

Required Action A.1 is modified by a Note indicating that LCO 3.0.3 does not apply.

When the configuration of fuel assemblies stored in the spent fuel pool is not in accordance with the LCO, the immediate action is to initiate action

NEW 3.7.15 BASES

BASES

LCO (continued)

to make the necessary fuel assembly movement(s) to bring the configuration into compliance.

If unable to move irradiated fuel assemblies while in MODE 5 or 6, LCO 3.0.3 would not be applicable. If unable to move irradiated fuel assemblies while in MODE 1, 2, 3, or 4, the action is independent of reactor operation. Therefore, inability to move fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.7.15.1

This SR verifies by administrative means that the fuel assembly is in accordance with the configurations specified in the accompanying LCO.

REFERENCES

1. UFSAR, Section 9.1.2.

2. Issuance of Amendments, McGuire Nuclear Station, Units 1 and 2 (TAC NOS. M89744 and M89745), November 6, 1995.

3. WCAP-14416-NP-A, Westinghouse Spent Fuel Rack Criticality Analysis Methodology, Revision 1, November 1996.

4. American Nuclear Society, “American National Standard Design Requirements for Light Water Reactor Fuel Storage Facilities at Nuclear Power Plants,” ANSI/ANS-57.2-1983, October 7, 1983.

5. Nuclear Regulatory Commission, Memorandum to Timothy Collins from Laurence Kopp, “Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light Water Reactor Power Plants,” August 19, 1998.

6. Double contingency principle of ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).

7. 10 CFR 50.36, Technical Specifications, (c)(2)(ii).

ATTACHMENT 11

REVISED MCGUIRE NUCLEAR STATION TECHNICAL SPECIFICATION BASES

B 3.7 PLANT SYSTEMS

B 3.7.14 Spent Fuel Pool Boron Concentration

BASES

BACKGROUND

In the two region poison fuel storage rack (Refs. 1 and 2) design, the spent fuel pool is divided into two separate and distinct regions. Region 1, with 286 storage positions, is designed and generally reserved for temporary storage of new or partially irradiated fuel. Region 2, with 1177 storage positions, is designed and generally used for normal, long term storage of permanently discharged fuel that has achieved qualifying burnup levels.

The McGuire spent fuel storage racks contain Boraflex neutron-absorbing panels that surround each storage cell on all four sides (except for peripheral sides). The function of these Boraflex panels is to ensure that the reactivity of the stored fuel assemblies is maintained within required limits. Boraflex, as manufactured, is a silicon rubber material that retains a powder of boron carbide (B4C) neutron absorbing material. The Boraflex panels are enclosed in a formed stainless steel wrapper sheet that is spot-welded to the storage tube. The wrapper sheet is bent at each end to complete the enclosure of the Boraflex panel. The Boraflex panel is contained in the plenum area between the storage tube and the wrapper plate. Since the wrapper plate enclosure is not sealed, spent fuel pool water is free to circulate through the plenum. It has been observed that after Boraflex receives a high gamma dose from the stored irradiated fuel ($>10^{10}$ rads) it can begin to degrade and dissolve in the wet environment. Thus, the B4C poison material can be removed, thereby reducing the poison worth of the Boraflex sheets. This phenomenon is documented in NRC Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks".

To address this degradation, each region of the spent fuel pool has been divided into two sub-regions; with and without credit for Boraflex. For the regions taking credit for Boraflex, a minimum amount of Boraflex was assumed that is less than the original design minimum B_{10} areal density.

The McGuire spent fuel storage racks have been analyzed taking credit for soluble boron as allowed in Reference 3. The methodology ensures that the spent fuel rack multiplication factor, k_{eff}, is less than or equal to 0.95 as recommended in ANSI/ANS-57.2-1983 (Ref. 4) and NRC guidance (Ref. 5). The spent fuel storage racks are analyzed to allow storage of fuel assemblies with enrichments up to a maximum nominal enrichment of 4.75 weight percent Uranium-235 while maintaining $k_{eff} \leq$

BASES

BACKGROUND (continued)

0.95 including uncertainties, tolerances, bias, and credit for soluble boron. Soluble boron credit is used to offset uncertainties, tolerances, and off-normal conditions and to provide subcritical margin such that the spent fuel pool k_{eff} is maintained less than or equal to 0.95. The soluble boron concentration required to maintain k_{eff} less than or equal to 0.95 under normal conditions is 730 ppm. In addition, sub-criticality of the pool (k_{eff} < 1.0) is assured on a 95/95 basis, without the presence of the soluble boron in the pool. The criticality analysis performed shows that the acceptance criteria for criticality is met for the storage of fuel assemblies when credit is taken for reactivity depletion due to fuel burnup, the presence of Integral Fuel Burnable Absorber (IFBA) rods, reduced credit for the Boraflex neutron absorber panels and storage configurations and enrichment limits Specified by LCO 3.7.15.

APPLICABLE SAFETY ANALYSES

Most accident conditions do not result in an increase in reactivity of the racks in the spent fuel pool. Examples of these accident conditions are the drop of a fuel assembly on top of a rack, the drop of a fuel assembly between rack modules (rack design precludes this condition), and the drop of a fuel assembly between rack modules and the pool wall. However, three accidents can be postulated which could result in an increase in reactivity in the spent fuel storage pools. The first is a drop or placement of a fuel assembly into the cask loading area. The second is a significant change in the spent fuel pool water temperature (either the loss of normal cooling to the spent fuel pool water which causes an increase in the pool water temperature or a large makeup to the pool with cold water which causes a decrease in the pool water temperature) and the third is the misloading of a fuel assembly into a location which the restrictions on location, enrichment, burnup and number of IFBA rods is not satisfied.

For an occurrence of these postulated accidents, the double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter (Ref. 6) can be applied. This states that one is not required to assume two unlikely, independent, concurrent events to ensure protection against a criticality accident. Thus, for these postulated accident conditions, the presence of additional soluble boron in the spent fuel pool water (above the 730 ppm required to maintain k_{eff} less than or equal to 0.95 under normal conditions) can be assumed as a realistic initial condition since not assuming its presence would be a second unlikely event.

Calculations were performed to determine the amount of soluble boron required to offset the highest reactivity increase caused by either of

BASES

APPLICABLE SAFETY ANALYSES (continued)

these postulated accidents and to maintain k_{eff} less than or equal to 0.95. It was found that a spent fuel pool boron concentration of 1470 ppm was adequate to mitigate these postulated criticality related accidents and to maintain k_{eff} less than or equal to 0.95. Specification 3.7.14 ensures the spent fuel pool contains adequate dissolved boron to compensate for the increased reactivity caused by these postulated accidents.

Specification 4.3.1.1 c. requires that the spent fuel rack k_{eff} be less than or equal to 0.95 when flooded with water borated to 730 ppm. A spent fuel pool boron dilution analysis was performed which confirmed that sufficient time is available to detect and mitigate a dilution of the spent fuel pool before the 0.95 k_{eff} design basis is exceeded. The spent fuel pool boron dilution analysis concluded that an unplanned or inadvertent event which could result in the dilution of the spent fuel pool boron concentration to 730 ppm is not a credible event.

The concentration of dissolved boron in the spent fuel pool satisfies Criterion 2 of 10 CFR 50.36 (Ref. 5).

LCO

The spent fuel pool boron concentration is required to be within the limits specified in the COLR. The specified concentration of dissolved boron in the spent fuel pool preserves the assumptions used in the analyses of the potential criticality accident scenarios as described in Reference 4. This concentration of dissolved boron is the minimum required concentration for fuel assembly storage and movement within the spent fuel pool.

APPLICABILITY

This LCO applies whenever fuel assemblies are stored in the spent fuel pool.

ACTIONS

A.1 and A.2

The Required Actions are modified by a Note indicating that LCO 3.0.3 does not apply.

When the concentration of boron in the fuel storage pool is less than required, immediate action must be taken to preclude the occurrence of an accident or to mitigate the consequences of an accident in progress. This is most efficiently achieved by immediately suspending the movement of fuel assemblies. The concentration of boron is restored simultaneously with suspending movement of fuel assemblies.

BASES

ACTIONS (continued)

If the LCO is not met while moving irradiated fuel assemblies in MODE 5 or 6, LCO 3.0.3 would not be applicable. If moving irradiated fuel assemblies while in MODE 1, 2, 3, or 4, the fuel movement is independent of reactor operation. Therefore, inability to suspend movement of fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.7.14.1

This SR verifies that the concentration of boron in the spent fuel pool is within the required limit. As long as this SR is met, the analyzed accidents are fully addressed. The 7 day Frequency is appropriate because no major replenishment of pool water is expected to take place over such a short period of time.

REFERENCES

1. UFSAR, Section 9.1.2.
2. Issuance of Amendments, McGuire Nuclear Station, Units 1 and 2 (TAC NOS. M89744 and M89745), November 6, 1995.
3. WCAP-14416-NP-A, Westinghouse Spent Fuel Rack Criticality Analysis Methodology, Revision 1, November 1996.
4. American Nuclear Society, "American National Standard Design Requirements for Light Water Reactor Fuel Storage Facilities at Nuclear Power Plants," ANSI/ANS-57.2-1983, October 7, 1983.
5. Nuclear Regulatory Commission, Memorandum to Timothy Collins from Laurence Kopp, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light Water Reactor Power Plants," August 19, 1998.
6. Double contingency principle of ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).
7. 10 CFR 50.36, Technical Specifications, (c)(2)(ii).
8. UFSAR, Section 15.7.4.

BASES

B 3.7 PLANT SYSTEMS

B 3.7.15 Spent Fuel Assembly Storage

BASES

BACKGROUND

In the two region poison fuel storage rack (Refs. 1 and 2) design, the spent fuel pool is divided into two separate and distinct regions. Region 1, with 286 storage positions, is designed and generally reserved for temporary storage of new or partially irradiated fuel. Region 2, with 1177 storage positions, is designed and generally used for normal, long term storage of permanently discharged fuel that has achieved qualifying burnup levels.

The McGuire spent fuel storage racks contain Boraflex neutron-absorbing panels that surround each storage cell on all four sides (except for peripheral sides). The function of these Boraflex panels is to ensure that the reactivity of the stored fuel assemblies is maintained within required limits. Boraflex, as manufactured, is a silicon rubber material that retains a powder of boron carbide (B4C) neutron absorbing material. The Boraflex panels are enclosed in a formed stainless steel wrapper sheet that is spot-welded to the storage tube. The wrapper sheet is bent at each end to complete the enclosure of the Boraflex panel. The Boraflex panel is contained in the plenum area between the storage tube and the wrapper plate. Since the wrapper plate enclosure is not sealed, spent fuel pool water is free to circulate through the plenum. It has been observed that after Boraflex receives a high gamma dose from the stored irradiated fuel ($>10^{10}$ rads) it can begin to degrade and dissolve in the wet environment. Thus, the B4C poison material can be removed, thereby reducing the poison worth of the Boraflex sheets. This phenomenon is documented in NRC Generic Letter 96-04, "Boraflex Degradation in Spent Fuel Pool Storage Racks".

To address this degradation, each region of the spent fuel pool has been divided into two sub-regions; with and without credit for Boraflex. For the regions taking credit for Boraflex, a minimum amount of Boraflex was assumed that is less than the original design minimum B10 areal density.
To address this degradation, each region of the spent fuel pool has been divided into two sub-regions; with and without credit for Boraflex. For the regions taking credit for Boraflex, a minimum amount of Boraflex was assumed that is less than the original design minimum B10 areal density.

Two storage configurations are defined for each region; Unrestricted and Restricted storage. Unrestricted storage allows storage in all cells without restriction on the storage configuration. Restricted storage allows storage of higher reactivity fuel when restricted to a certain storage

BASES

BACKGROUND (continued)

configuration with lower reactivity fuel. A third loading pattern, Checkerboard storage, was defined for Regions 1B, 2A and 2B. Checkerboard storage allows storage of the highest reactivity fuel in each region when checkerboarded with empty storage cells.

The McGuire spent fuel storage racks have been analyzed taking credit for soluble boron as allowed in Reference 3. The methodology ensures that the spent fuel rack multiplication factor, k_{eff}, is less than or equal to 0.95 as recommended in ANSI/ANS-57.2-1983 (Ref. 4) and NRC guidance (Ref. 5). The spent fuel storage racks are analyzed to allow storage of fuel assemblies with enrichments up to a maximum nominal enrichment of 4.75 weight percent Uranium-235 while maintaining $k_{eff} \leq$ 0.95 including uncertainties, tolerances, bias, and credit for soluble boron. Soluble boron credit is used to offset uncertainties, tolerances, and off-normal conditions and to provide subcritical margin such that the spent fuel pool k_{eff} is maintained less than or equal to 0.95. The soluble boron concentration required to maintain k_{eff} less than or equal to 0.95 under normal conditions is 730 ppm. In addition, sub-criticality of the pool (k_{eff} < 1.0) is assured on a 95/95 basis, without the presence of the soluble boron in the pool. The criticality analysis performed shows that the acceptance criteria for criticality is met for the storage of fuel assemblies when credit is taken for reactivity depletion due to fuel burnup, the presence of Integral Fuel Burnable Absorber (IFBA) rods, reduced credit for the Boraflex neutron absorber panels and storage configurations and enrichment limits Specified by LCO 3.7.15.

APPLICABLE SAFETY ANALYSES

Most accident conditions do not result in an increase in reactivity of the racks in the spent fuel pool. Examples of these accident conditions are the drop of a fuel assembly on top of a rack, the drop of a fuel assembly between rack modules (rack design precludes this condition), and the drop of a fuel assembly between rack modules and the pool wall. However, three accidents can be postulated which could result in an increase in reactivity in the spent fuel storage pools. The first is a drop or placement of a fuel assembly into the cask loading area. The second is a significant change in the spent fuel pool water temperature (either the loss of normal cooling to the spent fuel pool water which causes an increase in the pool water temperature or a large makeup to the pool with cold water which causes a decrease in the pool water temperature) and the third is the misloading of a fuel assembly into a location which the restrictions on location, enrichment, burnup and number of IFBA rods is not satisfied.

For an occurrence of these postulated accidents, the double contingency principle discussed in ANSI N-16.1-1975 and the April 1978 NRC letter

BASES

APPLICABLE SAFETY ANALYSES (continued)

(Ref. 6) can be applied. This states that one is not required to assume two unlikely, independent, concurrent events to ensure protection against a criticality accident. Thus, for these postulated accident conditions, the presence of additional soluble boron in the spent fuel pool water (above the 730 ppm required to maintain k_{eff} less than or equal to 0.95 under normal conditions) can be assumed as a realistic initial condition since not assuming its presence would be a second unlikely event.

Calculations were performed to determine the amount of soluble boron required to offset the highest reactivity increase caused by either of these postulated accidents and to maintain k_{eff} less than or equal to 0.95. It was found that a spent fuel pool boron concentration of 1470 ppm was adequate to mitigate these postulated criticality related accidents and to maintain k_{eff} less than or equal to 0.95. Specification 3.7.14 ensures the spent fuel pool contains adequate dissolved boron to compensate for the increased reactivity caused by these postulated accidents.

Specification 4.3.1.1 c. requires that the spent fuel rack k_{eff} be less than or equal to 0.95 when flooded with water borated to 730 ppm. A spent fuel pool boron dilution analysis was performed which confirmed that sufficient time is available to detect and mitigate a dilution of the spent fuel pool before the 0.95 k_{eff} design basis is exceeded. The spent fuel pool boron dilution analysis concluded that an unplanned or inadvertent event which could result in the dilution of the spent fuel pool boron concentration to 730 ppm is not a credible event.

The configuration of fuel assemblies in the spent fuel pool satisfies Criterion 2 of 10 CFR 50.36 (Ref. 7).

LCO

a

The restrictions on the placement of fuel assemblies within the Region 1A of the spent fuel pool, which have a number of IFBA rods greater than or equal to the minimum qualifying number of IFBA rods in Table 3.7.15-1 or accumulated burnup greater than or equal to the minimum qualified burnups in Table 3.7.15-2 in the accompanying LCO, ensures the k_{eff} of the spent fuel pool will always remain ≤ 0.95, assuming the pool to be flooded with water borated to 730 ppm. Fuel assemblies not meeting the criteria of Tables 3.7.15-1 or 3.7.15-2 shall be stored in accordance with Figure 3.7.15-1.

BASES

LCO (continued)

b

The restrictions on the placement of fuel assemblies within the Region 1B of the spent fuel pool, which have accumulated burnup greater than or equal to the minimum qualified burnups in Table 3.7.15-4 in the accompanying LCO, ensures the k_{eff} of the spent fuel pool will always remain $\leq$ 0.95, assuming the pool to be flooded with water borated to 730 ppm. Fuel assemblies not meeting the criteria of Table 3.7.15-4 shall be stored in accordance with either Figure 3.7.15-2 and Table 3.7.15-5 for Restricted storage, or Figure 3.7.15-3 for Checkerboard storage.

c

The restrictions on the placement of fuel assemblies within the Region 2A of the spent fuel pool, which have accumulated burnup greater than or equal to the minimum qualified burnups in Table 3.7.15-7 in the accompanying LCO, ensures the k_{eff} of the spent fuel pool will always remain $\leq$ 0.95, assuming the pool to be flooded with water borated to 730 ppm. Fuel assemblies not meeting the criteria of Table 3.7.15-7 shall be stored in accordance with either Figure 3.7.15-4 and Table 3.7.15-8 for Restricted storage, or Figure 3.7.15-5 for Checkerboard storage.

d

The restrictions on the placement of fuel assemblies within the Region 2B of the spent fuel pool, which have accumulated burnup greater than or equal to the minimum qualified burnups in Table 3.7.15-10 in the accompanying LCO, ensures the k_{eff} of the spent fuel pool will always remain $\leq$ 0.95, assuming the pool to be flooded with water borated to 730 ppm. Fuel assemblies not meeting the criteria of Table 3.7.15-10 shall be stored in accordance with either Figure 3.7.15-6 and Table 3.7.15-11 for Restricted storage, or Figure 3.7.15-7 for Checkerboard storage.

APPLICABILITY

This LCO applies whenever any fuel assembly is stored in the spent fuel pool.

ACTIONS

A.1

Required Action A.1 is modified by a Note indicating that LCO 3.0.3 does not apply.

When the configuration of fuel assemblies stored in the spent fuel pool is not in accordance with the LCO, the immediate action is to initiate action

BASES

LCO (continued)

to make the necessary fuel assembly movement(s) to bring the configuration into compliance.

If unable to move irradiated fuel assemblies while in MODE 5 or 6, LCO 3.0.3 would not be applicable. If unable to move irradiated fuel assemblies while in MODE 1, 2, 3, or 4, the action is independent of reactor operation. Therefore, inability to move fuel assemblies is not sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.7.15.1

This SR verifies by administrative means that the fuel assembly is in accordance with the configurations specified in the accompanying LCO.

REFERENCES

1. UFSAR, Section 9.1.2.

2. Issuance of Amendments, McGuire Nuclear Station, Units 1 and 2 (TAC NOS. M89744 and M89745), November 6, 1995.

3. WCAP-14416-NP-A, Westinghouse Spent Fuel Rack Criticality Analysis Methodology, Revision 1, November 1996.

4. American Nuclear Society, "American National Standard Design Requirements for Light Water Reactor Fuel Storage Facilities at Nuclear Power Plants," ANSI/ANS-57.2-1983, October 7, 1983.

5. Nuclear Regulatory Commission, Memorandum to Timothy Collins from Laurence Kopp, "Guidance on the Regulatory Requirements for Criticality Analysis of Fuel Storage at Light Water Reactor Power Plants," August 19, 1998.

6. Double contingency principle of ANSI N16.1-1975, as specified in the April 14, 1978 NRC letter (Section 1.2) and implied in the proposed revision to Regulatory Guide 1.13 (Section 1.4, Appendix A).

7. 10 CFR 50.36, Technical Specifications, (c)(2)(ii).

ATTACHMENT 12

SUMMARY OF CHANGES TO ORIGINAL LAR

SUMMARY OF CHANGES TO ORIGINAL LAR

Summarized in this attachment are the changes made to the original LAR submitted April 5, 1999. In general, the changes are as follows:

1. Inclusion of biases in the criticality calculations to account for non-conservative 2 dimensional calculations.
2. Changed boron credit required for non-accident conditions from 440 to 730 ppm and for accident conditions from 1170 to 1470 ppm.
3. Incorporation of supplemental information provided in the letter dated January 14, 2000.
4. Minor correction of fresh fuel enrichment limit for Region 1B Filler requirements from 1.45 to 1.44 w/o U-235.
5. Minor editorial corrections.

Changes made to each attachment are described below.

ATTACHMENT 1

Page 3.7.15-1, LCO 3.7.15: Added definition for IFBA.

LCO 3.7.15 tables: Changed units of burnup from MWD/kgU to GWD/MTU.

LCO 3.7.15: Moved Table 3.7.15-12 to 3.7.15-1 and renumbered Tables 3.7.15-1 through 3.7.15-11. Changed table numbers referenced in LCO, table footnotes, and restricted, filler and checkerboard definitions in figures.

Page 3.7.15-2, SR 3.7.15.1: Reworded surveillance requirement.

New Page 3.7.15-7: Changed fresh fuel enrichment limit for Region 1B Filler requirements from 1.45 to 1.44 w/o U-235.

Page 4.0-1, TS 4.3.1.1 c.: Changed boron concentration from 440 to 730 ppm.

ATTACHMENT 2

Page 3.7.15-1, LCO 3.7.15: Added definition for IFBA.

LCO 3.7.15 tables: Changed units of burnup from MWD/kgU to GWD/MTU.

LCO 3.7.15: Moved Table 3.7.15-12 to 3.7.15-1 and renumbered Tables 3.7.15-1 through 3.7.15-11. Changed table numbers referenced in LCO, table footnotes, and restricted, filler and checkerboard definitions in figures.

Page 3.7.15-2, SR 3.7.15.1: Reworded surveillance requirement.

Page 3.7.15-7: Changed fresh fuel enrichment limit for Region 1B Filler requirements from 1.45 to 1.44 w/o U-235.

Page 4.0-1, TS 4.3.1.1 c.: Changed boron concentration from 440 to 730 ppm.

ATTACHMENT 3

Page 1, list of proposed changes, #1: Changed boron concentration from 440 to 730 ppm. Included description of change for new sub-regions.

Page 1, list of proposed changes, #2: Changed "new" to "revised" to avoid incorrectly interpreting that "new" applies to "new fuel" (3 places). Added "and" before enrichment and burnup requirements to clarify that the requirements are for enrichment and burnup together.

Page 3, 2nd paragraph: Corrected the term "probabilistic risk assessment".

Page 3, Technical Justification, 2nd paragraph: Changed boron concentration from 440 to 730 ppm (2 places).

Page 4, 1st paragraph: Changed 3 ½ days to 2 ½ days.

Page 4, 1st paragraph: Changed boron concentration from 440 to 730 ppm.

Page 5, 2nd paragraph: Added "caused by" for clarity in sentence discussing significant spent fuel pool water temperature change.

Page 6, 1st paragraph: Changed boron concentration from 1170 to 1470 ppm.

Page 6, 1st paragraph: Changed "new" to "revised" to avoid incorrectly interpreting that "new" applies to "new fuel" (3 places). Added "and" before enrichment and burnup requirements to clarify that the requirements are for enrichment and burnup together.

Pages 6 and 7, Conclusion #1, 2 and 3: Changed "new" to "revised" to avoid incorrectly interpreting that "new" applies to "new fuel" (3 places each). Added "and" before enrichment and burnup requirements to clarify that the requirements are for enrichment and burnup together.

Page 6, Conclusion, #1: Changed boron concentration from 440 to 730 ppm.

Page 7, Conclusion, #3: Changed boron concentration from 1170 to 1470 ppm.

ATTACHMENT 4

Page 1, Fuel Misloading: Added additional information regarding station involvement in developing and preparing to use the revised TS.

Page 2, 2nd paragraph, 5th line: Added "soluble" before "boron concentration" for clarification.

Page 2, Significant Change in Spent Fuel Pool Temperature, 2nd paragraph: Changed boron concentration from 1170 to 1470 ppm.

Page 3, 2nd paragraph: Changed boron concentration from 1170 to 1470 ppm.

Page 3, last paragraph: Clarified that it is a criticality accident resulting from a dilution accident that is not credible.

Page 5, 1st paragraph: Changed boron concentration from 440 to 730 ppm.

Page 5, 2nd paragraph: Changed "plant's" to "facility's".

ATTACHMENT 5

No changes.

ATTACHMENT 6

All pages: Updated total number of pages in header.

Page 1: Updated page numbers.

Page 1: Added new Section 3.4 to Table of Contents.

Page 2, 2nd and 4th bullet items: Included "takes" to correct grammar.

Page 3, 2nd paragraph: Changed boron concentration from 440 to 730 ppm and changed boron concentration from 1170 to 1470 ppm.

Page 3, Section 1.1, 3rd paragraph: Capitalized "Units".

Page 4, 1st paragraph: Capitalized "Units".

Page 7, assumption #1: Changed Performance Plus to Robust Fuel to correctly identify the new fuel design as it is currently referred to. Also added the Oconee fuel to the list of fuel types analyzed for completeness.

Page 7, assumption #3: Revised to include bias for differences between 2-dimensional and 3-dimensional models.

Page 8, Section 3.1, 2nd paragraph: Included bias for differences between 2-dimensional and 3-dimensional models.

Page 8, last paragraph, 1st line: Corrected grammar usage of "effect".

Page 8, last paragraph: Added clarification that gaps in the Boraflex panels are not included in the models.

Page 8, last paragraph: Reworded the last 2 sentences for clarification.

Page 11, 2nd paragraph: Included bias for axial burnup distribution.

Page 11, 3rd paragraph: Corrected Dk to Δk.

Page 15, list of burnup credit uncertainties: Included bias for axial burnup distribution.

Page 15, 5th paragraph: Corrected Dk to Δk (2 places).

Page 16, 2nd and 3rd paragraphs: Added discussion of axial burnup distribution bias.

Page 17, Section 3.3, 1st paragraph: Changed the description of the full density water case as a "base" rather than "normal" condition to avoid the implication that flooded is a normal condition for the new fuel vault.

Page 18: Included results for fully flooded condition for new fuel vault criticality results. Other editorial corrections consistent with plural results instead of singular result.

Page 18, Section 3.4: Added a new section to discuss fuel located outside the storage rack.

Page 20, 2nd paragraph, last line: Editorial change. Changed "with" to "for".

Page 20, 5th paragraph: Corrected the maximum design k_{eff} used in accident analysis. This is an editorial change and not a change in the calculation.

Page 22: Changed boron concentration from 440 to 730 ppm and changed boron concentration from 1170 to 1470 ppm.

Page 23, 3rd line: Corrected "is" to "are".

Page 24, 1st paragraph, 4th line: Deleted extraneous "in".

Page 24, 3rd paragraph: Changed boron concentration from 440 to 730 ppm and changed boron concentration from 1170 to 1470 ppm.

Page 29: Included 3-dimensional bias. Noted biases and uncertainties are for use with CASMO / SIMULATE. Included asterisk note to indicate the negative 3 Dimensional Bias is not included. Added note regarding KENO-Va biases and uncertainties.

Page 30: Included 3-dimensional bias. Included asterisk note to indicate the negative 3 Dimensional Bias is not included. Noted biases and uncertainties are for use with CASMO / SIMULATE.

Page 31: Changed fresh fuel enrichment limit for Region 1B Filler requirements from 1.45 to 1.44 w/o U-235.

Page 32: Changed fresh fuel enrichment limit for Region 1B Filler requirements from 1.45 to 1.44 w/o U-235.

Page 34: Updated Table 11. Included changes discussed in January 14, 2000 supplemental information. Added boron credit required for axial burnup distribution. Other minor corrections to include all burned fuel in burnup uncertainty calculations and improved boron search for misload accident. Changed "man unc" to "manuf unc" for clarity to reflect this is the manufacturing uncertainty.

Page 42: Updated Figure 8 to change fresh fuel enrichment limit for Region 1B Filler requirements from 1.45 to 1.44 w/o U-235.

ATTACHMENT 7

All pages: Updated total number of pages in header.

Page 1: Updated page numbers. Revised title for Section 3. Changed second Section number 2.4 to 2.5.

Page 2: Deleted 2nd paragraph related to reactivity management. This is not necessary for a summary of this analysis.

Page 4 2nd paragraph: added text "and the length of time required to do so".

Page 4: Moved Section 2.0 heading back one sentence.

Page 6, last paragraph: Last 2 sentences corrected to present tense from future tense.

Page 8: Revised title for Section 3.0.

Page 11, asterisk note ("By definition"): Corrected "Values" to be plural.

Page 11, 2nd equation: Corrected equation by including factor of 60 to convert from minutes to hours.

Page 12, 1st paragraph: Corrected reference to Table 2 (was Table 1).

Page 12, 2nd paragraph: Added paragraph and equation for clarification on how times were calculated.

Page 14, 2nd paragraph: Corrected FSAR to UFSAR.

Page 14, 2nd paragraph: Deleted reference to McGuire piping specification for Schedule 40 Carbon Steel.

Page 14, 3rd paragraph: Editorial change to clarify paragraph including the break size.

Page 14, 4th paragraph: Editorial change to clarify 1.382" equivalent diameter break size and combine two paragraphs.

Page 14, last paragraph: Added last sentence and equation to provide more detail on how dilution time was calculated.

Page 15, 1st paragraph: Deleted irrelevant sentence that referred to non-existent Attachment 2. This was addressed in the January 14, 2000 supplemental information provided.

Page 15, last paragraph: Added sentence the time to reach 1834 ppm.

Page 16, 2nd and 3rd paragraphs: Editorial change to provide added clarification. Added the time required to dilute to 1068 ppm. Added last paragraph in Section 5.2.2.

Page 17, 1st paragraph: Added last sentence providing time required to dilute to 1489 ppm.

Page 17, 2nd paragraph: Added clarification regarding the two Recycle Monitor Tank Pumps.

Page 17, 2nd paragraph: Added last sentence providing time required to dilute to 1791 ppm.

Page 18, Section 5.2.5: Added last sentence providing time required to dilute to 730 ppm.

Page 19, 4th and 5th paragraphs: Relocated reference to Table 2 to a new paragraph and added time required to dilute to 730 ppm.

Page 22, 1st paragraph: Added clarification regarding conditions necessary to dilute to 1255 ppm.

Page 23, last paragraph: Updated the results of the boron dilution analysis to be consistent with the new amount of boron credit required. Specifically changed the time required from 12 hours to 10, changed the final boron concentration from 440 to 730 ppm and changed the time to go unnoticed from 3 ½ to 2 ½ days.

Page 24, summary table: Updated table. Provided final boron concentrations with dilution times and time to reach 730 ppm.

Page 25, 1st paragraph: Added 3rd sentence for additional discussion.

Page 25, 1st paragraph: Revised last sentence and added list of 4 items supporting conclusion to include the discussions provided in the January 14, 2000 supplemental information.

Page 35: Re-labeled lower section of Table 2 as provided in January 14, 2000 supplemental information.

Page 36: Added data for time required to dilute to 730 ppm.

ATTACHMENT 8

Page 4, Boraflex Loss: Added clarification that the Boraflex loss reported in Reference 6.2 is in terms of original as built areal density.

Page 4, Section 3.2, b.: Removed extra line.

ATTACHMENT 9

Page 16.9-24, 3rd paragraph Changed boron concentration from 440 to 730 ppm.

Page 16.9-25, 2nd paragraph, 9th line: Added "to" between needed and maintain.

ATTACHMENT 10

New page B 3.7.14-2, 1st paragraph: Changed boron concentration from 440 to 730 ppm.

New page B 3.7.14-2, 1st paragraph: Corrected Integrated Fuel Burnable Absorber to Integral Fuel Burnable Absorber.

New page B 3.7.14-2, 3rd paragraph: Changed boron concentration from 440 to 730 ppm.

New page B 3.7.14-3, 1st paragraph: Changed boron concentration from 1170 to 1470 ppm.

New page B 3.7.14-3, 2nd paragraph: Changed boron concentration from 440 to 730 ppm (2 places).

New page B 3.7.15-2, 2nd paragraph: Changed boron concentration from 440 to 730 ppm.

New page B 3.7.15-2, 2nd paragraph: Corrected Integrated Fuel Burnable Absorber to Integral Fuel Burnable Absorber.

New page B 3.7.15-3, 1st paragraph: Changed boron concentration from 440 to 730 ppm.

New page B 3.7.15-3, 2nd paragraph: Changed boron concentration from 1170 to 1470 ppm.

New page B 3.7.15-3, 3rd paragraph: Changed boron concentration from 440 to 730 ppm (2 places).

New page B 3.7.15-3, last paragraph: Updated table numbers referenced consistent with moving TS Table 3.7.15-12 to Table 3.7.15-1.

New page B 3.7.15-3, last paragraph: Changed boron concentration from 440 to 730 ppm.

New page B 3.7.15-4, 1st, 2nd and 3rd paragraphs: Updated table numbers referenced consistent with reordering of TS tables.

New page B 3.7.15-4, 1st, 2nd and 3rd paragraphs: Changed boron concentration from 440 to 730 ppm (1 place each).

ATTACHMENT 11

Page B 3.7.14-2, 1st paragraph: Changed boron concentration from 440 to 730 ppm.

Page B 3.7.14-2, 1st paragraph: Corrected Integrated Fuel Burnable Absorber to Integral Fuel Burnable Absorber.

Page B 3.7.14-2, 3rd paragraph: Changed boron concentration from 440 to 730 ppm.

Page B 3.7.14-3, 1st paragraph: Changed boron concentration from 1170 to 1470 ppm.

Page B 3.7.14-3, 2nd paragraph: Changed boron concentration from 440 to 730 ppm (2 places).

Page B 3.7.15-2, 2nd paragraph: Changed boron concentration from 440 to 730 ppm.

Page B 3.7.15-2, 2nd paragraph: Corrected Integrated Fuel Burnable Absorber to Integral Fuel Burnable Absorber.

Page B 3.7.15-3, 1st paragraph: Changed boron concentration from 440 to 730 ppm.

Page B 3.7.15-3, 2nd paragraph: Changed boron concentration from 1170 to 1470 ppm.

Page B 3.7.15-3, 3rd paragraph: Changed boron concentration from 440 to 730 ppm (2 places).

Page B 3.7.15-3, last paragraph: Updated table numbers referenced consistent with moving TS Table 3.7.15-12 to Table 3.7.15-1.

Page B 3.7.15-3, last paragraph: Changed boron concentration from 440 to 730 ppm.

Page B 3.7.15-4, 1st, 2nd and 3rd paragraphs: Updated table numbers referenced consistent with reordering of TS tables.

Page B 3.7.15-4, 1st, 2nd and 3rd paragraphs: Changed boron concentration from 440 to 730 ppm (1 place each).