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軽水炉使用済燃料中の核種組成データ集

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軽水炉使用済燃料中の核種組成データ集

日本原子力研究所東海研究所燃料安全工学部

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使用済燃料中の核種組成を計算するためのコードの精度把握に必要な核種組成の実測データを、シグマ委員会の中に設置されている核種生成量評価WGの活動の一環として収集した。収集したデータは、ベンチマーク計算に必要な情報を提供するために、サンプル燃料の照射履歴、サンプル燃料集合体の構成、サンプル収集位置及び核種組成データに分類して編集した。ここでは、欧米の軽水炉9基（PWR 5基、BWR 4基）および日本の軽水炉4基（PWR 2基、BWR 2基）の計13基から収集したデータを記す。その他、これら核種組成の典型的な燃焼特性についても参考のため記す。

Databook of the Isotopic Composition
of Spent Fuel in Light Water Reactors

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(Received February 24, 1993)

In the framework of the activity of the nuclide production evaluation WG in the sigma committee, we summarized the measurement data of the isotopic composition of LWR spent fuels necessary to evaluate the accuracy of the burnup calculation codes.

The collected data were arranged to be classified into the irradiation history of the fuel samples, the composition of the fuel assemblies, the sampling position and the isotopic composition of the fuel samples, in order to supply the information necessary to the benchmark calculation.

This report describes the data collected from the 13 LWRs including the 9 LWRs (5 PWR and 4 BWR) in Europe and the USA, the 4 LWRs (2 PWR and 2 BWR) in Japan. Finally, the study on the burnup characteristics of the U, Pu isotopes is described.

Keyword: Databook, Isotopic Composition, Spent Fuel, Light Water Reactor
Burnup, Benchmark Data, Measured Data

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1. はじめに

軽水炉による発電量が増大し、使用済燃料の蓄積が著しい。その貯蔵、再処理、プルトニウムの再利用等使用済燃料に関して今後さらに検討を必要とする項目は多い。それらを検討するために基礎データとして使用済燃料中の核種組成を把握しておくことは重要である。また、原子炉の運転管理においても燃料に伴う燃料中の核種組成を知っておくと便利である。

使用済燃料中の核種組成を把握するために多くの計算コードが開発されている。それらの精度把握のためには実測データが必要である。シグマ委員会の中に設置されている核種生成量評価WGでは、炉型の違いによる使用済燃料中の核種組成の差異を把握するとともに、計算コードの精度検証のためのベンチマーク問題を作成することを目指して核種組成測定データの収集を続けてきた。

本報告の目的は多くの実測データを調査収集し、調査された測定データをベンチマークに適した形で利用者に提供することにある。

世界中で多くの測定の報告がなされているが、ベンチマークに必要なデータの一部が特許等のため非公開であるなど、ベンチマークデータとして十分な要件を備えたものばかりではない。その中から、比較的データの整っている世界の軽水炉 9 基 (PWR 5 基, BWR 4 基) 及び日本の軽水炉 4 基 (PWR 2 基, BWR 2 基) 計13基を選び、使用済燃料の核種組成測定データを整理し、計算コードで解析するのに便利な形にまとめた。

本報告書は 2 章で、採録した原子炉の型式等の概要及び測定データの種類などについて概説する。3 章は、核種組成測定データを原子炉毎にまとめ、炉心構成と炉心性能、燃料の照射履歴とサンプル位置、核種組成データの順に述べる。また、4 章では、W. B. Wilson のまとめたベンチマークデータの一部を 3 章に準じた形で原子炉毎に記述する。最後の 5 章で、これらの核種組成測定データをもとに、各核種の燃焼特性を炉型による違いなどについて比較、検討した結果について述べる。

2. 概 要

計算コードの精度評価のためのベンチマークデータには、核種組成データの他に測定されたサンプルの照射履歴やその原子炉の炉心構成などの情報が必要である。

ここでは、原子炉心の型式や炉心構成等の概要を述べるとともに、測定データの種類や測定方法について概説する。炉心構成等の詳細については3章及び4章で述べる。

2.1 原子炉と炉心構成の概要

この報告で測定データを収録した原子炉はPWR 7基、BWR 6基の計13基である。これらの原子炉の炉心の構成と炉心性能についてまとめたものをTable 2.1に示す。以下、各原子炉について概要を述べる。

*Yankee炉^{1) 2)}*は米国マサチューセッツ州にある熱出力392MWtのPWRで、十字型制御棒を用いて反応度制御をするのが特徴である。初臨界は1960年8月である。

*Trino Vercellese炉^{3) 4)}*はイタリアのトリノにある熱出力825MWtのPWRで、Westinghouse社の設計になる。『fuel bearing follower』が付いている変形十字型制御棒を有するのが特徴であるが、ホウ酸水を用いたケミカルシムも用いられている。初臨界は1964年6月である。

*Obrigheim炉⁵⁾*はドイツのオブリハイムにある熱出力907.5MWtのPWRで、シーメンス社の設計になる。初臨界は1968年9月である。1集合体あたりの燃料棒数は14×14であるが、Ag-In-Cdのクラスター状の制御棒とホウ酸水を用いて反応度制御している点は現在のわが国の発電用PWRに近いものである。

*Garigliano炉⁶⁾*はイタリアのナポリ北方20kmガリリアーノ河畔にある熱出力506MWtの原子炉でGE社設計のBWRである。1集合体あたりの燃料棒数は9×9と多く、2本の十字型制御棒で取り囲まれる構造になっているのが特徴である。初臨界は1963年6月である。

*Gundremmingen炉^{7) 8)}*はドイツのバーバリア地方にある電気出力250MWeのBWRである。十字型制御棒を有し、1集合体あたりの燃料棒数は6×6である。

*Monticello⁹⁾*炉は米国ミネソタ州ミネアポリスの北西13マイルにあるGE社設計のBWRである。初臨界は1970年10月、電気出力536MWeで運転された。1燃料集合体あたりの燃料棒数は当初7×7であったが、その後8×8に変更された。また、1本の十字型制御棒の周囲に4つの燃料集合体が配置される設計となっており、現在のわが国の発電用BWRに近いものである。

日本の原子炉では、美浜3号炉及び玄海1号炉¹⁰⁾、敦賀1号炉¹¹⁾及びJPDR^{12) 13) 14)}の実測データがある。敦賀1号炉は福井県敦賀市にある電気出力357MWeのBWRである。初臨界は1969年10月である。また、JPDRは、茨城県東海村に設置された熱出力45MWthのBWRで、日本で最初に発電を行った原子炉であるが、現在廃炉となり、原子炉解体の研究に供されている。

W. B. Wilsonらがまとめた原子炉¹⁵⁾ のうち本報告に収録したものは TMI-2炉, Robinson-2炉及び Quad-Cities-1炉である。TMI-2炉は米国ペンシルバニア州ゴールズボローにある電気出力559MWeの PWRで, B&W社の設計になる。1979年3月に事故を起こして以来現在まで停止している。Robinson-2炉は米国南カロライナ州ハーツビルにある熱出力2200MWeのPWRでWestinghouse社の設計になる。初臨界は1970年9月である。Quad-Cities-1炉は米国イリノイ州コルドバにある熱出力2500MWeのBWRでGE社の設計になる。

炉心構成等の詳細については3章及び4章で述べる。

2.2 測定データの種類と測定方法

燃焼度及び核種組成の測定のために, ガンマスキャニング, ガンマスペクトロメトリー, 放射化学分析, 質量分析及びアルファスペクトロメトリーが行われた。燃料棒の燃焼度分布の測定にはグロスガンマスキャニングが用いられ, 各サンプルの燃焼度測定には, ¹³⁷Csの非破壊のガンマスペクトロメトリー, ¹³⁷Cs及び¹⁴⁸Ndの原子含有量から燃焼度を求める¹³⁷Cs法及び¹⁴⁸Nd法が用いられる。核種組成の測定には, 質量分析及びアルファスペクトロメトリーが使われた。放射化学分析は, このための試料を純化するため用いられた。

Trino Vercellese炉, Obrigheim炉, Garigliano炉及び Gundremmingen炉については, Ispra研究所及び Karlsruhe研究所の2つの研究所で, 上述のような測定が行われた。測定された核種も多く, U同位体, Pu同位体, TRU及び希ガスFPのKr, Xeが同定されている。また, 測定データの精度や信頼性についても議論された報告がなされている。

Yankee炉の測定は, TRACERLABとGE Vallecitos Atomic Laboratoryで行われた。また, いくつかの試料はUSAEC New Brunswick Laboratories(NB)でクロスチェック分析がなされた。多くの測定がなされており, サンプルの数も多くデータは豊富である。

Monticello炉の測定はGE Vallecitos Nuclear Center(VNC)で行われた。測定データは¹⁴⁸Nd法による燃焼度, UとPuの同位体組成及び²⁴²Cmの同定である。

日本の原子炉のデータは全て日本原子力研究所で測定されたものである。美浜3号炉及び玄海1号炉については, U, Puの同位体, TRU及びFPの一部が測定されている。敦賀1号炉ではU, Puの同位体組成JPDRではU, Puの同位体組成及びAm, Cm, Nd, Npの測定データが報告されている。

TMI-2炉のデータは, 事故時に原子炉建屋内の空気をサンプリングし, それをBettis Atomic Power Laboratory(BAPL)においてIとXeの放射能分析を行ったものでIとXeの同位体組成が得られている。

Robinson-2炉の測定はBattelle Columbus Laboratories(BCL)とロスアラモスで行われた。BCLでの測定ではUとPuの同位体組成と¹⁴⁸Nd法による燃焼度が報告され, ロスアラモスの測定では14個のアクチナイドと8個のFPについての同定と¹⁴⁸Nd法による燃焼度測定がなされた。ただし, サンプルは別個のものである。

Quad Cities-1炉のデータはGE Vallecitosで測定された。測定データは¹⁴⁸Nd法による燃焼度, U, Pu及びAmの同位体組成などである。

Table 2.1 Core Composition and Performance

| Reactor Name | Yankee | Trino Vercellese | | Obriheim | Cargilano | | Gundremmingen | Monticello |
|---|--------------|------------------|-----------------|-----------------------|--------------|------------|---------------|------------|
| | | Core I | Cycle I | | Cycle II | Cycle II | | |
| Reactor Type | PWR | PWR | | PWR | BWR | BWR | BWR | BWR |
| Fuel Pellet Diameter | 0.74676 | 0.89 | 0.89 | 0.904 | 1.191 | 1.290 | 1.224 | 1.057 |
| Length of pellet stack in fuel rod | (cm) 230.05 | 264.1 | 264.1 | 295.6 | 267.72 | 271.8 | 330.2 | 365.76 |
| Fuel Clad Material | SUS348 | SUS304 | SUS304 | Zircaloy-4 | Zircaloy-2 | Zircaloy-2 | Zircaloy-2 | Zircaloy-2 |
| Square fuel assembly | | | | | | | | |
| Rod array | 1.8 × 18 | 1.5 × 15 | 1.5 × 15 | 14 × 14 | 9 × 9 | 8 × 8 | 6 × 6 | 8 × 8 |
| Number of rods | 304/305 | 208 | 208 | 180 | 81 | 64 | 36 | 63 |
| Fuel rod pitch | (cm) 1.07188 | 1.303 | 1.303 | 1.430 | 1.73 | 1.93 | 1.78 | |
| Initial enrichment (%) (reloaded assembly+) | 1.15824 | 3.4 | 2.72/3.13/ 3.90 | 2.72/3.13/ 3.90/4.00+ | 2.5/2.8/ 3.1 | 1.6/2.1 | 1.83/2.41 | 1.87/2.53 |
| Control rod Absorbing material | Ag-In-Cd | Ag-In-Cd | Ag-In-Cd | Ag-In-Cd | Ag-In-Cd | Ag-In-Cd | Ag-In-Cd | Ag-In-Cd |
| Core Equivalent diameter | (cm) 190.75 | 249.9 | 240.0 | 250.0 | 291.084 | 274.8 | | |
| Active height | (cm) 233.4 | 264.9 | 264.9 | 275.0 | 267.72 | 271.8 | | |
| No. of square assemblies | 76 | 120 | 112 | 121 | 208 | 208 | | |
| Power (MWth) | (MWe) 392 | 825 | 825 | 907.5 | 506 | 506 | | |
| | | | | 350 | | | 250 | 536 |

Table 2.1 Core Composition and Performance (continue-1)

| Reactor Name | Mihama-3 | Genkai-1 | Tsuruga-1 | JPDTR | TMI | Robinson-2 | Quad Cities-1 |
|------------------------------------|----------|----------|------------|-------------------------|--------------|----------------------------|--------------------|
| Reactor Type | PWR | PWR | BWR | BWR | PWR | PWR | BWR |
| Fuel Pellet Diameter | (cm) | | 1.237 | 1.25 | 0.94 | 0.93 | 1.24 |
| Length of pellet stack in fuel rod | (cm) | 365.7 | | | | 386.1 | 366 |
| Fuel Clad Material | | | Zircaloy-2 | Zircaloy-2 | Zircaloy-4 | Zircaloy-4 | Zircaloy-2 |
| Square fuel assembly | | | | | | | |
| Rod array | 15 × 15 | 14 × 14 | 7 × 7 | 6 × 6 | 208 | 15 × 15 | 7 × 7 |
| Number of rods | (cm) | | | 36 | | 204 | 49 |
| Fuel rod pitch | (cm) | 3.24 | 3.42 | 1.40/1.80/ 2.10/2.79 | 1.956 2.6 | 1.36 2.29/2.64/ 2.90 | 1.85/2.55/ 3.10 |
| Initial enrichment | (%) | | | | | | 1.20/1.69/ 2.44 |
| Control rod | | | | | | | |
| Absorbing material | | | | | | | |
| Core | | | | | | | |
| Equivalent diameter | (cm) | | | 127 | 328 | 304 | 463 |
| Active height | (cm) | | | 147 | 366 | 366 | 366 |
| No. of square assemblies | | | | 177 | 157 | 157 | 724 |
| Power | (MWth) | | | 2772 | 2200 | 2511 | 2511 |
| | (MWe) | | | 907 | 700 | 809 | 809 |

3. 核種組成実測データ

3章では、10基の原子炉に関する核種組成の実測データについて記す。炉毎に節を設け、炉心構成と炉心性能、燃焼履歴とサンプリング燃料の配置、核種組成データの順に説明する。原子炉の記載順は次の通りである。

3. 1 Yankee炉(PWR, 米国)
3. 2 Trino Vercellese炉(PWR, イタリア)
3. 3 Obrigheim炉(PWR, ドイツ)
3. 4 Garigliano炉(BWR, イタリア)
3. 5 Gundremmingen炉(BWR, ドイツ)
3. 6 Monticello炉(BWR, 米国)
3. 7 美浜 3号炉及び玄海 1号炉(PWR, 日本)
3. 8 敦賀 1号炉 (BWR, 日本)
3. 9 JPDR(BWR, 日本)

3. 1 Yankee炉(PWR)

Yankee炉での使用済燃料中の核種組成の測定は3つのPhaseに分けて行われた。Phase IではCore I の14の燃料集合体から56本の燃料棒が選ばれ測定された。サンプル燃料の燃焼度は 1,300～18,000MWd/tであった。Phase IIではCore I, Core IIで照射された燃料集合体1体から取り出した7本の燃料棒について測定した。燃焼度の範囲は10～31GWd/tであった。Phase IIIでは、Core I, Core II及びCore IVで照射された燃料集合体1体から取り出された燃料棒8本が測定された。最高燃焼度は46,000MWd/t であった。

なお、本節で使用した図表は次の文献から転載したものである。

- 1) R. J. Nodvik et.al: "Evaluation of Mass Spectrometric and Radiochemical Analyses of Yankee Core I Spent Fuel", WCAP-6068(1966).
- 2) R. J. Nodvik et.al: "Supplementary Report on Evaluation of Mass Spectrometric and Radiochemical Analyses of Yankee core I Spent Fuel, including Isotopes of Elements Thorium through Curium", TID 4500, WCAP-6086(1969) .

3. 1. 1 炉心構成と炉心性能

炉心構成と炉心性能をTable 3. 1 - 1 に示す。また、炉心の構成図をFig. 3. 1 - 1 に示す。炉心

の燃料集合体位置はA～K例と1～10行の行列で表される。制御棒は、Rod Group Number 6を除き、原子炉運転中のある時点でAg-In-Cdの吸収体が挿入された状態になっている。また、Rod Group Number 6の制御棒とシム棒は、運転中ジルカロイで満たされている。制御棒の引き抜きパターンはRod Group 645321の順に引き抜くパターンとRod Group 631452の順に引く抜くパターンの2つがあり、炉心が変わる毎に交互に繰り返される。

3.1.2 燃焼履歴とサンプリング燃料の配置

Yankee炉の運転履歴をFig. 3.1-2に示す。また、Core IからCore IVまでの燃料サイクルをFig. 3.1-3及びTable 3.1-2に示す。Core Iは76本の燃料集合体からなり、燃料集合体は304または305本の燃料棒からなっている。Core IIは、Core Iで照射された燃料集合体2体が炉心中央に装荷された他はCore Iと同じである。Core IIIには測定対象となった燃料はなかった。Core IVにはCore I, Core IIで照射された燃料集合体1体が再装荷された。

測定のPhase I, Phase II, Phase IIIで測定対象となった燃料棒の位置をFig. 3.1-4に示す。Phase IIIではE6燃料集合体から8本、Phase IIではP5燃料集合体から7本、Phase Iではその他の14体の燃料集合体から56本の燃料棒が選ばれた。燃料集合体内の燃料棒配置図を、Phase IIIで測定対象となった燃料棒の位置とともにFig. 3.1-5に示す。燃料集合体は9つの領域に分けられ、Fig. 3.1-5の下図に示すように中心部をCとしてNW, SEなどの方位名が付けられている。また、その各領域には 6×6 の燃料棒が配置されており、左からa, b, c, d, e及びf列、上から1, 2, 3, 4, 5, 及び6行と名付けられている。したがって、E6燃料集合体のSE領域の左から3列目、上から2行目の燃料棒はE6-SE-c2と呼んで特定される。

Yankee炉は十字型制御棒を有するので、制御棒の近傍と離れた位置では中性子のエネルギースペクトルが異なる。そこで、燃料集合体中の燃料棒を3つの群(Asymptotic, Intermediate, Perturbed)に分けて、核種組成データを整理している。各群のしめる領域をFig. 3.1-6に示す。また、Phase I及びPhase IIで測定された燃料サンプルの数を群毎に整理してTable 3.1-3に示す。

測定試料の軸方向サンプリング位置をFig. 3.1-7に示す。サンプリング位置は上から領域1～6と名付けられた。

3.1.3 核種組成データ

Table 3.1-4にYankee Core Iに使用されたUO₂ペレットの組成を示す。

Phase I及びPhase IIで測定された燃料サンプルの燃焼度及びU/PuなどをTable 3.1-5に示す。燃焼度は、Heavy Element(U, Pu同位体)組成から算出する方法(U, Pu同位体比法またはHE法と呼ぶ。), ¹³⁷Cs法及び⁸⁰Srの放射能から求める方法の3方法で算出された。

Table 3.1-6にPhase I及びPhase IIで測定された燃料サンプルのU, Puの同位体組成、¹³⁷Cs及び⁸⁰Srの放射能などを示す。また、Fig. 3.1-6に示した3つの領域(Perturbed, Intermediate, Asymptotic)毎の体積平均のU, Pu同位体組成をTable 3.1-7に示す。

Fig. 3.1-8, Fig. 3.1-9にAsymptotic領域におけるU及びPu同位体の²³⁵U減損に対する変

化を LEOPARD コードによるユニットセル計算値とともに示す。また、Fig. 3. 1 - 10 に制御棒近傍の Perturbed 領域における Pu 同位体の ^{235}U 減損に対する変化を Asymptotic 領域と比較して示す。この図では、Perturbed 領域における ^{239}Pu と ^{241}Pu は Asymptotic 領域より小さく、 ^{240}Pu と ^{242}Pu は Asymptotic 領域より大きい。図の横軸を ^{235}U 減損にしたためで、燃焼度を横軸にしたときの初期 U に対する実質の Pu 生成量は 4 核種とも Asymptotic 領域の方が大きい。これは、Perturbed 領域の中性子スペクトルが Asymptotic 領域より柔らかいためである。

Table 3. 1 - 8 に、Phase III で測定されたサンプル及び Phase I 及び Phase II の再測定サンプルの U, Pu 同位体組成、 ^{137}Cs , ^{90}Sr 及び ^{148}Nd の放射能、HE 法による燃焼度などを示す。

Table 3. 1 - 9 に U, Pu 同位体の初期 ^{238}U に対する比、HE 法、 ^{137}Cs , ^{90}Sr 及び ^{148}Nd 法による燃焼度などを示す。これによれば、HE 法と ^{148}Nd 法による燃焼度は非常に良い一致を示している。

U, Pu の希少同位体、 ^{232}U の ^{235}U に対する比、 ^{236}Pu の ^{239}Pu に対する比及び ^{148}Nd 法による燃焼度などを Table 3. 1 - 10 に示す。

^{237}Np , ^{241}Am , ^{243}Am , ^{242}Cm 及び ^{244}Cm に関する測定のまとめを Table 3. 1 - 11, Table 3. 1 - 12, Table 3. 1 - 13, Table 3. 1 - 14 に示す。

燃焼度と Heavy Element (HE) すなわち U, Pu 同位体の生成消滅から算出された総核分裂数 (F^{TOT}) との関係を Fig. 3. 1 - 11 に示す。この図には Phase I, Phase II 及び Phase III で測定されたデータ全てが含まれている。 ^{234}U 量の総核分裂数 (F^{TOT}) に対する変化を LASER-HIC コードによる計算値とともに Fig. 3. 1 - 12 に示す。

^{237}Np , ^{238}Pu , ^{236}Pu , ^{232}U , ^{241}Am , ^{243}Am , ^{242}Cm 及び ^{244}Cm 量の総核分裂数 (F^{TOT}) に対する変化を LASER-HIC コードによる計算値とともに Fig. 3. 1 - 13 ~ Fig. 3. 1 - 20 に示す。ただし、このときの F^{TOT} は ^{148}Nd の分析より算出された総核分裂数である。

Table 3.1-1 Core Composition and Performance(Yankee)

| | | | | |
|-------------------------|----------------------|---------|--|------------------------------------|
| Fuel pellet | | | Control rod | |
| UO ₂ density | (g/cm ³) | 10.18 | Absorbing material | |
| Linear density | (g/cm) | 4.46 | Core | |
| Diameter | (cm) | 0.74676 | Equivalent diameter | (cm) 190.75 |
| Length of pellet stack | (cm) | 230.05 | Active height | (cm) 233.4 |
| in fuel rod | (cm) | 0.00508 | No. of square assemblies | 76 |
| Clad-pellet clearance | (cm) | 0.8636 | No. of control rods | 24 |
| Fuel clad | (cm) | 0.75692 | UO ₂ in square assemblies(kg) | |
| Outside diameter | (cm) | 0.05334 | Total UO ₂ weight | (kg) 23,730 |
| Inside diameter | (cm) | SUS348 | Total U weight | (kg) 20,909 |
| Wall thickness | | | Core thermo-hydraulic characteristics | |
| Material | | | Power | (MWth) 392 |
| Square fuel assembly | | | Coolant pressure | (MWe) (kg/cm ²) 140.74 |
| Rod array | 18 × 18 | | Coolant temperature(ave., °C) | 262.2 |
| Number of rods | 304/305 | | | |
| Fuel rod pitch | (cm) | 1.07188 | | |
| UO ₂ weight | (kg) | 1.15824 | | |
| Initial enrichment | (%) | 311.72 | | |
| | | 312.75 | | |
| | | 3.4 | | |

Table 3.1-2 Operating Summary for Yankee Cores, I, II, III, and IV

| | Core I | Core II | Core III | Core IV |
|---------------------------------------|--------------|--------------|--------------|--------------|
| Initial criticality | 8-19-60 | 9-12-62 | 10-23-63 | 8-31-64 |
| At power | 1-16-61 | 9-24-62 | 11-14-63 | 9-6-64 |
| Maximum power (MWe) | 150 | 170 | 185 | 185 |
| Maximum power (MWt) | 485 | 540 | 600 | 600 |
| Average power during generation (MWe) | 119* | 150* | 154* | 164* |
| Gross energy (MWH electrical) | 1,330,521 | 1,205,597 | 944,772 | 1,309,059 |
| Net energy (MWH electrical) | 1,222,960 | 1,125,863 | 882,072 | 1,224,892 |
| Gross energy (MWH thermal) | 4,249,646 | 3,926,634 | 3,174,626 | 4,349,046 |
| Times critical | 262 | 44 | 19 | 32 |
| Hours critical | 13,247.43 | 8,305.68 | 6,257.38 | 8,160.27 |
| Times scrammed | 30 | 8 | 6 | 5 |
| Core average burnup (MWD/MTU) | 8,470 | 7,866 | 6,329 | 8,724 |
| Final shutdown | 5-18-62 | 9-2-63 | 8-2-64 | 8-9-65 |
| Conditions at End of Core Life | | | | |
| Power (MWe) | 78.4 | 83.3 | 92.0 | 96 |
| Power (MWt) | 260 | 308 | 340 | 320 |
| Condenser back pressure ("Hg) | 0.9 | 2.0 | 1.95 | 2.10 |
| Avg. moderator temperature (°F) | 429.5 | 441.0 | 452.6 | 479 |
| Control rod configuration | all rods out | all rods out | all rods out | all rods out |

* Includes core extension period (coast-down) at reduced power and coolant temperature.

Table 3.1-3 Number of Spent Fuel Rods and Number of Core Locations Sampled in EYC Phases I and II

| Phase I | | | | Phase II | | | |
|-------------------------------------|---|------------------------------------|---|------------------------|----------------------------|------------------------------|--|
| Asymptotic (Center) | Neutron Spectrum | | Total No. of Core Locations Sampled | Neutron Spectrum | | Total No. of Fuel Rods | No. of Core Locations Sampled |
| | Intermediate ^a (Diagonal) | Perturbed ^b (Corner) | | Asymptotic (Center) | Intermediate (Diagonal) | | |
| 6-Pellet Rod ^d | 4 | 1 | 5 | 30 | 1 | 1 | 2 |
| 4-Pellet Rod | 20 | 8 | 9 | 148 | 1 | 1 | 4 |
| 2-Pellet Rod | 4 | 1 | 5 | 10 | 2 | 1 | 16 |
| 1-Pellet Rod | 3 | | 3 | 3 | | | |
| 0-Pellet Rod | 3 | 3 | 6 | | 1 | | |
| Total No. of Rods Removed from Core | 34 | 12 | 10 | 56 | 2 | 3 | 7 |
| Total No. of Rods Sectioned | 31 | 9 | 10 | 50 | 2 | 2 | 6 |
| Total No. of Core Locations Sampled | 115 | 34 | 42 | 191 | 10 | 8 | 10 |
| | | | | | | | 28 |

Notes: a) Includes two 4-pellet and one 2-pellet fuel rods on the diagonal approaching the core reflector.

b) Includes one 4-pellet fuel rod immediately adjacent to the reflector.

c) All fuel rods removed from assembly #A21, core location F5.

d) Includes a nominal 4-pellet rod from which two additional pellets were cut from zone 3.

Table 3.1-4 Summary of Yankee Core I Fuel Beginning-of-Life Isotopic Composition

| Isotope i | Weight Percent | Atom Percent | N^i/N^{28} | N^i/N^{25} |
|-----------|----------------------|----------------------|-----------------------|----------------------|
| Th-232 | 4.0×10^{-5} | 4.0×10^{-5} | 4.2×10^{-7} | 1.2×10^{-5} |
| Pa-231 | 5.5×10^{-9} | 5.7×10^{-9} | 5.9×10^{-11} | 1.6×10^{-9} |
| U-232 | 3.6×10^{-9} | 3.7×10^{-9} | 3.8×10^{-11} | 1.1×10^{-9} |
| U-233 | 9.0×10^{-5} | 9.2×10^{-5} | 9.5×10^{-7} | 2.7×10^{-5} |
| U-234 | 0.021 | 0.021 | 0.00022 | 0.0061 |
| U-235 | 3.40 | 3.44 | 0.0356 | 1.0 |
| U-236 | 0.020 | 0.020 | 0.00021 | 0.0058 |
| U-238 | 96.560 | 96.519 | 1.0 | 28.048 |
| Total | 100.00 | 100.00 | 1.03603 | 29.060 |

Table 3.1-5 Burnup and Fuel Characteristics Inferred from Results of EYC Mass Spectrometric, Radiochemical, and X-ray Spectrographic Analyses (1/8)

| Core Rod Location Number | Axial Sample Code | Sample Zone Number | U-235 Atom Depletion (fission/atom) | Total Fissions | Accumulated Fissions (total fissions) | Relative to N ₀ (fission/atom) | N ₀ U-238 Pu-239 Pu-241 | PHASE I, ASYMPTOTIC NEUTRON SPECTRUM, CENTER SUBASSEMBLIES | | Burnup (MWD/MTU) ^b | Isotopic Cs-137 sr-90 | (B _m × 10 ³) | Isotopic K-ray | Alpha-25 ^e NCD/MWD ^f | |
|--------------------------------|-------------------------|--|---|--|---|--|--|--|--|--|--|--|--|--|--|
| | | | | | | | | N ₀ U | N ₀ Pu | | | | | | |
| | | | | | | | | N ₀ N ₀ 28 | N ₀ N ₀ 28 | | | | | | |
| C3-C-a1 | 9578 | 3A ^d 3B | T-132 T-133 | .270 .272 | .01011 .01027 | .755 .753 | .0759 .0759 | .164 .166 | .00476 .00484 | 9,360 9,510 | 9,140 9,150 | 1.0204 1.0202 | 5.394 5.527 | .259 .253 | |
| C3-C-f6 | 9595 | 1 3 5 6 | T-100 T-101 T-102 T-103 | .158 .304 .306 .192 | .00550 .01185 .01182 .00679 | .806 .719 .729 .791 | .0737 .0766 .0766 .0743 | .119 .197 .188 .132 | .00147 .00740 .00676 .00255 | 5,080 10,950 10,960 6,280 | 5,360 11,100 10,840 6,430 | 1.0271 1.0176 1.0178 1.0253 | 3.436 6.477 6.273 3.946 | .270 .269 .263 .276 | |
| C8-C-a6 | 569 | 3A ^d 3B | T-134 T-135 | .263 .263 | .00994 .00990 | .757 .754 | .0757 .0757 | .163 .166 | .00451 .00470 | 9,260 9,160 | 9,110 9,090 | 1.0207 1.0207 | 5.25 5.29 | .245 .256 | |
| C8-C-f1 | 5551 | 1 3 5 6 | T-105 T-106 T-107 T-108 | .163 .308 .300 .203 | .00570 .01201 .01164 .00725 | .808 .727 .729 .801 | .0738 .0767 .0765 .0745 | .166 .189 .188 .122 | .00142 .00702 .00685 .00207 | 5,270 11,130 11,120 6,790 | 5,520 11,230 11,220 6,790 | 1.0269 1.0176 1.0181 6,790 | 3.386 6,308 6,167 3,893 | .480 .458 .458 .516 | |
| E5-C-a6 | 7992 | 1 3 3B 3B 6 | T-11 T-12 N-10-1 ^h N-10-2 T-13 T-14 T-14 | .234 .333 .357 .357 .373 .243 .360 | .00855 .01367 .01450 .01449 .01499 .00894 .00946 | .792 .700 .701 .701 .718 .780 .780 | .0751 .0772 .0778 .0778 .0781 .0753 .0753 | .129 .213 .211 .211 .194 .142 .142 | .00337 .00962 .01009 .01012 .00947 .003228 .003228 | 7,900 12,680 13,450 13,440 13,900 8,270 8,070 | 6,720 13,690 13,690 13,690 13,690 8,070 8,070 | 1.0234 1.0150 1.0142 1.0142 1.0139 4,645 4,645 | 4,036 7,232 7,184 7,138 6,925 4,57 4,64 | .234 .240 .252 .252 .234 .242 .509 | |
| E5-C-f1 | 7980 | 1 3 3B 3B 5 6 | G-15 G-1 T-2 ^j T-2 ^j G-16 G-16 | .210 .363 .360 .354 .368 .243 | .00759 .01470 .01472 .01434 .01491 .00894 | .801 .707 .699 .700 .712 .770 | .0746 .0779 .0778 .0777 .0780 .0753 | .123 .206 .213 .212 .200 .151 | .00211 .00963 .01024 .00964 .00954 .00377 | 6,540 13,640 13,660 13,300 13,830 8,770 | 13,960 14,410 14,410 14,050 13,900 8,220 | 1.0244 1.0139 1.0137 1.0142 1.0138 1.0223 | 3.97 7,249 7,400 7,356 7,088 4,737 | .229 7,19 7,34 7,30 7,03 4,66 | .506 .458 .443 .439 .476 .500 |
| F4-C-a1 | 8982 | 3E 3E 3B 3B 5 6 | G-2 T-9 N-5-j T-9 T-87 T-88 T-89 T-89 T-90 | .363 .351 .345 .345 .184 .345 .348 .348 .232 | .01486 .01427 .01370 .01370 .006660 .01394 .01417 .01417 .008585 | .709 .698 .711 .711 .791 .705 .701 .701 .773 | .0779 .0776 .0775 .0775 .0742 .0775 .0776 .0776 .0751 | .203 .214 .202 .202 .133 .208 .211 .211 .149 | .01039 .00996 .00941 .00941 .00219 .00935 .00966 .00966 .00338 | 13,780 13,240 12,700 12,700 6,380 12,350 13,140 13,140 8,940 | 12,680 12,680 12,680 12,680 13,780 13,130 13,100 13,100 8,090 | 1.0137 1.0141 1.0151 1.0151 1.0254 1.0148 1.0144 1.0144 1.0226 | 7,272 7,39 7,106 7,106 3.959 7,186 7,286 7,286 4,738 | .228 7,17 7,17 7,17 3.88 7,12 7,22 7,22 4,66 | .451 .426 .449 .449 .454 .439 .439 .439 .474 |
| F4-C-f1 | 8997 | 1 2 3 3B 3B 4 5 6 | T-37 T-38 T-39 N-14-1 ^h N-14-2 T-40 T-41 T-42 G-3 T-10 N-6-j | .201 .323 .353 .354 .351 .364 .360 .246 .363 .348 .348 .232 | .00724 .01280 .01414 .01414 .01416 .01489 .01456 .00910 .01466 .0144 .348 .342 | .797 .715 .708 .706 .703 .695 .703 .774 .706 .690 .693 | .0745 .0770 .0777 .0777 .0776 .0779 .0778 .0754 .0779 .0776 .0774 .0774 | .127 .200 .205 .205 .210 .216 .209 .147 .206 .223 .219 .219 | .00215 .00817 .00947 .00950 .00967 .01071 .01071 .00356 .00994 .01035 .01041 .01041 | 6,700 11,870 13,250 13,250 13,140 13,820 13,230 8,420 13,600 13,120 12,920 | 6,190 11,810 12,500 12,500 12,500 13,820 13,230 8,350 14,780 14,770 14,770 | 1.0248 1.0164 1.0146 1.0146 1.0145 1.0135 1.0141 1.0221 | 3.973 6,721 7,096 7,098 7,199 7,428 7,178 4,749 | .243 .445 .459 .459 .447 .446 .460 .502 | |
| F4-C-f6 | 19579 | 3 38 38 38 | G-3 T-10 N-6-j | .363 .348 .342 | .01466 .0144 .01392 | .706 .690 .693 | .0779 .0776 .0774 | .206 .223 .219 | .00994 .01035 .01058 | 13,600 13,120 12,920 | 14,780 14,770 14,770 | 1.0138 1.0141 1.0146 | 7,414 7,659 7,350 | .448 .409 .422 | |

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Table 3.1-5 (continued, 2/8)

| Core Location Number | Fuel Rod Sample Zone | Axial Sample Code | Sample a | U-235 Atom Depletion (fission/atom) | Total Accumulated Fissions Relative to N ₀ ^b | U-235 U-238 Pu-239 Pu-241 Accumulated Fission Fraction (fissions / total fissions) | Burnup (MWd/MTU) b | | | N ₀ ^c | Pu/U Mass Ratio c |
|---|----------------------|---------------------|----------|-------------------------------------|--|--|-----------------------|--------------------|--------------------|-----------------------------|-------------------|
| | | | | | | | Isotopic Cs-137 Sr-90 | Burnup (MWd/MTU) b | Isotopic X-ray | | |
| PHASE III, ASYMPTOTIC NEUTRON SPECTRUM, CENTER SUBASSEMBLIES | | | | | | | | | | | |
| F5-C-a1 | 553 | 1 | G-43 | .315 | .01229 | .731 .0768 .186 .00675 | 11,390 | 11,390 15,370 | 1,0173 | 6.284 | 6.21 |
| | | 3 | G-44 | .538 | .02544 | .603 .0823 .289 .0291 | 23,680 | 23,740 21,180 | .9990 | 11,111 | 11,20 |
| | 5 | G-45 | .540 | .02554 | .607 .0823 .284 .02576 | 23,780 | 23,660 21,180 | .9991 | 10,906 | 10,38 | |
| | 6 | G-46 | .398 | .01639 | .704 .0787 .207 .01070 | 15,210 | 14,780 13,390 | 1,0120 | 7,473 | 7,43 | |
| F5-C-f6 | 541 | 1 | T-117 | .300 | .01173 | .721 .0765 .196 .00713 | 10,880 | 11,570 15,630 | 1,0179 | 6.309 | 6.23 |
| | 2 | T-118 | .491 | .02240 | .622 .0810 .275 .02182 | 20,840 | 21,280 23,440 | 1,0031 | 16,136 | 10,17 | |
| | 3 | T-119 | .520 | .02465 | .595 .0818 .297 .02643 | 22,950 | 24,340 23,880 | .9998 | 11,070 | 11,14 | |
| | 4 | T-120 | .540 | .02607 | .588 .0823 .302 .02822 | 24,280 | 25,620 22,400 | .9980 | 11,477 | 11,57 | |
| | 5 | T-121 | .528 | .02499 | .601 .0820 .290 .02616 | 23,270 | 23,630 20,150 | .9997 | 10,814 | 10,96 | |
| | 6 | T-122 | .374 | .01548 | .688 .0782 .222 .01133 | 14,370 | 14,570 11,550 | 1,0127 | 7,631 | 7,58 | |
| PHASE I, ASYMPTOTIC NEUTRON SPECTRUM, CENTER SUBASSEMBLIES | | | | | | | | | | | |
| G4-C-a1 | 0994 | 1 | T-43 | .193 | .00696 | .791 .0743 .133 .00230 | 6,430 | 6,640 | 1,0250 | 4,038 | 3.96 |
| | 3 | k | T-18 | .329 | .01304 | .726 .0771 .190 .00760 | 12,080 | 11,760 11,560 | 1,0162 | 6,627 | 6.56 |
| | 3 | T-36 | .321 | .01262 | .725 .0770 .191 .00762 | 11,700 | 11,710 | 1,0168 | 6,424 | 6.37 | |
| | 3 | T-58 | .324 | .01288 | .719 .0770 .196 .00783 | 11,940 | 11,660 | 1,0164 | 6,657 | 6.58 | |
| | 3 | T-91 | .323 | .01286 | .718 .0770 .197 .00781 | 11,920 | 11,780 | 1,0163 | 6,777 | 6.55 | |
| | 3 | T-104 | .323 | .01282 | .720 .0770 .195 .00784 | 11,880 | 11,500 | 1,0165 | 6,618 | 6.62 | |
| | 3 | T-144 | .322 | .01279 | .720 .0770 .196 .00779 | 11,850 | 11,460 | 1,0164 | 6,707 | 6.64 | |
| | 3 | T-150 | .328 | .01296 | .726 .0771 .190 .00761 | 12,010 | 11,730 | 1,0164 | 6,495 | 6.43 | |
| | 3 | G-6 | .333 | .01320 | .728 .0772 .188 .00756 | 12,240 | 11,630 | 1,0161 | 6,596 | 6.55 | |
| | 3 | G-17 | .324 | .01286 | .725 .0770 .191 .00759 | 11,920 | 11,780 | 1,0165 | 6,605 | 6.58 | |
| | 3 | G-42 | .324 | .01293 | .719 .0770 .196 .00775 | 11,990 | 11,570 | 1,0163 | 6,724 | 6.65 | |
| | 3 | G-51 | .321 | .01271 | .717 .0770 .198 .00782 | 11,780 | 11,620 | 1,0165 | 6,700 | 6.63 | |
| | 3 | N-12-1 ^h | .318 | .01268 | .715 .0769 .197 .00796 | 11,760 | 11,350 | 1,0167 | 6,575 | 6.32 | |
| | 3 | N-12-2 ^h | .324 | .01275 | .722 .0770 .193 .00772 | 11,820 | 11,600 | 1,0166 | 6,348 | 6.48 | |
| | 5 | T-44 | .363 | .01501 | .692 .0779 .220 .01095 | 13,930 | 13,930 | 1,0133 | 7,560 | 7.50 | |
| | 6 | T-45 | .244 | .00916 | .774 .0753 .147 .00360 | 8,480 | 8,200 | 1,0220 | 4,781 | 4,70 | |
| | 6 | N-13-1 ^h | .243 | .00898 | .775 .0753 .146 .00368 | 8,310 | 8,200 | 1,0223 | 4,728 | 4,65 | |
| | 6 | N-13-2 ^h | .243 | .00839 | .775 .0753 .146 .00353 | 8,310 | 8,200 | 1,0222 | 4,736 | 4,59 | |
| G4-C-a6 | 0985 | 1 | T | .207 | .00739 | .796 .0746 .127 .00225 | 6,830 | 6,590 6,180 | 1,0246 | 4,057 ^m | 3.98 |
| | 3 | T | .363 | .01475 | .703 .0779 .209 .00996 | 13,680 | 13,410 12,340 | 1,0138 | 7,352 ^m | 7.29 | |
| | 5 | G | .378 | .01545 | .706 .0782 .206 .00974 | 14,330 | 13,500 12,340 | 1,0129 | 7,477 ^m | 7.42 | |
| | 5 | T | .369 | .01506 | .703 .0780 .209 .01054 | 13,970 | 13,500 12,380 | 1,0134 | 7,414 ^m | 7.36 | |
| | 6 | T | .251 | .00919 | .790 .0755 .130 .00359 | 8,500 | 9,590 7,560 | 1,0222 | 4,567 ^m | 4,49 | |
| G4-C-f1 | 0979 | 1 | T | .195 | .00700 | .796 .0744 .127 .00233 | 6,470 | 6,020 5,660 | 1,0251 | 3,954 ^m | 3.88 |
| | 3 | T | .366 | .01486 | .712 .0780 .201 .00945 | 13,780 | 12,650 14,000 | 1,0138 | 7,239 ^m | 7.18 | |
| | 5 | T | .363 | .01470 | .710 .0779 .203 .00946 | 13,630 | 13,180 13,320 | 1,0139 | 7,239 ^m | 7.18 | |
| | 6 | T | .252 | .00938 | .776 .0755 .144 .00407 | 8,680 | 8,120 8,730 | 1,0217 | 4,864 ^m | 4,78 | |
| G4-C-f1 | 0982 | 1 | G-22 | .198 | .00713 | .797 .0744 .126 .00213 | 6,600 | 6,790 | 1,0248 | 4,029 | 3.95 |
| | 3 | G-23 | .324 | .01287 | .719 .0770 .196 .00806 | 11,930 | 12,380 | 1,0163 | 6,768 | 6.57 | |
| | 5 | G-24 | .369 | .01526 | .690 .0780 .221 .01098 | 14,160 | 14,310 | 1,0128 | 7,805 | 7.75 | |
| | 6 | G-25 | .246 | .00916 | .774 .0754 .147 .00351 | 8,470 | 8,110 | 1,0220 | 4,834 | 4.97 | |

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Table 3.1-5 (continued, 3/8)

| PHASE I, ASYMPTOTIC NEUTRON SPECTRUM, CENTER ASSEMBLIES | | | | | | | | | | PHASE II, ASYMPTOTIC NEUTRON SPECTRUM, CENTER ASSEMBLIES | | | | | | | | | | | |
|---|---------------|-------------------|-------------------------------------|--------------------|--------|----------------|----------------------|------------------------|---|--|--------|--------------------|--------|------------------------------|--------|------------|------------|------------------------------|------------------------------|------------------------------|------------------------------|
| Core Location Number | Fuel Rod Zone | Axial Sample Code | U-235 Atom Depletion (fission/atom) | Sample Zone Number | U-235 | Total Fissions | Accumulated Fissions | Relative to N_0^{28} | $\frac{\text{Accumulated Fission Fraction}}{\text{total fissions}}$ | Burnup (MW/MTU) ^b | | | | Burnup (MW/MTU) ^b | | | | $\frac{N^U}{N_0^{28}}$ | $\frac{N^{Pu}}{N_0^{28}}$ | Pu/U Mass Ratio ^c | |
| | | | | | | | | | | U-235 | U-238 | Pu-239 | Pu-241 | Isotopic Cs-137 | Str-90 | atoms/atom | atoms/atom | $(\text{atoms} \times 10^3)$ | $(\text{atoms} \times 10^3)$ | $(\text{atoms} \times 10^3)$ | $(\text{atoms} \times 10^3)$ |
| H3-C-a1 | 8537 | 5 | G | .303 | .01175 | .753 | .0766 | .166 | .00534 | 10,880 | 10,460 | 8,050 | 1,0183 | 5,857 ^m | 5.78 | .221 | .485 | | | | |
| H3-C-a6 | 8510 | 2 | T | .262 | .01020 | .729 | .0757 | .189 | .00638 | 9,450 | 1,0197 | 6,056 ^m | 5.97 | .256 | .390 | | | | | | |
| H3-C-a6 | 8510 | 1 | T | .167 | .00589 | .816 | .0739 | .109 | .00150 | 5,440 | 5,070 | 3,730 | 1,0268 | 3,349 ^m | 3.28 | .241 | .495 | | | | |
| | | | | .279 | .01075 | .748 | .0760 | .171 | .00516 | 9,960 | 9,650 | 7,160 | 1,0195 | 5,598 ^m | 5.62 | .237 | .461 | | | | |
| | | | | .306 | .01200 | .732 | .0766 | .185 | .00657 | 11,120 | 10,880 | 8,520 | 1,0177 | 6,252 ^m | 6.18 | .242 | .456 | | | | |
| | | | | .294 | .01155 | .716 | .0764 | .199 | .00769 | 10,710 | 10,830 | 8,850 | 1,0180 | 6,369 ^m | 6.29 | .266 | .426 | | | | |
| | | | | .318 | .01262 | .730 | .0769 | .186 | .00679 | 11,690 | 10,830 | 8,760 | 1,0189 | 6,444 ^m | 6.37 | .231 | .456 | | | | |
| | | | | .309 | .01219 | .738 | .0767 | .179 | .00636 | 11,300 | 10,880 | 9,080 | 1,0176 | 6,206 ^m | 6.13 | .224 | .461 | | | | |
| | | | | .207 | .00757 | .805 | .0746 | .118 | .00208 | 7,000 | 6,230 | 3,990 | 1,0245 | 3,366 ^m | 3.89 | .208 | .503 | | | | |
| H3-C-f1 | 8528 | 1 | G ^d | .137 | .00467 | .832 | .0733 | .0942 | .000846 | 4,320 | 4,030 | 4,690 | 1,0286 | 2,779 ^m | 2.72 | .257 | .497 | | | | |
| | | | | .262 | .00992 | .750 | .0757 | .169 | .00690 | 9,180 | 9,290 | 1,0206 | 5,459 | 5.38 | 5.26 | .256 | .457 | | | | |
| | | | | .267 | .01010 | .752 | .0758 | .161 | .00500 | 9,350 | 8,630 | 9,130 | 1,0204 | 5,045 ^m | 5.38 | .254 | .468 | | | | |
| | | | | .214 | .00791 | .756 | .0748 | .165 | .00426 | 7,330 | 8,060 | 1,0233 | 4,743 | 4.66 | 4.20 | .278 | .430 | | | | |
| | | | | .214 | .00791 | .755 | .0757 | .165 | .00453 | 9,050 | 7,990 | 7,060 | 1,0208 | 5,345 ^m | 5.26 | .261 | .470 | | | | |
| | | | | .261 | .00978 | .745 | .0754 | .175 | .00491 | 8,680 | 7,980 | 7,110 | 1,0212 | 5,374 ^m | 5.29 | .272 | .441 | | | | |
| | | | | .249 | .00937 | .822 | .0739 | .103 | .00122 | 5,450 | 5,230 | 4,260 | 1,0288 | 3,275 ^m | 3.21 | .230 | .506 | | | | |
| | | | | .167 | .00590 | | | | | | | | | | | | | | | | |
| H3-C-f6 | 8574 | 1 | T-138 | .148 | .00507 | .826 | .0735 | .100 | .00101 | 4,680 | 4,610 | 1,0280 | 2,949 | 2.88 | 3.04 | .257 | .505 | | | | |
| | | | | .295 | .01128 | .749 | .0764 | .169 | .00554 | 10,440 | 9,910 | 1,0189 | 5,749 | 5.65 | 5.83 | .244 | .489 | | | | |
| | | | | .284 | .01095 | .746 | .0762 | .172 | .00350 | 10,140 | 9,980 | 1,0192 | 5,771 | 5.59 | 5.71 | .238 | .462 | | | | |
| | | | | .180 | .00642 | .812 | .0761 | .113 | .00158 | 5,930 | 5,750 | 1,0260 | 3,546 | 3.47 | 3.75 | .234 | .501 | | | | |
| H4-C-a1 | 2021 | 1 | G-11 | .188 | .00658 | .808 | .0742 | .116 | .00174 | 6,080 | 5,490 | 1,0258 | 3,650 | 3.58 | 3.59 | .261 | .319 | | | | |
| | | | | .333 | .01305 | .722 | .0772 | .193 | .00764 | 12,100 | 14,100 | 1,0162 | 6,657 | 6.59 | 6.85 | .258 | .468 | | | | |
| | | | | .327 | .01292 | .711 | .0771 | .204 | .00839 | 11,980 | 12,200 | 1,0162 | 6,767 | 6.70 | 7.00 | .270 | .450 | | | | |
| | | | | .224 | .00805 | .792 | .0750 | .131 | .00248 | 7,450 | 6,620 | 1,0236 | 4,316 | 4.24 | 4.24 | .255 | .515 | | | | |
| H5-C-a1 | 1000 | 1 | T-25 | .194 | .00697 | .806 | .0744 | .118 | .00178 | 6,440 | 6,200 | 1,0252 | 3,784 | 3.71 | 3.56 | .234 | .306 | | | | |
| | | | | .345 | .01409 | .707 | .0775 | .205 | .00972 | 13,070 | 12,840 | 1,0146 | 7,215 | 7.15 | 7.07 | .235 | .433 | | | | |
| | | | | .335 | .01348 | .703 | .0773 | .211 | .00906 | 12,500 | 12,840 | 1,0152 | 7,189 | 7.12 | 6.72 | .261 | .426 | | | | |
| | | | | .322 | .01290 | .699 | .0770 | .215 | .00935 | 11,970 | 12,830 | 1,0160 | 7,037 | 6.96 | 6.72 | .271 | .416 | | | | |
| | | | | .358 | .01440 | .706 | .0778 | .196 | .00886 | 13,350 | 13,280 | 1,0146 | 6,901 | 6.84 | 7.00 | .236 | .477 | | | | |
| | | | | .345 | .01394 | .706 | .0775 | .207 | .00930 | 12,930 | 13,260 | 1,0149 | 7,040 | 6.98 | 7.35 | .249 | .449 | | | | |
| | | | | .342 | .01380 | .706 | .0774 | .207 | .00936 | 12,800 | 13,280 | 1,0152 | 6,921 | 6.86 | 7.36 | .251 | .454 | | | | |
| | | | | .236 | .00870 | .781 | .0752 | .140 | .00309 | 8,050 | 6,820 | 1,0226 | 4,662 | 4.58 | 4.59 | .235 | .488 | | | | |
| H8-C-a1 | 21305 | 1 | T-113 | .168 | .00586 | .819 | .0739 | .106 | .00124 | 5,420 | 5,340 | 1,0268 | 3,340 | 3.27 | 3.18 | .245 | .500 | | | | |
| | | | | .306 | .01192 | .731 | .0766 | .186 | .00674 | 11,050 | 11,270 | 1,0177 | 6,287 | 6.21 | 6.04 | .253 | .456 | | | | |
| | | | | .304 | .01182 | .732 | .0766 | .185 | .00666 | 10,960 | 11,220 | 1,0179 | 6,233 | 6.16 | 5.98 | .253 | .458 | | | | |
| | | | | .298 | .00741 | .814 | .0746 | .110 | .00172 | 6,840 | 6,260 | 1,0248 | 3,740 | 3.67 | 4.00 | .232 | .550 | | | | |
| H8-C-f6 | 1306 | 3A ^d | T-136 | .268 | .00394 | .769 | .0758 | .151 | .00422 | 9,200 | 8,920 | 1,0210 | 4,997 | 4.92 | 5.46 | .251 | .521 | | | | |
| | | 3B | T-137 | .270 | .01014 | .758 | .0759 | .162 | .00446 | 9,390 | 9,030 | 1,0204 | 5,396 | 5.32 | 5.48 | .253 | .482 | | | | |

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Table 3.1-5 (continued, 4/8)

| Total | | | | | | | | | | | | Total | | | | | | | | | | | | | | | | | | | | |
|---|--|--|------|---|---|-----------------|-------------------|-------------|-------------|----------------|----------------|--------------------------------------|----------|--|--|------|---|-----------------|-------------------|-------------|-------------|----------------|----------------|------------------------------|--------|-------|--------|-------|------|------|------|------|
| Core | | | | | | Fuel Rod Number | Axial Sample Zone | Sample Code | Atom Number | Atom Depletion | (Fission/atom) | Core | | | | | | Fuel Rod Number | Axial Sample Zone | Sample Code | Atom Number | Atom Depletion | (Fission/atom) | | | | | | | | | |
| 3-3-C-a1 | | | 3477 | 3 | G | T-19 | .159 | .00555 | .783 | .0737 | .142 | .00203 | 3-3-C-a1 | | | 3480 | 1 | T | .191 | .00674 | .808 | .0743 | .116 | .00173 | .5,130 | 5,680 | 1.0267 | 3.804 | 3.72 | 3.71 | .305 | .393 |
| 3-3-C-f6 | | | 3480 | 1 | T | T-20 | .191 | .00671 | .815 | .0743 | .109 | .00156 | 3-3-C-f6 | | | 3480 | 1 | T | .184 | .00644 | .803 | .0742 | .121 | .00193 | .6,220 | 5,680 | 1.0255 | 3.752 | 3.68 | 3.71 | .252 | .508 |
| U-235 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Relative to N ₀ ²⁸ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Accumulated Fissions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| ($\frac{\text{Fissions}}{\text{total Fissions}}$) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| U-235 U-238 Pu-239 Pa-241 | | | | | | | | | | | | MMD/MFTU) ^b | | | | | | | | | | | | Burnup (MMD/MFTU) | | | | | | | | |
| Isotopic Cs-137 Sr-90 | | | | | | | | | | | | Isotopic X-ray Alpha-25 ^e | | | | | | | | | | | | NGD/MWD ^f | | | | | | | | |
| N ₀ ²⁸ | | | | | | | | | | | | (atoms × 10 ³) | | | | | | | | | | | | Pu/U Mass Ratio ^c | | | | | | | | |
| N ₀ | | | | | | | | | | | | (atoms / atom) | | | | | | | | | | | | (gm × 10 ³) | | | | | | | | |
| U-235 | | | | | | | | | | | | (atoms / atom) | | | | | | | | | | | | (gm) | | | | | | | | |
| Sample a | | | | | | | | | | | | N ₀ ²⁸ | | | | | | | | | | | | N ₀ | | | | | | | | |
| Atom Code | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| Atom Number | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | | | | | N ₀ | | | | | | | | |
| N ₀ | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

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Table 3.1-5 (continued, 5/8)

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| Core Location Number | Fuel Rod | Axial Sample Zone | U-235 Atom Number | Depletion | Total Fissions | Accumulated Fission Fraction | (fission/atom) | U-235 (t-238 Pu-239) | Burnup (MWD/MTU) ^b | Burnup (MWD/MTU) Isotopic Cs-137 Sr-90 | $\frac{N_U}{N_0}$ (atoms/atom) | $\frac{N_{Pu}}{N_0}$ (atoms/atom) | $\frac{N_{Pu}}{N_{28}}$ | Pu/U Mass Ratio (gm/gm $\times 10^3$) | | | |
|--|----------|-------------------|-------------------|-----------|-----------------------------|------------------------------|----------------|----------------------|-------------------------------|--|--------------------------------|-----------------------------------|-------------------------|--|------|------|------|
| | | | | | Relative to N ₂₈ | (total fissions) | | | | | | | | | | | |
| PHASE I, ASYMPTOTIC NEUTRON SPECTRUM, CENTER SUBASSEMBLIES | | | | | | | | | | | | | | | | | |
| K4-C-f6 | 2905 | 1 | T-15 | .0721 | .00234 | .887 | .0722 | .0405 | .000228 | 2,160 | 1,900 | 1,0325 | 1,22 | 1.16 | .239 | .594 | |
| | 3 | T-16 | .143 | .00185 | .847 | .0734 | .0793 | .000651 | 4,480 | 4,500 | 1,0286 | 2,51 | 2.51 | .242 | .566 | | |
| | 5 | T-17 | .140 | .00177 | .849 | .0734 | .0711 | .000651 | 4,400 | 3,670 | 1,0287 | 2,534 | 2.48 | .236 | .561 | | |
| | 6 | T-23 | .0743 | .00235 | .877 | .0722 | .0503 | | 2,170 | 2,120 | 1,0322 | 1,449 | 1.41 | .42 | .283 | | |
| K5-C-a1 | 0877 | 1 | T-28 | .111 | .00382 | .866 | .0729 | .0609 | .000369 | 3,530 | 2,940 | 1,0303 | 1,942 | 1.89 | 2.00 | .195 | |
| | 3 | T-29 | .216 | .00782 | .806 | .0748 | .117 | .00204 | 7,230 | 6,450 | 1,0242 | 4,007 | 3,93 | 3.98 | .218 | | |
| | 5 | T-30 | .207 | .00751 | .806 | .0746 | .117 | .00208 | 6,940 | 6,450 | 1,0246 | 3,912 | 3.84 | 3.93 | .221 | | |
| | 6 | T-31 | .126 | .00437 | .856 | .0731 | .0698 | .000570 | 3,420 | 4,030 | 1,0294 | 2,210 | 2.16 | 2.04 | .205 | | |
| K5-C-f6 | 011 | 1 | G-18 | .0914 | .00310 | .882 | .0725 | .0457 | .000134 | 2,860 | 2,480 | 1,0313 | 1,615 | 1.57 | 1.53 | .192 | |
| | 3 | G-19 | .170 | .00600 | .829 | .0739 | .098 | .00118 | 5,540 | 6,440 | 1,0268 | 3,206 | 3.14 | 2.29 | .220 | | |
| | 5 | G-20 | .170 | .00601 | .832 | .0739 | .0935 | .00109 | 5,550 | 7,860 | 1,0268 | 3,157 | 3.09 | 3.16 | .212 | | |
| | 6 | G-21 | .0945 | .00317 | .866 | .0726 | .0607 | .003357 | 2,930 | 3,000 | 1,0310 | 1,831 | 1.78 | 2.08 | .225 | | |
| PHASE II, PERTURBED NEUTRON SPECTRUM, CORNER SUBASSEMBLIES | | | | | | | | | | | | | | | | | |
| E5-NE-f1 | 2300 | 1 | G-38 | .255 | .00941 | .773 | .0581 | .165 | .00426 | 8,720 | 9,490 | 1,0217 | 4,860 | 4.78 | 4.68 | .247 | |
| | 3 | G-39 | .415 | .0172 | .699 | .0619 | .226 | .0134 | 15,980 | 15,460 | 1,0113 | 7,307 | 7.27 | 7.45 | .231 | | |
| | 5 | G-40 | .368 | .0149 | .714 | .0607 | .215 | .0104 | 13,830 | 13,380 | 1,0138 | 7,080 | 7.02 | 6.32 | .234 | | |
| | 6 | G-41 | .236 | .00834 | .803 | .0578 | .136 | .00288 | 7,900 | 7,840 | 1,0232 | 4,251 | 4.18 | 3.75 | .228 | | |
| E5-SW-a5 | 15025 | 1 | T-46 | .246 | .00888 | .790 | .0580 | .148 | .00357 | 8,220 | 8,670 | 1,0227 | 4,405 | 4.33 | 4.23 | .250 | |
| | 3 | T-47 | .436 | .0182 | .683 | .0624 | .239 | .0157 | 16,910 | 17,680 | 1,0096 | 7,75 | 7.75 | 7.55 | .250 | | |
| | 5 | T-48 | .419 | .0172 | .698 | .0619 | .226 | .0137 | 15,98 | 16,350 | 1,0113 | 7,348 | 7.31 | 7.31 | .242 | | |
| | 6 | T-49 | .270 | .00936 | .767 | .0585 | .169 | .00491 | 9,230 | 9,830 | 1,0209 | 5.067 | 4.99 | 4.68 | .256 | | |
| F4-NE-f1 | 20036 | 1 | T-50 | .256 | .00924 | .795 | .0582 | .144 | .00357 | 8,560 | 8,920 | 1,0223 | 4,406 | 4.33 | 4.35 | .248 | |
| | 3 | T-51 | .463 | .0191 | .691 | .0631 | .229 | .0168 | 17,790 | 17,330 | 1,0092 | 7,383 | 7.36 | 7.46 | .247 | | |
| | 5 | T-52 | .468 | .0194 | .687 | .0632 | .232 | .0175 | 18,070 | 18,340 | 1,0088 | 7,481 | 7.46 | 7.63 | .248 | | |
| | 6 | T-53 | .312 | .0116 | .764 | .0594 | .170 | .00616 | 10,730 | 11,220 | 1,0191 | 5.258 | 5.19 | 5.29 | .256 | | |
| F4-NE-f1 | 20036 | 1 | T-50 | .256 | .00924 | .795 | .0582 | .144 | .00357 | 8,560 | 8,920 | 1,0223 | 4,406 | 4.33 | 4.35 | .248 | |
| | 3 | T-51 | .463 | .0191 | .691 | .0631 | .229 | .0168 | 17,790 | 17,330 | 1,0092 | 7,383 | 7.36 | 7.46 | .247 | | |
| | 5 | T-52 | .468 | .0194 | .687 | .0632 | .232 | .0175 | 18,070 | 18,340 | 1,0088 | 7,481 | 7.46 | 7.63 | .248 | | |
| | 6 | T-53 | .312 | .0116 | .764 | .0594 | .170 | .00616 | 10,730 | 11,220 | 1,0191 | 5.258 | 5.19 | 5.29 | .256 | | |
| F4-SW-a5 | 17383 | 1 | T-75 | .212 | .00758 | .804 | .0573 | .136 | .00245 | 7,020 | 6,350 | 1,0244 | 4,009 | 3.93 | 3.96 | .241 | |
| | 3 | T-76 | .373 | .01569 | .706 | .0608 | .222 | .01112 | 14,010 | 14,190 | 1,0137 | 7,075 | 7.02 | 7.17 | .248 | | |
| | 5 | T-77 | .388 | .01567 | .712 | .0612 | .216 | .01147 | 14,550 | 14,970 | 1,0132 | 6,929 | 6.88 | 7.07 | .240 | | |
| | 6 | T-78 | .253 | .00925 | .784 | .0581 | .154 | .00377 | 8,560 | 8,640 | 1,0220 | 4,678 | 4.60 | 4.49 | .241 | | |
| PHASE III, PERTURBED NEUTRON SPECTRUM, CORNER SUBASSEMBLIES | | | | | | | | | | | | | | | | | |
| F5-NW-a1 | 8604 | 1 | G-47 | .324 | .01254 | .741 | .0597 | .192 | .00704 | 11,620 | 11,760 | 1,0170 | 6,356 | 6.28 | 6.38 | .242 | |
| | 3 | G-48 | .612 | .03001 | .580 | .0673 | .315 | .03823 | 27,990 | 28,680 | 28,000 | .9946 | 10,674 | 11,37 | .254 | | |
| | 5 | G-49 | .637 | .03105 | .586 | .0680 | .307 | .03971 | 28,960 | 29,160 | 27,320 | .9941 | 10,140 | 10,27 | .249 | | |
| | 6 | G-50 | .465 | .01970 | .682 | .0632 | .238 | .01677 | 18,300 | 17,850 | 14,310 | 1,0081 | 7,900 | 7.88 | .234 | | |
| F5-SE-f5 | 8717 | 1 | T-123 | .358 | .01423 | .716 | .0605 | .214 | .01001 | 13,200 | 13,090 | 17,630 | 1,0147 | 6,904 | 6.84 | 7.29 | .253 |
| | 2 | T-124 | .607 | .02918 | .591 | .0671 | .306 | .03609 | 27,200 | 28,630 | 25,620 | 1,0215 | 10,32 | 10,24 | .256 | .484 | |
| | 3 | T-125 | .649 | .03253 | .568 | .0684 | .321 | .04262 | 30,150 | 31,740 | 30,040 | .9920 | 10,738 | 10,80 | .254 | .458 | |
| | 4 | T-126 | .646 | .03263 | .567 | .0683 | .323 | .04222 | 30,440 | 32,340 | 28,910 | .9916 | 11,005 | 11,17 | .256 | .468 | |
| | 5 | T-127 | .623 | .03030 | .588 | .0676 | .307 | .03717 | 28,700 | 28,030 | 10,417 | 1,0417 | 11,05 | 11,00 | .245 | .456 | |
| | 6 | T-128 | .439 | .01822 | .696 | .0625 | .227 | .01426 | 16,920 | 16,960 | 17,590 | 1,0100 | 7,587 | 7.56 | .242 | .475 | |

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Table 3.1-5 (continued, 6/8)

| Core Location Number | Fuel Rod Number | Axial Sample Zone | Sample Code | Total NEUTRON SPECTRUM, CORNER SUBASSEMBLIES | | | Burnup (MWd/MTU) ^b | $\frac{N_U}{N_{^{238}U}}$ | $\frac{N_{^{235}U}}{N_0}$ | $\frac{N_{^{239}Pu}}{N_0}$ | $\frac{N_{^{240}Pu}}{N_0}$ | $\frac{N_{^{242}Pu}}{N_0}$ | Pu/U Mass Ratio ^c | |
|--|-----------------|-------------------|-------------|--|-------------------------|--------------------------|-------------------------------|---------------------------|---------------------------|----------------------------|----------------------------|----------------------------|------------------------------|--------------------|
| | | | | Accumulated Fissions | Relative to N_0^{238} | Depletion (Fission/atom) | | | | | | | | |
| PHASE I, PERTURBED NEUTRON SPECTRUM, CORNER SUBASSEMBLIES | | | | | | | | | | | | | | |
| G4-NW-a1 1XY39 | 1 | T | | .266 | .00971 | .801 | .0584 | .137 | .00333 | 8,990 | 8,540 | 8,200 | 1,0218 | 4.442 ^m |
| | 3 | T | | .471 | .0197 | .691 | .0633 | .229 | .0168 | 18,310 | 17,750 | 17,120 | 1,0085 | 7.530 ^m |
| | 5 | T | | .482 | .0201 | .694 | .0636 | .226 | .0169 | 18,640 | 17,550 | 21,330 | 1,0082 | 7.52 |
| | 6 | T | | .308 | .0115 | .761 | .0593 | .173 | .00628 | 10,640 | 10,720 | 10,040 | 1,0191 | 5.330 ^m |
| G4-SE-f5 12760 | 1 | G-34 | | .228 | .00805 | .785 | .0576 | .154 | .00352 | 7,460 | 8,210 | 1,0235 | 4.407 | 4.33 |
| | 3 | G-35 | | .456 | .01889 | .687 | .0629 | .233 | .01688 | 17,550 | 18,40 | 1,0093 | 7,601 | 7.49 |
| | 5 | G-36 | | .474 | .01982 | .687 | .0634 | .232 | .01752 | 18,410 | 18,370 | 1,0082 | 7,749 | 8.16 |
| | 6 | G-37 | | .320 | .01179 | .774 | .0596 | .161 | .00582 | 10,920 | 11,500 | 1,0189 | 5.205 | 5.14 |
| H3-SE-f5 220 Comp ⁿ | G | | | .346 | .0130 | .778 | .057 | .158 | .007 | 12,070 | | 1,0175 | 5.391 | 5.32 |
| H3-SE-f5 | 220 | 1 | G | .203 | .00710 | .835 | .0571 | .106 | .00169 | 6,560 | 6,450 | 6,650 | 1,0256 | 3.340 |
| | 2 | G | | .358 | .01365 | .771 | .0604 | .162 | .00702 | 12,640 | 12,360 | 12,210 | 1,0170 | 5.292 |
| | 3 | G | | .392 | .01532 | .744 | .0613 | .185 | .00950 | 14,200 | 14,330 | 13,190 | 1,0144 | 6,084 |
| | 4 | G | | .406 | .01586 | .747 | .0616 | .182 | .00967 | 14,700 | 14,760 | 13,670 | 1,0138 | 6,128 |
| | 5 | G | | .370 | .01432 | .744 | .0608 | .186 | .00877 | 13,280 | 13,390 | 14,440 | 1,0155 | 6,023 |
| | 5g | T-7 | | .374 | .01452 | .744 | .0608 | .186 | .00873 | 13,460 | 13,390 | 14,420 | 1,0152 | 6,106 |
| | 5g | N-3j | | .367 | .0142 | .742 | .0607 | .188 | .00916 | 13,140 | 13,390 | 14,440 | 1,0156 | 6,071 |
| | 6 | G | | .254 | .00915 | .824 | .0581 | .115 | .00241 | 8,460 | 7,630 | 9,080 | 1,0228 | 3.997 |
| H5-NW-a1 9709 | 1 | T-54 | | .237 | .00844 | .806 | .0578 | .133 | .00285 | 7,800 | 7,820 | | 1,0234 | 4.131 |
| | 3 | T-55 | | .450 | .01851 | .698 | .0627 | .224 | .01525 | 17,190 | 17,400 | | 1,0100 | 7,330 |
| | 5 | T-56 | | .466 | .01915 | .701 | .0632 | .220 | .01573 | 17,780 | 17,620 | | 1,0093 | 7,269 |
| | 6 | T-57 | | .326 | .01213 | .778 | .0597 | .156 | .00555 | 11,230 | 11,200 | | 1,0186 | 5.183 |
| J4-NW-a1 11183 | 1 | T | | .203 | .00718 | .832 | .0571 | .169 | .00174 | 6,630 | 6,060 | 4,730 | 1,0254 | 3.422 ^m |
| | 2 | T | | .364 | .01405 | .764 | .0606 | .168 | .00729 | 13,010 | 12,280 | 10,820 | 1,0162 | 5.646 ^m |
| | 3 | T | | .406 | .01598 | .749 | .0616 | .180 | .00928 | 14,810 | 13,940 | 13,080 | 1,0138 | 6,127 ^m |
| | 4 | T | | .406 | .01602 | .742 | .0616 | .187 | .00985 | 14,850 | 14,590 | 13,150 | 1,0136 | 6,243 ^m |
| | 5 | | | | | | | | | 13,050 | 12,200 | | | 6,20 |
| | 6 | | | | | | | | | 7,140 | 7,370 | | | 6,06 |
| PHASE I, INTERMEDIATE NEUTRON SPECTRUM, ON DIAGONAL OF CORNER SUBASSEMBLY | | | | | | | | | | | | | | |
| F4-SW-b4 17457 | 1 | T-79 | | .194 | .00694 | .805 | .0657 | .127 | .00218 | 6,420 | 6,580 | | 1,0253 | 3.788 |
| | 3 | T-80 | | .338 | .0135 | .713 | .0688 | .209 | .00926 | 12,500 | 13,160 | | 1,0157 | 6,662 |
| | 5 | T-81 | | .348 | .0139 | .711 | .0690 | .211 | .00962 | 12,880 | 13,400 | | 1,0153 | 6,719 |
| | 6 | T-82 | | .232 | .00855 | .785 | .0665 | .146 | .00316 | 7,910 | 8,090 | | 1,0230 | 4,459 |
| F4-SW-d2 17460 | 1 | T-83 | | .176 | .00615 | .784 | .0740 | .140 | .00214 | 5,690 | 6,300 | | 1,0259 | 3.912 |
| | 3 | T-84 | | .333 | .01339 | .706 | .0772 | .203 | .00883 | 12,420 | 12,660 | | 1,0155 | 7,015 |
| | 5 | T-85 | | .315 | .01340 | .704 | .0773 | .210 | .00914 | 12,430 | 12,960 | | 1,0155 | 6,960 |
| | 6 | T-86 | | .227 | .00837 | .780 | .0750 | .142 | .00303 | 7,740 | 7,750 | | 1,0231 | 4.538 |

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Table 3.1-5 (continued, 7/8)

| Core Location Number | Fuel Rod Number | Axial Sample Zone Number | Sample Code | Atom Depletion | Total Fissions | Accumulated Fissions | Accumulated Fission Fraction (total fissions) | Burnup (MWd/MTU) ^b | | | Burnup (MWd/MTU) ^b | | | $\frac{N^U}{N_0^{28}}$ | $\frac{N^{Pu}}{N_0^{28}}$ | $\frac{Pu/U \text{ Mass Ratio}}{(g_m \times 10^3)}$ | | |
|---|-----------------|--------------------------|-------------|----------------|----------------|---------------------------------------|--|-------------------------------|-----------------------|----------------|-------------------------------|-----------------------|----------------|------------------------|---------------------------|---|------|------|
| | | | | | U-235 | Relative to N_0^{28} (fission/atom) | U-235 U-238 Pu-239 Pu-241 | Isotopic Cs-137 Sr-90 | Isotopic Cs-137 Sr-90 | Isotopic X-ray | Isotopic Cs-137 Sr-90 | Isotopic Cs-137 Sr-90 | Isotopic X-ray | | | | | |
| PHASE I, INTERMEDIATE NEUTRON SPECTRUM, ON DIAGONAL OF CORNER SUBASSEMBLY | | | | | | | | | | | | | | | | | | |
| F5-NW-b2 8172 | 1 | 3 | G-56 | .297 | .01145 | .735 | .0678 | .190 | .00683 | 10,620 | 11,220 | 10,920 | 1,0184 | 6,075 | 6,00 | 6,86 | .257 | .464 |
| | | 5 | G-57 | .574 | .02732 | .604 | .0748 | .292 | .02983 | 25,440 | 25,630 | 24,560 | 0,9977 | 10,480 | 10,57 | 11,67 | .242 | .451 |
| | | 6 | G-58 | .571 | .01598 | .615 | .0747 | .277 | .03322 | 24,190 | 26,370 | 24,390 | 0,9996 | 9,863 | 9,93 | 11,26 | .273 | .474 |
| | | | G-59 | .412 | .01692 | .692 | .0705 | .224 | .01320 | 15,710 | 15,650 | 16,970 | 1,0115 | 7,420 | 7,38 | 8,00 | .255 | .508 |
| F5-NW-d4 8163 | 1 | 3 | G-52 | .309 | .01237 | .723 | .0767 | .189 | .01095 | 11,470 | 10,880 | 11,990 | 1,0174 | 6,202 | 6,13 | 6,78 | .231 | .456 |
| | | 5 | G-53 | .534 | .02528 | .605 | .0822 | .287 | .0298 | 23,530 | 23,190 | 20,500 | 0,9996 | 10,707 | 10,78 | 11,24 | .246 | .412 |
| | | 6 | G-54 | .534 | .02497 | .601 | .0822 | .290 | .02636 | 23,250 | 23,460 | 20,980 | 1,0001 | 10,305 | 10,57 | 11,00 | .269 | .425 |
| | | | G-55 | .383 | .01155 | .692 | .0784 | .218 | .01150 | 14,430 | 14,140 | 15,760 | 1,0129 | 7,324 | 7,27 | 7,50 | .270 | .482 |
| PHASE I, INTERMEDIATE NEUTRON SPECTRUM, ON DIAGONAL OF CORNER SUBASSEMBLY | | | | | | | | | | | | | | | | | | |
| H3-SE-b1 204 | 1 | 3 | G | .126 | .00439 | .806 | .0731 | .119 | .00122 | 4,060 | 4,550 | 4,520 | 1,0286 | 3,032 ^m | 2.96 | .264 | .379 | |
| | | 5 | T | .285 | .01111 | .748 | .0762 | .171 | .00551 | 10,290 | 9,960 | 9,670 | 1,0191 | 5,754 ^m | 5,68 | .223 | .462 | |
| | | 6 | G | .282 | .01075 | .748 | .0761 | .171 | .00532 | 9,950 | 9,610 | 9,940 | 1,0195 | 5,681 ^m | 5,61 | .250 | .472 | |
| | | | G | .267 | .01019 | .741 | .0758 | .178 | .00558 | 9,940 | 9,600 | 8,980 | 1,0201 | 5,624 ^m | 5,54 | .262 | .450 | |
| | | | G | .182 | .00648 | .821 | .0741 | .103 | .00139 | 5,980 | 5,600 | 5,700 | 1,0261 | 3,425 ^m | 3,35 | .222 | .525 | |
| | | | G | .182 | .00648 | .830 | .0732 | .0956 | .00084 | 4,120 | 4,960 | 4,0288 | 1,0288 | 2,702 | 2.64 | .250 | .488 | |
| | | | G | .131 | .00446 | .747 | .0764 | .171 | .00565 | 10,360 | 10,460 | 10,620 | 1,0191 | 5,613 | 5,54 | .253 | .501 | |
| | | | G | .131 | .00446 | .810 | .0744 | .114 | .00185 | 6,340 | 6,740 | 6,0232 | 1,0232 | 3,751 | 3,36 | .228 | .518 | |
| | | | G | .131 | .00446 | .825 | .0740 | .100 | .00129 | 5,660 | 5,600 | 5,0266 | 1,0266 | 3,296 | 3,23 | .223 | .519 | |
| | | | G | .198 | .00708 | .825 | .0742 | .198 | .00129 | 5,660 | 5,600 | 5,0266 | 1,0266 | 3,296 | 3,23 | .223 | | |
| | | | G | .198 | .00612 | .825 | .0740 | .100 | .00129 | 5,660 | 5,600 | 5,0266 | 1,0266 | 3,296 | 3,23 | .223 | | |
| | | | G | .173 | .00612 | .825 | .0740 | .100 | .00129 | 5,660 | 5,600 | 5,0266 | 1,0266 | 3,296 | 3,23 | .223 | | |
| | | | G | .173 | .00612 | .825 | .0740 | .100 | .00129 | 5,660 | 5,600 | 5,0266 | 1,0266 | 3,296 | 3,23 | .223 | | |
| | | | G | .152 | .00530 | .820 | .0693 | .109 | .00123 | 4,900 | 4,540 | 4,260 | 1,0275 | 3,170 ^m | 3,10 | .249 | .478 | |
| | | | G | .152 | .00530 | .743 | .0723 | .178 | .00646 | 10,940 | 10,730 | 9,440 | 1,0182 | 5,880 ^m | 5,81 | .242 | .494 | |
| | | | G | .306 | .01181 | .743 | .0723 | .178 | .00646 | 10,940 | 10,630 | 9,150 | 1,0194 | 5,730 ^m | 5,65 | .257 | .470 | |
| | | | G | .282 | .01083 | .783 | .0718 | .184 | .00616 | 10,040 | 10,630 | 9,150 | 1,0194 | 5,560 ^m | 5,49 | .251 | .494 | |
| | | | G | .176 | .00621 | .810 | .0697 | .119 | .00166 | 5,740 | 6,280 | 5,300 | 1,0262 | 3,612 | 3,54 | .243 | .578 | |
| | | | G | .164 | .00566 | .841 | .0651 | .0930 | .00108 | 5,230 | 5,660 | 1,0275 | 2,854 | 2.79 | 2.90 | .228 | .564 | |
| | | | G | .164 | .00566 | .752 | .0687 | .172 | .00707 | 11,980 | 12,520 | 1,0173 | 5,631 | 5,57 | 5,50 | .237 | .558 | |
| | | | G | .338 | .01294 | .755 | .0684 | .170 | .00656 | 11,370 | 13,270 | 1,0181 | 5,502 | 5,53 | 5,72 | .242 | .571 | |
| | | | G | .323 | .01227 | .755 | .0684 | .170 | .00656 | 11,370 | 13,270 | 1,0251 | 3,612 | 3,54 | 4,01 | .243 | .571 | |
| | | | G | .323 | .01227 | .813 | .0659 | .119 | .00211 | 6,720 | 7,630 | 1,0251 | 3,612 | 3,54 | 4,01 | .243 | | |
| PHASE I, INTERMEDIATE NEUTRON SPECTRUM, ON DIAGONAL OF CORNER SUBASSEMBLY ADJACENT REFLECTOR | | | | | | | | | | | | | | | | | | |
| J3-NE-b5 22871 | 1 | 3 | T-92 | .0558 | .00174 | .888 | .0720 | .0398 | .00016 | 1,610 | 1,660 | 1,0332 | 1,067 | 1,04 | .89 | .284 | .557 | |
| | | 5 | T-93 | .115 | .00319 | .846 | .0729 | .0805 | .00055 | 3,500 | 3,660 | 1,0300 | 2,279 | 2.22 | 1,54 | .283 | .527 | |
| | | 6 | T-94 | .115 | .00378 | .853 | .0729 | .0741 | .00044 | 3,480 | 3,640 | 1,0301 | 2,171 | 2.12 | 2,17 | .270 | .550 | |
| | | | T-95 | .0709 | .00226 | .887 | .0722 | .0608 | .00013 | 2,080 | 1,960 | 1,0326 | 1,222 | 1,19 | .93 | .258 | .607 | |
| | | | T-109 | .0523 | .00171 | .906 | .0676 | .0259 | .00036 | 1,580 | 1,320 | 1,0336 | .781 | .76 | .86 | .200 | .659 | |
| | | | T-110 | .105 | .00347 | .875 | .0684 | .0560 | .00026 | 3,200 | 3,050 | 1,0308 | 1,726 | 1,68 | 1,78 | .232 | .620 | |
| | | | T-111 | .101 | .00332 | .877 | .0684 | .0542 | .00029 | 3,060 | 2,950 | 1,0311 | 1,619 | 1,58 | 1,85 | .236 | .636 | |
| | | | T-112 | .0554 | .00178 | .898 | .0676 | .0338 | .00013 | 1,640 | 1,640 | 1,0333 | .941 | .91 | 1,14 | .233 | .609 | |

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Table 3.1-5 (continued, 8/8)

| Core Location Number | Fuel Rod Zone | Axial Sample Number | Sample Code | Total | | Accumulated Fissions | | Accumulated Fission Fraction | | Burnup (MWD/MTU) ^b | $\frac{N^{Pu}}{N^{28}}$ | $\frac{N^{Pu}}{N_0}$ | Pu/U Mass Ratio ^c | | | |
|---|---------------|---------------------|-------------|------------|----------|---|----------------|------------------------------|------------------|-------------------------------|-------------------------|----------------------|------------------------------|------|------|------|
| | | | | U-235 Atom | Fissions | Relative to N ₀ ^d | (fission/atom) | U-235 (fission/atom) | (total fissions) | | | | | | | |
| PHASE I, INTERMEDIATE NEUTRON SPECTRUM, ON DIAGONAL OF CORNER SUBASSEMBLY ADJACENT REFLECTOR | | | | | | | | | | | | | | | | |
| J3-NE-e2 | 31 | 3 | T-130 | .114 | .00376 | .890 | .0642 | .0453 | .00021 | 3,460 | 2,980 | 1.0308 | 1.46 | 1.84 | .218 | .726 |
| | 5 | T-31 | .0922 | .00298 | .892 | .0639 | .0456 | .00018 | | 2,750 | 2,540 | 1.0318 | 1.27 | 1.71 | .235 | .701 |
| J3-NE-f1 | 23018 | 1 | T-96 | .0463 | .00139 | .921 | .0542 | .0250 | .00018 | 1,280 | 1,420 | 1.0340 | .620 | .60 | .58 | .288 |
| | 3 | T-37 | .106 | .00144 | .901 | .0553 | .0432 | .00019 | | 3,180 | 3,090 | 1.0312 | 1.342 | 1.31 | 1.50 | .771 |
| | 5 | T-98 | .109 | .00354 | .903 | .0553 | .0414 | .00017 | | 3,270 | 3,040 | 1.0312 | 1.319 | 1.28 | 1.32 | .748 |
| | 6 | T-99 | .0599 | .00187 | .914 | .0545 | .0312 | .00038 | | 1,720 | 1,720 | 1.0334 | .749 | .73 | 1.17 | .768 |
| | | | | | | | | | | | | | | | .251 | .777 |

Notes: a) The letters T, G, and N indicate that the mass spectrometric analyses were performed by the TRACERLAB (TL), General Electric-Vallecitos (GE), and the New Brunswick (NB) analytical laboratories, respectively. The radiochemical analyses for Cs-137 and Sr-89, and the X-ray fluorescence analyses for Pu/U mass ratio were performed by the Technical Service Laboratories, Westinghouse Atomic Power Division.

b) Units are megawatt days per metric tonne of initial uranium loading (MT = 106 gm).

c) All Phase I data are referenced to the Core I end-of-life (May 18, 1962), all Phase II data are referenced to the Core II end-of-life (Sept. 2, 1963).

d) The letters A and B denote the pellet samples immediately above and below the nominal zone 3 pellet, respectively.

e) Alpha-25 is the ratio of total captures to total fissions in U-235.

f) The parameter NGD/MWD is the net number of grams of fissile materials destroyed per megawatt day of energy release.

g) Interlaboratory crosscheck sample.

h) The numerals 1 and 2 in the NB sample code numbers indicate that the results are inferred from the first and second runs of a mass spectrometric analysis performed in duplicate.

i) Original sample dilution.

j) New dilution of original sample.

k) Seven solutions of the monitor sample 0994-3 were submitted to TRACERLAB over the time interval Jan. 1964 to Nov. 1964, four solutions of the monitor were submitted to GE-Vallecitos over the time interval April 1964 to Oct. 1964.

l) All mass spectrometric data for this sample are consistent. However, the relatively low burnup inferred from the data indicates a high probability that the sample solution was incorrectly labeled.

m) Dilute acid sample. Samples submitted for mass spectrometric analysis prior to June 7, 1963 had nitric acid concentrations of about 0.01 M, and are referred to as dilute acid samples. All other samples, submitted after this date, were in approximately 2 M HNO₃, and are referred to as concentrated acid samples. The sample history of shipping, spiking, and data reporting dates can be found in the Yankee Core Evaluation quarterly progress reports.

The values of Pu-239/U-238 atom ratio reported for the dilute acid samples have been adjusted, or corrected, with the use of plutonium data obtained for concentrated samples. The values of burnup and fuel characteristics listed for the dilute acid samples in this table were inferred from the mass spectrometric data, using the adjusted values of Pu-239/U-238 atom ratio.

n) A fuel rod section of 1.9 inches (approximately 3 pellets), was cut from a position immediately above the nominal 1-pellet sample location in each of the six axial sample zones. The six sections were then dissolved and diluted to make one composite sample solution.

Table 3.1-6 Results of Mass Spectrometric and Radiochemical Analysis of EYC Phase I and Phase II Spent Fuel Samples (1/8)

| Core Location Number | Fuel Rod Sample Zone | Axial Sample Code | ATOM PERCENT URANIUM ^b | | | ATOM PERCENT PLUTONIUM ^c | | | Cs-137 ^c (dpm/gmU × 10 ⁻¹⁰) | | | Sr-90 ^c (dpm/gmU × 10 ⁻¹⁰) | | | | |
|---|----------------------|--|--|--|--|--|---|--|--|--|---|--|--|--|--|--|
| | | | U-234 | | | U-235 | | | Pu-239 Conc. (a/mi × 10 ⁻¹⁵) | | | Pu-239/U-238 (a/a × 10 ⁻³) | | | | |
| | | | | | | | | | Pu-239 | Pu-240 | Pu-241 | Pu-242 | | | | |
| PHASE I, ASYMPTOTIC NEUTRON SPECTRUM, CENTER SUBASSEMBLIES | | | | | | | | | | | | | | | | |
| C3-C-a1 | 9378 | 3A ^d T-132 3B T-133 | 0.84 ± .0005 ^e 0.84 ± .0005 0.84 ± .0005 | 2.551 ± .004 2.544 ± .004 2.544 ± .004 | 2.066 ± .0025 2.066 ± .0013 2.066 ± .0013 | 97.224 ± .005 97.234 ± .0013 97.234 ± .0013 | 10.662 ± .037 ^e 10.676 ± .024 10.676 ± .024 | 4.949 ± .017 4.938 ± .019 4.938 ± .019 | .332 ± .003 .335 ± .002 | 6.128 ± .010 ^e 7.384 ± .159 7.384 ± .159 | 4.570 ± .042 ^f 4.682 ± .111 4.682 ± .111 | 6.63 ± .33 ^f 6.64 ± .33 6.64 ± .33 | | | | |
| C3-C-f6 | 9395 | 1 T-100 5 T-102 6 T-103 | 0.198 ± .0006 0.180 ± .0002 0.180 ± .0001 | 2.922 ± .012 2.439 ± .008 2.808 ± .008 | 1.338 ± .012 2.337 ± .009 1.695 ± .008 | 96.924 ± .019 97.307 ± .025 97.316 ± .026 | 7.753 ± .018 11.732 ± .025 8.790 ± .046 | 2.374 ± .008 6.064 ± .020 8.790 ± .044 | .0067 .005 .0046 | 6.976 ± .071 5.794 ± .031 6.938 ± .031 | 5.794 ± .031 5.794 ± .031 6.693 ± .020 | 3.88 ± .19 3.88 ± .19 7.87 ± .39 | | | | |
| C8-C-a6 | 569 | 3A ^d T-134 3B T-135 | 0.96 ± .0002 0.96 ± .0002 | 2.574 ± .003 2.574 ± .004 | 1.942 ± .005 2.002 ± .007 | 97.212 ± .003 97.212 ± .019 | 10.546 ± .035 10.621 ± .034 | 4.872 ± .029 4.894 ± .0217 | .314 ± .005 .314 ± .003 | 5.746 ± .010 6.508 ± .010 | 4.528 ± .053 4.552 ± .050 | 6.61 ± .33 6.60 ± .33 | | | | |
| C8-C-f1 | 5551 | 1 T-105 3 T-106 5 T-107 6 T-108 | 0.200 ± .0005 0.184 ± .0002 0.189 ± .0001 0.198 ± .0002 | 2.904 ± .004 2.423 ± .010 2.420 ± .011 2.772 ± .013 | 1.351 ± .005 2.339 ± .001 2.287 ± .008 1.548 ± .007 | 96.941 ± .004 97.326 ± .015 97.303 ± .010 97.053 ± .013 | 89.477 ± .025 11.780 ± .012 81.902 ± .033 87.899 ± .016 | 7.999 ± .025 6.033 ± .013 5.912 ± .024 8.829 ± .011 | .009 .009 .006 .006 | .0018 ± .0006 4.309 ± .013 5.498 ± .006 3.155 ± .011 | 5.331 ± .018 5.331 ± .018 5.480 ± .006 1.166 ± .006 | 3.99 ± .06 8.16 ± .05 8.16 ± .05 4.76 ± .24 | | | | |
| E5-C-a6 | 7992 | 1 T-11 3 T-12 N-10-1h | 0.182 ± .0003 0.172 ± .0002 0.15 ± .003 ^e | 2.666 ± .013 2.342 ± .007 2.26 ± .003 | 1.700 ± .010 2.346 ± .005 2.26 ± .002 | 97.146 ± .014 97.404 ± .007 97.404 ± .007 | 85.863 ± .051 79.864 ± .031 78.80 ± .08 ^a | 9.776 ± .049 12.517 ± .018 13.06 ± .008 | .025 .025 .025 | .267 ± .004 6.103 ± .020 6.103 ± .020 | 6.391 ± .058 5.842 ± .220 5.727e ± .050 | 3.52 ± .13 9.95 ± .50 9.95 ± .50 | | | | |
| E5-C-f1 | 38 | T-12 N-10-2 T-13 T-14 | 0.172 ± .0002 0.16 ± .0003 0.159 ± .0003 0.119 ± .0003 | 2.342 ± .007 2.26 ± .003 2.26 ± .003 2.639 ± .012 | 1.700 ± .010 2.334 ± .005 2.295 ± .005 1.799 ± .016 | 97.212 ± .014 97.404 ± .007 97.524 ± .010 97.163 ± .013 | 87.364 ± .007 97.524 ± .015 97.524 ± .015 85.676 ± .102 | 9.776 ± .049 12.517 ± .018 13.12 ± .008 10.011 ± .072 | .025 .025 .025 .025 | .267 ± .004 6.103 ± .020 6.103 ± .020 7.331 ± .002 | 6.746 ± .013 5.531 ± .018 5.531 ± .018 7.216 ± .038 | 3.99 ± .06 8.16 ± .05 8.16 ± .05 7.78 ± .65 | | | | |
| E5-C-f1 | 38 | T-12 T-13 T-14 | 0.16 ± .0002 0.16 ± .0002 0.159 ± .0003 0.119 ± .0003 | 2.342 ± .007 2.26 ± .003 2.26 ± .003 2.639 ± .012 | 1.700 ± .010 2.334 ± .005 2.295 ± .005 1.799 ± .016 | 97.212 ± .014 97.404 ± .007 97.524 ± .010 97.163 ± .013 | 87.364 ± .007 97.524 ± .015 97.524 ± .015 85.676 ± .102 | 9.776 ± .049 12.517 ± .018 13.12 ± .008 10.011 ± .072 | .025 .025 .025 .025 | .267 ± .004 6.103 ± .020 6.103 ± .020 7.331 ± .002 | 6.746 ± .013 5.531 ± .018 5.531 ± .018 7.216 ± .038 | 3.99 ± .06 8.16 ± .05 8.16 ± .05 7.78 ± .65 | | | | |
| F4-C-a1 | 7980 | 1 G-15 3 G-16 G-17 | 0.18 ± .004 ^e 0.172 ± .0027 0.168 ± .0003 0.17 ± .003 | 2.75 ± .02 2.24 ± .02 2.24 ± .02 2.30 ± .03 | 1.52 ± .004 1.52 ± .004 1.52 ± .004 1.52 ± .004 | 97.08 ± .20 97.08 ± .20 97.08 ± .20 97.08 ± .20 | 87.77 ± .40 87.77 ± .40 87.77 ± .40 87.77 ± .40 | 8.87 ± .08 8.87 ± .08 8.87 ± .08 8.87 ± .08 | .20 .20 .20 .20 | .150 ± .004 13.06 ± .008 13.06 ± .008 13.06 ± .008 | 21.4 ± .8 7.39 ± .004 7.39 ± .004 7.39 ± .004 | 3.57 ± .08 5.81 ± .024 5.81 ± .024 5.81 ± .024 | 4.97 ± .25 9.95 ± .50 9.95 ± .50 8.17 ± .65 | | | |
| F4-C-a1 | 8982 | 38 G-2 T-9 N-5j | 0.172 ± .0027 0.168 ± .0003 0.17 ± .003 | 2.24 ± .02 2.24 ± .02 2.24 ± .02 | 1.032 ± .002 1.032 ± .002 1.032 ± .002 | 97.469 ± .006 97.443 ± .006 97.443 ± .006 | 79.51 ± .76 79.51 ± .76 79.51 ± .76 | 12.75 ± .30 12.75 ± .30 12.75 ± .30 | .15 .15 .15 | .162 ± .030 12.615 ± .054 12.615 ± .054 | 21.4 ± .8 7.17 ± .024 7.17 ± .024 | 4.74 ± .24 10.48 ± .63 10.48 ± .63 | | | | |
| F4-C-a1 | 38 | T-87 T-88 T-89 T-90 | 0.170 ± .0001 0.164 ± .0002 0.161 ± .0002 0.175 ± .0001 | 2.834 ± .007 2.300 ± .007 2.289 ± .007 2.616 ± .004 | 1.496 ± .012 1.527 ± .012 1.511 ± .012 1.762 ± .004 | 96.988 ± .007 97.431 ± .008 97.442 ± .008 97.130 ± .004 | 88.206 ± .018 79.774 ± .045 79.463 ± .038 85.835 ± .024 | 8.610 ± .017 12.589 ± .033 12.749 ± .034 9.911 ± .024 | .009 .009 .009 .007 | .1395 ± .0010 5.650 ± .0040 7.110 ± .0028 4.022 ± .0027 | 5.220 ± .0026 6.232 ± .006 6.232 ± .006 2.308 ± .0030 | 6.305 ± .002 6.304 ± .002 6.304 ± .002 6.304 ± .002 | 9.95 ± .50 9.95 ± .50 9.95 ± .50 9.95 ± .50 | | | |
| F4-C-f1 | 8994 | 1 T-37 T-38 T-39 T-40 T-41 T-42 | 0.181 ± .0001 0.164 ± .0002 0.161 ± .0002 0.175 ± .0001 0.175 ± .0001 0.175 ± .0001 | 2.834 ± .007 2.300 ± .007 2.273 ± .007 2.273 ± .007 2.273 ± .007 2.273 ± .007 | 1.496 ± .012 1.527 ± .012 1.511 ± .012 1.532 ± .011 1.532 ± .011 1.532 ± .011 | 97.367 ± .010 97.450 ± .005 97.466 ± .006 97.465 ± .006 97.466 ± .006 97.466 ± .006 | 80.765 ± .047 79.668 ± .119 79.668 ± .119 79.329 ± .052 79.329 ± .052 79.329 ± .052 | .047 .047 .047 .048 .048 .048 | .009 .009 .009 .009 .009 .009 | .1395 ± .0010 5.650 ± .0040 7.110 ± .0028 6.684 ± .0050 6.866 ± .006 6.866 ± .006 | 5.204 ± .0020 5.397 ± .0020 5.397 ± .0020 7.216 ± .010 7.216 ± .010 7.216 ± .010 | 6.304 ± .002 6.304 ± .002 6.304 ± .002 5.837 ± .002 5.837 ± .002 5.837 ± .002 | 4.62 ± .23 9.54 ± .48 9.54 ± .48 9.52 ± .48 9.52 ± .48 9.52 ± .48 | | | |
| F4-C-f1 | 8997 | 1 T-37 T-38 T-39 N-14-1h N-14-2 T-40 T-41 T-42 | 0.173 ± .0002 0.170 ± .0004 0.172 ± .0003 0.166 ± .003 ^e 0.177 ± .0003 0.179 ± .0002 0.178 ± .0001 0.176 ± .0001 | 2.778 ± .011 2.374 ± .009 2.273 ± .007 2.273 ± .007 2.273 ± .007 2.273 ± .007 2.273 ± .007 2.273 ± .007 | 1.532 ± .011 1.532 ± .011 | 87.715 ± .012 97.367 ± .010 97.450 ± .005 97.466 ± .006 97.465 ± .006 97.466 ± .006 97.466 ± .006 97.466 ± .006 | 8.913 ± .023 12.157 ± .062 12.629 ± .109 12.749 ± .106 12.749 ± .106 13.145 ± .048 13.145 ± .048 13.145 ± .048 | .023 .023 .023 .023 .023 .023 .023 .023 | .023 .023 .023 .023 .023 .023 .023 .023 | .1395 ± .0010 5.650 ± .0040 7.110 ± .0028 6.684 ± .0050 6.866 ± .006 6.866 ± .006 7.216 ± .010 7.216 ± .010 | 5.204 ± .0020 5.397 ± .0020 5.397 ± .0020 7.216 ± .010 7.216 ± .010 7.216 ± .010 7.216 ± .010 7.216 ± .010 | 4.62 ± .23 9.54 ± .48 9.54 ± .48 9.52 ± .48 9.52 ± .48 9.52 ± .48 9.52 ± .48 9.52 ± .48 | | | | |
| F4-C-f1 | 19579 | 3 G-3 T-10 N-6j | 0.189 ± .0026 0.186 ± .0002 0.186 ± .0002 0.17 ± .003 | 2.24 ± .02 2.24 ± .02 2.24 ± .02 2.6 ± .03 | 1.032 ± .005 1.032 ± .005 1.032 ± .005 1.816 ± .009 | 97.448 ± .006 97.448 ± .006 97.448 ± .006 97.447 ± .006 | 79.71 ± .80 79.513 ± .043 79.513 ± .043 80.528 ± .039 | .30 .30 .30 .16 | .705 ± .028 7.156 ± .038 7.156 ± .038 8.226 ± .029 | 6.05 ± .010 6.804 ± .0110 6.804 ± .0110 7.119 ± .006 | 5.98 ± .22 6.164 ± .20 6.164 ± .20 7.327 ± .139 | 6.06 ± .30 10.74 ± .53 10.74 ± .53 | | | | |

Table 3.1-6 (continued, 2/8)

| Core Location Number | Fuel Rod Number | Axial Sample Code | ATOM PERCENT URANIUM ^b | | | ATOM PERCENT PLUTONIUM ^c | | | U-238 Conc. (dpm/gmI $\times 10^{-16}$) | | | Pu-239/U-238 (a/a $\times 10^3$) | | | Cs-137/C (dpm/gmI $\times 10^{-19}$) | | | Sr-90/C (dpm/gmI $\times 10^{-19}$) | | | | | | | | | |
|--|-----------------|-------------------|-----------------------------------|-------------|-------------|-------------------------------------|-------------|-------------|--|-------------|-------------|-----------------------------------|------------|------------|---------------------------------------|------------|------------|--------------------------------------|------------|------------|------------|------------|------------|------------|-----------|-----------|-----------|
| | | | U-234 | | | U-235 | | | U-238 | | | Pu-239 | | | Pu-240 | | | Pu-241 | | | Pu-242 | | | | | | |
| | | | Center Subassemblies | | | | | | | | | | | | | | | | | | | | | | | | |
| PHASE II, ASYMPTOTIC NEUTRON SPECTRUM, CENTER SUBASSEMBLIES | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| F5-C-a1 | 553 | 1 | G-43 | .019 | \pm .004 | 2.40 | \pm .02 | .231 | \pm .004 | 97.34 | \pm .80 | 81.63 | \pm .60 | 11.86 | \pm .10 | 6.02 | \pm .06 | .484 | \pm .010 | 24.1 | \pm .8 | 5.18 | \pm .10 | 8.18 | \pm .41 | 9.05 | \pm .63 |
| | | 3 | G-44 | .016 | \pm .004 | 1.65 | \pm .02 | .369 | \pm .008 | 97.97 | \pm .80 | 70.53 | \pm .60 | 16.13 | \pm .12 | 11.42 | \pm .11 | 1.933 | \pm .020 | 25.5 | \pm .10 | 8.01 | \pm .16 | 17.14 | \pm .36 | 14.40 | \pm .01 |
| | 5 | G-45 | .017 | \pm .004 | 1.64 | \pm .02 | .361 | \pm .008 | 97.98 | \pm .80 | 70.50 | \pm .60 | 16.24 | \pm .12 | 11.44 | \pm .11 | 1.933 | \pm .020 | 29.7 | \pm .12 | 7.84 | \pm .16 | 17.08 | \pm .35 | 11.32 | \pm .79 | |
| | 6 | G-46 | .017 | \pm .006 | 2.12 | \pm .02 | .267 | \pm .006 | 97.59 | \pm .80 | 77.84 | \pm .60 | 13.56 | \pm .12 | 7.77 | \pm .06 | .837 | \pm .016 | 29.7 | \pm .12 | 5.89 | \pm .12 | 10.63 | \pm .53 | 7.73 | \pm .54 | |
| F5-C-f6 | 541 | 1 | T-117 | .034 | \pm .001 | 2.449 | \pm .0224 | .2228 | \pm .0004 | 97.2987 | \pm .0024 | 81.590 | \pm .042 | 11.812 | \pm .041 | 6.109 | \pm .020 | .4990 | \pm .036 | 6.035 | \pm .006 | 5.198 | \pm .054 | 8.32 | \pm .42 | 9.14 | \pm .64 |
| | 2 | T-118 | .0164 | \pm .0005 | 1.8084 | \pm .0014 | .3482 | \pm .0073 | 97.827 | \pm .0087 | 70.455 | \pm .033 | 15.496 | \pm .023 | 10.678 | \pm .036 | 1.6109 | \pm .024 | 5.847 | \pm .018 | 7.459 | \pm .077 | 15.35 | \pm .77 | 12.79 | \pm .90 | |
| | 3 | T-119 | .0158 | \pm .0002 | 1.6435 | \pm .0020 | .3779 | \pm .0006 | 97.9645 | \pm .0021 | 69.735 | \pm .018 | 16.418 | \pm .018 | 11.772 | \pm .022 | 2.0754 | \pm .0071 | 5.257 | \pm .011 | 8.186 | \pm .102 | 18.50 | \pm .88 | 12.62 | \pm .88 | |
| | 4 | T-120 | .0142 | \pm .0001 | 1.6810 | \pm .0020 | .3680 | \pm .0005 | 97.9366 | \pm .0021 | 70.106 | \pm .022 | 16.368 | \pm .020 | 11.553 | \pm .019 | 1.9726 | \pm .0037 | 5.779 | \pm .014 | 7.742 | \pm .093 | 17.06 | \pm .85 | 10.71 | \pm .75 | |
| | 5 | T-121 | .0144 | \pm .0001 | 1.6810 | \pm .0020 | .2707 | \pm .0012 | 97.5099 | \pm .0062 | 77.933 | \pm .012 | 13.474 | \pm .009 | 7.753 | \pm .010 | .8302 | \pm .0033 | 6.427 | \pm .025 | 6.022 | \pm .063 | 10.48 | \pm .52 | 6.58 | \pm .46 | |
| | 6 | T-122 | .0152 | \pm .0001 | 2.2031 | \pm .0061 | | | | | | | | | | | | | | | | | | | | | |
| PHASE I, ASYMPTOTIC NEUTRON SPECTRUM, CENTER SUBASSEMBLIES | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| G4-C-a1 | 0994 | 1 | T-43 | .0179 | \pm .0002 | 2.8005 | \pm .007 | .1517 | \pm .0005 | 97.026 | \pm .008 | 87.865 | \pm .016 | 8.810 | \pm .015 | 3.174 | \pm .008 | .151 | \pm .002 | 4.526 | \pm .020 | 3.568 | \pm .046 | 4.81 | \pm .24 | | |
| | 2 | T-18 | .0171 | \pm .0003 | 2.354 | \pm .007 | .2322 | \pm .0011 | 97.397 | \pm .008 | 81.141 | \pm .086 | 11.980 | \pm .120 | 6.334 | \pm .071 | .544 | \pm .011 | 7.216 | \pm .038 | 5.433 | \pm .170 | 8.564 | \pm .427 | | | |
| | 3 | T-36 | .0162 | \pm .0001 | 2.379 | \pm .004 | .2366 | \pm .0004 | 97.368 | \pm .004 | 81.073 | \pm .032 | 11.979 | \pm .070 | 6.406 | \pm .015 | .547 | \pm .004 | 7.219 | \pm .030 | 5.260 | \pm .117 | 8.505 | \pm .425 | | | |
| | 5 | T-58 | .0161 | \pm .0001 | 2.371 | \pm .025 | .2342 | \pm .0025 | 80.829 | \pm .070 | 12.131 | \pm .064 | 6.449 | \pm .047 | .551 | \pm .006 | 7.183 | \pm .116 | 5.437 | \pm .057 | 8.471 | \pm .423 | | | | | |
| | 7 | T-91 | .0164 | \pm .0002 | 2.375 | \pm .003 | .2361 | \pm .0005 | 97.375 | \pm .004 | 81.048 | \pm .006 | 11.990 | \pm .043 | 6.412 | \pm .030 | .544 | \pm .003 | 7.165 | \pm .013 | 5.351 | \pm .057 | 8.563 | \pm .428 | | | |
| | 9 | T-104 | .0164 | \pm .0002 | 2.375 | \pm .003 | .2354 | \pm .0006 | 97.375 | \pm .004 | 81.048 | \pm .009 | 12.057 | \pm .019 | 6.456 | \pm .032 | .554 | \pm .006 | 7.208 | \pm .030 | 5.411 | \pm .057 | 8.36 | \pm .422 | | | |
| | 11 | T-144 | .0164 | \pm .0002 | 2.318 | \pm .008 | .2353 | \pm .0006 | 97.372 | \pm .004 | 81.141 | \pm .004 | 11.940 | \pm .043 | 6.366 | \pm .038 | .542 | \pm .008 | 7.176 | \pm .020 | 5.499 | \pm .047 | 8.33 | \pm .422 | | | |
| | 13 | T-150 | .0164 | \pm .0001 | 2.357 | \pm .005 | .2344 | \pm .0005 | 97.392 | \pm .005 | 80.861 | \pm .071 | 12.166 | \pm .068 | 6.456 | \pm .043 | .554 | \pm .008 | 7.282 | \pm .018 | 5.305 | \pm .066 | 8.52 | \pm .51 | | | |
| | 15 | G-6 | .017 | \pm .0084 | 2.34 | \pm .02 | .232 | \pm .006 | 97.441 | \pm .020 | 81.03 | \pm .080 | 11.95 | \pm .12 | 6.477 | \pm .006 | .550 | \pm .010 | 7.30 | \pm .020 | 5.40 | \pm .10 | 8.45 | \pm .422 | | | |
| | 17 | G-17 | .019 | \pm .0064 | 2.37 | \pm .02 | .232 | \pm .004 | 97.38 | \pm .020 | 81.22 | \pm .074 | 11.86 | \pm .10 | 6.388 | \pm .007 | .539 | \pm .010 | 7.08 | \pm .021 | 5.42 | \pm .10 | 8.56 | \pm .423 | | | |
| | 19 | G-42 | .018 | \pm .0064 | 2.38 | \pm .02 | .240 | \pm .004 | 97.36 | \pm .020 | 80.95 | \pm .060 | 12.04 | \pm .12 | 6.466 | \pm .007 | .542 | \pm .010 | 7.08 | \pm .021 | 5.44 | \pm .10 | 8.40 | \pm .422 | | | |
| | 21 | G-51 | .018 | \pm .0034 | 2.38 | \pm .02 | .239 | \pm .003 | 97.36 | \pm .020 | 80.84 | \pm .066 | 12.01 | \pm .06 | 6.449 | \pm .002 | .542 | \pm .006 | 7.08 | \pm .021 | 5.44 | \pm .10 | 8.40 | \pm .422 | | | |
| | 23 | N-12-1-h | .019 | \pm .0033 | 2.39 | \pm .02 | .23 | \pm .003 | 97.36 | \pm .020 | 81.01 | \pm .066 | 12.10 | \pm .06 | 6.449 | \pm .002 | .549 | \pm .006 | 6.419 | \pm .002 | 6.442 | \pm .002 | 5.359 | \pm .422 | | | |
| | 25 | N-12-2 | .016 | \pm .0033 | 2.37 | \pm .02 | .237 | \pm .003 | 97.37 | \pm .020 | 81.01 | \pm .066 | 12.10 | \pm .06 | 6.449 | \pm .002 | .549 | \pm .006 | 6.419 | \pm .002 | 6.442 | \pm .002 | 5.359 | \pm .422 | | | |
| | 27 | T-44 | .0162 | \pm .0003 | 2.2490 | \pm .008 | .1729 | \pm .0006 | 97.494 | \pm .0009 | 85.267 | \pm .045 | 13.176 | \pm .029 | 6.423 | \pm .021 | .520 | \pm .021 | 6.260 | \pm .004 | 5.827 | \pm .038 | 10.13 | \pm .51 | | | |
| | 29 | G-17-1-h | .0174 | \pm .0004 | 2.635 | \pm .006 | .18 | \pm .03 | 97.175 | \pm .0006 | 85.49 | \pm .06 | 10.03 | \pm .06 | 4.21 | \pm .02 | .523 | \pm .008 | 7.629 | \pm .023 | 4.105 | \pm .074 | 5.94 | \pm .39 | | | |
| | 31 | G-13-2 | .018 | \pm .0033 | 2.644 | \pm .03 | .18 | \pm .02 | 97.17 | \pm .006 | 85.48 | \pm .02 | 10.05 | \pm .02 | 4.21 | \pm .04 | .525 | \pm .002 | 7.348 | \pm .008 | 4.076 | \pm .076 | | | | | |
| G4-C-f6 | 0995 | 1 | T | .02 | \pm .01 | 2.76 | \pm .01 | .16 | \pm .01 | 97.06 | \pm .01 | 87.74 | \pm .05 | 8.88 | \pm .04 | 3.22 | \pm .02 | .16 | \pm .01 | 4.76 | \pm .02 | 3.58 | \pm .046 | 4.77 | \pm .29 | 3.87 | \pm .31 |
| | 3 | T | .02 | \pm .01 | 2.24 | \pm .02 | .254 | \pm .01 | 97.48 | \pm .01 | 79.47 | \pm .12 | 12.62 | \pm .12 | 7.82 | \pm .09 | .72 | \pm .01 | 4.807 | \pm .025 | 5.97 | \pm .046 | 9.75 | \pm .58 | 7.20 | \pm .58 | |
| | 5 | G | .0157 | \pm .0012 | 2.19 | \pm .02 | .26 | \pm .01 | 97.53 | \pm .044 | 78.88 | \pm .12 | 13.00 | \pm .12 | 7.40 | \pm .06 | .717 | \pm .010 | 4.74 | \pm .02 | 4.884 | \pm .024 | 5.92 | \pm .046 | 9.82 | \pm .59 | |
| | 7 | T | .02 | \pm .01 | 2.22 | \pm .01 | .18 | \pm .01 | 97.51 | \pm .01 | 79.03 | \pm .11 | 12.92 | \pm .12 | 7.29 | \pm .08 | .717 | \pm .02 | 4.825 | \pm .025 | 5.93 | \pm .047 | 9.82 | \pm .59 | | | |
| | 9 | T | .02 | \pm .01 | 2.61 | \pm .01 | .18 | \pm .01 | 97.18 | \pm .01 | 86.36 | \pm .123 | 9.06 | \pm .079 | 4.31 | \pm .058 | .27 | \pm .03 | 4.432 | \pm .025 | 3.97 | \pm .120 | 6.95 | \pm .42 | | | |
| G4-C-f1 | 0979 | 1 | T | .02 | \pm .01 | 2.80 | \pm .02 | .15 | \pm .01 | 97.03 | \pm .01 | 88 | | | | | | | | | | | | | | | |

Table 3.1-6 (continued, 3/8)

| Cora Rod. | Axial Sample Zone Number | Sample Code | ATOM PERCENT URANIUM ^b | | | ATOM PERCENT PLUTONIUM ^c | | | URANIUM-238 (a/m ³ × 10 ⁻¹⁶) | | | PLUTONIUM-239 (a/m ³ × 10 ³) | | | CERIUM-137 ^c (dpm/gmU × 10 ⁻¹⁰) | | | |
|--|-----------------------------------|-------------------|-----------------------------------|---------------|--------------|-------------------------------------|---------------|---------------|--|--------------|---|--|---|--|---|---|------------|--|
| | | | U-234 | U-235 | U-236 | U-238 | Pu-239 | Pu-240 | Pu-241 | Pu-242 | U-238 Gone (a/m ³ × 10 ⁻¹⁶) | Pu-239 Gone (a/m ³ × 10 ³) | U-238 Cene (a/m ³ × 10 ⁻¹⁶) | Pu-239 Cene (a/m ³ × 10 ³) | Ce-137 Cene (dpm/gmU × 10 ⁻¹⁰) | Str-90 Cene (dpm/gmU × 10 ⁻¹⁰) | | |
| PHASE I., ASYMPTOTIC NEUTRON SPECTRUM, CENTER SUBASSEMBLIES | | | | | | | | | | | | | | | | | | |
| H3-C-a1 | 8537 | S | G | .0175 ± .0016 | 2.44 ± .02 | .204 ± .004 | 97.34 ± .01 | 82.93 ± .74 | 11.26 ± .08 | 5.41 ± .04 | .395 ± .012 | 5.69 ± .22 | 4.90 ± .04 ^m | 7.59 ± .46 | 4.88 ± .39 | | | |
| H3-C-a6 | 8510 | Comp ⁿ | T | .02 | .01 | 2.58 ± .01 | .20 ± .01 | 97.20 ± .01 | 83.63 ± .06 | 10.86 ± .04 | 5.11 ± .02 | .40 ± .01 | 7.14 ± .05 | 5.11 ± .07 ^m | | | | |
| H3-C-a6 | 8510 | 1 | T | .02 ± .01 | 2.89 ± .01 | .13 ± .01 | 96.96 ± .01 | 89.77 ± .06 | 7.80 ± .06 | 2.33 ± .03 | .19 ± .01 | 5.06 ± .02 | 3.02 ± .04 ^m | 3.67 ± .18 | 2.37 ± .19 | | | |
| H3-C-a6 | 8510 | 2 | T | .02 ± .01 | 2.52 ± .01 | .20 ± .01 | 97.26 ± .01 | 81.36 ± .07 | 11.06 ± .07 | 5.21 ± .03 | .36 ± .01 | 4.50 ± .02 | 4.79 ± .06 ^m | 7.01 ± .35 | 4.33 ± .34 | | | |
| H3-C-a6 | 8510 | 3 | T | .02 ± .01 | 2.43 ± .01 | .22 ± .01 | 97.33 ± .01 | 81.02 ± .06 | 11.86 ± .06 | 5.94 ± .03 | .46 ± .02 | 4.63 ± .02 | 5.17 ± .02 ^m | 5.08 ± .41 | 5.22 ± .42 | | | |
| H3-C-a6 | 8510 | 4 | T | .0192 ± .0012 | 2.468 ± .024 | .2270 ± .0136 | 97.11 ± .01 | 81.64 ± .60 | 11.895 ± .086 | 6.04 ± .080 | .515 ± .024 | 4.36 ± .16 | 5.25 ± .02 ^m | 7.87 ± .39 | 5.22 ± .39 | | | |
| H3-C-a6 | 8510 | 5 | T | .02 ± .01 | 2.39 ± .01 | .22 ± .01 | 97.38 ± .01 | 81.44 ± .04 | 11.96 ± .03 | 6.12 ± .04 | .49 ± .01 | 4.35 ± .02 | 5.30 ± .06 ^m | 7.90 ± .39 | 5.44 ± .44 | | | |
| H3-C-a6 | 8510 | 6 | T | .02 ± .01 | 2.42 ± .01 | .21 ± .01 | 97.35 ± .01 | 82.04 ± .04 | 11.68 ± .03 | 5.82 ± .02 | .46 ± .01 | 3.90 ± .02 | 5.14 ± .06 ^m | 7.52 ± .22 | 2.52 ± .20 | | | |
| H3-C-f1 | 8528 | 1 | C | .0226 ± .0014 | 2.99 ± .02 | .115 ± .002 | 96.87 ± .60 | 91.42 ± .40 | 6.76 ± .02 | 1.76 ± .02 | .0548 ± .0002 | 5.64 ± .22 | 2.55 ± .04 ^m | 2.92 ± .18 | 3.01 ± .24 | | | |
| H3-C-f1 | 8528 | 2 | C | .0226 ± .0014 | 2.99 ± .02 | .115 ± .002 | 96.87 ± .60 | 91.42 ± .40 | 6.76 ± .02 | 1.76 ± .02 | .0548 ± .0002 | 5.64 ± .22 | 2.55 ± .04 ^m | 2.92 ± .18 | 3.01 ± .24 | | | |
| H3-C-f1 | 8528 | 3 | C | .0210 ± .0004 | 2.56 ± .02 | .202 ± .002 | 97.20 ± .48 | 84.05 ± .009 | 10.71 ± .006 | 4.900 ± .002 | .333 ± .002 | 5.650 ± .013 | 4.625 ± .047 | 6.74 ± .34 | | | | |
| H3-C-f1 | 8528 | 4 | C | .0210 ± .0004 | 2.56 ± .02 | .202 ± .002 | 97.22 ± .48 | 83.98 ± .009 | 10.83 ± .010 | 4.84 ± .019 | .345 ± .004 | 5.82 ± .024 | 4.62 ± .046 | 6.26 ± .38 | 5.53 ± .44 | | | |
| H3-C-f1 | 8528 | 5 | C | .0204 ± .0004 | 2.736 ± .018 | .1776 ± .0013 | 97.067 ± .020 | 84.599 ± .025 | 9.860 ± .021 | 4.272 ± .018 | .270 ± .002 | 4.658 ± .024 | 4.087 ± .060 | 5.84 ± .35 | 5.80 ± .35 | 4.26 ± .34 | | |
| H3-C-f1 | 8528 | 6 | C | .0204 ± .0004 | 2.58 ± .02 | .202 ± .004 | 97.20 ± .38 | 84.28 ± .020 | 10.65 ± .008 | 4.76 ± .004 | .310 ± .006 | 6.63 ± .26 | 4.54 ± .04 ^m | 6.76 ± .05 | 4.56 ± .06 ^m | | | |
| H3-C-f1 | 8528 | 7 | C | .0184 ± .0008 | 2.89 ± .02 | .126 ± .002 | 96.96 ± .66 | 84.19 ± .04 | 10.72 ± .03 | 4.77 ± .02 | .32 ± .01 | 6.76 ± .02 | 4.26 ± .04 ^m | 6.75 ± .26 | 2.96 ± .04 ^m | 3.79 ± .23 | 2.71 ± .22 | |
| H3-C-f6 | 8574 | 1 | I-138 | .0210 ± .0035 | 2.955 ± .005 | .1225 ± .0002 | 96.901 ± .005 | 90.721 ± .014 | 7.204 ± .014 | 2.058 ± .015 | .067 ± .007 | 7.401 ± .001 | 2.685 ± .029 | 3.34 ± .17 | | | | |
| H3-C-f6 | 8574 | 2 | I-139 | .0187 ± .003 | 2.466 ± .005 | .2146 ± .0017 | 97.300 ± .005 | 82.930 ± .038 | 11.204 ± .035 | 5.462 ± .026 | .403 ± .013 | 5.573 ± .023 | 4.792 ± .047 | 7.19 ± .36 | | | | |
| H3-C-f6 | 8574 | 3 | I-140 | .0174 ± .002 | 2.504 ± .002 | .2036 ± .0012 | 97.275 ± .013 | 83.199 ± .031 | 11.902 ± .032 | 5.321 ± .047 | .387 ± .015 | 5.991 ± .048 | 4.843 ± .053 | 7.24 ± .36 | | | | |
| H3-C-f6 | 8574 | 4 | I-141 | .0186 ± .002 | 2.847 ± .009 | .1356 ± .0004 | 96.993 ± .009 | 89.073 ± .024 | 8.188 ± .023 | 2.629 ± .010 | .110 ± .002 | 5.607 ± .020 | 3.174 ± .034 | 4.16 ± .21 | | | | |
| H4-C-a1 | 2021 | 1 | G-11 | .021 ± .006 | 2.82 ± .02 | .152 ± .004 | 97.00 ± .20 | 88.87 ± .40 | 8.24 ± .08 | 2.76 ± .02 | .120 ± .02 | .002 | 19.8 ± .02 | 3.97 ± .20 | 10.25 ± .51 | | | |
| H4-C-a1 | 2021 | 2 | G-4 | .018 ± .004 | 2.34 ± .02 | .249 ± .006 | 97.40 ± .40 | 80.42 ± .80 | 11.96 ± .12 | 6.62 ± .06 | .544 ± .010 | 3.69 ± .14 | 5.44 ± .20 | 9.25 ± .46 | | | | |
| H4-C-a1 | 2021 | 3 | G-5 | .019 ± .004 | 2.36 ± .02 | .253 ± .006 | 97.10 ± .20 | 87.06 ± .40 | 9.42 ± .08 | 12.32 ± .12 | 6.66 ± .06 | .598 ± .012 | 4.95 ± .20 | 4.79 ± .08 | 4.79 ± .29 | | | |
| H4-C-a1 | 2021 | 4 | G-6 | .019 ± .004 | 2.70 ± .02 | .174 ± .004 | 97.00 ± .20 | 87.06 ± .40 | 9.42 ± .08 | 3.54 ± .04 | .175 ± .01 | 2.59 ± .10 | 3.78 ± .08 | | | | | |
| H5-C-a1 | 1000 | 1 | T-25 | .0181 ± .0001 | 2.800 ± .010 | .1448 ± .0006 | 97.037 ± .011 | 86.397 ± .041 | 8.540 ± .029 | 2.938 ± .021 | .125 ± .01 | .067 ± .001 | 6.427 ± .030 | 3.362 ± .087 | 4.49 ± .22 | | | |
| H5-C-a1 | 1000 | 2 | T-26 | .0173 ± .0038 | 2.30 ± .032 | .240 ± .008 | 97.47 ± .98 | 80.03 ± .80 | 12.45 ± .30 | 6.84 ± .13 | .687 ± .056 | 7.38 ± .30 | 5.84 ± .20 | 9.33 ± .47 | | | | |
| H5-C-a1 | 1000 | 3 | T-27 | .0170 ± .0032 | 2.334 ± .009 | .2523 ± .014 | 97.397 ± .009 | 80.171 ± .037 | 1.394 ± .035 | 8.18 ± .020 | .617 ± .008 | 7.206 ± .040 | 5.829 ± .16 | | | | | |
| H5-C-a1 | 1000 | 4 | N-11-1 | .0166 ± .001 | 2.255 ± .006 | .2480 ± .010 | 97.480 ± .006 | 79.576 ± .042 | 12.741 ± .022 | 7.019 ± .034 | .664 ± .003 | 6.548 ± .023 | 5.552 ± .121 | 9.65 ± .48 | | | | |
| H5-C-a1 | 1000 | 5 | N-11-2 | .017 ± .003 | 2.30 ± .03 | .25 ± .002 | 97.43 ± .005 | 97.147 ± .006 | 80.22 ± .034 | 12.38 ± .04 | .677 ± .006 | .666 ± .010 | 7.98 ± .056 | 5.661 | | | | |
| H5-C-a1 | 1000 | 6 | T-27 | .0185 ± .0003 | 2.666 ± .005 | .1714 ± .015 | 97.147 ± .005 | 9.677 ± .071 | 9.677 ± .050 | 3.888 ± .025 | .218 ± .004 | 8.223 ± .020 | 4.046 ± .089 | 4.87 ± .24 | | | | |
| H8-C-a1 | 21305 | 1 | T-113 | .0193 ± .001 | 2.889 ± .010 | .1318 ± .0008 | 96.960 ± .010 | 89.360 ± .016 | 7.645 ± .013 | 2.312 ± .021 | .0835 ± .0013 | 6.662 ± .025 | 3.02 ± .04 | 3.87 ± .19 | | | | |
| H8-C-a1 | 21305 | 2 | T-114 | .0174 ± .0009 | 2.430 ± .003 | .2273 ± .0042 | 97.326 ± .005 | 82.012 ± .029 | 11.594 ± .025 | 5.926 ± .023 | .4701 ± .0022 | 6.171 ± .010 | 5.206 ± .074 | 8.19 ± .41 | | | | |
| H8-C-a1 | 21305 | 3 | T-115 | .0183 ± .0007 | 2.437 ± .004 | .2259 ± .0032 | 97.319 ± .005 | 82.08 ± .14 | 11.664 ± .046 | 5.79 ± .17 | .465 ± .003 | 5.665 ± .018 | 5.164 ± .075 | 8.15 ± .41 | | | | |
| H8-C-a1 | 21305 | 4 | T-116 | .0192 ± .0034 | 2.753 ± .021 | .1527 ± .005 | 97.075 ± .021 | 88.381 ± .023 | 8.539 ± .023 | 2.951 ± .007 | .1290 ± .0014 | 5.146 ± .043 | 3.322 ± .054 | 4.53 ± .23 | | | | |
| H8-C-f6 | 1306 | 1 | T-136 | .0181 ± .0004 | 2.554 ± .007 | .2014 ± .0014 | 97.227 ± .008 | 86.415 ± .020 | 10.514 ± .014 | 4.757 ± .020 | .313 ± .003 | 3.793 ± .005 | 4.749 ± .061 | 6.47 ± .32 | | | | |
| H8-C-f6 | 1306 | 2 | T-137 | .0181 ± .0003 | 2.549 ± .008 | .2038 ± .008 | 97.229 ± .008 | 84.190 ± .070 | 10.643 ± .067 | 4.856 ± .038 | .313 ± .005 | 4.096 ± .015 | 4.579 ± .069 | 6.55 ± .33 | | | | |

Table 3.1-6 (continued, 4/8)

| Core Location Number | Fuel Rod Number | Axial Sample Code | Sample Number | ATOM PERCENT URANIUM ^b | | | | ATOM PERCENT PLUTONIUM ^c | | | | U-238 Conc. ($\text{ppm/gmU} \times 10^{-10}$) | Cs-137^{c} ($\text{ppm/gmU} \times 10^{-10}$) | Sr-90 ^d ($\text{ppm/gmU} \times 10^{-10}$) | | | | | | | | |
|----------------------|-----------------|-------------------|---------------|-----------------------------------|---------------|---------------|---------------|-------------------------------------|-------------|---------------|-------------|--|---|---|---------------|---------------|----------------|---------------|----------------|---------------|--------------|------------|
| | | | | U-234 | | U-235 | | U-238 | | Pu-239 | | Pu-240 | | | | | | | | | | |
| | | | | U-234 | U-235 | U-238 | Pu-239 | Pu-240 | Pu-241 | Pu-242 | Pu-242 | Pu-242 | Pu-242 | Pu-242 | | | | | | | | |
| J3-C-41 | 3477 | 3 | G | .0202 ± .0004 | .92 ± .02 | .146 ± .002 | .96 ± .002 | .96 ± .002 | .94 ± .02 | .88 ± .03 | .82 ± .02 | .80 ± .04 | .75 ± .02 | .114 ± .006 | 5.62 ± .22 | 3.40 ± .04 | 4.11 ± .25 | | | | | |
| N-1 | 38 | T-1 | .0199 ± .0002 | .811 ± .011 | .1503 ± .0021 | .97 ± .019 | .0014 | .96 ± .003 | .96 ± .003 | .88 ± .039 | .021 ± .021 | .277 ± .020 | .275 ± .020 | .119 ± .010 | .119 ± .002 | 5.720 ± .040 | 3.350 ± .046 | 5.635 ± .053 | | | | |
| N-1 | 38 | T-1 | .017 ± .003 | .836 ± .020 | .2836 ± .020 | .95 ± .020 | .0014 | .96 ± .003 | .96 ± .003 | .88 ± .039 | .021 ± .021 | .277 ± .020 | .278 ± .020 | .107 ± .014 | .117 ± .005 | 5.635 ± .053 | 3.353 ± .049 | 5.639 ± .053 | | | | |
| N-1 | 38 | T-3 | .0202 ± .0002 | .836 ± .020 | .2837 ± .020 | .95 ± .020 | .0014 | .96 ± .003 | .96 ± .003 | .89 ± .040 | .019 ± .019 | .278 ± .020 | .278 ± .020 | .117 ± .014 | .117 ± .005 | 5.639 ± .053 | 3.353 ± .049 | 5.639 ± .053 | | | | |
| N-2 | 38 | T-3 | .021 ± .003 | .821 ± .021 | .2837 ± .021 | .95 ± .021 | .0012 | .96 ± .004 | .96 ± .004 | .89 ± .040 | .019 ± .019 | .278 ± .020 | .278 ± .020 | .117 ± .014 | .117 ± .005 | 5.639 ± .053 | 3.353 ± .049 | 5.639 ± .053 | | | | |
| N-2 | 38 | T-3 | .0194 ± .0008 | .822 ± .022 | .2837 ± .022 | .95 ± .022 | .0012 | .96 ± .004 | .96 ± .004 | .89 ± .040 | .019 ± .019 | .278 ± .020 | .278 ± .020 | .117 ± .014 | .117 ± .005 | 5.639 ± .053 | 3.353 ± .049 | 5.639 ± .053 | | | | |
| J3-C-56 | 3480 | 1 | T-19 | .0206 ± .0003 | .9111 ± .0022 | .0024 ± .0024 | .96 ± .0024 | .0023 | .96 ± .0024 | .0022 ± .0022 | .97 ± .0022 | .0022 ± .0022 | .97 ± .0022 | .0022 ± .0022 | .037 ± .037 | .4.636 ± .030 | .07725 ± .0132 | .0171 ± .0007 | .6.930 ± .0008 | .1.649 ± .058 | 1.46 ± .07 | |
| J3-C-56 | 3480 | 3 | T-20 | .0202 ± .0003 | .8904 ± .0022 | .0022 ± .0022 | .96 ± .0022 | .0022 | .96 ± .0022 | .0022 ± .0022 | .97 ± .0022 | .0022 ± .0022 | .97 ± .0022 | .0022 ± .0022 | .063 ± .063 | .8.044 ± .036 | .1.087 ± .036 | .3.260 ± .092 | .10.66 ± .066 | 3.24 ± .16 | 3.62 ± .18 | |
| J3-C-56 | 3480 | 5 | T-22 | .0212 ± .0008 | .8083 ± .0016 | .0043 ± .0008 | .96 ± .0016 | .0008 | .96 ± .0016 | .0008 ± .0008 | .97 ± .0016 | .0008 ± .0008 | .97 ± .0016 | .0008 ± .0008 | .006 ± .006 | .8.162 ± .177 | .2.429 ± .135 | .0938 ± .050 | .7.871 ± .050 | 3.111 ± .084 | 3.180 ± .084 | |
| J4-C-41 | 305 | 1 | T | .02 ± .01 | .92 ± .01 | .2.96 ± .01 | .11 ± .01 | .01 | .96 ± .02 | .01 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .18 | 2.38 ± .19 | |
| J4-C-41 | 305 | 3 | T | .02 ± .01 | .92 ± .01 | .2.96 ± .01 | .11 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .18 | 2.38 ± .19 | |
| J4-C-41 | 305 | 5 | T | .02 ± .01 | .917 ± .0014 | .2.92 ± .01 | .1912 ± .0030 | .0030 | .97 ± .12 | .04 | .84 ± .13 | .04 | .10 ± .07 | .2.0 ± .07 | .4.763 ± .076 | .3.399 ± .046 | .06 ± .01 | .4.58 ± .04 | .6.18 ± .12 | .4.58 ± .04 | 5.07 ± .40 | 5.07 ± .40 |
| J4-C-41 | 305 | 6 | T | .02 ± .01 | .917 ± .0014 | .2.92 ± .01 | .1912 ± .0030 | .0030 | .97 ± .12 | .04 | .84 ± .13 | .04 | .10 ± .07 | .2.0 ± .07 | .4.763 ± .076 | .3.399 ± .046 | .06 ± .01 | .4.58 ± .04 | .6.18 ± .12 | .4.58 ± .04 | 5.07 ± .40 | 5.07 ± .40 |
| J4-C-56 | 0918 | 1 | T-73 | .0190 ± .0001 | .9001 ± .0001 | .0029 ± .0009 | .96 ± .0029 | .0009 | .96 ± .0029 | .0009 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 3 | T-73 | .0175 ± .0017 | .919 ± .002 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 5 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 6 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 7 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 8 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 9 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 10 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 11 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 12 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 13 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 14 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 15 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 16 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 17 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 18 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 19 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 20 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 21 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 22 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 23 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 24 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 25 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 26 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 27 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2.38 ± .19 | 2.38 ± .19 | |
| J4-C-56 | 0918 | 28 | T-73 | .0175 ± .0017 | .9188 ± .0009 | .2.13 ± .02 | .01 ± .01 | .01 | .97 ± .12 | .04 | .91 ± .12 | .04 | .6.97 ± .03 | .1.85 ± .02 | .06 ± .01 | .1.85 ± .01 | .2.63 ± .02 | .2.36 ± .18 | 2.38 ± .19 | 2 | | |

Table 3.1-6 (continued, 5/8)

| Core Location Number | Fuel Rod Number | Axial Sample Code | Sample Zone Number | ATOM PERCENT URANIUM ^b | | | | ATOM PERCENT PLUTONIUM ^c | | | | U-238 Conc. ($\text{dpm/gmU} \times 10^{-10}$) | | | | Pu-239/u-238 ($\text{dpm/gmU} \times 10^{-10}$) | | | | Cs-137 ^e ($\text{dpm/gmU} \times 10^{-10}$) | | | | | |
|---|-----------------------|-------------------------|--------------------------|-----------------------------------|---------------|----------------|---------------|-------------------------------------|---------------|----------------|----------------|---|---------------|---------------|---------------|--|---------------|---------------|---------------|---|---------------|---------------|---------------|---------------|--------------|
| | | | | U-234 | U-235 | U-236 | U-238 | Pu-239 | Pu-240 | Pu-241 | Pu-242 | Pu-244 | Pu-245 | Pu-246 | Pu-247 | Pu-248 | Pu-249 | Pu-250 | Pu-251 | Pu-252 | Pu-253 | Pu-254 | Pu-255 | Pu-256 | Pu-257 |
| PHASE I. ASYMMETRIC NEUTRON SPECTRUM, CENTER SUBASSEMBLIES | | | | | | | | | | | | | | | | | | | | | | | | | |
| K4-C-f6 | 2905 | 1 | T-15 | .0211 ± .0006 | 3.203 ± .008 | .0671 ± .0015 | 96.709 ± .008 | 95.861 ± .027 | 3.663 ± .024 | 0.4592 ± .0061 | 0.065 ± .0009 | 4.557 ± .015 | 1.203 ± .028 | 1.39 ± .007 | 4.608 ± .013 | 2.373 ± .028 | 2.342 ± .059 | 2.69 ± .13 | 3.25 ± .16 | 2.342 ± .059 | 2.69 ± .13 | 1.53 ± .08 | 1.53 ± .08 | 1.53 ± .08 | 1.53 ± .08 |
| | 3 | T-16 | .0209 ± .0002 | 2.969 ± .012 | .1146 ± .0009 | 96.896 ± .013 | 91.866 ± .023 | 6.336 ± .017 | 1.388 ± .013 | 0.073 ± .0013 | 0.073 ± .0013 | 5.427 ± .023 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 |
| | 5 | T-17 | .0201 ± .0002 | 2.978 ± .010 | .1110 ± .0007 | 96.891 ± .010 | 92.131 ± .023 | 6.336 ± .017 | 1.388 ± .013 | 0.073 ± .0013 | 0.073 ± .0013 | 5.427 ± .023 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 | 2.342 ± .059 |
| | 6 | T-23 | .0208 ± .0004 | 3.196 ± .006 | .0756 ± .0006 | 96.707 ± .007 | 95.482 ± .029 | 3.979 ± .024 | 0.340 ± .011 | Not Detected | 10.26 ± .04 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | 1.386 ± .030 | |
| K5-C-a1 | 0877 | 1 | T-28 | .0197 ± .0005 | 3.075 ± .011 | .0816 ± .0004 | 96.824 ± .012 | 93.457 ± .010 | 5.476 ± .009 | 1.061 ± .006 | 0.0281 ± .0006 | 2.27 ± .01 | 1.82 ± .04 | 2.06 ± .10 | 1.82 ± .04 | 2.06 ± .10 | 1.82 ± .04 | 2.06 ± .10 | 1.82 ± .04 | 2.06 ± .10 | 1.82 ± .04 | 2.06 ± .10 | 1.82 ± .04 | 2.06 ± .10 | 1.82 ± .04 |
| | 3 | T-29 | .0176 ± .0002 | 2.730 ± .004 | .1470 ± .0008 | 97.102 ± .004 | 87.864 ± .033 | 8.693 ± .023 | 0.158 ± .028 | 0.151 ± .002 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | 8.693 ± .033 | |
| | 5 | T-30 | .0183 ± .0002 | 2.757 ± .004 | .1470 ± .0008 | 97.076 ± .004 | 88.077 ± .035 | 8.693 ± .031 | 0.158 ± .021 | 0.152 ± .002 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | 8.693 ± .035 | |
| | 6 | T-31 | .0188 ± .0003 | 3.024 ± .007 | .0931 ± .0015 | 96.864 ± .007 | 92.307 ± .014 | 6.098 ± .012 | 1.352 ± .009 | 0.035 ± .0012 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | 5.763 ± .002 | |
| K5-C-f6 | 011 | 1 | G-18 | .019 ± .004 | 3.14 ± .004 | .070 ± .014 | 96.77 ± .20 | 95.18 ± .40 | 4.20 ± .04 | 0.615 ± .013 | 0.010 ± .004 | 2.22 ± .04 | 1.54 ± .04 | 1.79 ± .09 | 1.54 ± .04 | 1.79 ± .09 | 1.54 ± .04 | 1.79 ± .09 | 1.54 ± .04 | 1.79 ± .09 | 1.54 ± .04 | 1.79 ± .09 | 1.54 ± .04 | 1.79 ± .09 | 1.54 ± .04 |
| | 3 | G-19 | .018 ± .004 | 2.88 ± .004 | .124 ± .004 | 96.97 ± .20 | 90.38 ± .40 | 7.32 ± .04 | 0.622 ± .013 | 0.010 ± .004 | 2.12 ± .04 | 1.54 ± .04 | 1.77 ± .09 | 1.54 ± .04 | 1.77 ± .09 | 1.54 ± .04 | 1.77 ± .09 | 1.54 ± .04 | 1.77 ± .09 | 1.54 ± .04 | 1.77 ± .09 | 1.54 ± .04 | 1.77 ± .09 | 1.54 ± .04 | |
| | 5 | G-20 | .018 ± .004 | 2.88 ± .004 | .121 ± .002 | 96.98 ± .20 | 90.52 ± .40 | 7.28 ± .06 | 0.616 ± .012 | 0.009 ± .004 | 2.12 ± .02 | 1.52 ± .02 | 1.77 ± .09 | 1.52 ± .02 | 1.77 ± .09 | 1.52 ± .02 | 1.77 ± .09 | 1.52 ± .02 | 1.77 ± .09 | 1.52 ± .02 | 1.77 ± .09 | 1.52 ± .02 | 1.77 ± .09 | 1.52 ± .02 | |
| | 6 | G-21 | .020 ± .004 | 3.13 ± .012 | .079 ± .014 | 96.77 ± .20 | 94.25 ± .40 | 4.88 ± .06 | 0.889 ± .016 | 0.024 ± .004 | 1.90 ± .016 | 1.36 ± .016 | 1.79 ± .09 | 1.36 ± .016 | 1.79 ± .09 | 1.36 ± .016 | 1.79 ± .09 | 1.36 ± .016 | 1.79 ± .09 | 1.36 ± .016 | 1.79 ± .09 | 1.36 ± .016 | 1.79 ± .09 | | |
| PHASE I, PERTURBED NEUTRON SPECTRUM, CORNER SUBASSEMBLIES | | | | | | | | | | | | | | | | | | | | | | | | | |
| E5-NE-f1 | 2300 | 1 | G-38 | .0119 ± .0004 | 2.60 ± .006 | .072 ± .002 | 97.18 ± .20 | 83.37 ± .04 | 11.92 ± .12 | 4.40 ± .04 | 0.309 ± .006 | 0.239 ± .006 | 2.239 ± .08 | 1.54 ± .08 | 1.88 ± .08 | 1.54 ± .08 | 1.88 ± .08 | 1.54 ± .08 | 1.88 ± .08 | 1.54 ± .08 | 1.88 ± .08 | 1.54 ± .08 | 1.88 ± .08 | 1.54 ± .08 | 1.88 ± .08 |
| | 3 | G-39 | .0116 ± .0004 | 2.06 ± .006 | .278 ± .006 | 97.64 ± .20 | 74.20 ± .73 | 16.18 ± .16 | 8.53 ± .09 | 1.10 ± .02 | 25.75 ± .02 | 1.0 ± .02 | 11.24 ± .10 | 1.0 ± .02 | 11.24 ± .10 | 1.0 ± .02 | 11.24 ± .10 | 1.0 ± .02 | 11.24 ± .10 | 1.0 ± .02 | 11.24 ± .10 | 1.0 ± .02 | 11.24 ± .10 | 1.0 ± .02 | |
| | 5 | G-40 | .0114 ± .0004 | 2.22 ± .002 | .253 ± .006 | 97.51 ± .20 | 77.50 ± .77 | 14.56 ± .14 | 7.16 ± .07 | 0.779 ± .016 | 23.68 ± .016 | .96 ± .06 | 5.55 ± .12 | .96 ± .06 | 5.55 ± .12 | .96 ± .06 | 5.55 ± .12 | .96 ± .06 | 5.55 ± .12 | .96 ± .06 | 5.55 ± .12 | .96 ± .06 | 5.55 ± .12 | .96 ± .06 | |
| | 6 | G-41 | .0118 ± .0004 | 2.66 ± .002 | .168 ± .004 | 97.14 ± .20 | 85.36 ± .86 | 10.52 ± .10 | 5.67 ± .04 | 0.218 ± .008 | 19.41 ± .08 | .80 ± .08 | 3.66 ± .10 | .80 ± .08 | 3.66 ± .10 | .80 ± .08 | 3.66 ± .10 | .80 ± .08 | 3.66 ± .10 | .80 ± .08 | 3.66 ± .10 | .80 ± .08 | 3.66 ± .10 | .80 ± .08 | |
| E5-SW-a5 | 15025 | 1 | T-46 | .0197 ± .0004 | 2.627 ± .014 | .1858 ± .016 | 97.167 ± .005 | 84.320 ± .042 | 11.191 ± .042 | 4.021 ± .009 | 0.271 ± .004 | 0.271 ± .004 | 2.727 ± .072 | 1.54 ± .072 | 1.88 ± .072 | 1.54 ± .072 | 1.88 ± .072 | 1.54 ± .072 | 1.88 ± .072 | 1.54 ± .072 | 1.88 ± .072 | 1.54 ± .072 | 1.88 ± .072 | 1.54 ± .072 | 1.88 ± .072 |
| | 3 | T-47 | .0169 ± .0002 | 1.990 ± .0001 | .3080 ± .0016 | 97.685 ± .0016 | 73.316 ± .058 | 16.411 ± .052 | 9.003 ± .050 | 1.270 ± .012 | 6.075 ± .012 | 6.075 ± .012 | 5.778 ± .066 | 5.443 ± .066 | 5.778 ± .066 | 5.443 ± .066 | 5.778 ± .066 | 5.443 ± .066 | 5.778 ± .066 | 5.443 ± .066 | 5.778 ± .066 | 5.443 ± .066 | 5.778 ± .066 | 5.443 ± .066 | 5.778 ± .066 |
| | 5 | T-48 | .0177 ± .0001 | 2.049 ± .001 | .2903 ± .001 | 97.643 ± .002 | 74.387 ± .050 | 15.990 ± .050 | 8.504 ± .033 | 1.120 ± .007 | 6.075 ± .007 | 6.075 ± .007 | 6.075 ± .013 | 5.536 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 |
| | 6 | T-49 | .0194 ± .0003 | 2.550 ± .007 | .2051 ± .0017 | 97.226 ± .007 | 82.734 ± .034 | 12.110 ± .033 | 4.797 ± .018 | 0.360 ± .003 | 0.360 ± .003 | 0.360 ± .003 | 6.877 ± .007 | 6.877 ± .007 | 6.877 ± .007 | 6.877 ± .007 | 6.877 ± .007 | 6.877 ± .007 | 6.877 ± .007 | 6.877 ± .007 | 6.877 ± .007 | 6.877 ± .007 | 6.877 ± .007 | 6.877 ± .007 | |
| E4-NE-11 | 20036 | 1 | T-50 | .0192 ± .0002 | 2.389 ± .006 | .1924 ± .006 | 97.200 ± .007 | 84.247 ± .030 | 11.257 ± .028 | 4.214 ± .016 | 0.281 ± .004 | 0.281 ± .004 | 6.877 ± .047 | 6.877 ± .047 | 6.877 ± .047 | 6.877 ± .047 | 6.877 ± .047 | 6.877 ± .047 | 6.877 ± .047 | 6.877 ± .047 | 6.877 ± .047 | 6.877 ± .047 | 6.877 ± .047 | 6.877 ± .047 | |
| | 3 | T-51 | .0171 ± .0002 | 1.879 ± .001 | .3259 ± .001 | 97.779 ± .013 | 71.763 ± .13 | 17.113 ± .13 | 9.581 ± .067 | 9.430 ± .029 | 9.581 ± .067 | 9.581 ± .067 | 13.542 ± .142 | 13.542 ± .142 | 13.542 ± .142 | 13.542 ± .142 | 13.542 ± .142 | 13.542 ± .142 | 13.542 ± .142 | 13.542 ± .142 | 13.542 ± .142 | 13.542 ± .142 | 13.542 ± .142 | 13.542 ± .142 | |
| | 5 | T-52 | .0177 ± .0001 | 2.040 ± .004 | .2046 ± .004 | 97.342 ± .004 | 80.841 ± .044 | 13.014 ± .045 | 5.647 ± .018 | 0.495 ± .004 | 7.087 ± .035 | 7.087 ± .035 | 7.087 ± .035 | 4.285 ± .105 | 4.285 ± .105 | 4.285 ± .105 | 4.285 ± .105 | 4.285 ± .105 | 4.285 ± .105 | 4.285 ± .105 | 4.285 ± .105 | 4.285 ± .105 | 4.285 ± .105 | 4.285 ± .105 | 4.285 ± .105 |
| | 6 | T-53 | .0177 ± .0001 | 2.049 ± .001 | .2903 ± .001 | 97.643 ± .002 | 74.387 ± .050 | 15.990 ± .050 | 8.504 ± .033 | 1.120 ± .007 | 6.075 ± .007 | 6.075 ± .007 | 6.075 ± .013 | 5.536 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | 6.075 ± .013 | |
| E4-SW-a5 | 17383 | 1 | T-75 | .0179 ± .0001 | 2.740 ± .003 | .1595 ± .004 | 97.083 ± .003 | 86.348 ± .042 | 10.116 ± .040 | 3.361 ± .021 | 0.1757 ± .009 | 0.1757 ± .009 | 6.012 ± .010 | 7.856 ± .020 | 6.471 ± .016 | 6.471 ± .016 | 6.471 ± .016 | 6.471 ± .016 | 6.471 ± .016 | 6.471 ± .016 | 6.471 ± .016 | 6.471 ± .016 | 6.471 ± .016 | 6.471 ± .016 | 6.471 ± .016 |
| | 3 | T-76 | .0159 ± .0003 | 2.204 ± .006 | .2671 ± .006 | 97.513 ± .005 | 76.561 ± .060 | 14.993 ± .031 | 7.600 ± .038 | 1.018 ± .017 | 7.777 ± .017 | 7.777 ± .017 | 7.777 ± .017 | 10.88 ± .020 | 10.88 ± .020 | 10.88 ± .020 | 10.88 ± .020 | 10.88 ± .020 | 10.88 ± .020 | 10.88 ± .020 | 10.88 ± .020 | 10.88 ± .020 | 10.88 ± .020 | 10.88 ± .020 | |
| | 5 | T-77 | .0164 ± .0002 | 2.153 ± .004 | .2695 ± .004 | 97.361 ± .004 | 75.395 ± .020 | 10.308 ± .018 | 4.2424 ± .012 | 0.2480 ± .002 | 0.2480 ± .002 | 0.2480 ± .002 | | | | | | | | | | | | | |

Table 3.1-6 (continued, 6/8)

| Core Location Number | Fuel Rod Number | Axial Sample Code | Sample Number | ATOM PERCENT URANIUM ^b | | | ATOM PERCENT PLUTONIUM ^c | | | Cs-137/C (dpm/gmU × 10 ⁻⁶) | | | Sr-90/C (dpm/gmU × 10 ⁻⁶) | | |
|--|--------------------|----------------------|------------------|-----------------------------------|---------------|---------------|-------------------------------------|---------------|---------------|---|--------------|--------------------------------------|--|---|--|
| | | | | U-234 | U-235 | U-238 | Pu-239 | Pu-240 | Pu-241 | Pu-242 | Pu-243 | Cs-137/C (dpm × 10 ³) | Pu-239/U-238 (a/a × 10 ⁻¹⁶) | Cs-137/C (dpm/gmU × 10 ⁻⁶) | Sr-90/C (dpm/gmU × 10 ⁻⁶) |
| PHASE I, PERTURBED NEUTRON SPECTRUM, CORNER SUBASSEMBLIES | | | | | | | | | | | | | | | |
| G4-NW-ai LXX39 | 1 | T | .02 ± .001 | 2.56 ± .01 | .18 ± .01 | 97.24 ± .02 | 84.329 ± .044 | 11.285 ± .030 | 4.114 ± .022 | 0.2721 ± .0021 | 6.06 ± .05 | 3.77 ± .05 ^b | 6.19 ± .37 | 5.13 ± .41 | |
| G4-NW-ai LXX39 | 3 | T | .02 ± .01 | 1.87 ± .01 | .31 ± .01 | 97.80 ± .01 | 71.913 ± .044 | 17.114 ± .060 | 9.406 ± .041 | 1.487 ± .015 | 6.07 ± .05 | 5.49 ± .04 ^b | 12.91 ± .16 ^b | 9.86 ± .79 | |
| G4-NW-ai LXX39 | 5 | T | .02 ± .01 | 1.83 ± .01 | .32 ± .01 | 97.84 ± .01 | 71.882 ± .048 | 17.099 ± .064 | 9.502 ± .043 | 1.517 ± .002 | 6.02 ± .05 | 5.49 ± .04 ^b | 12.77 ± .77 | 12.31 ± .98 | |
| G4-NW-ai LXX39 | 6 | T | .02 ± .01 | 2.42 ± .01 | .23 ± .01 | 97.34 ± .01 | 80.952 ± .051 | 12.971 ± .035 | 5.579 ± .019 | 0.4977 ± .0026 | 5.79 ± .02 | 4.35 ± .06 ^b | 7.78 ± .47 | 6.10 ± .49 | |
| G4-SE-f5 L2760 | 1 | G-34 | .021 ± .004 | 2.69 ± .02 | .189 ± .004 | 97.10 ± .20 | 85.24 ± .86 | 10.53 ± .10 | 3.99 ± .04 | 0.243 ± .008 | 22.00 ± .02 | 3.78 ± .08 | 5.95 ± .30 | 13.28 ± .66 | |
| G4-SE-f5 L2760 | 3 | G-35 | .018 ± .004 | 1.92 ± .02 | .323 ± .006 | 97.73 ± .20 | 72.67 ± .71 | 16.50 ± .16 | 9.41 ± .09 | 1.41 ± .02 | 20.04 ± .80 | 5.68 ± .10 | 13.37 ± .67 | 13.37 ± .67 | |
| G4-SE-f5 L2760 | 5 | G-36 | .016 ± .002 | 1.86 ± .02 | .321 ± .006 | 97.79 ± .20 | 72.27 ± .71 | 16.63 ± .16 | 9.58 ± .09 | 1.51 ± .02 | 16.62 ± .66 | 4.27 ± .08 | 8.34 ± .42 | 8.34 ± .42 | |
| G4-SE-f5 L2760 | 6 | G-37 | .020 ± .004 | 2.38 ± .02 | .233 ± .004 | 97.36 ± .20 | 81.38 ± .80 | 12.58 ± .12 | 5.56 ± .04 | 0.482 ± .008 | 4.27 ± .08 | 4.27 ± .08 | 8.34 ± .42 | 8.34 ± .42 | |
| H3-SE-f5 220 Comp ^a | C | C | .0165 ± .0004 | 2.29 ± .02 | .231 ± .004 | 97.46 ± .44 | 78.886 ± .538 | 13.851 ± .100 | 6.549 ± .021 | 0.7130 ± .0080 | 4.94 ± .20 | 4.46 ± .08 | 4.46 ± .08 | 4.46 ± .08 | |
| H3-SE-f5 220 | 1 | G | .0182 ± .0002 | 2.77 ± .02 | .144 ± .002 | 97.07 ± .44 | 87.93 ± .54 | 9.20 ± .06 | 2.73 ± .04 | 0.137 ± .006 | 6.99 ± .28 | 2.95 ± .06 | 4.67 ± .37 | 4.26 ± .38 | |
| H3-SE-f5 220 | 2 | G | .0175 ± .0004 | 2.25 ± .02 | .229 ± .002 | 97.50 ± .44 | 79.06 ± .44 | 13.88 ± .08 | 6.40 ± .06 | 0.486 ± .010 | 4.68 ± .18 | 4.22 ± .08 | 7.47 ± .77 | 7.47 ± .77 | |
| H3-SE-f5 220 | 3 | G | .0162 ± .0004 | 2.137 ± .02 | .259 ± .004 | 97.59 ± .32 | 76.97 ± .38 | 14.82 ± .08 | 7.37 ± .11 | 0.846 ± .032 | 6.39 ± .18 | 4.73 ± .18 | 10.40 ± .83 | 7.91 ± .72 | |
| H3-SE-f5 220 | 4 | G | .0156 ± .0008 | 2.09 ± .02 | .262 ± .002 | 97.64 ± .32 | 76.89 ± .30 | 14.76 ± .06 | 7.47 ± .04 | 0.879 ± .008 | 5.31 ± .22 | 4.76 ± .18 | 8.22 ± .86 | 8.22 ± .74 | |
| H3-SE-f5 220 | 5 | G | .0179 ± .0002 | 2.21 ± .02 | .257 ± .002 | 97.52 ± .68 | 77.94 ± .32 | 14.37 ± .06 | 6.95 ± .02 | 0.746 ± .006 | 5.15 ± .20 | 4.74 ± .18 | 9.72 ± .04 | 9.72 ± .78 | |
| H3-SE-f5 220 | 58 | T-7 | .0172 ± .0003 | 2.198 ± .008 | .255 ± .0012 | 97.530 ± .009 | 77.934 ± .053 | 14.422 ± .054 | 6.904 ± .026 | 0.740 ± .009 | 4.514 ± .023 | 4.81 ± .30 | 5.52 ± .44 | 5.77 ± .52 | |
| H3-SE-f5 220 | 58 | N-3 | .016 ± .003 | 2.192 ± .008 | .251 ± .002 | 97.50 ± .06 | 78.23 ± .06 | 14.14 ± .06 | 6.76 ± .04 | 0.746 ± .006 | 4.56 ± .22 | 4.80 ± .22 | 5.52 ± .44 | 5.77 ± .52 | |
| H3-SE-f5 220 | 6 | G | .0170 ± .0006 | 2.26 ± .02 | .266 ± .002 | 97.22 ± .38 | 86.08 ± .16 | 10.23 ± .06 | 3.49 ± .03 | 0.326 ± .004 | 5.44 ± .22 | 3.46 ± .18 | 5.52 ± .44 | 5.77 ± .52 | |
| H5-NW-ai 9709 | 1 | T-54 | .0196 ± .0003 | 2.658 ± .007 | .1745 ± .0013 | 97.148 ± .008 | 85.696 ± .036 | 10.493 ± .033 | 3.681 ± .019 | 0.219 ± .002 | 5.741 ± .020 | 3.561 ± .065 | 5.67 ± .28 | 12.65 ± .63 | |
| H5-NW-ai 9709 | 3 | T-55 | .0171 ± .0001 | 1.941 ± .004 | .3075 ± .0006 | 97.735 ± .003 | 73.162 ± .023 | 16.462 ± .025 | 16.604 ± .023 | 1.319 ± .003 | 5.366 ± .020 | 5.433 ± .131 | 12.81 ± .64 | 12.81 ± .64 | |
| H5-NW-ai 9709 | 5 | T-56 | .0169 ± .0001 | 1.884 ± .004 | .3163 ± .0020 | 97.785 ± .005 | 72.724 ± .023 | 16.604 ± .019 | 9.038 ± .025 | 1.406 ± .010 | 6.024 ± .020 | 5.356 ± .108 | 8.12 ± .41 | 8.12 ± .41 | |
| H5-NW-ai 9709 | 6 | T-57 | .0184 ± .0001 | 2.357 ± .006 | .2258 ± .0010 | 97.399 ± .007 | 81.299 ± .051 | 12.733 ± .048 | 5.505 ± .030 | 0.473 ± .005 | 6.621 ± .023 | 4.247 ± .095 | 4.247 ± .095 | 4.247 ± .095 | |
| J4-NW-ai 11183 | 1 | T | .02 ± .01 | 2.77 ± .01 | .14 ± .01 | 97.08 ± .01 | 87.838 ± .047 | 9.309 ± .045 | 2.715 ± .020 | 0.1385 ± .0030 | 6.60 ± .08 | 3.02 ± .05 ^b | 4.38 ± .26 | 3.03 ± .24 | |
| J4-NW-ai 11183 | 2 | T | .02 ± .01 | 2.23 ± .02 | .25 ± .01 | 97.52 ± .01 | 76.980 ± .055 | 13.984 ± .050 | 6.386 ± .035 | 0.6501 ± .0120 | 5.97 ± .05 | 4.50 ± .07 ^b | 8.91 ± .53 | 6.58 ± .53 | |
| J4-NW-ai 11183 | 3 | T | .02 ± .01 | 2.09 ± .01 | .25 ± .01 | 97.64 ± .01 | 76.898 ± .067 | 14.939 ± .060 | 7.314 ± .051 | 0.8495 ± .0120 | 6.07 ± .02 | 4.76 ± .02 | 10.12 ± .61 | 7.88 ± .63 | |
| J4-NW-ai 11183 | 4 | T | .02 ± .01 | 2.09 ± .01 | .26 ± .01 | 97.64 ± .01 | 76.398 ± .049 | 15.129 ± .049 | 7.587 ± .027 | 0.8867 ± .0043 | 6.43 ± .02 | 4.82 ± .02 | 10.59 ± .64 | 8.32 ± .66 | |
| J4-NW-ai 11183 | 5 | T | | | | | | | | | | 5.17 ± .31 | 4.69 ± .37 | 4.69 ± .37 | |
| PHASE I, INTERMEDIATE NEUTRON SPECTRUM, ON DIAGONAL OF CORNER SUBASSEMBLY | | | | | | | | | | | | | | | |
| F4-SW-b4 17457 | 1 | T-79 | .0187 ± .0002 | 2.800 ± .019 | .1472 ± .011 | 97.034 ± .020 | 87.622 ± .071 | 9.230 ± .064 | 2.995 ± .044 | .153 ± .006 | 7.196 ± .053 | 3.336 ± .048 | 4.77 ± .24 | | |
| F4-SW-b4 17457 | 3 | T-80 | .0163 ± .0001 | 2.321 ± .007 | .2514 ± .014 | 97.412 ± .008 | 13.654 ± .047 | 6.892 ± .017 | .680 ± .005 | 5.004 ± .033 | 5.304 ± .089 | 9.57 ± .48 | | | |
| F4-SW-b4 17457 | 5 | T-81 | .0172 ± .0002 | 2.289 ± .004 | .2578 ± .009 | 97.436 ± .004 | 13.955 ± .032 | 7.066 ± .014 | .718 ± .005 | 5.845 ± .010 | 5.316 ± .075 | 9.74 ± .49 | | | |
| F4-SW-b4 17457 | 6 | T-82 | .0176 ± .0002 | 2.674 ± .004 | .1696 ± .006 | 97.139 ± .005 | 85.296 ± .074 | 10.522 ± .070 | 3.953 ± .036 | .228 ± .005 | 4.618 ± .008 | 3.828 ± .047 | 5.86 ± .29 | | |
| F4-SW-d2 17460 | 1 | T-83 | .0196 ± .0001 | 2.864 ± .001 | .1560 ± .006 | 96.961 ± .001 | 88.281 ± .082 | 6.610 ± .081 | 2.980 ± .028 | .129 ± .003 | 6.255 ± .005 | 3.472 ± .043 | 4.57 ± .23 | | |
| F4-SW-d2 17460 | 3 | T-84 | .0162 ± .0001 | 2.342 ± .002 | .2458 ± .004 | 97.396 ± .003 | 80.019 ± .030 | 12.546 ± .032 | 6.801 ± .008 | .613 ± .002 | 5.450 ± .010 | 5.677 ± .080 | 9.20 ± .46 | | |
| F4-SW-d2 17460 | 5 | T-85 | .0180 ± .0002 | 2.334 ± .003 | .2558 ± .007 | 97.393 ± .003 | 79.750 ± .014 | 12.758 ± .012 | 6.853 ± .011 | .639 ± .003 | 5.162 ± .008 | 5.612 ± .090 | 9.42 ± .47 | | |
| F4-SW-d2 17460 | 6 | T-86 | .0180 ± .0002 | 2.693 ± .004 | .1681 ± .005 | 97.121 ± .004 | 80.187 ± .028 | 9.782 ± .027 | 3.820 ± .012 | .211 ± .002 | 6.037 ± .010 | 3.936 ± .048 | 5.62 ± .28 | | |

Table 3.1-6 (continued, 7/8)

| Core Location Number | Fuel Rod Sample Zone Number | Axial Sample Code | Sample | ATOM PERCENT URANIUM ^b | | | | ATOM PERCENT PLUTONIUM ^c | | | | Cs-137 ^c (dpm/gm ^d × 10 ⁻¹⁰) | Sr-90 ^c (dpm/gm ^d × 10 ⁻¹⁰) | | |
|---|-----------------------------|-------------------|---------------|-----------------------------------|--------------------------|--------------------------|--------------------------|-------------------------------------|--------------------------|--------------------------|--------------------------|---|--|----------------|---------------|
| | | | | U-234 | | U-235 | | U-236 | | Pu-239 | | Pu-240 | | | |
| | | | | (a/a × 10 ³) | (a/a × 10 ³) | (a/a × 10 ³) | (a/a × 10 ³) | (a/a × 10 ³) | (a/a × 10 ³) | (a/a × 10 ³) | (a/a × 10 ³) | (a/a × 10 ³) | (a/a × 10 ³) | | |
| PHASE I, INTERMEDIATE NEUTRON SPECTRUM, ON DIAGONAL OF CORNER SUBASSEMBLY | | | | | | | | | | | | | | | |
| F5-NW-b2 | 8172 | 1 | G-56 | .018 ± .004 | 2.46 ± .02 | .224 ± .004 | .97.29 ± .80 | .81.88 ± .80 | .80.11.79 ± .12 | .5.86 ± .06 | .0.475 ± .010 | .27.6 ± .1.0 | .5.02 ± .1.0 | .8.06 ± .4.60 | .6.44 ± .4.45 |
| | 3 | C-57 | .014 ± .002 | 1.52 ± .02 | .380 ± .008 | .98.08 ± .80 | .67.13 ± .60 | .16.36 ± .16 | .12.06 ± .11 | .2.45 ± .04 | .24.8 ± .06 | .7.19 ± .1.0 | .18.50 ± .9.92 | .13.06 ± .9.91 | |
| | 5 | G-58 | .017 ± .004 | 1.53 ± .02 | .414 ± .008 | .69.04 ± .80 | .60.14.77 ± .14 | .13.09 ± .13 | .2.77 ± .05 | .21.7 ± .06 | .7.04 ± .1.0 | .19.3 ± .1.4 | .13.09 ± .9.95 | .13.09 ± .9.92 | |
| | 6 | G-59 | .018 ± .004 | 2.07 ± .02 | .298 ± .006 | .91.61 ± .60 | .75.45 ± .60 | .15.01 ± .14 | .8.49 ± .08 | .1.05 ± .02 | .24.9 ± .1.0 | .5.67 ± .1.0 | .11.26 ± .5.56 | .9.69 ± .6.68 | |
| F5-NW-d4 | 8163 | 1 | G-52 | .020 ± .004 | 2.42 ± .02 | .215 ± .004 | .97.34 ± .80 | .81.75 ± .60 | .11.57 ± .12 | .5.88 ± .06 | .0.892 ± .016 | .31.2 ± .1.2 | .5.12 ± .1.0 | .7.82 ± .3.39 | .7.02 ± .4.59 |
| | 3 | G-53 | .014 ± .002 | 1.66 ± .02 | .363 ± .006 | .97.96 ± .80 | .69.87 ± .60 | .16.64 ± .16 | .11.50 ± .11 | .1.99 ± .04 | .24.5 ± .1.0 | .7.04 ± .1.4 | .16.73 ± .8.34 | .10.93 ± .7.76 | |
| | 5 | G-54 | .020 ± .004 | 1.66 ± .02 | .388 ± .008 | .97.92 ± .80 | .69.37 ± .60 | .16.93 ± .18 | .11.65 ± .11 | .2.05 ± .04 | .25.5 ± .1.0 | .7.44 ± .1.4 | .16.93 ± .8.55 | .11.15 ± .7.78 | |
| | 6 | G-55 | .013 ± .002 | 2.17 ± .02 | .291 ± .006 | .97.52 ± .80 | .77.42 ± .60 | .13.82 ± .14 | .7.89 ± .15 | .0.867 ± .018 | .28.0 ± .1.2 | .5.74 ± .1.2 | .10.18 ± .5.51 | .9.01 ± .6.53 | |
| PHASE I, INTERMEDIATE NEUTRON SPECTRUM, ON DIAGONAL OF CORNER SUBASSEMBLY | | | | | | | | | | | | | | | |
| H3-SE-b1 | 204 | 1 | G | .0201 ± .0004 | 3.03 ± .02 | .109 ± .004 | .96.84 ± .88 | .90.68 ± .1.56 | .1.56 ± .12 | .2.03 ± .04 | .0.068 ± .008 | .6.33 ± .04 | .2.76 ± .02 ^m | .3.30 ± .2.0 | .2.85 ± .2.23 |
| | 3 | G | .0174 ± .0006 | 2.59 ± .02 | .195 ± .01 | .97.29 ± .80 | .97.25 ± .08 | .11.25 ± .08 | .1.10 ± .04 | .5.167 ± .034 | .5.167 ± .034 | .4.82 ± .04 ^m | .7.23 ± .4.3 | .5.84 ± .4.3 | |
| | T | G | .02 ± .01 | 2.51 ± .01 | .21.97 ± .01 | .97.26 ± .01 | .83.373 ± .054 | .11.087 ± .030 | .5.107 ± .020 | .0.3735 ± .0034 | .6.15 ± .02 | .4.78 ± .02 | .5.40 ± .4.3 | .5.40 ± .4.3 | |
| | 5 | G | .0174 ± .0004 | 2.56 ± .02 | .207 ± .004 | .97.22 ± .1.08 | .83.41 ± .1.48 | .11.05 ± .06 | .5.17 ± .02 | .0.377 ± .006 | .5.90 ± .02 | .4.73 ± .02 | .6.97 ± .4.42 | .5.40 ± .4.3 | |
| | 6 | G | .0176 ± .0004 | 2.84 ± .02 | .132 ± .004 | .97.01 ± .60 | .89.52 ± .1.80 | .7.90 ± .04 | .2.48 ± .02 | .0.101 ± .004 | .5.94 ± .02 | .3.08 ± .04 ^m | .4.05 ± .2.24 | .3.63 ± .2.29 | |
| H3-SE-e2 | 116 | 1 | G-26 | .019 ± .004 | 3.01 ± .02 | .112 ± .002 | .97.66 ± .20 | .97.45 ± .1.06 | .1.06 ± .06 | .1.71 ± .02 | .0.054 ± .010 | .19.9 ± .08 | .2.48 ± .04 | .3.59 ± .1.18 | |
| | 3 | G-27 | .016 ± .004 | 2.47 ± .02 | .219 ± .004 | .97.86 ± .20 | .82.50 ± .20 | .11.62 ± .08 | .11.62 ± .08 | .5.46 ± .06 | .0.416 ± .010 | .4.67 ± .1.0 | .7.59 ± .3.38 | | |
| | 5 ^e | G-28 | .017 ± .0006 | 2.79 ± .02 | .144 ± .02 | .97.05 ± .20 | .88.58 ± .40 | .8.46 ± .08 | .2.82 ± .04 | .0.133 ± .002 | .15.5 ± .06 | .3.36 ± .06 | .7.69 ± .3.38 | | |
| | 6 | C-29 | .017 ± .004 | 2.87 ± .02 | .127 ± .002 | .96.98 ± .20 | .90.02 ± .40 | .7.54 ± .08 | .2.35 ± .04 | .0.092 ± .018 | .23.5 ± .06 | .4.05 ± .20 | | | |
| H3-SE-d3 | 103 | 1 | G | .0178 ± .0004 | 2.94 ± .02 | .123 ± .02 | .96.93 ± .80 | .90.17 ± .1.34 | .7.63 ± .16 | .2.12 ± .04 | .0.079 ± .010 | .6.22 ± .08 | .2.87 ± .04 ^m | .3.29 ± .2.0 | .2.71 ± .2.2 |
| | 3 | G | .0166 ± .0010 | 2.43 ± .02 | .220 ± .004 | .97.33 ± .88 | .81.74 ± .84 | .11.92 ± .12 | .5.71 ± .12 | .0.477 ± .018 | .5.69 ± .20 | .4.85 ± .04 ^m | .7.79 ± .4.7 | .5.67 ± .4.55 | |
| | 5 | G | .0181 ± .0006 | 2.51 ± .02 | .214 ± .006 | .97.04 ± .1.16 | .82.19 ± .20 | .11.92 ± .12 | .5.45 ± .04 | .0.433 ± .010 | .5.48 ± .10 | .4.75 ± .04 ^m | .7.72 ± .4.6 | .5.48 ± .4.44 | |
| | 6 | G | .0178 ± .0006 | 2.86 ± .02 | .1400 ± .0012 | .96.98 ± .62 | .86.89 ± .64 | .8.39 ± .04 | .2.61 ± .02 | .0.111 ± .002 | .5.82 ± .10 | .3.18 ± .10 | .4.54 ± .2.7 | .3.34 ± .2.7 | |
| H3-SE-e4 | 111 | 1 | G-30 | .019 ± .004 | 2.90 ± .02 | .123 ± .002 | .96.96 ± .20 | .90.06 ± .90 | .7.74 ± .08 | .2.11 ± .02 | .0.0824 ± .0032 | .34.16 ± .1.36 | .2.58 ± .06 | .4.10 ± .20 | |
| | 3 | C-31 | .017 ± .004 | 2.32 ± .02 | .226 ± .006 | .97.42 ± .20 | .86.09 ± .80 | .13.06 ± .12 | .6.26 ± .06 | .0.590 ± .024 | .20.41 ± .82 | .6.55 ± .10 | .9.09 ± .4.45 | | |
| | 5 | G-32 | .017 ± .002 | 2.37 ± .02 | .231 ± .004 | .97.38 ± .20 | .80.73 ± .82 | .12.76 ± .12 | .5.98 ± .06 | .0.534 ± .022 | .30.65 ± .124 | .4.48 ± .10 | .9.63 ± .5.58 | | |
| | 6 | G-33 | .018 ± .004 | 2.76 ± .02 | .156 ± .004 | .97.06 ± .20 | .87.33 ± .88 | .9.36 ± .10 | .3.15 ± .02 | .0.161 ± .006 | .30.01 ± .1.20 | .3.17 ± .06 | .5.52 ± .3.33 | | |
| PHASE I, INTERMEDIATE NEUTRON SPECTRUM, ON DIAGONAL OF CORNER SUBASSEMBLY ADJACENT REFLECTOR | | | | | | | | | | | | | | | |
| J3-NF-55 22871 | 1 | T-92 | .0208 ± .0002 | 3.257 ± .008 | .0618 ± .001 | .96.661 ± .099 | .96.419 ± .010 | .3.240 ± .009 | .0.331 ± .003 | .0.0098 ± .0043 | .6.389 ± .023 | .1.030 ± .018 | .1.20 ± .06 | | |
| | 3 | T-93 | .0209 ± .0001 | 3.061 ± .005 | .1065 ± .0005 | .96.812 ± .005 | .92.715 ± .011 | .5.364 ± .009 | .1.285 ± .008 | .0.036 ± .0012 | .5.668 ± .023 | .2.119 ± .030 | .2.65 ± .1.6 | | |
| | 5 | T-94 | .0199 ± .0001 | 3.063 ± .005 | .1027 ± .0005 | .96.814 ± .005 | .92.968 ± .005 | .5.813 ± .004 | .1.189 ± .004 | .0.0299 ± .0004 | .5.802 ± .013 | .2.024 ± .032 | .2.63 ± .1.3 | | |
| | 6 | T-95 | .0217 ± .002 | 3.207 ± .030 | .0693 ± .020 | .96.702 ± .031 | .95.848 ± .010 | .3.705 ± .009 | .0.438 ± .004 | .0.0094 ± .0004 | .5.754 ± .063 | .1.173 ± .022 | .1.41 ± .07 | | |
| J3-NE-d3 | 1425 | 1 | T-109 | .0205 ± .0002 | 3.268 ± .005 | .095 ± .003 | .96.663 ± .005 | .96.933 ± .039 | .2.775 ± .037 | .0.261 ± .016 | .0.031 ± .008 | .7.183 ± .015 | .0.758 ± .021 | .0.95 ± .05 | |
| | 3 | T-110 | .0206 ± .0001 | 3.094 ± .003 | .0873 ± .003 | .96.798 ± .003 | .93.835 ± .019 | .5.274 ± .018 | .0.871 ± .007 | .0.0202 ± .0006 | .6.022 ± .015 | .1.62 ± .020 | .2.20 ± .1.1 | | |
| | 5 | T-111 | .0207 ± .0005 | 3.107 ± .010 | .0856 ± .0014 | .96.387 ± .010 | .93.921 ± .010 | .5.216 ± .012 | .0.839 ± .007 | .0.0236 ± .0016 | .6.333 ± .016 | .1.52 ± .021 | .2.13 ± .1.0 | | |
| | 6 | T-112 | .0215 ± .003 | 3.258 ± .008 | .0555 ± .007 | .96.665 ± .008 | .96.475 ± .009 | .3.231 ± .008 | .0.285 ± .003 | .0.0393 ± .0088 | .5.657 ± .023 | .0.908 ± .017 | .1.19 ± .06 | | |

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Table 3.1-6 (continued, 8/8)

| Core Location Number | Fuel Rod Sample Zone Number | Axial Sample Code | ATOM PERCENT URANIUM ^b | | | ATOM PERCENT PLUTONIUM ^c | | | U-238 Conc. (dpm/gal) × 10 ⁻¹⁰ | Pu-239/U-238 (dpm/gal) × 10 ⁻¹⁰ | Cs-137 Conc. (dpm/gal) × 10 ⁻¹⁰ | Sr-90 Conc. (dpm/gal) × 10 ⁻¹⁰ |
|--|-----------------------------|-------------------|-----------------------------------|--------------|---------------|-------------------------------------|---------------|--------------|---|--|--|---|
| | | | U-234 | U-235 | U-236 | U-238 | Pu-239 | Pu-240 | | | | |
| PHASE I: INTERMEDIATE NEUTRON SPECTRUM, ON DIAGONAL OF SUBASSEMBLY ADJACENT REFLECTOR | | | | | | | | | | | | |
| J3-NE-e2 | 31 | T-130 | .0200 ± .0006 | 3.062 ± .006 | .0895 ± .0008 | 96.827 ± .006 | 93.756 ± .027 | 5.414 ± .026 | 0.809 ± .008 | 0.0205 ± .0027 | 1.403 ± .015 | 2.15 ± .10 |
| | 5 | F-131 | .0202 ± .0002 | 3.136 ± .018 | .0796 ± .0006 | 96.764 ± .018 | 94.532 ± .035 | 4.815 ± .033 | 0.601 ± .017 | 0.163 ± .0032 | 1.238 ± .016 | 1.83 ± .09 |
| J3-NE-II 23018 | 1 | T-96 | .0204 ± .0002 | 3.287 ± .005 | .0551 ± .0004 | 96.637 ± .005 | 96.915 ± .016 | 2.823 ± .016 | 0.226 ± .003 | 0.0160 ± .0005 | 5.668 ± .018 | 6.602 ± .012 |
| | 3 | T-97 | .0201 ± .0001 | 3.089 ± .008 | .0847 ± .004 | 96.807 ± .008 | 93.918 ± .034 | 5.382 ± .034 | 0.681 ± .006 | 0.0187 ± .0002 | 1.263 ± .020 | 2.23 ± .13 |
| | 5 | T-98 | .0202 ± .0003 | 3.078 ± .005 | .0866 ± .004 | 96.815 ± .005 | 83.908 ± .016 | 5.472 ± .016 | 0.651 ± .003 | 0.0181 ± .0012 | 1.241 ± .015 | 2.20 ± .13 |
| | 6 | T-99 | .0206 ± .0001 | 3.242 ± .004 | .0607 ± .004 | 96.667 ± .004 | 95.789 ± .013 | 3.689 ± .012 | 0.485 ± .007 | 0.0366 ± .0016 | 6.970 ± .010 | 1.68 ± .08 |

Notes: a) The letters T, G, and N indicate that the mass spectrometric analyses were performed by the TRACERLAB (T), General Electric - Vallecitos (G), and the AEC New Brunswick (N) analytical laboratories, respectively. The radiochemical analyses for Cs-137 and Sr-90 were performed by the Technical Service Laboratories, Atomic Power Division, Westinghouse.

b) The atom percent of U-234, U-235, U-236, and U-238 are relative to the total uranium atoms. The atom percent of Pu-239, Pu-240, Pu-241, and Pu-242 are relative to the total plutonium atoms, not including Pu-238.

c) All Phase I data are referenced to the Yankee Core I end-of-life on May 18, 1962; all Phase II data are referenced to the Yankee Core II end-of-life on September 2, 1963. To account for radioactive decays, half-lives of 13.2, 29.4, and 28.0 years were used for Pu-241, Cs-137, and Sr-90, respectively.

d) The letters A and B denote the pellet samples immediately above and below the nominal zone 3 pellet, respectively.

e) The uncertainty listed for all TL and GF mass spectrometric data is ± 2-standard deviation precision. The limits of uncertainty for the NB uranium composition are believed to be within that value listed, based on NBS U-030. There is a recognized bias of approximately ± 1% relative to the NB U-235 3/o (see Ref. 8, p. 350-9). The NB plutonium composition data is ± 2-standard deviation precision only. No estimate of uncertainty is given for the NB U-238 /m and Pu-139/U-238 data.

f) The uncertainty listed for all radiochemical data is ± 2-standard deviation accuracy.

g) Interlaboratory crosscheck sample.

h) The numerals 1 and 2 in the NB sample code numbers indicate that the results are for the first and second runs of a mass spectrometric analysis performed in duplicate.

i) Original sample dilution.

j) New dilution of original sample.

k) Seven solutions of the monitor sample 0994-3 were submitted to TRACERLAB over the time interval January 1964 to November 1964; four solutions of the monitor were submitted to GE-Vallecitos over the time interval April 1964 to October 1964.

l) The analytical laboratories require monitor samples of different concentration.

m) Dilute acid sample. Samples submitted for isotopic analysis prior to June 7, 1963 had nitric acid concentrations of about 0.01 M, and are referred to as dilute acid samples. All other samples, submitted after this date, were in approximately 2 M HNO₃, and are referred to as concentrated acid samples. The sample history of shipping, spiking, and data reporting dates can be found in the Yankee Core Evaluation quarterly progress reports.

The Pu-239/U-238 atom ratios shown for the dilute acid samples in this table have been adjusted with the use of plutonium data obtained for concentrated acid samples. The U and Pu atom percent data are not affected by the acidity of the sample solution.

n) A fuel rod section of 1.9 inches (approximately 3 pellets), was cut from a position immediately above the nominal 1-pellet sample location in each of the six axial sample zones. The 6 sections were then dissolved and diluted to make one composite sample solution.

o) All mass spectrometric data for this sample are consistent. However, the relatively low burnup inferred from the data indicates a high probability that the sample solution was incorrectly identified.

Table 3.1-7 Volume Average Atomic Densities of U and Pu Isotopes Relative to Initial U-238 Atomic Density, by Region of the Assembly

| Isotope ^a | Region #1 (Perturbed) ^b | Region #2 (Intermediate) | Region #3 (Asymptotic) | Total Core Average |
|----------------------|---------------------------------------|-----------------------------|---------------------------|--------------------------|
| | | | | |
| U-234 | 0.01958 | 0.01896 | 0.01899 | 0.01906 |
| U-235 | 2.603 | 2.716 | 2.727 | 2.707 |
| U-236 | 0.1943 | 0.1840 | 0.1811 | 0.1838 |
| U-238 | 99.25 | 99.26 | 99.28 | 99.27 |
| Total U | 102.07 | 102.18 | 102.21 | 102.18 |
| Pu-239 | 0.4076 | 0.3997 | 0.4005 | 0.4012 |
| Pu-240 | 0.05768 | 0.05028 | 0.04888 | 0.05053 |
| Pu-241 | 0.02730 | 0.02426 | 0.02330 | 0.02417 |
| Pu-242 | 0.002841 | 0.002167 | 0.001910 | 0.002124 |
| Total Pu | 0.4954 | 0.4764 | 0.4746 | 0.4780 |

NOTE:

- a) The atomic density of each isotope at the time of Core I shutdown, May 18, 1962 (i.e., at 8.44 GWD/MTU burnup), has been ratioed to the U-238 atomic density in the fresh fuel. All values shown have been multiplied by 100. For example, the atomic density of Pu-239 at the end-of-life, relative to the atomic density of U-238 at the beginning-of-life, is 0.004076 in characteristic Region #1.
- b) The effect on the core average isotopic inventory caused by the perturbation in Region #1 is small as is evident from these data. The isotopic atom densities on the core periphery tend to compensate for the peaks and/or depression in the isotopic distributions in assemblies in the core interior.

Table 3.1-8 Summary of Result of Mass Spectrometric and Radiochemical Analyses
of Yankee Core I Spent Fuel Samples (1/4)

| EYC Phase | Core (a) Location | Fuel Rod No. | Axial (b) Sample Zone | Isotopic (c) Sample No. | Uranium Atom Percent | | | | Plutonium Atom Percent (d, e) | | | | Pu-236 and Pu-238 Measurements | | | | Pu-238 at Time of Analysis (g) | | | | Heavy (k) Element Burnup (GWD/MTU) | | | | | |
|-----------|-------------------|--------------|-----------------------|-------------------------|----------------------|--------|-------|-------|-----------------------------------|-------------------------------|--------|--------|--------------------------------|--------|---|--|--------------------------------|-----------------|-----------------|-----------------|------------------------------------|-----------------|-----------------|-----------------|------|--|
| | | | | | U-234 | | U-235 | | U-236 | | U-238 | | N ⁴⁹ | | N ⁴⁸ | | N ⁴⁹ | | N ⁴⁸ | | N ⁴⁹ | | N ⁴⁸ | | | |
| | | | | | Date of Analysis | U-234 | U-235 | U-236 | U-238 | atom/ml ($\times 10^{-16}$) | Pu-239 | Pu-240 | Pu-241 | Pu-242 | Cs-137 (e) dpm/g ^U ($\times 10^3$) | Sr-90 (e) dpm/g ^U ($\times 10^{-10}$) | N ⁴⁸ | N ⁴⁹ | N ⁴⁸ | N ⁴⁹ | N ⁴⁸ | N ⁴⁹ | N ⁴⁸ | N ⁴⁹ | | |
| 1 | F4-C-f1 | 8977 | 1 (EXT) | G-113 | 7-18-67 | 0.0178 | 2.800 | 0.145 | 97.037 | 88.441 | 8.432 | 2.986 | 0.141 | 3.56 | 4.11 | 1.123 | 3-10-67 | WARD | 0.383 ± 0.089 | 1.13 ± 0.01 | 6.33 | 4.22 ± 0.04 | 13.6 | 4.12 ± 0.04 | 13.1 | |
| | | | 4 (EXT) | G-114 | 7-11-67 | 0.0142 | 2.227 | 0.271 | 97.486 | 78.752 | 12.919 | 7.575 | 0.754 | 5.62 | 10.33 | 2.476 | 3-13-67 | WARD | 1.12 ± 0.29 | 1.07 ± 0.20 | | | | | | |
| | | | 5 (EXT) | G-115 | 7-11-67 | 0.0172 | 2.236 | 0.263 | 97.467 | 78.812 | 12.952 | 7.487 | 0.749 | 5.62 | 7.487 | 2.450 | 3-14-67 | WARD | 1.07 ± 0.20 | | | | | | | |
| 1 | F4-C-f6 | 19579 | 3 (EXT) | G-116 | 6-26-67 | 0.0160 | 2.233 | 0.269 | 97.482 | 78.651 | 12.330 | 7.649 | 0.770 | 5.58 | 10.31 | 2.418 | 3-11-67 | WARD | 1.20 ± 0.23 | | | | | | | |
| | | | 4 (EXT) | G-117 | 7-11-67 | 0.0174 | 2.336 | 0.259 | 97.388 | 80.192 | 12.140 | 7.023 | 0.645 | 5.20 | 9.39 | 2.169 | 3-12-67 | WARD | 1.16 ± 0.23 | | | | | | | |
| 1 | E5-C-a6 | 7992 | 3 (EXT) | G-101 | 4-11-67 | 0.0166 | 2.291 | 0.262 | 97.430 | 78.703 | 13.030 | 7.524 | 0.743 | 5.67 | 8.26 | 2.402 | 3-7-67 | WARD | 1.28 ± 0.28 | | | | | | | |
| | | | 5 (EXT) | G-102 | 4-11-67 | 0.0154 | 2.284 | 0.262 | 97.439 | 78.869 | 13.067 | 7.350 | 0.714 | 5.31 | 9.71 | 2.328 | 3-8-67 | WARD | 1.06 ± 0.24 | | | | | | | |
| | | | 6 (EXT) | G-103 | 4-11-67 | 0.0194 | 2.689 | 0.193 | 97.099 | 84.687 | 10.460 | 4.562 | 0.291 | 4.11 | 6.38 | 1.626 | 3-9-67 | WARD | 0.60 ± 0.18 | | | | | | | |
| 2 | F5-C-a1 | 553 | 1 (EXT) | G-104 | 4-11-67 | 0.0199 | 2.555 | 0.209 | 97.206 | 83.470 | 11.097 | 5.088 | 0.345 | 4.26 | 6.72 | 1.730 | 3-12-67 | WARD | 1.13 ± 0.18 | | | | | | | |
| | | | 3 (EXT) | G-105 | 4-11-67 | 0.0136 | 1.712 | 0.429 | 97.843 | 70.482 | 16.167 | 11.412 | 1.939 | 7.76 | 16.51 | 4.261 | 3-11-67 | WARD | 4.58 ± 0.48 | | | | | | | |
| | | | 3 (EXT) | T-211 | 5-1-67 | 0.0165 | 1.711 | 0.367 | 97.906 | 4.367 | 70.841 | 16.043 | 11.241 | 1.875 | 7.70 | 0.990 | 0.013 | TLAB | | | | | | | | |
| 2 | F5-C-f6 | 541 | 1 (EXT) | G-106 | 4-11-67 | 0.0192 | 2.576 | 0.225 | 97.229 | 82.484 | 11.471 | 5.619 | 0.426 | 4.71 | 7.46 | 1.695 | 3-13-67 | WARD | 1.21 ± 0.20 | | | | | | | |
| | | | 2 (EXT) | G-118 | 6-26-67 | 0.0172 | 1.835 | 0.344 | 97.804 | 72.786 | 15.366 | 10.316 | 1.532 | 7.15 | 13.95 | 3.859 | 3-12-67 | WARD | 3.85 ± 0.65 | | | | | | | |
| | | | 4 (EXT) | G-119 | 7-18-67 | 0.0153 | 1.670 | 0.376 | 97.988 | 69.811 | 16.359 | 11.726 | 2.105 | 7.16 | 17.84 | 4.453 | 3-14-67 | WARD | 5.26 ± 0.59 | | | | | | | |
| | | | 5 (EXT) | G-120 | 7-18-67 | 0.0155 | 1.670 | 0.355 | 97.962 | 70.482 | 16.199 | 11.153 | 2.166 | 7.32 | 16.74 | 4.201 | 3-15-67 | WARD | 3.88 ± 0.41 | | | | | | | |
| | | | 6 (EXT) | G-121 | 6-26-67 | 0.0168 | 2.090 | 0.281 | 97.612 | 77.134 | 13.789 | 8.153 | 0.924 | 5.78 | 11.22 | 2.743 | 3-15-67 | WARD | 1.89 ± 0.23 | | | | | | | |
| 3 | E6-C-a1 | 369 | 1 | T-168 | 4-14-66 | 0.0160 | 2.001 | 0.313 | 97.670 | 7.626 | 75.285 | 14.683 | 8.866 | 1.166 | 6.36 | 12.30 | 10.96 | TLAB | 0.22 ± 0.07 | | | | | | | |
| | | | 2 | T-169 | 4-14-66 | 0.0139 | 1.413 | 0.423 | 98.150 | 2.408 | 67.135 | 17.616 | 12.564 | 2.684 | 8.14 | 20.90 | 15.60 | TLAB | 1.0 ± 0.2 | | | | | | | |
| | | | 3 (EXT) | G-107 | 4-11-67 | 0.0170 | 1.448 | 0.424 | 98.120 | 66.718 | 17.862 | 12.659 | 2.761 | 8.12 | 20.62 | 16.52 | TLAB | 1.8 ± 0.3 | | | | | | | | |
| | | | 3 (EXT) | T-170 | 4-14-66 | 0.0124 | 1.261 | 0.436 | 98.291 | 6.273 | 65.440 | 18.201 | 13.222 | 3.137 | 8.40 | 22.16 | 16.52 | TLAB | 1.8 ± 0.3 | | | | | | | |
| | | | 3 (EXT) | N-19 | 5-17-66 | 0.0120 | 1.280 | 0.432 | 98.276 | 67.82 | 65.346 | 18.190 | 13.307 | 3.137 | 8.87 | 21.62 | 16.52 | TLAB | 1.8 ± 0.3 | | | | | | | |
| | | | 3 (EXT) | G-108 | 4-11-67 | 0.0153 | 1.297 | 0.434 | 98.253 | 6.282 | 64.498 | 18.895 | 13.301 | 3.306 | 7.61 | 21.62 | 16.52 | TLAB | 1.8 ± 0.3 | | | | | | | |
| | | | 3 (EXT) | T-212 | 5-1-67 | 0.0134 | 1.301 | 0.430 | 98.255 | 7.338 | 64.716 | 18.826 | 13.211 | 3.247 | 7.89 | 21.62 | 16.52 | TLAB | 1.8 ± 0.3 | | | | | | | |
| | | | 3 (EXT) | T-219 (h) | 2-15-68 | 0.0139 | 1.280 | 0.429 | 98.278 | 85.24 | 64.533 | 18.862 | 13.317 | 3.268 | 7.66 | 21.62 | 16.52 | TLAB | 1.8 ± 0.3 | | | | | | | |
| | | | 4 (EXT) | T-171 | 4-14-66 | 0.0125 | 1.217 | 0.453 | 98.317 | 5.313 | 64.375 | 18.618 | 13.573 | 3.434 | 8.62 | 23.59 | 17.56 | TLAB | 1.9 ± 0.3 | | | | | | | |
| | | | 4 (EXT) | N-20 | 5-17-66 | 0.0130 | 1.204 | 0.445 | 98.338 | 58.33 | 64.406 | 18.580 | 13.586 | 3.428 | 8.84 | 22.12 | 17.44 | TLAB | 1.3 ± 0.2 | | | | | | | |
| | | | 5 (EXT) | T-172 | 4-4-66 | 0.0126 | 1.245 | | | | | | | | | | | | | | | | | | | |

Table 3.1-8 (continued, 2/4)

| EYC Phase | Core (a) Location | Fuel Rod No. | Axial Sample Zone | Isotopic (e) Sample No. | Date of Analysis | U-234 | U-235 | U-236 | U-238 | Plutonium Atom Percent (d,e) | | | Nd-148 Measurements | Pu-236 at Time of Analysis (g) | Pu-238 at Time of Analysis (j) | Heavy (k) Element Burnup (GWd/MTU) | | | |
|-----------|-------------------|--------------|-------------------|-------------------------|------------------|--------------------|--------|---------|---------|------------------------------|-----------------|-----------------|---------------------|--------------------------------|--------------------------------|------------------------------------|-------|------------|-------|
| | | | | | | | | | | Uranium Atom Percent | | | | | | | | | |
| | | | | | | U-atom/ml (x10-16) | Pu-239 | Pu-240 | Pu-241 | Pu-242 | N ⁴⁹ | N ⁴⁸ | N ⁴⁷ | N ⁴⁶ | N ⁴⁵ | N ⁴⁴ | | | |
| 3 | E6-C-a6 | 5352 | 1 | T-153 | 3-2-66 | 0.0161 | 2.027 | 0.294 | 97.6663 | 76.223 | 8.469 | 1.025 | 6.26 | 12.24 | 0.5055 | 0.0082 | 16.4 | | |
| | | 2 | | T-154 | 3-2-66 | 0.0133 | 1.407 | 0.421 | 98.159 | 5.478 | 67.069 | 17.585 | 2.711 | 8.39 | 0.550 | 0.126 | 28.4 | | |
| | | 3 | | T-155 | 3-2-66 | 0.0126 | 1.273 | 0.441 | 98.223 | 5.437 | 65.477 | 18.121 | 13.243 | 3.159 | 0.460 | 0.03 | 31.7 | | |
| | | 4 | | T-156 | 3-2-66 | 0.0125 | 1.208 | 0.445 | 98.334 | 5.690 | 64.777 | 18.394 | 13.469 | 3.360 | 2.57 | 0.04 | 32.8 | | |
| | | 5 | | T-157 | 3-2-66 | 0.0164 | 1.306 | 0.380 | 97.830 | 4.784 | 72.669 | 15.754 | 10.014 | 1.563 | 0.8440 | 0.0139 | 20.1 | | |
| | | 6 | | N-18 | 5-17-66 | 0.0150 | 1.793 | 0.343 | 97.849 | 53.75 | 72.476 | 15.732 | 10.178 | 1.614 | 7.00 | | 20.4 | | |
| 3 | E6-C-f1 | 536 | 1 | T-158 | 3-2-66 | 0.0162 | 2.044 | 0.298 | 97.642 | 5.010 | 76.028 | 14.430 | 8.488 | 1.052 | 6.04 | 12.14 | 0.491 | 0.008 | |
| | | 1 | | N-17 | 5-17-66 | 0.0150 | 2.028 | 0.295 | 97.662 | 55.66 | 76.182 | 14.335 | 8.438 | 1.046 | 6.27 | | 16.1 | | |
| | | 2 | | T-159 | 3-2-66 | 0.0135 | 1.385 | 0.419 | 98.182 | 3.909 | 66.755 | 17.758 | 12.700 | 2.788 | 8.35 | 21.65 | 16.45 | | |
| | | 6 | | T-160 | 3-2-66 | 0.0152 | 1.781 | 0.343 | 97.861 | 5.121 | 72.058 | 16.052 | 10.229 | 1.661 | 6.74 | 15.38 | 20.4 | | |
| | | 2 | | T-175 | 5-16-66 | 0.0162 | 2.063 | 0.298 | 97.623 | 6.062 | 76.357 | 14.207 | 8.419 | 1.018 | 6.25 | | 16.0 | | |
| | | 1 | | T-176 | 5-16-66 | 0.0131 | 1.420 | 0.421 | 98.145 | 6.019 | 67.166 | 17.614 | 12.516 | 2.704 | 8.15 | 22.50 | 16.0 | | |
| 3 | E6-C-f6 | 354 | 2 | (EXT) | 7-18-67 | 0.0140 | 1.410 | 0.430 | 98.144 | 51.133 | 68.182 | 17.184 | 12.053 | 2.600 | 7.71 | 19.20 | 20.19 | ± 0.20 (n) | |
| | | 2 | | G-125 | 5-16-66 | 0.0126 | 1.282 | 0.432 | 98.273 | 5.903 | 65.536 | 18.205 | 13.170 | 3.089 | 8.48 | 23.84 | 26.8 | | |
| | | 3 | | T-177 | 7-18-66 | 0.0120 | 1.296 | 0.437 | 98.255 | 64.70 | 65.629 | 18.108 | 13.173 | 3.090 | 8.80 | | 30.9 | | |
| | | 3 | | N-26 | 7-18-66 | 0.0151 | 1.374 | 0.421 | 98.190 | 66.420 | 67.770 | 17.770 | 12.926 | 2.884 | 8.36 | | 31.1 | | |
| | | 3 | | (EXT) | G-126 | 7-26-67 | 0.0121 | 1.219 | 0.450 | 98.319 | 5.880 | 64.496 | 18.575 | 13.522 | 3.407 | 8.58 | | 29.2 | |
| | | 4 | | T-178 | 5-16-66 | 0.0126 | 1.267 | 0.437 | 98.283 | 4.706 | 65.098 | 18.398 | 13.299 | 3.204 | 8.43 | 24.00 | 32.5 | | |
| 3 | E6-SE-c2 | 3198 | 5 | T-179 | 5-16-66 | 0.0130 | 1.273 | 0.443 | 98.271 | 51.23 | 65.265 | 18.274 | 13.256 | 3.205 | 8.62 | | 31.3 | | |
| | | 5 | | N-27 | 7-18-66 | 0.0151 | 1.799 | 0.345 | 97.841 | 5.926 | 72.638 | 15.794 | 9.988 | 1.580 | 6.95 | 15.62 | 31.4 | | |
| | | 6 | | T-180 | 5-16-66 | 0.0124 | 1.261 | 0.434 | 98.293 | 3.499 | 64.485 | 19.010 | 13.183 | 3.322 | 8.17 | | 20.2 | | |
| | | 3 | | T-187 | 5-16-66 | 0.0122 | 1.255 | 0.444 | 98.290 | 4.820 | 64.344 | 18.971 | 13.328 | 3.357 | 8.51 | 26.42 | 32.0 | | |
| | | 5 | | T-188 | 5-16-66 | 0.0124 | 1.261 | 0.434 | 98.293 | 3.499 | 64.485 | 19.010 | 13.183 | 3.322 | 8.17 | | 31.4 | | |
| | | 3 | | E6-SE-e4 | 3187 | 3 | T-185 | 5-16-66 | 0.0127 | 1.046 | 0.473 | 98.468 | 6.933 | 59.592 | 21.860 | 14.194 | 4.654 | 7.42 | 27.81 |
| 1 | E5-SW-a5 | 15025 | 3 | (EXT) | G-111 | 7-11-67 | 0.0165 | 1.986 | 0.318 | 97.997 | 73.244 | 16.336 | 9.138 | 1.282 | 5.42 | 12.63 | 36.0 | | |
| | | 5 | | (EXT) | G-112 | 7-18-67 | 0.0116 | 2.037 | 0.301 | 97.645 | 74.451 | 15.861 | 8.560 | 1.127 | 5.33 | 11.74 | 35.3 | | |
| | | 2 | | F5-SE-f5 | 8717 | 3 | G-122 | 7-18-67 | 0.0151 | 1.250 | 0.433 | 98.305 | 61.447 | 20.970 | 13.750 | 3.833 | 6.74 | 21.78 | 16.3 |
| | | 6 | | (EXT) | G-123 | 7-18-67 | 0.0166 | 1.690 | 0.305 | 97.089 | 72.927 | 16.432 | 9.274 | 1.367 | 5.26 | 13.05 | 15.6 | | |

See attachment for Table A-1 footnotes

Table 3.1-8 (continued, 3/4)

| EYC Phase | Core (a) Location | Fuel Rod No. | Axial Sample Zone | Isotopic (c) Sample No. | Date of Analysis | Uranium Atom Percent | | | Plutonium Atom Percent (d,e) | | | Nd-148 Measurements N ₀₈ N ₂₈ (x10 ⁴) | Pu-236 and Pu-238 Measurements N ₄₆ N ₂₈ (x10 ⁸) | Pu-238 at Time of Analysis (j) N ₄₈ N ₄₉ (x10 ³) | Heavy (k) Element Burnup (GWD/MTU) | | | | |
|-----------|-------------------|--------------|-------------------|-------------------------|------------------|--|-----------------|---------------------|--|-----------------|---------------------|--|---|--|---------------------------------------|-----------------|-----------------|-----------------|--------------|
| | | | | | | U-238 atom/ml (x10 ⁻¹⁶) | | U-236 | U-238 atom/ml (x10 ⁻¹⁶) | | Pu-240 | Pu-241 | Pu-242 | | | | | | |
| | | | | | | N ₄₉ | N ₂₈ | (x10 ³) | N ₄₉ | N ₂₈ | (x10 ³) | N ₄₉ | N ₂₈ | | | | | | |
| 3 | E6-NW-a1 | 44 | 1 | T-162 | 4-14-66 | 0.0157 | 1.902 | 0.321 | 97.762 | 5.746 | 73.656 | 15.570 | 9.415 | 1.358 | 6.36 | 13.09 | 10.42 | 0.5627 ± 0.0045 | 18.0 |
| | | | 2 | T-163 | 4-14-66 | 0.0119 | 0.914 | 0.479 | 98.596 | 5.546 | 57.124 | 22.101 | 15.073 | 5.702 | 6.72 | 27.11 | 17.98 | 2.39 ± 0.02 | 38.1 |
| | | | 3 | T-164 | 4-14-66 | 0.0109 | 0.791 | 0.493 | 98.706 | 5.232 | 54.832 | 23.026 | 15.505 | 6.637 | 6.70 | 30.14 | 21.11 | 3.03 ± 0.03 | 41.9 |
| | | | 3 | N-21 | 5-17-66 | 0.0110 | 0.791 | 0.488 | 98.710 | 57.20 | 54.860 | 22.989 | 15.494 | 6.657 | 6.90 | 30.32 | 21.37 | 4.02 ± 0.44 | 42.6 |
| | | | 3 | (EXT) | G-127 | 7-26-67 | 0.0120 | 0.777 | 0.510 | 98.702 | 53.886 | 22.924 | 15.743 | 7.447 | 6.34 | 20.52 | 7.808 | 3-24-67 | 42.5 |
| | | | 4 | T-165 | 4-14-66 | 0.0112 | 0.754 | 0.503 | 98.732 | 4.347 | 53.984 | 23.265 | 15.660 | 7.080 | 6.63 | 29.68 | 1.0 | ± 0.2 | 43.2 |
| | | | 4 | N-22 | 5-17-66 | 0.0100 | 0.744 | 0.491 | 98.754 | 47.97 | 53.818 | 23.242 | 15.795 | 7.145 | 6.86 | 28.84 | 7.523 | 3-23-67 | 44.4 |
| | | | 4 | (EXT) | G-128 | 7-18-67 | 0.0114 | 0.764 | 0.491 | 98.734 | 53.492 | 23.274 | 15.994 | 7.249 | 6.25 | 20.66 | 7.523 | 15.05 ± 1.87 | 45.01 ± 0.45 |
| | | | 5 | T-166 | 4-14-66 | 0.0115 | 0.821 | 0.490 | 98.678 | 5.240 | 55.122 | 23.057 | 15.403 | 6.418 | 6.52 | 28.97 | 12.07 | 2.87 ± 0.02 | 42.5 |
| | | | 6 | T-167 | 4-14-66 | 0.0143 | 1.482 | 0.394 | 98.110 | 5.847 | 65.960 | 19.371 | 11.969 | 2.700 | 6.09 | 18.17 | 1.024 | ± 0.010 | 24.6 |
| 3 | E6-SE-f5 | 3113 | 1 | T-181 | 5-16-66 | 0.0170 | 1.933 | 0.325 | 97.725 | 7.183 | 73.698 | 15.583 | 9.373 | 1.346 | 7.05 | 14.06 | 0.6231 ± 0.0093 | 18.2 | |
| | | | 3 | T-182 | 5-16-66 | 0.0124 | 0.809 | 0.495 | 98.684 | 6.510 | 54.865 | 23.018 | 13.449 | 6.668 | 6.76 | 28.87 | 0.74 ± 0.27 | 16.62 ± 2.10 | 41.8 |
| | | | 3 | T-183 | 5-16-66 | 0.0124 | 0.816 | 0.498 | 98.672 | 71.22 | 54.921 | 22.977 | 15.452 | 6.650 | 6.76 | 3.09 | 3.29 ± 0.06 | 41.6 | |
| | | | 3 | T-213 (1) | 5-1-67 | 0.0137 | 0.816 | 0.499 | 98.672 | 54.815 | 22.922 | 15.554 | 6.708 | 6.78 | 3.09 | 3.09 ± 0.03 (p) | 41.8 | | |
| | | | 3 | G-110 | 4-11-67 | 0.0154 | 0.809 | 0.494 | 98.681 | 54.347 | 23.068 | 15.695 | 6.890 | 6.60 | 7.918 | 3-6-67 | 41.85 ± 0.42 | 41.8 | |
| | | | 3 | G-124 | 7-18-67 | 0.0120 | 0.821 | 0.471 | 98.696 | 71.82 | 54.539 | 22.980 | 15.634 | 6.847 | 6.36 | 7.760 | 3-28-67 | 42.0 | |
| | | | 3 | N-24 | 7-18-66 | 0.0120 | 0.801 | 0.488 | 98.699 | 55.004 | 22.908 | 15.454 | 6.635 | 6.78 | 7.263 | 0.74 ± 0.27 | 17.12 ± 3.20 | 41.2 | |
| | | | 3 | N-28 | 7-18-66 | 0.0120 | 0.812 | 0.499 | 98.677 | 70.21 | 54.849 | 22.952 | 15.501 | 6.697 | 6.76 | 3.09 | 3.09 ± 0.06 | 42.0 | |
| | | | 3 | T-183 | 5-16-66 | 0.0133 | 0.814 | 0.494 | 98.679 | 2.275 | 55.339 | 22.718 | 15.382 | 6.560 | 6.69 | 30.57 | 0.73 ± 0.29 | 41.8 | |
| | | | 5 | N-25 | 7-18-66 | 0.0120 | 0.810 | 0.494 | 98.684 | 25.17 | 55.361 | 22.604 | 15.485 | 6.550 | 6.73 | 3.09 | 3.03 ± 0.05 | 41.2 | |
| | | | 6 | T-184 | 5-16-66 | 0.0150 | 1.408 | 0.406 | 98.171 | 5.779 | 64.658 | 19.670 | 12.575 | 3.097 | 6.26 | 20.55 | 0.30 ± 0.12 | 1.18 ± 0.02 | 26.2 |

See attachment for Table A-1 footnotes

Table 3.1-8 (continued, 4/4)

NOTES:

- (a) In the fuel rod designation, the letter C indicates asymptotic neutron spectrum; the letters SE, SW, and NW indicate non-asymptotic neutron spectra.
- (b) Entries in brackets indicate interlaboratory crosscheck analyses; EXT in parentheses indicates EYC Program Extension samples.
- (c) The letters T, G, and N indicate mass spectrometric analysis for main chain U and Pu isotopes by TRACERLAB, GE-Vallecitos, and New Brunswick, respectively. All analyses for Cs-137 and Sr-90 by Westinghouse Advanced Reactors Division (WARD).
- (d) Pu-236 and Pu-238 not included.
- (e) Referenced to core end-of-life (EOL); Phase 1, 2, and 3 data referenced to Core I, II, and IV EOL, respectively.
- (f) Date of analysis for Pu-236 and Pu-238 by Westinghouse Advanced Reactors Division (WARD); dates for TRACERLAB analyses taken to be those indicated for mass spectrometric analysis for main chain U and Pu isotopes.
- (g) Not corrected for α -decay from core EOL to time of analysis.
- (h) Analyzed in fuel accountability evaluation program -- Reference 10.
- (i) Analyzed in SAXTON Plutonium Project -- Reference 61.
- (j) Not corrected for Pu-238 and Cm-242 α -decay from core EOL to time of analysis.
- (k) Units on burnup are 10^9 watt-days per 10^6 grams initial uranium loading.
- (l) Re-analysis for N^{48}/N^{49} gave 9.61 (± 0.20) $\times 10^{-3}$ atoms/atom.
- (m) Re-analysis for N^{48}/N^{49} gave 13.5 (± 0.4) $\times 10^{-3}$ atoms/atom.
- (n) Re-analysis for N^{48}/N^{49} gave 20.6 (± 0.4) $\times 10^{-3}$ atoms/atom.
- (o) Re-analysis for N^{48}/N^{49} gave 5.46 (± 0.15) $\times 10^{-3}$ atoms/atom.
- (p) N^{48}/N^{28} analyzed by TRACERLAB on 5/1/67.
- (q) N^{48}/N^{28} analyzed by TRACERLAB on 6/20/67.

Table 3.1-9 Burnup, Atom Densities, and Fuel Characteristics Determined from Mass Spectrometric, Alpha Spectrographic, and Radiochemical Analyses (1/3)

| EYC Phase | Core (a) Location | Fuel Rod No. | Axial (b) Sample Zone | Isotopic (c) Sample No. | Atomic density, relative to initial U-238 atomic density, $N_i^1/n_0^{28} (\times 10^2)$ | | | | | | Total accumulated fissions, relative to initial U-238 atoms, $F_i^{\text{TOT}}/N_0^{28} (\times 10^2)$ | | | | | | Burnup (GWD/MTU) | | | | | | | | | | | |
|-----------|-------------------|--------------|-----------------------|-------------------------|--|-------|-------|------------------------------|------------|---------|--|------------|----------|----------------------------|--------|--------|------------------|---------|--------|--------|--------|--------|--------|--------|-------|--------|---------------|------------|
| | | | | | U-235 | U-236 | U-238 | Pu-236 (d) ($\times 10^6$) | Pu-238 (e) | Pu-239 | Pu-240 | Pu-241 (e) | Pu-242 | U-235 Fractional Depletion | U-235 | U-238 | Pu-239 | Pu-241 | HE | Cs-137 | Sr-90 | Nd-148 | HE | Cs-137 | Sr-90 | Nd-148 | Alpha-235 (f) | NGD/MD (g) |
| 1 | F4-C-f1 | 8977 | 1 (EXT) | G-113 | 0.0182 | 2.870 | 0.149 | 99.463 | 0.00207 | 0.374 | 0.0338 | 0.0120 | 0.000565 | 0.195 | 0.8058 | 0.0744 | 0.1174 | 0.00241 | 0.701 | 0.635 | 0.668 | 6.33 | 5.73 | 6.03 | 0.234 | 0.484 | | |
| | | | 4 (EXT) | G-114 | 0.0144 | 2.257 | 0.215 | 98.809 | 0.0192 | 0.589 | 0.0966 | 0.0566 | 0.00563 | 0.367 | 0.7033 | 0.0781 | 0.2066 | 0.0119 | 1.485 | 1.558 | 1.459 | 13.56 | 14.22 | 12.34 | 13.32 | 0.258 | | |
| | | | 5 (EXT) | G-115 | 0.0174 | 2.289 | 0.267 | 98.876 | 0.0206 | 0.556 | 0.0913 | 0.0528 | 0.00528 | 0.358 | 0.7098 | 0.0779 | 0.2007 | 0.0115 | 1.435 | 1.352 | 1.445 | 13.09 | 12.34 | 13.18 | 13.32 | 0.256 | | |
| 1 | F4-C-f6 | 19579 | 3 (EXT) | G-116 | 0.0162 | 2.265 | 0.273 | 98.876 | 0.0230 | 0.552 | 0.0907 | 0.0536 | 0.00540 | 0.364 | 0.7115 | 0.0781 | 0.1988 | 0.0117 | 1.458 | 1.556 | 1.426 | 13.30 | 14.20 | 11.78 | 12.91 | 0.258 | | |
| | | | 4 (EXT) | G-117 | 0.0177 | 2.375 | 0.263 | 99.000 | 0.0193 | 0.515 | 0.0709 | 0.0451 | 0.00414 | 0.334 | 0.7250 | 0.0773 | 0.1878 | 0.00994 | 1.293 | 1.417 | 1.280 | 11.78 | 12.91 | 11.66 | 11.66 | 0.273 | | |
| 1 | E5-C-a6 | 7992 | 3 (EXT) | G-101 | 0.0168 | 2.325 | 0.266 | 98.868 | 0.0220 | 0.560 | 0.0928 | 0.0536 | 0.00530 | 0.348 | 0.7023 | 0.0777 | 0.2082 | 0.0118 | 1.402 | 1.246 | 1.416 | 12.79 | 11.36 | 12.92 | 12.92 | 0.263 | | |
| | | | 5 (EXT) | G-102 | 0.0156 | 2.319 | 0.266 | 98.939 | 0.0198 | 0.525 | 0.0870 | 0.0490 | 0.00476 | 0.349 | 0.7164 | 0.0777 | 0.1951 | 0.0107 | 1.384 | 1.465 | 1.374 | 12.62 | 13.36 | 12.52 | 12.52 | 0.262 | | |
| | | | 6 (EXT) | G-103 | 0.0198 | 2.750 | 0.197 | 99.316 | 0.00770 | 0.408 | 0.0504 | 0.0220 | 0.00140 | 0.228 | 0.7589 | 0.0750 | 0.1611 | 0.00503 | 0.834 | 0.366 | 0.962 | 7.55 | 8.75 | 8.71 | 8.71 | 0.289 | | |
| 2 | F5-C-a1 | 553 | 1 (EXT) | G-104 | 0.0203 | 2.619 | 0.213 | 99.256 | 0.00106 | 0.423 | 0.0562 | 0.0258 | 0.00175 | 0.265 | 0.7602 | 0.0758 | 0.1586 | 0.00539 | 0.981 | 1.036 | 1.023 | 8.90 | 9.40 | 9.27 | 9.27 | 0.269 | | |
| | | | 3 (EXT) | T-211 | 0.0165 | 1.713 | 0.367 | 97.949 | 0.00848 | 0.760 | 0.174 | 0.123 | 0.0209 | 0.519 | 0.5942 | 0.0819 | 0.2937 | 0.0301 | 2.363 | 2.519 | 2.500 | 21.81 | 23.26 | 23.07 | 0.322 | 0.414 | | |
| 2 | F5-C-f6 | 541 | 1 (EXT) | G-106 | 0.0196 | 2.576 | 0.229 | 99.158 | 0.00136 | 0.467 | 0.0649 | 0.0318 | 0.00241 | 0.277 | 0.7387 | 0.0761 | 0.1783 | 0.00701 | 1.045 | 1.149 | 1.001 | 9.49 | 10.44 | 9.09 | 9.09 | 0.282 | | |
| | | | 2 (EXT) | G-118 | 0.0173 | 1.843 | 0.346 | 98.247 | 0.0688 | 0.00622 | 0.702 | 0.148 | 0.0996 | 0.148 | 0.483 | 0.6380 | 0.0810 | 0.2581 | 0.0229 | 2.147 | 2.134 | 2.269 | 19.76 | 19.64 | 20.87 | 0.259 | 0.435 | |
| | | | 4 (EXT) | G-119 | 0.0153 | 1.621 | 0.376 | 98.028 | 0.119 | 0.00870 | 0.702 | 0.164 | 0.118 | 0.0212 | 0.545 | 0.6198 | 0.0827 | 0.2684 | 0.0232 | 2.506 | 2.727 | 2.615 | 23.14 | 25.18 | 24.15 | 0.255 | 0.456 | |
| | | | 5 (EXT) | G-120 | 0.0155 | 1.671 | 0.355 | 98.019 | 0.284 | 98.763 | 0.0274 | 0.00309 | 0.571 | 0.102 | 0.114 | 0.165 | 0.102 | 0.0220 | 0.531 | 0.6166 | 0.0823 | 0.2706 | 0.0305 | 2.478 | 2.558 | 2.465 | 22.87 | 23.61 |
| | | | 6 (EXT) | G-121 | 0.0170 | 2.115 | 0.284 | 98.763 | 0.0274 | 0.00309 | 0.571 | 0.0663 | 0.0664 | 0.407 | 0.0663 | 0.7048 | 0.0791 | 0.2030 | 0.0132 | 1.663 | 1.725 | 1.617 | 15.20 | 15.78 | 14.78 | 0.241 | 0.505 | |
| 3 | E6-C-a1 | 369 | 1 | T-168 | 0.0161 | 2.019 | 0.316 | 98.546 | 0.0805 | 0.627 | 0.122 | 0.0738 | 0.00971 | 0.434 | 0.6694 | 0.0797 | 0.2337 | 0.0171 | 1.841 | 1.949 | 2.174 | 16.88 | 17.87 | 19.94 | 19.94 | 0.258 | | |
| | | | 2 | T-169 | 0.0138 | 1.404 | 0.420 | 97.495 | 0.118 | 0.794 | 0.208 | 0.148 | 0.0317 | 0.606 | 0.5701 | 0.0844 | 0.3075 | 0.0381 | 3.003 | 3.192 | 3.369 | 27.86 | 30.54 | 31.25 | 31.25 | 0.407 | | |
| | | | 2 (EXT) | G-107 | 0.0169 | 1.428 | 0.421 | 97.472 | 0.0155 | 0.792 | 0.212 | 0.150 | 0.0328 | 0.599 | 0.5626 | 0.0842 | 0.3140 | 0.0392 | 2.994 | 3.246 | 3.026 | 27.78 | 30.12 | 28.06 | 28.06 | 0.400 | | |
| | | | 3 | T-170 | 0.0123 | 1.247 | 0.431 | 97.220 | 0.210 | 0.817 | 0.227 | 0.165 | 0.0391 | 0.650 | 0.5529 | 0.0857 | 0.3179 | 0.0435 | 3.343 | 3.487 | 3.624 | 31.08 | 32.43 | 33.71 | 33.71 | 0.259 | | |
| | | | 3 (EXT) | N-19 | 0.0118 | 1.264 | 0.427 | 97.072 | 0.175 | 0.861 | 0.240 | 0.175 | 0.0416 | 0.645 | 0.5392 | 0.0856 | 0.3301 | 0.0451 | 3.408 | 3.408 | 3.170 | 31.70 | 31.62 | 33.71 | 33.71 | 0.400 | | |
| | | | 4 (EXT) | G-108 | 0.0152 | 1.286 | 0.430 | 97.392 | 0.0165 | 0.741 | 0.217 | 0.153 | 0.0380 | 0.639 | 0.5597 | 0.0854 | 0.3116 | 0.0432 | 3.235 | 3.403 | 3.160 | 30.06 | 31.62 | 29.36 | 29.36 | 0.430 | | |
| | | | 3 (EXT) | T-212 | 0.0133 | 1.289 | 0.426 | 97.327 | 0.0172 | 0.768 | 0.223 | 0.157 | 0.0385 | 0.638 | 0.5555 | 0.0854 | 0.3157 | 0.0434 | 3.265 | 3.403 | 3.277 | 30.35 | 30.54 | 30.46 | 30.46 | 0.415 | | |
| | | | 3 (EXT) | T-319 (b) | 0.0138 | 1.268 | 0.425 | 97.380 | 0.214 | 0.746 | 0.218 | 0.154 | 0.0378 | 0.644 | 0.5620 | 0.0855 | 0.3097 | 0.0427 | 3.265 | 3.403 | 3.277 | 30.34 | 30.54 | 30.46 | 30.46 | 0.430 | | |
| | | | 4 (EXT) | T-171 | 0.0123 | 1.201 | 0.447 | 97.028 | 0.150 | 0.837 | 0.242 | 0.176 | 0.0446 | 0.663 | 0.5343 | 0.0861 | 0.3318 | 0.0477 | 3.304 | 3.707 | | | | | | | | |

Table 3.1-9 (continued, 2/3)

| EYC Phase | Core (a) Location | Fuel Rod No. | Axial (b) Sample Zone | Isotopic (c) Sample No. | Atomic density, relative to initial U-238 atomic density, N^4/n_0^{28} ($\times 10^2$) | | | | | | | | | | Total accumulated fissions, relative to initial U-238 atoms, $F_i^{\text{TOT}}/N_0^{28}$ ($\times 10^2$) | | | | | | | | | | Burnup (GWD/MTU) | | | |
|-----------|-------------------|--------------|-----------------------|-------------------------|--|-------|-------|------------------------------|------------|--------|------------|--------|----------------------------|--------|--|--------|--------|--------|--------|-------|--------|-------|--------|-------|------------------|--------------|-------------|-------|
| | | | | | U-234 | U-235 | U-236 | Pu-236 (d) ($\times 10^6$) | Pu-238 (e) | Pu-240 | Pu-241 (e) | Pu-242 | U-235 Fractional Depletion | U-235 | U-238 | Pu-239 | Pu-241 | HE | Cs-137 | Sr-90 | Nd-148 | HE | Cs-137 | Sr-90 | Nd-148 | Alpha-25 (f) | NGD/MBD (g) | |
| 3 | E6-C-a6 | 5352 | 1 | T-153 | 0.0162 | 2.047 | 0.297 | 98.610 | 0.0257 | 0.618 | 0.116 | 0.0686 | 0.00830 | 0.426 | 0.6836 | 0.0795 | 0.2219 | 0.0150 | 1.793 | 1.942 | 16.42 | 17.79 | 28.36 | 32.82 | 0.242 | 0.472 | | |
| | | | | T-154 | 0.0132 | 1.396 | 0.418 | 97.414 | 0.0618 | 0.318 | 0.154 | 0.239 | 0.0331 | 0.608 | 0.5636 | 0.0844 | 0.3130 | 0.0390 | 3.536 | 3.506 | 3.403 | 3.849 | 0.264 | 0.392 | | | | |
| | | | | T-155 | 0.0124 | 1.257 | 0.435 | 97.072 | 0.121 | 0.364 | 0.175 | 0.0417 | 0.647 | 0.5388 | 0.0856 | 0.3302 | 0.0454 | 3.403 | 3.519 | 3.753 | 31.66 | 35.81 | 32.77 | 34.75 | 0.263 | 0.372 | | |
| | | | | T-156 | 0.0123 | 1.192 | 0.439 | 97.017 | 0.111 | 0.551 | 0.242 | 0.177 | 0.0441 | 0.666 | 0.5373 | 0.0862 | 0.3294 | 0.0471 | 2.180 | 2.465 | 2.056 | 22.69 | 20.06 | 20.40 | 0.260 | 0.382 | | |
| | | | | T-157 | 0.0165 | 1.814 | 0.349 | 98.257 | 0.0556 | 0.684 | 0.148 | 0.0943 | 0.491 | 0.6403 | 0.0812 | 0.2559 | 0.0226 | 0.0232 | 2.216 | 2.216 | 2.216 | 2.216 | 0.258 | 0.452 | 0.251 | 0.448 | | |
| | | | | N-18 | 0.0150 | 1.800 | 0.344 | 98.232 | | 0.688 | 0.149 | 0.0966 | 0.495 | 0.6387 | 0.0813 | 0.2568 | 0.0232 | | | | | | | | | | 0.251 | 0.448 |
| 3 | E6-C-f1 | 536 | 1 | T-158 | 0.0164 | 2.065 | 0.301 | 98.649 | 0.0429 | 0.596 | 0.113 | 0.0666 | 0.00826 | 0.420 | 0.6843 | 0.0794 | 0.2211 | 0.0152 | 1.758 | 1.926 | 16.10 | 17.64 | 16.44 | 20.40 | 0.250 | 0.485 | | |
| | | | | N-17 | 0.0151 | 2.048 | 0.298 | 98.605 | | 0.619 | 0.116 | 0.0685 | 0.00849 | 0.425 | 0.6822 | 0.0795 | 0.2229 | 0.0153 | 1.795 | 1.926 | 16.44 | 17.79 | 28.79 | 31.64 | 0.244 | 0.471 | | |
| | | | | T-159 | 0.0134 | 1.374 | 0.416 | 97.392 | 0.118 | 0.814 | 0.216 | 0.155 | 0.0340 | 0.614 | 0.5628 | 0.0846 | 0.3129 | 0.0396 | 3.102 | 3.408 | 2.220 | 2.433 | 0.260 | 0.395 | | | | |
| | | | | T-160 | 0.0153 | 1.788 | 0.344 | 98.269 | 0.0484 | 0.663 | 0.148 | 0.0941 | 0.0153 | 0.498 | 0.6626 | 0.0814 | 0.2559 | 0.0231 | 2.220 | 2.220 | 2.220 | 2.220 | 0.249 | 0.466 | | | | |
| | | | | T-175 | 0.0164 | 2.084 | 0.302 | 98.622 | | 0.616 | 0.115 | 0.0680 | 0.00822 | 0.415 | 0.6796 | 0.0793 | 0.2260 | 0.0152 | 1.742 | 1.921 | 15.95 | 17.60 | 16.44 | 20.40 | 0.255 | 0.485 | | |
| | | | | T-176 | 0.0130 | 1.410 | 0.418 | 97.492 | | 0.795 | 0.208 | 0.148 | 0.0320 | 0.604 | 0.5693 | 0.0843 | 0.3081 | 0.0383 | 3.002 | 3.543 | 2.220 | 2.220 | 0.265 | 0.405 | | | | |
| 3 | E6-C-f6 | 354 | 1 | G-125 | 0.0139 | 1.403 | 0.428 | 97.682 | | 0.0140 | 0.753 | 0.190 | 0.134 | 0.0287 | 0.606 | 0.5900 | 0.0844 | 0.2898 | 0.0358 | 2.887 | 3.027 | 2.944 | 26.76 | 28.06 | 27.29 | 0.273 | 0.444 | |
| | | | | G-125 (EXT) | 0.0137 | | | | | 0.824 | 0.229 | 0.166 | 0.0388 | 0.644 | 0.5515 | 0.0855 | 0.3198 | 0.0432 | 3.324 | 3.750 | 30.90 | 34.87 | 31.13 | 31.13 | 0.258 | 0.394 | | |
| | | | | T-177 | 0.0125 | 1.268 | 0.427 | 97.214 | | 0.855 | 0.236 | 0.172 | 0.0402 | 0.640 | 0.5625 | 0.0854 | 0.3278 | 0.0443 | 3.348 | 3.750 | 31.13 | 31.13 | 31.13 | 31.13 | 0.262 | 0.375 | | |
| | | | | N-26 | 0.0119 | 1.281 | 0.432 | 97.128 | | 0.814 | 0.218 | 0.158 | 0.0354 | 0.618 | 0.5384 | 0.0847 | 0.3161 | 0.0408 | 3.140 | 3.195 | 3.092 | 3.092 | 29.67 | 28.70 | 20.44 | 22.40 | 0.260 | 0.392 |
| | | | | G-126 (EXT) | 0.0150 | 1.362 | 0.417 | 97.354 | | 0.833 | 0.240 | 0.174 | 0.0440 | 0.662 | 0.5372 | 0.0861 | 0.3295 | 0.0472 | 3.489 | 3.783 | 32.48 | 35.22 | 32.48 | 32.48 | 0.265 | 0.388 | | |
| | | | | T-178 | 0.0120 | 1.203 | 0.444 | 97.054 | | 0.820 | 0.232 | 0.167 | 0.0403 | 0.648 | 0.5474 | 0.0857 | 0.3225 | 0.0444 | 3.468 | 3.774 | 31.29 | 35.11 | 31.36 | 31.36 | 0.260 | 0.394 | | |
| 3 | E6-SE-c2 | 3198 | 3 | N-27 | 0.0124 | 1.253 | 0.432 | 97.180 | | 0.833 | 0.234 | 0.170 | 0.0411 | 0.647 | 0.5626 | 0.0856 | 0.3267 | 0.0452 | 3.372 | 3.774 | 31.36 | 35.11 | 31.36 | 31.36 | 0.265 | 0.385 | | |
| | | | | T-180 | 0.0152 | 1.807 | 0.346 | 97.255 | | 0.683 | 0.148 | 0.0939 | 0.0148 | 0.493 | 0.6413 | 0.0812 | 0.2547 | 0.0227 | 2.194 | 2.472 | 20.19 | 22.75 | 20.19 | 22.75 | 0.254 | 0.453 | | |
| | | | | T-187 | 0.0120 | 1.240 | 0.438 | 97.083 | | 0.826 | 0.244 | 0.171 | 0.0431 | 0.652 | 0.5369 | 0.0858 | 0.3308 | 0.0466 | 3.442 | 4.152 | 32.03 | 38.64 | 31.41 | 35.25 | 0.263 | 0.386 | | |
| | | | | T-188 | 0.0122 | 1.247 | 0.429 | 97.204 | | 0.794 | 0.234 | 0.162 | 0.0409 | 0.650 | 0.5480 | 0.0857 | 0.3213 | 0.0450 | 3.377 | 3.774 | 31.41 | 35.25 | 31.41 | 35.25 | 0.257 | 0.404 | | |
| | | | | T-185 | 0.0125 | 1.029 | 0.466 | 96.898 | | 0.719 | 0.265 | 0.172 | 0.0564 | 0.711 | 0.5217 | 0.0793 | 0.3420 | 0.0570 | 3.852 | 4.365 | 35.97 | 40.76 | 35.26 | 37.68 | 0.266 | 0.428 | | |
| | | | | T-186 | 0.0127 | 1.035 | 0. | | | | | | | | | | | | | | | | | | | | | |

Table 3.1-9 (continued, 3/3)

| EYC Phase | Core (a) Location | Fuel Rod No. | Axial (b) Sample Zone | Isotopic (c) Sample No. | Atomic density, relative to initial U-238 atomic density, $N^1/n_0^{28} (\times 10^2)$ | | | | | | | | | | | | Total accumulated fissions, relative to initial | | | | | | | | Burnup (GMD/MTU) | | | | Alpha-25 (f) | | | | NGD/MWD (g) | | | | | | | | | | | | | | | | | |
|-----------|-------------------|--------------|-----------------------|-------------------------|--|----------|-------|--------|--------|--------|--------|-------|--------|--------|------------------------------|--------|---|------------|--------|--------|--------|--------|------------|-------|------------------|-------|----------------------------|-------|--------------|-------|-------|-------|------------------------------|-------|--|-------|--------|-------|-------|-------|--------|-------|-------|--|--------|--|--------------|--|-------------|--|
| | | | | | U-234 | | | | U-235 | | U-236 | | U-238 | | Pu-236 (d) ($\times 10^6$) | | Pu-238 (e) | | Pu-239 | | Pu-240 | | Pu-241 (e) | | Pu-242 | | U-235 Fractional Depletion | | U-235 | | U-238 | | Accumulated Fission Fraction | | U-238 atoms, $F_1^{\text{TOT}}/N_0^{28} (\times 10^2)$ | | Nd-148 | | HE | | Cs-137 | | Sr-90 | | Nd-148 | | Alpha-25 (f) | | NGD/MWD (g) | |
| | | | | | 3 | E6-NW-al | 44 | 1 | T-162 | 0.0158 | 1.916 | 0.323 | 98.496 | 0.0522 | 0.0801 | 0.0116 | 0.462 | 0.5749 | 0.0632 | 0.2425 | 0.0194 | 1.963 | 2.073 | 2.067 | 18.04 | 19.05 | 18.99 | 0.248 | 0.488 | 0.239 | 0.454 | 0.259 | 0.439 | 0.256 | 0.427 | 0.256 | 0.446 | 0.270 | 0.426 | 0.256 | 0.429 | 0.256 | 0.439 | | | | | | | |
| 3 | E6-NW-al | 44 | 1 | T-162 | 0.0158 | 1.916 | 0.323 | 98.496 | 0.0522 | 0.0801 | 0.0116 | 0.462 | 0.5749 | 0.0632 | 0.2425 | 0.0194 | 1.963 | 2.073 | 2.067 | 18.04 | 19.05 | 18.99 | 0.248 | 0.488 | 0.239 | 0.454 | 0.259 | 0.439 | 0.256 | 0.427 | 0.256 | 0.446 | 0.270 | 0.426 | 0.256 | 0.429 | 0.256 | 0.439 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-181 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.603 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735 | 0.3516 | 0.0750 | 0.3518 | 0.4384 | 0.234 | 0.499 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | 0.256 | 0.449 | | | | | | | | | | | | |
| 3 | E6-SE-f5 | 3113 | 1 | T-182 | 0.0171 | 1.945 | 0.327 | 98.351 | 0.194 | 0.0244 | 0.0244 | 0.631 | 0.262 | 0.180 | 0.0818 | 0.790 | 0.4959 | 0.0735</td | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

Table 3.1-10 Summary of Measurements for U-232

| EXC (a) Phase | Core (b) Location | Rod No. | Axial Sample Zone | Isotopic (c) | U-232 (d) | | | Pu-236 | | | U-232 (e) | | | | | |
|------------------|----------------------|---------|-------------------------|-------------------------|-------------------------|-------------------------|--------------------------------------|-------------------------|------------------------------|-------------------------|---------------------------------|---|---------------------------------------|----------------|---------------|--------------|
| | | | | | $\frac{N^{49}}{N^{28}}$ | $\frac{N^{22}}{N^{25}}$ | Elapsed(e) Time (days) | $\frac{N^{46}}{N^{49}}$ | Elapsed(e) Time (days) | $\frac{N^{22}}{N^{25}}$ | Relative Fractional Error | $\frac{F_{TOT}}{N^{28}}$ ($\times 10^2$) | Burnup (GWD/MTU) | | | |
| 1 | G4-C-a1 | 0994 | 3 | T-161 (g) | 2.416 | 5.364 | 0.129 0.0906 ($\times 10^7$) | 0.003 0.296 | 2343 2343 | 0.150 | 0.259 | 1399 | 0.0690 0.0281 ($\times 10^7$) | 1.27 11.5 | | |
| | F4-C-f1 | 8977 | 1 | G-113 G-114 | 2.870 | 3.541 | 0.0421 0.173 | 1.131 0.312 | 1931 1931 | 0.0383 0.112 | 0.232 0.259 | 1757 1760 | 0.0331 0.112 | 1.518 0.530 | 0.668 1.46 | 6.03 13.3 |
| | E5-C-a6 | 7992 | 3 | G-101 G-102 G-103 | 2.325 | 5.606 | 0.159 | 0.541 | 1932 | 0.128 | 0.219 | 1754 | 0.0941 | 0.978 | 1.42 | 12.9 |
| 2 | F5-C-a1 | 553 | 1 | G-104 G-105 | 2.619 | 4.228 | 0.273 | 0.567 | 1443 | 0.113 | 0.159 | 1287 | 0.257 | 0.737 | 1.02 | 9.27 |
| | F5-C-f6 | 541 | 1 | G-106 G-118 | 2.576 | 4.760 | 0.216 | 0.759 | 1443 | 0.121 | 0.165 | 1288 | 0.192 | 0.888 | 1.00 | 9.09 |
| | E6-C-a1 | 369 | 2 | G-107 G-108 G-109 | 1.428 | 7.913 | 1.62 | 0.234 | 736 | 0.971 | 0.0958 | 586 | 1.34 | 0.289 | 3.03 | 28.1 |
| 3 | E6-C-f6 | 354 | 2 | G-125 G-126 | 1.403 | 7.530 | 1.35 | 0.237 | 747 | 0.970 | 0.141 | 590 | 1.07 | 0.307 | 2.94 | 27.3 |
| | E6-NW-a1 | 44 | 3 | G-127 G-128 | 0.7588 | 6.112 | 3.52 | 0.114 | 743 | 1.537 | 0.0891 | 591 | 2.87 | 0.282 | 3.09 | 28.7 |
| | E6-SE-f5 | 3113 | 3 | G-124 (h) | 0.7974 | 6.515 | 3.10 | 0.458 0.684 | 784 784 | 1.700 | 0.113 | 574 | 2.33 | 0.624 0.930 | 4.50 | 42.1 |

Notes: (a) Phase 1 samples were irradiated in Yankee Core I; Phase 2 samples were irradiated in Cores I and II; Phase 3 samples were irradiated in Cores I, II, and IV.

(b) Subassembly designation C indicates asymptotic neutron spectrum; subassembly designations NW and SE indicate non-asymptotic neutron spectra.

(c) The letters T and G indicate mass spectrometric analysis for main chain U and Pu isotopes by TRACERLAB and General Electric-Vallecitos, respectively.

(d) Analysis for U-232 by WARD; relative fractional error on U-232/U-235 atom ratio is $\pm 3\sigma$.

(e) From core end-of-life to time of analysis.

(f) Phase 1, 2, and 3 data referenced to Core I, Core II, and Core IV end-of-life, respectively. Decay constants for U-232 and Pu-236 are 0.0000268 d^{-1} and 0.000666 d^{-1} , respectively.

(g) EYC Phase 1 control sample.

(h) EYC Phase 3 control sample.

Table 3.1-11 Summary of Measurements for Np-237

| EYC ^(a) Phase | Core ^(b) Location | Rod No. | Axial Sample Zone | Isotopic ^(c) Sample No. | U-238 Atom Percent | $\frac{N^{28}}{N_0^{28}}$ | Np-237 ^(d) (ppm) | $\frac{N^{37}}{N_0^{28}}$ ($\times 10^{-4}$) | F _{TOT} $\frac{N^{28}}{N_0^{28}}$ ($\times 10^{-2}$) | Burnup (GWD/MTU) |
|-----------------------------|---------------------------------|---------|-------------------------|--|--------------------------|---------------------------|--------------------------------|---|---|---------------------|
| 1 | E5-C-f1 | 8977 | 1 (e) | G-113 | 97.037 | 0.99463 | 46 | 0.47 | 0.668 | 6.03 |
| | | | 4 | G-114 | 97.487 | 0.98809 | 52 | 0.54 | 1.46 | 13.3 |
| | | 7992 | 3 | G-101 | 97.430 | 0.98868 | 159 | 1.62 | 1.42 | 12.9 |
| | | | 5 (e) | G-102 | 97.439 | 0.98939 | 197 | 2.01 | 1.37 | 12.5 |
| 2 | E5-C-a1 | 553 | 1 | G-104 | 97.206 | 0.99256 | 114 | 1.49 | 0.962 | 8.71 |
| | | | 6 | G-103 | 97.099 | 0.99316 | 90 | 0.92 | 1.17 | 1.02 |
| | | 541 | 1 (e) | G-106 | 97.229 | 0.99158 | 92 | 0.94 | 1.00 | 9.27 |
| | | | 4 (e) | G-119 | 97.988 | 0.98028 | 112 | 1.15 | 3.43 | 24.2 |
| 3 | E6-C-a1 | 369 | 2 | G-107 | 98.120 | 0.97472 | 516 | 3.41 | 2.62 | 24.2 |
| | | | 3 (e) | G-108 | 98.253 | 0.97792 | 493 | 3.50 | 2.46 | 22.8 |
| | | 354 | 2 (e) | G-125 | 98.144 | 0.97682 | 497 | 1.91 | 1.62 | 14.8 |
| | | | 3 | G-126 | 98.190 | 0.97554 | 552 | 4.95 | 3.34 | 31.1 |
| E6-NW-a1 | 44 | 3 | G-127 | 98.702 | 0.96487 | 591 | 5.15 | 3.03 | 28.1 | 27.3 |
| | | 4 (e) | G-128 | 98.734 | 0.96521 | 619 | 4.25 | 2.94 | 3.16 | 29.4 |
| | | | | | | 603 | 5.05 | 3.09 | 28.7 | 41.1 |
| | | | | | | | 5.92 | 4.38 | 42.7 | |
| | | | | | | | | 5.92 | 41.1 | |

Notes: (a) Phase 1 samples were irradiated in Yankee Core I; Phase 2 samples were irradiated in Cores I and II; Phase 3 samples were irradiated in Cores I, II, and IV.

(b) Subassembly designation C indicates asymptotic neutron spectrum; subassembly designation NW indicates non-asymptotic neutron spectrum.

(c) The letters G indicate mass spectrometric analysis for main chain U and Pu isotopes by General Electric-Vallelectics.

(d) Analysis for Np-237 by WARD; uncertainties are $\pm 10\%$, relative.

(e) Duplicate analysis.

Table 3.1-12 Summary of Measurements for Am-241 (1/2)

| EYC (a) Phase | Core (b) Location | Rod No. | Axial Sample Zone | Isotopic (c) Sample No. | Pu-241 | | | | Am-241 | | | | Am-241 | | | |
|------------------|----------------------|---------|-------------------------|-------------------------------|--|--|---|---------|--|---|--------|--|---|---|---------------------|------|
| | | | | | $\frac{N^{41}}{N^{49}}$ $\times 10^3$ | $\frac{N^{41}}{N^{49}}$ $\times 10^3$ | At Time of Analysis Elapsed (d) Time (days) | Lab | $\frac{N^{51}}{N^{49}}$ $\times 10^2$ | At Time of Analysis Elapsed (d) Time (days) | Lab | $\frac{N^{51}}{N^{28}}$ $\times 10^5$ | At Core EOL (e) Relative Fractional Error | F _{TOT} $\frac{N^{28}}{N_0}$ $\times 10^2$ | Burnup (GWD/MTU) | |
| 1 | G4-C-a1 | 0994 | 3 | T-161 (f) | 5.364 | 0.06623 | 0.00168 | 1384 | WARD(h) | 2.47 | 0.0810 | 2373 | 1.18 | 0.918 | 1.27 | 11.5 |
| | F4-C-f1 | 8977 | 4 | G-114 | 5.888 | 0.0740 | 0.0136 | 1880 | TLAB(k) | 3.63 | 0.0551 | 1910 | 8.24 | 0.146 | 1.46 | 13.3 |
| | | | 5 | G-115 | 5.556 | 0.0731 | 0.0105 | 1880 | WARD(h) | 2.46 | 0.0406 | 1910 | 1.31 | 0.473 | 1.44 | 13.2 |
| | E5-C-a6 | 7992 | 3 | G-101 | 5.605 | 0.07448 | 0.00447 | 1789 | TALB(j) | 2.01 | 0.0796 | 1828 | -0.751 | 1.209 | 1.42 | 12.9 |
| | | 5 | G-102 | 5.253 | 0.07255 | 0.00447 | 1789 | TLAB(j) | 1.78 | 0.0786 | 1828 | -1.62 | 0.456 | 1.37 | 12.5 | |
| | | 6 | G-103 | 4.082 | 0.04200 | 0.00447 | 1789 | TLAB(j) | 1.20 | 0.0833 | 1828 | -0.0356 | 11.60 | 0.962 | 8.71 | |
| 2 | F5-C-a1 | 553 | 1 | G-104 | 4.228 | 0.05077 | 0.00447 | 1317 | TLAB(j) | 1.22 | 0.0820 | 1356 | 0.731 | 0.584 | 1.02 | 9.27 |
| | | 3 | G-105 | 7.600 | 0.1348 | 0.00447 | 1317 | TLAB(i) | 3.15 | 0.0825 | 1356 | 2.80 | 0.710 | 2.50 | 23.1 | |
| | F5-C-f6 | 541 | 1 | G-106 | 4.670 | 0.05673 | 0.00447 | 1317 | WARD(h) | 2.93 | 0.0819 | 1353 | 1.16 | 1.592 | | |
| | | 2 | G-118 | 7.204 | 0.1117 | 0.00956 | 1393 | TLAB(j) | 1.32 | 0.0758 | 1356 | 0.696 | 0.678 | 1.00 | 9.09 | |
| | | 2 | G-119 | 7.018 | 0.1338 | 0.00844 | 1415 | TLAB(k) | 3.47 | 0.0576 | 1421 | 1.50 | 0.662 | 2.27 | 20.9 | |
| | | 4 | G-121 | 5.708 | 0.0870 | 0.0119 | 1393 | WARD(h) | 3.65 | 0.0384 | 1424 | 2.28 | 0.378 | | | |
| | | 6 | | | | | | WARD(k) | 2.31 | 0.0693 | 1425 | 3.47 | 0.447 | 2.62 | 24.2 | |
| | | 6 | G-107 | 7.914 | 0.1742 | 0.00447 | 610 | TLAB(j) | 2.74 | 0.0803 | 649 | 2.36 | 0.225 | 2.36 | | |
| | | 3 | G-108 | 7.411 | 0.1894 | 0.00447 | 610 | TLAB(i) | 2.76 | 0.0797 | 649 | 2.30 | 0.256 | 1.62 | 14.8 | |
| | | 3 | G-109 | 7.764 | 0.1883 | 0.00447 | 610 | WARD(h) | 2.90 | 0.0828 | 647 | 8.37 | 0.224 | 3.16 | | |
| | | 5 | G-125 | 7.531 | 0.1606 | 0.00933 | 708 | TLAB(k) | 2.45 | 0.0653 | 714 | 8.70 | 0.200 | 3.03 | 28.1 | |
| | | 2 | G-126 | 8.138 | 0.1761 | 0.00870 | 686 | WARD(h) | 2.54 | 0.0394 | 714 | 7.26 | 0.213 | 3.16 | 29.4 | |
| | | 3 | G-111 | 5.351 | 0.0960 | 0.0114 | 1880 | TLAB(k) | 3.31 | 0.0604 | 1897 | 0.172 | 0.214 | 3.34 | 31.1 | |
| | E5-SW-a5 | 369 | 3 | | | | | WARD(h) | 2.95 | 0.0407 | 1897 | 2.27 | 0.481 | 1.90 | 28.7 | |
| | | 354 | 2 | | | | | | | | 0.326 | 0.0407 | 2.052 | | | |
| 1 | | 15025 | 3 | | | | | | | | | | | 1.90 | 17.4 | |

Table 3.1-12 Summary of Measurements for Am-241 (2/2)

| EYC (a) Phase | Core (b) Location | Rod No. | Axial Sample Zone | Isotopic (c) $\frac{N^{49}}{N^{28}}$ $\frac{N^{11}}{N^{49}}$ ($\times 10^3$) | Pu-241 | | | At Time of Analysis | | | Am-241 | | | Am-241 | | |
|------------------|----------------------|---------|-------------------------|---|-------------------------|---------------------------------|-------------------------------|---------------------|--|---------------------------------|-------------------------------|--|---------------------------------|---|---------------------|------|
| | | | | | $\frac{N^{49}}{N^{28}}$ | Relative Fractional Error | Elapsed (d) Time (days) | Lab | $\frac{N^{51}}{N^{49}}$ ($\times 10^2$) | Relative Fractional Error | Elapsed (d) Time (days) | $\frac{N^{51}}{N^{28}}$ ($\times 10^5$) | Relative Fractional Error | $\frac{F_{TOT}}{N^{28}}$ ($\times 10^2$) | Burnup (GWD/MTU) | |
| 2 | F5-SE-f5 | 8717 | 3 | G-122 | 6.571 | 0.1836 | 0.00892 | 1415 | T LAB (k) WARD (h) | 4.37 5.23 | 0.0595 0.0382 | 1425 1425 | 2.31 8.02 | 0.750 0.167 | 3.29 | 30.6 |
| 3 | E6-NW-a1 | 44 | 3 | G-127 | 6.112 | 0.2644 | 0.00993 | 708 | T LAB (k) WARD (h) | 3.77 4.26 | 0.0584 0.0422 | 712 712 | 6.23 9.23 | 0.219 0.120 | 4.55 | 42.7 |
| | | | 4 | G-128 | 6.027 | 0.2709 | 0.00856 | 708 | T LAB (k) WARD (h) | 3.84 5.34 | 0.0573 0.0374 | 712 712 | 6.15 15.2 | 0.218 0.0802 | 4.38 | 41.1 |
| | | | 3 | G-124 (g) | 6.141 | 0.2550 | 0.00870 | 708 | T LAB (i) WARD (h) | 3.39 3.10 | 0.0826 0.0774 | 649 718 | 5.90 6.39 | 0.294 0.194 | 4.50 | 42.1 |
| | | | 3 | | | | | | T LAB (k) WARD (h) | 3.47 3.91 | 0.0576 0.0409 | 718 718 | 7.61 7.61 | 0.131 | | |

Notes: (a) Phase I samples were irradiated in Yankee Core I; Phase 2 samples were irradiated in Cores I and II; Phase 3 samples were irradiated in Cores I, II, and IV.

(b) Subassembly designation C indicates asymptotic neutron spectrum; subassembly designations NW, SE, and SW indicate non-asymptotic neutron spectra.

(c) The letters T and G indicate mass spectrometric analysis for main chain U and Pu isotopes by TRACERLAB and General Electric-Vallecitos, respectively.

(d) From core end-of-life to time of analysis.

(e) Phase 1, 2, and 3 data referenced to Core I, Core II, and Core IV end-of-life, respectively. Decay constants for Am-241 and Pu-241 = 0.00000415 d⁻¹ and 0.000140 d⁻¹, respectively.

(f) EYC Phase 1 control sample.

(g) EYC Phase 3 control sample.

(h) From alpha spectrometric measurements by WARD.

(i) Measurements by TRACERLAB; Am by alpha spectrometry and Pu by mass spectrometry.

(j) From TRACERLAB alpha spectrometry for Am as dpm/ml, and use of gross alpha spectrometry on sample measured at WARD.

(k) From TRACERLAB measurements for Am-241 and Cm-244 dpm/ml; TRACERLAB data converted using Cm-244/Pu-239 atom ratio measured by WARD.

Table 3.1-13 Summary of Measurements for Am-243

| EYC (a) Phase | Core (b) Location | Rod No. | Axial Sample Zone | Isotopic (c) Sample No. | $\frac{N^{49}}{N^{28}}$ ($\times 10^2$) | $\frac{N^{53} (d)}{N^{49}}$ ($\times 10^3$) | $\frac{N^{53}}{N^{28}}$ ($\times 10^5$) | $\frac{F_{TOT}}{N_0^{28}}$ ($\times 10^2$) | Burnup (GWD/MTU) |
|------------------|----------------------|---------|-------------------------|-------------------------------|--|--|--|---|---------------------|
| 3 | E6-C-f6 | 354 | 2 | G-125 | 0.7530 | 3.34 ± 1.52 | 2.52 ± 1.15 | 2.94 | 27.3 |
| | | | 3 | G-126 | 0.8137 | 5.14 ± 4.06 | 4.18 ± 3.30 | 3.09 | 28.7 |
| | E6-NW-a1 | 44 | 4 | G-128 | 0.6027 | 35.8 ± 6.0 | 21.6 ± 3.62 | 4.38 | 41.1 |
| | E6-SE-f5 | 3113 | 3 | G-124 | 0.6141 | 9.46 ± 2.14 | 5.81 ± 1.31 | 4.50 | 42.1 |
| | | | 3 | | 8.94 ± 4.56 | 5.49 ± 2.80 | | | |

Notes: (a) Phase 3 samples were irradiated in Yankee Core I, II, and IV.

(b) Subassembly designation C indicates asymptotic neutron spectrum; subassembly designation NW and SE indicates non-asymptotic neutron spectra.

(c) The letters G indicates mass spectrometric analysis for main chain U and Pu isotopes by General Electric-Vallecitos.

(d) From alpha spectrometric analysis by WARD; uncertainties are 2σ .

Table 3.1-14 Summary of Measurements for Cm-242 and Cm-244 (1/2)

| EYC ^(a) Phase | Core ^(b) Location | Rod No. | Axial Sample Zone | Isotopic Sample No. | Cm-242 and Cm-244 At Time of Analysis | | | | | Cm-242 and Cm-244 at Core EOL(e) | | | | Burnup (GWD/MTU) | | | |
|-----------------------------|---------------------------------|---------|-------------------------|---------------------------|--|---------|--|---|--|---|------------------------------|--|--|---|---------|------|------|
| | | | | | N ⁶⁴ N ₆ ($\times 10^3$) | Lab | N ⁶² N ₆ ($\times 10^4$) | Relative Fractional Error on N ⁶² /N ₆ | N ⁶⁴ N ₆ ($\times 10^4$) | Relative Fractional Error on N ⁶⁴ /N ₆ | Elapsed(d) Time (days) | N ⁶² N ₆ ($\times 10^4$) | N ⁶⁴ N ₆ ($\times 10^5$) | F ^{TOT} N ₆ ($\times 10^2$) | | | |
| 1 | G4-C-a1 | 0994 | 3 | T-161(f) | 5.364 | WARD(h) | 0.000585 | 0.588 | 0.464 | 0.0948 | 2373 | 12.9 | 0.595 | 0.694 | 0.0319 | 1.27 | 11.5 |
| | F4-C-f1 | 8977 | 4 | G-114 | 5.888 | TLAB(k) | 0.00164 | 0.0732 | 0.96 | 0.0625 | 1910 | 5.15 | 0.303 | 0.470 | 0.069 | 1.46 | 13.3 |
| E5-C-a6 | | 5 | G-115 | | 5.556 | WARD(h) | 0.00254 | 0.236 | 0.96 | 0.0833 | 1910 | 7.98 | 1.2 | 0.278 | 0.44 | 1.44 | 13.2 |
| | | 5 | G-101 | | 5.605 | WARD(k) | 0.00159 | 0.0755 | 0.84 | 0.0714 | 1910 | 5.00 | 0.293 | 0.057 | | | |
| 2 | F5-C-a1 | 7992 | 3 | G-102 | 5.253 | TLAB(j) | 0.00157 | 0.0637 | 0.765 | 0.0810 | 1828 | 3.49 | 0.927 | 0.196 | 0.0519 | 1.42 | 12.9 |
| | | 5 | G-103 | | 4.082 | TLAB(j) | 0.00204 | 0.0588 | 0.643 | 0.0809 | 1828 | 4.54 | 0.779 | 0.238 | 0.0409 | 1.37 | 12.5 |
| E5-C-f6 | | 553 | 1 | G-104 | 4.228 | TLAB(j) | 0.00696 | 0.0603 | 0.179 | 0.0447 | 1353 | 2.09 | 0.206 | 0.0883 | 0.00872 | 1.02 | 9.27 |
| | | 3 | G-105 | | 7.600 | TLAB(i) | 0.0368 | 0.0598 | 8.61 | 0.0372 | 1353 | 11.0 | 9.93 | 0.839 | 0.754 | 2.50 | 23.1 |
| 3 | E6-C-a1 | 541 | 1 | G-106 | 4.670 | TLAB(i) | 0.00817 | 0.0588 | 0.274 | 0.0365 | 1356 | 2.48 | 0.316 | 0.116 | 0.0148 | 1.00 | 9.09 |
| | | 2 | G-118 | | 7.024 | TLAB(k) | 0.0253 | 0.0553 | 4.68 | 0.0598 | 1421 | 10.1 | 0.705 | 0.710 | 0.382 | 2.27 | 20.9 |
| 3 | E6-C-f6 | | 2 | G-119 | 7.018 | WARD(h) | 0.0251 | 0.0398 | 4.68 | 0.0385 | 1421 | 10.0 | 5.43 | 0.977 | 0.864 | 2.62 | 24.2 |
| | | 4 | G-121 | | 5.708 | TLAB(k) | 0.0344 | 0.0523 | 10.6 | 0.0566 | 1424 | 13.9 | 1.01 | 0.355 | 0.103 | 1.62 | 14.8 |
| 3 | | 369 | 2 | G-107 | 7.914 | WARD(h) | 0.0336 | 0.0337 | 10.6 | 0.0377 | 1424 | 14.4 | 12.3 | 0.864 | | | |
| | | 3 | G-108 | | 7.411 | TLAB(l) | 0.0153 | 0.0654 | 1.56 | 0.0153 | 1425 | 6.22 | 5.53 | 1.81 | | | |
| 3 | | 5 | G-109 | | 7.764 | WARD(h) | 1.76 | 0.0341 | 29.1 | 0.0435 | 649 | 23.8 | 24.6 | 1.88 | 1.95 | 3.03 | 28.1 |
| | | 2 | G-125 | | 7.531 | TLAB(k) | 1.74 | 0.0345 | 29.9 | 0.0412 | 649 | 27.2 | 31.2 | 2.01 | 2.31 | 3.16 | 29.4 |
| 3 | E6-C-f6 | 354 | 2 | G-126 | 8.138 | WARD(h) | 1.16 | 0.0508 | 20.5 | 0.0585 | 714 | 23.9 | 1.80 | 2.37 | 2.55 | 3.34 | 31.1 |
| | | 3 | | | | | 1.32 | 0.0345 | 20.5 | 0.0390 | 714 | 23.5 | 22.1 | 1.77 | 1.66 | 2.94 | 27.3 |
| 3 | | | | | | | 1.28 | 0.0606 | 27.2 | 0.0588 | 714 | 26.8 | 2.18 | 2.11 | 3.09 | 3.09 | 28.7 |
| | | | | | | | 1.28 | 0.0312 | 27.2 | 0.0368 | 714 | 26.0 | 29.3 | 2.11 | 2.39 | | |

Table 3.1-14 Summary of Measurements for Cm-242 and Cm-244 (2/2)

| Expt.(a) Phase | Core (b) Location | Rod No. | Axial Sample Zone | Isotopic (c) $\frac{N^{49}}{N_6^{28}}$ ($\times 10^3$) | Cm-242 and Cm-244 At Time of Analysis | | | | | Cm-242 and Cm-244 at Core EOL (e) | | | | | | |
|-------------------|----------------------|---------|-------------------------|--|--|--|---|--|---|--------------------------------------|--|--|--|--|---|---------------------|
| | | | | | Lab | $\frac{N^{62}}{N^{49}}$ ($\times 10^4$) | Relative Error on N^{62}/N^{49} | $\frac{N^{64}}{N^{49}}$ ($\times 10^4$) | Relative Error on N^{64}/N^{49} | Elapsed(d) Time (days) | $\frac{N^{62}}{N^{49}}$ ($\times 10^4$) | $\frac{N^{64}}{N^{49}}$ ($\times 10^5$) | $\frac{N^{62}}{N^{28}}$ ($\times 10^5$) | $\frac{N^{64}}{N^{28}}$ ($\times 10^5$) | $\frac{F_{TOT}}{N_6^{28}}$ ($\times 10^2$) | Burnup (GWd/MTU) |
| 1 | E5-SW-f5 | 15025 | 3 | G-111 | 5.350 | TLAB(k) WARD(h) | 0.00187 0.00204 | 0.0642 0.235 | 1.56 1.56 | 0.0641 0.0385 | 1897 1897 | 5.56 6.07 | 0.298 1.90 | 0.325 0.102 | 1.90 | 17.4 |
| 2 | F5-SE-f5 | 8717 | 3 | G-122 | 6.572 | TLAB(k) WARD(h) | 0.0586 0.0581 | 0.0512 0.0344 | 21.1 21.1 | 0.0569 0.0379 | 1425 1425 | 23.8 23.6 | 1.56 1.55 | 1.61 | 3.29 | 30.6 |
| 3 | E6-NW-f5 | 44 | 3 | G-127 | 6.120 | TLAB(k) WARD(h) | 2.78 2.61 | 0.0576 0.0383 | 104. 104. | 0.0577 0.0577 | 712 712 | 55.9 57.5 | 3.42 112. | 4.55 | 42.7 | |
| | | 4 | 4 | G-128 | 6.035 | TLAB(k) WARD(h) | 2.78 2.72 | 0.0576 0.0368 | 105. 105. | 0.0571 0.0571 | 712 712 | 55.9 54.7 | 3.38 113. | 3.30 | 6.83 | 4.38 |
| | E6-SE-f5 | 3113 | 3 | G-124 (g) | 6.148 | TLAB(1) WARD(h) | 3.19 3.25 | 0.0376 0.0431 | 93.2 90.6 | 0.0386 0.0397 | 649 647 | 48.8 49.7 | 99.8 97.0 | 3.00 3.06 | 6.13 5.96 | 4.50 |
| | | 3 | 3 | | | TLAB(k) WARD(h) | 2.46 2.39 | 0.0569 0.0618 | 88.9 88.9 | 0.0540 0.0405 | 718 718 | 37.6 49.3 | 2.31 95.9 | 3.03 | 5.89 | 42.1 |

Notes: (a) Phase I samples were irradiated in Yankee Core I; Phase 2 samples were irradiated in Cores I and II; Phase 3 samples were irradiated in Cores I, II, and IV.

(b) Subassembly designation C indicates asymptotic neutron spectrum; subassembly designations NW, SE, and SW indicate non-asymptotic neutron spectra.

(c) The letters T and G indicate mass spectrometric analysis for main chain U and Pu isotopes by TRACERLAB and General Electric-Vallecitos, respectively.

(d) From core end-of-life to time of analysis; the results of cross check analysis for dpm/ml by TRACERLAB are referenced to WARD time of analysis on same sample.

(e) Phase 1, 2, and 3 data referenced to Core I, Core II, and Core IV end-of-life, respectively. Decay constants for Cm-242 are 0.004216 d^{-1} and 0.000105 d^{-1} , respectively.(f) EYC Phase 1 control sample.
(g) EYC Phase 3 control sample.

(h) From alpha spectrometric measurements by WARD.

(i) Measurements by TRACERLAB; Cm by alpha spectrometry and Pu by mass spectrometry.

(j) From TRACERLAB alpha spectrometry for Cm as dpm/ml, and use of gross alpha spectrometry on sample measured at WARD.

(k) From TRACERLAB measurements for Cm dpm/ml; TRACERLAB data converted using Cm-244/Pu-239 atom ratio measured by WARD.

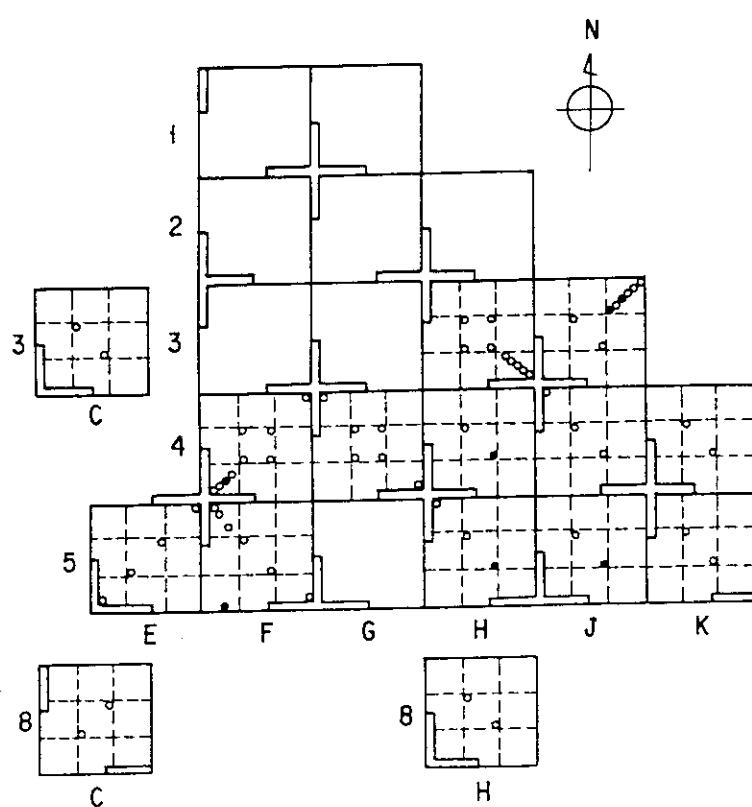
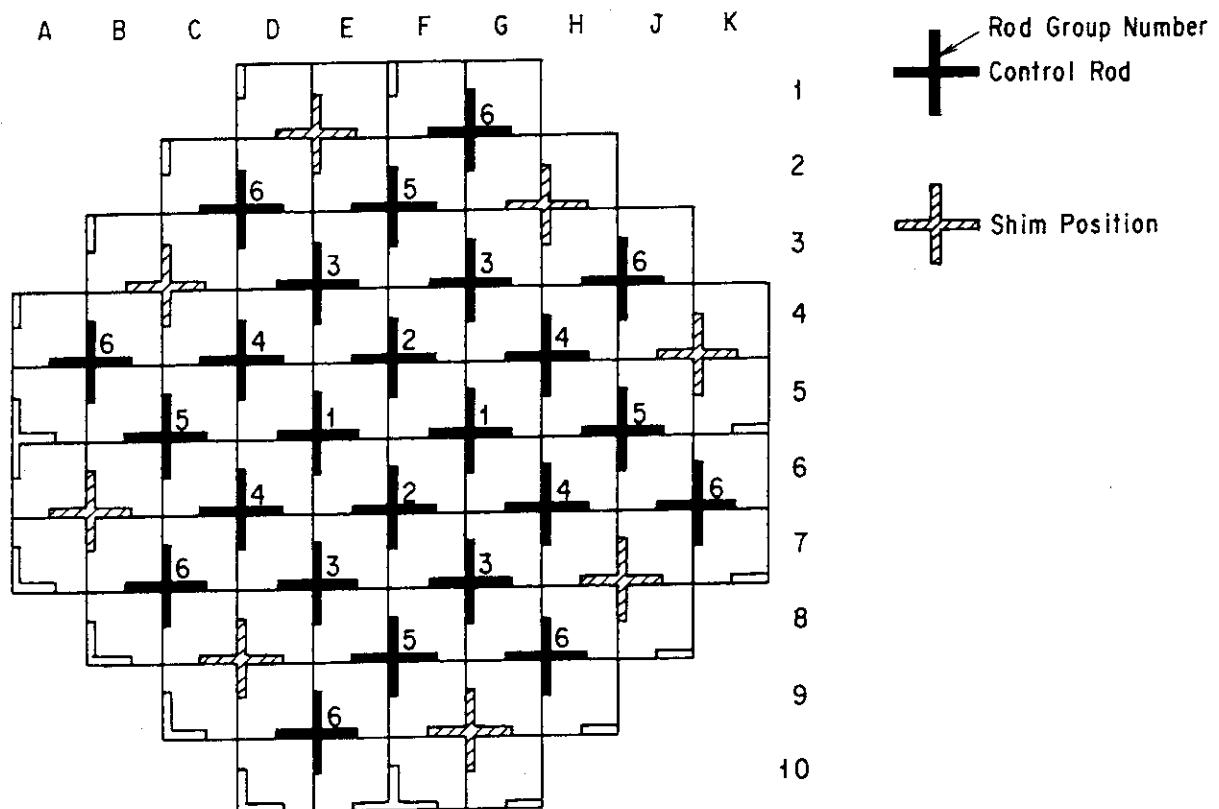


Fig. 3.1-1 Core configuration of Yankee core

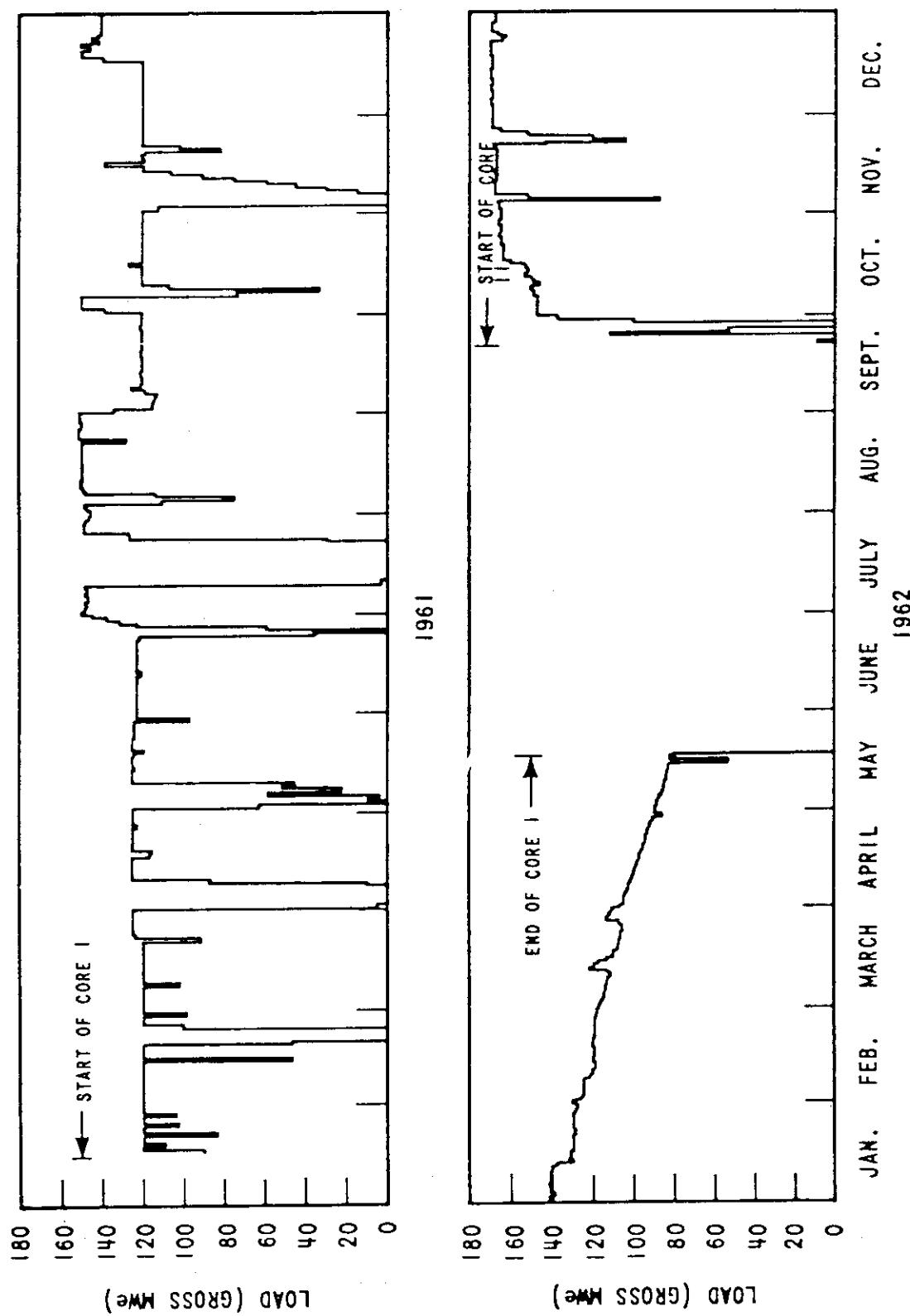


Fig. 3.1-2 Power history of Yankee core (1/3)

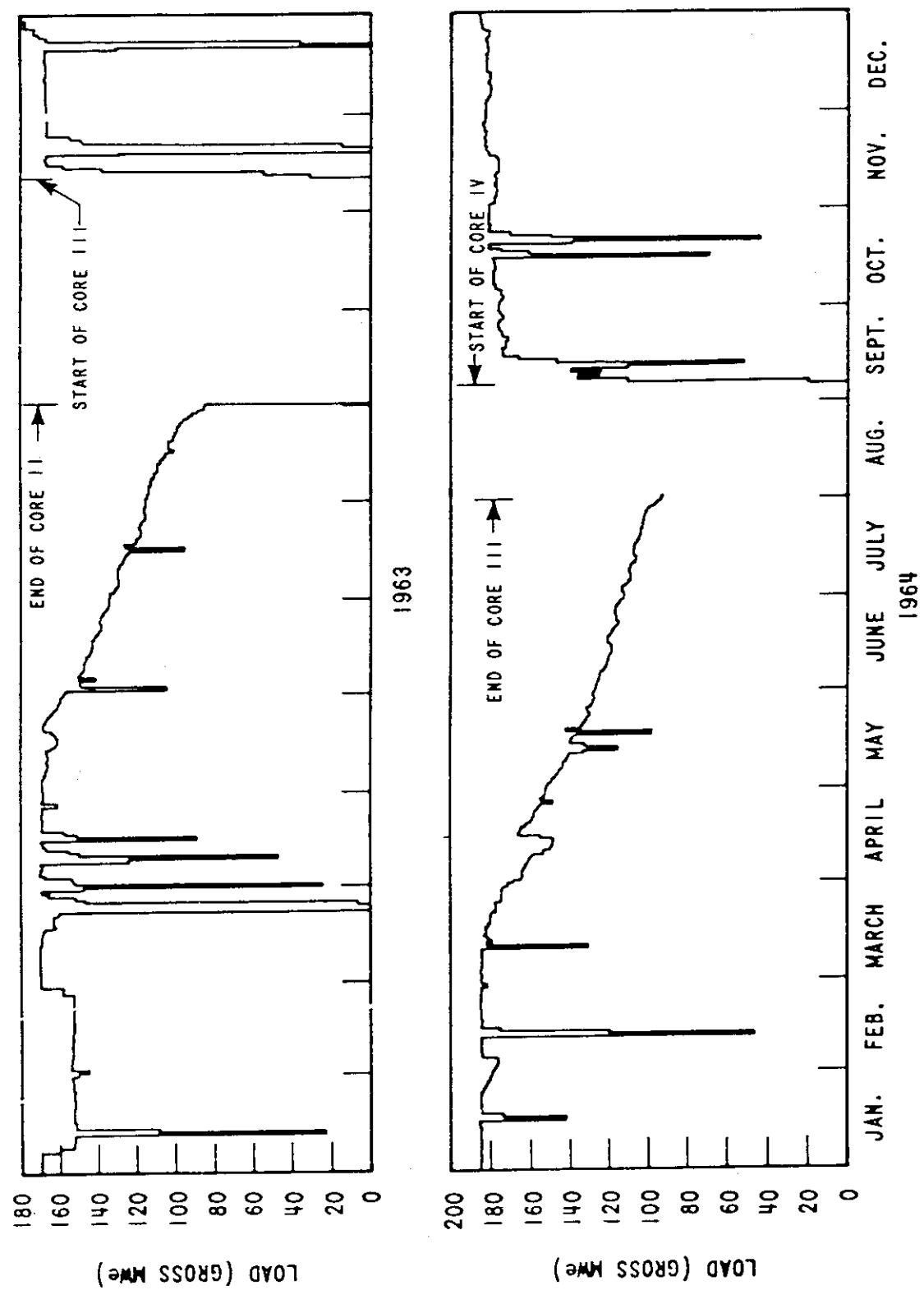


Fig. 3.1-2 Power history of Yankee core (2/3)

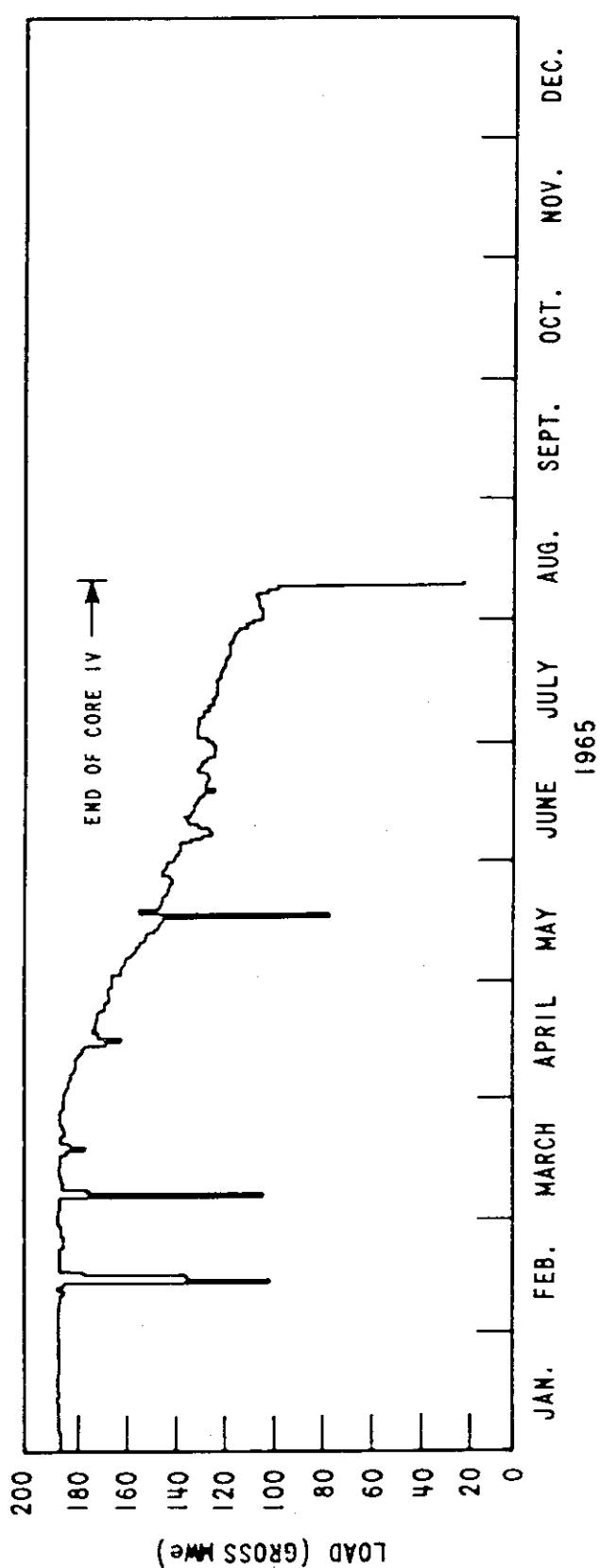


Fig. 3.1-2 Power history of Yankee core (3/3)

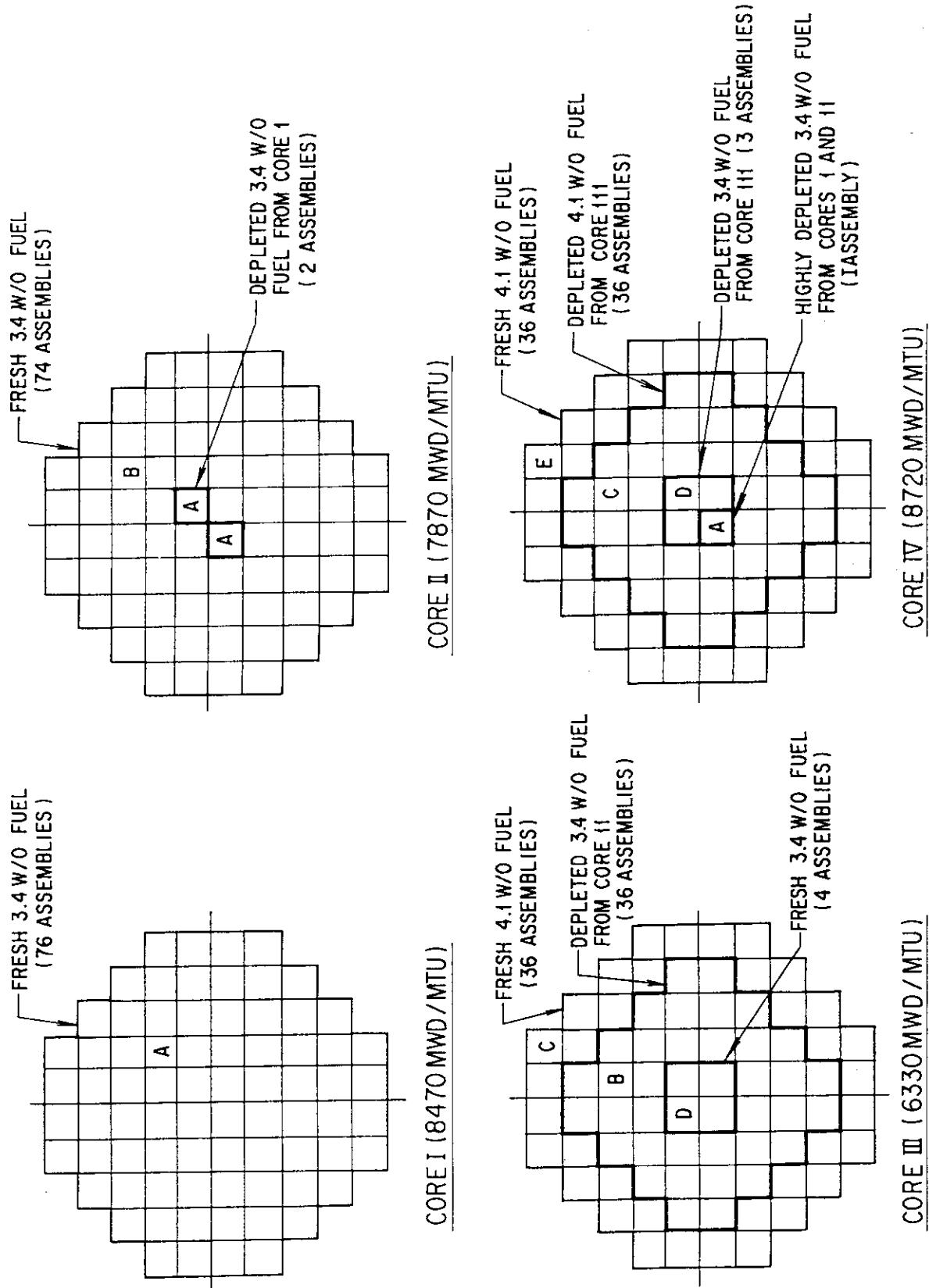


Fig. 3.1-3 Fuel cycling in four Yankee cores

NOTE: THE 8 PHASE III RODS ARE IN ASSEMBLY E6.
 THE 7 PHASE II RODS ARE IN ASSEMBLY F5.
 THE 56 PHASE I RODS ARE IN THE REMAINING 14 ASSEMBLIES
 AS SHOWN.

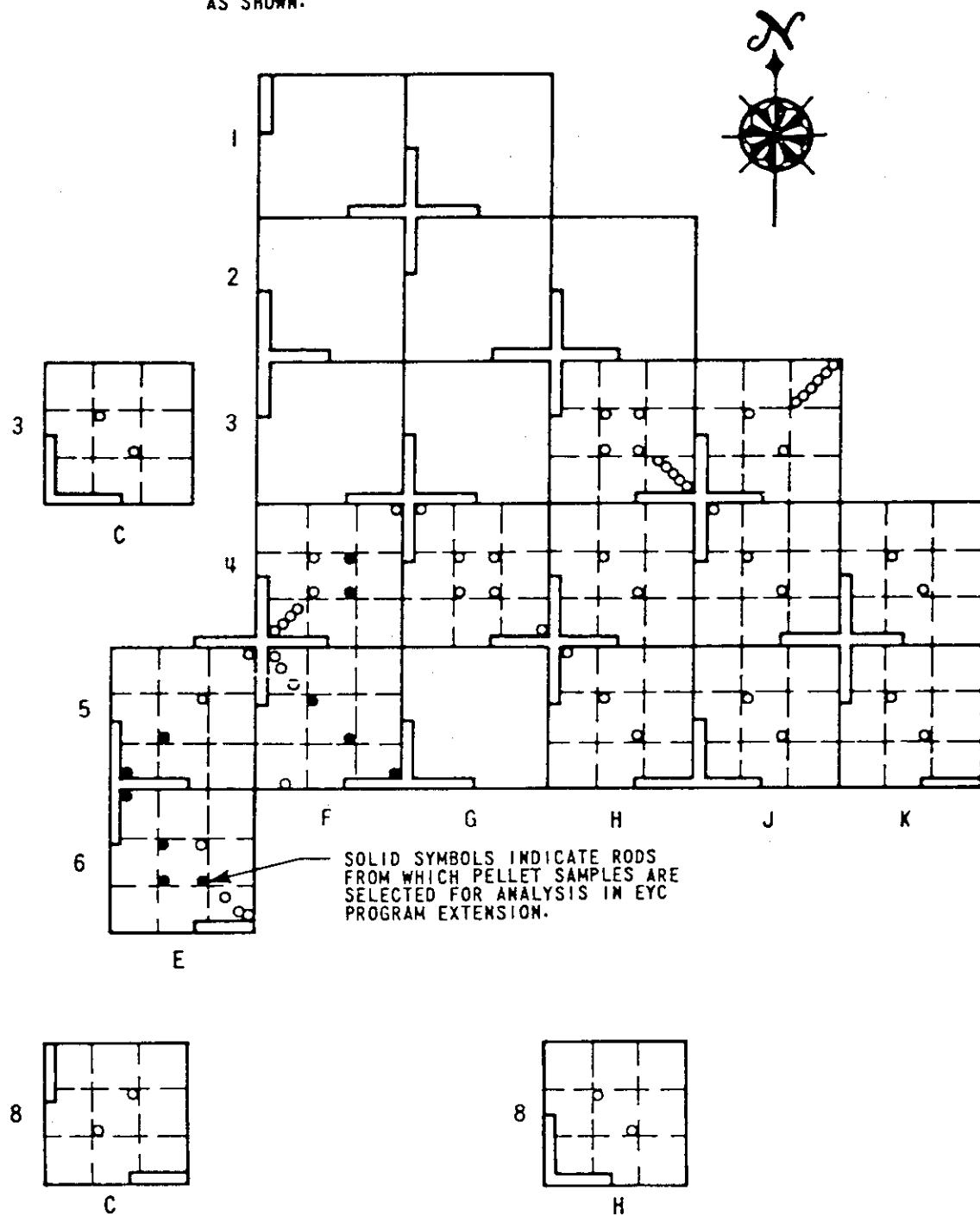


Fig. 3.1-4 Core location of EYC fuel rods selected
 for post-irradiation analyses

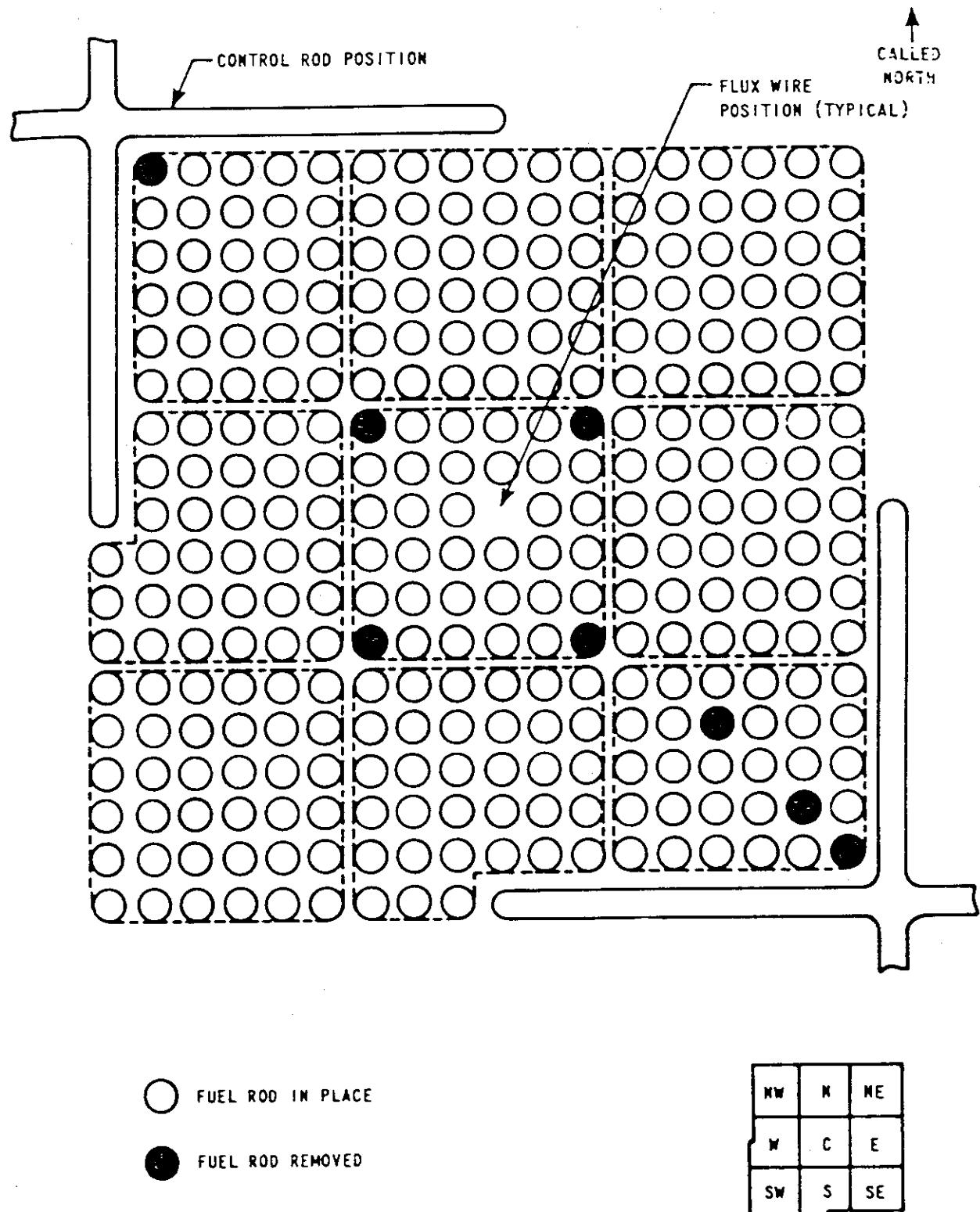


Fig. 3.1-5 Plan view of EYC phase 3 fuel assembly showing locations of fuel rods removed for physics analysis

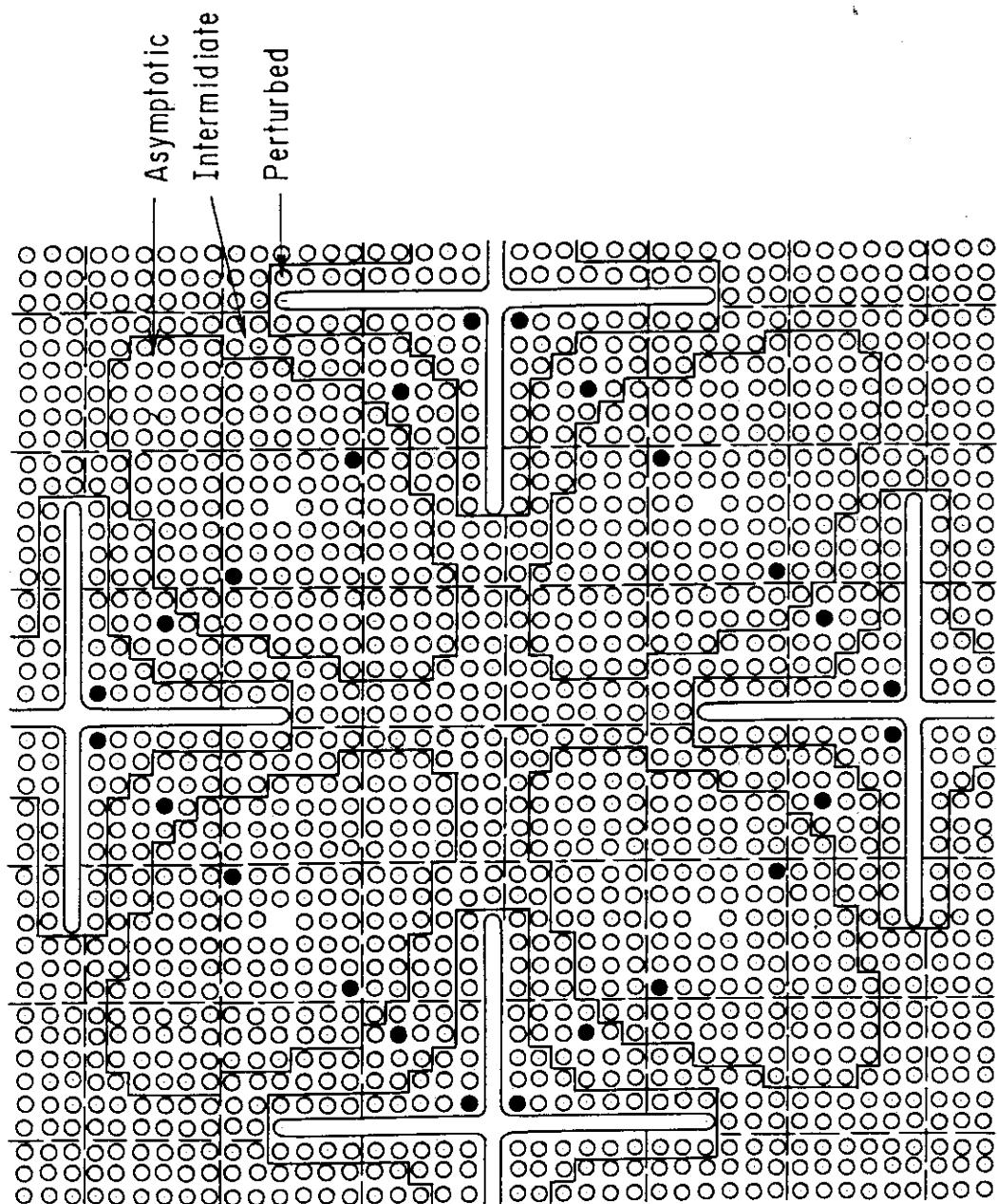


Fig. 3.1-6 Junction of four fuel assemblies showing the division of lattice into characteristic regions

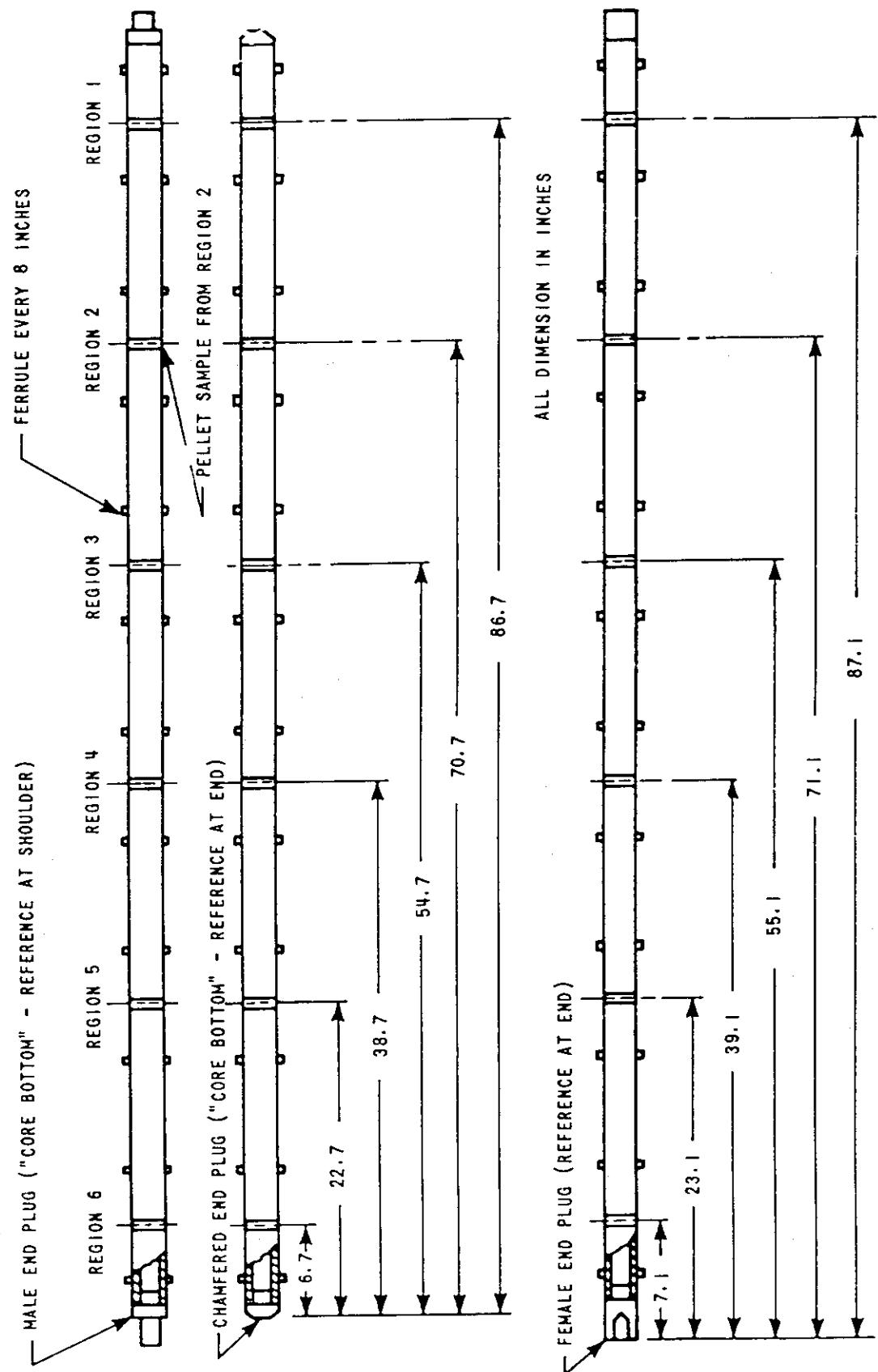


Fig. 3.1-7 Axial location of spent fuel samples within a fuel rod

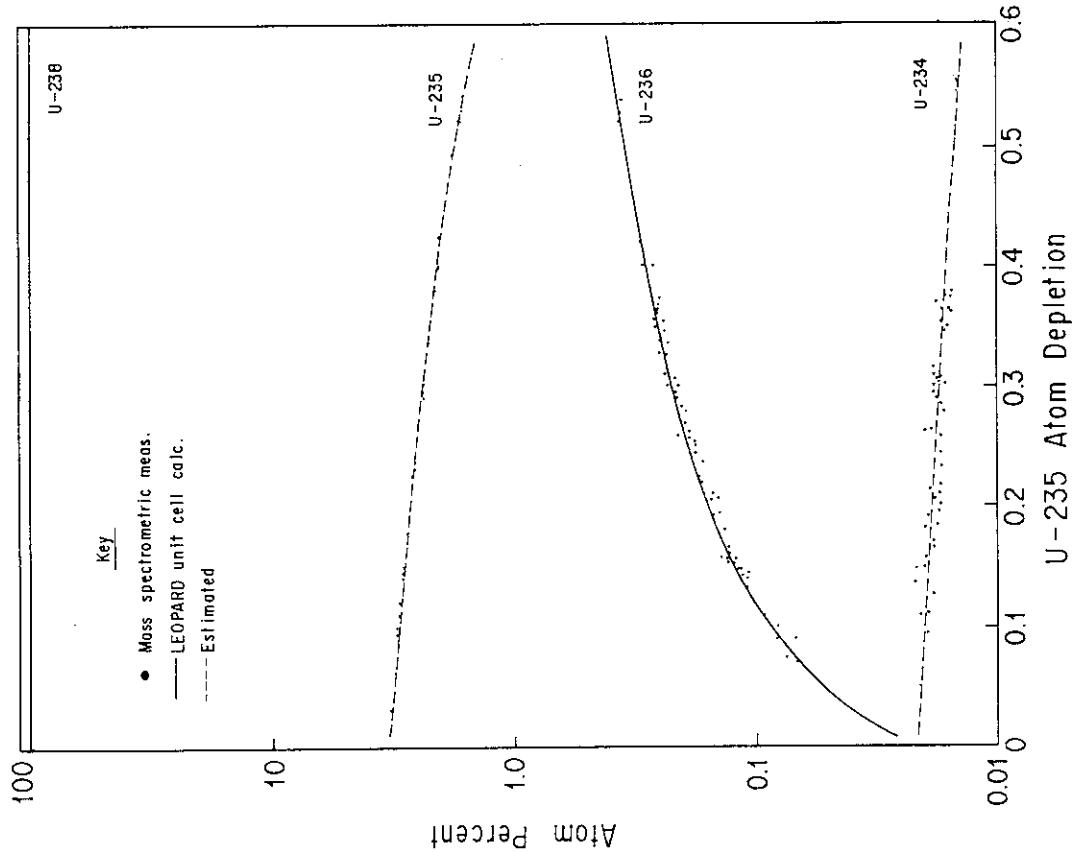


Fig. 3.1-8 Uranium composition versus U-235 atom depletion in the Yankee asymptotic neutron spectrum

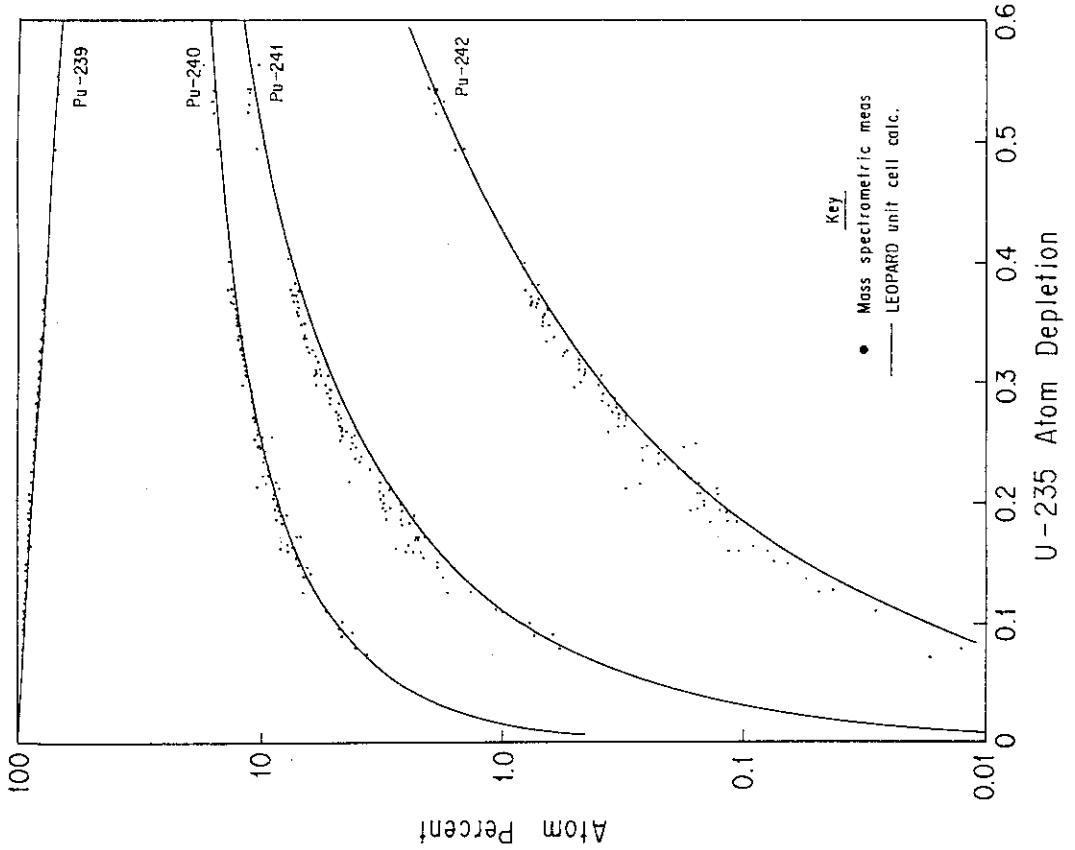


Fig. 3.1-9 Plutonium composition versus U-235 atom depletion in the Yankee asymptotic neutron spectrum

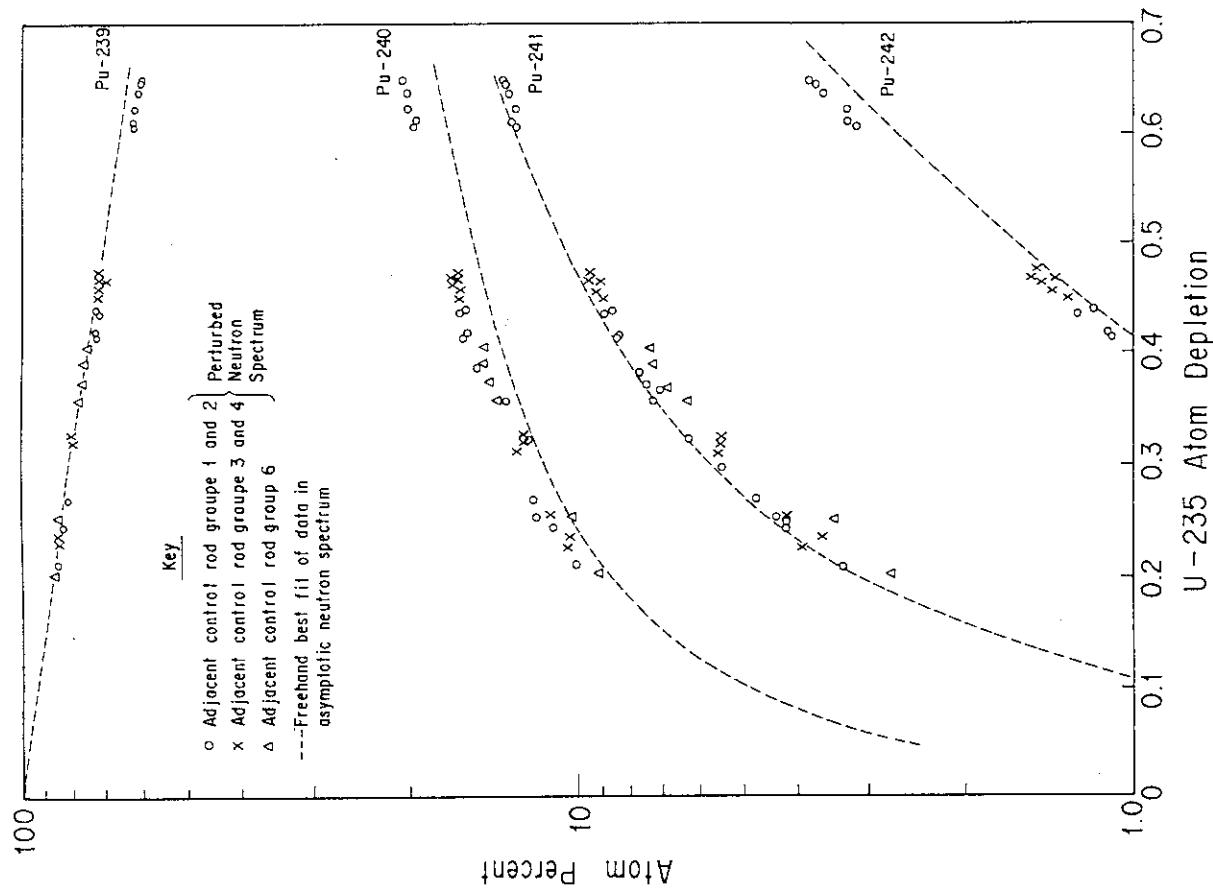


Fig. 3.1-10 Plutonium composition versus U-235 atom depletion in the Yankee perturbed neutron spectrum

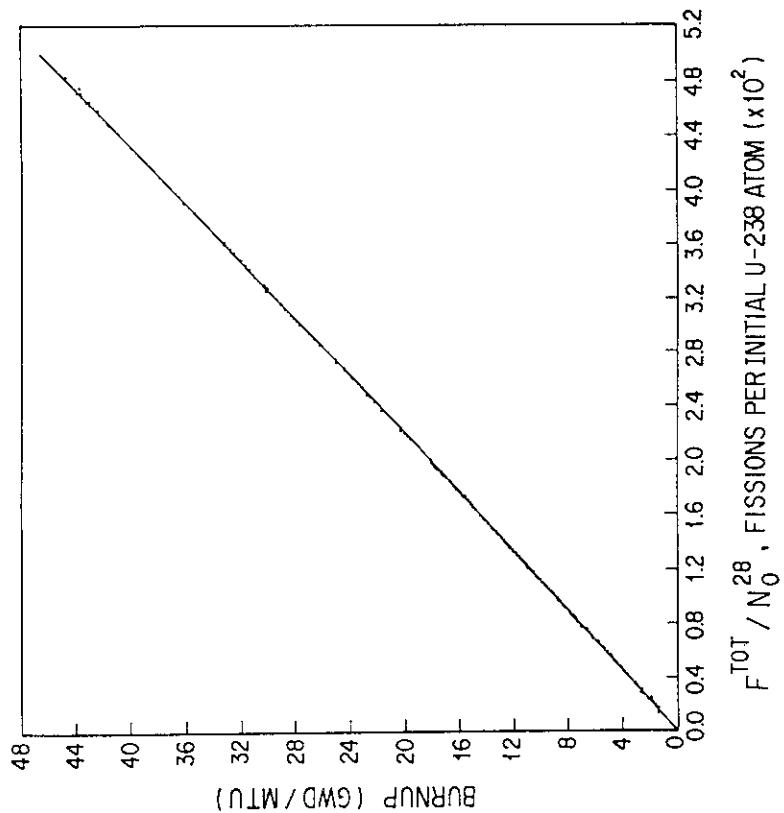


Fig. 3.1-11 Fuel burnup versus total accumulated fissions

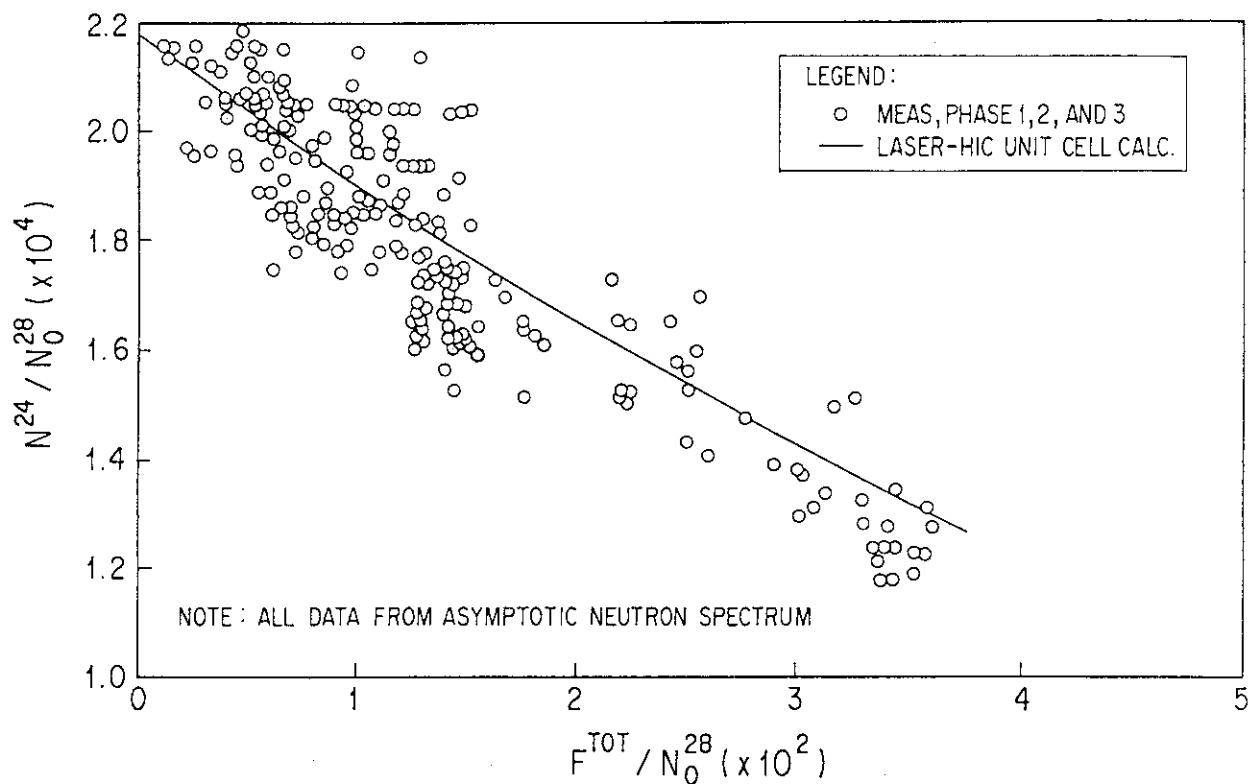


Fig. 3.1-12 U-234 concentrations versus accumulated fissions

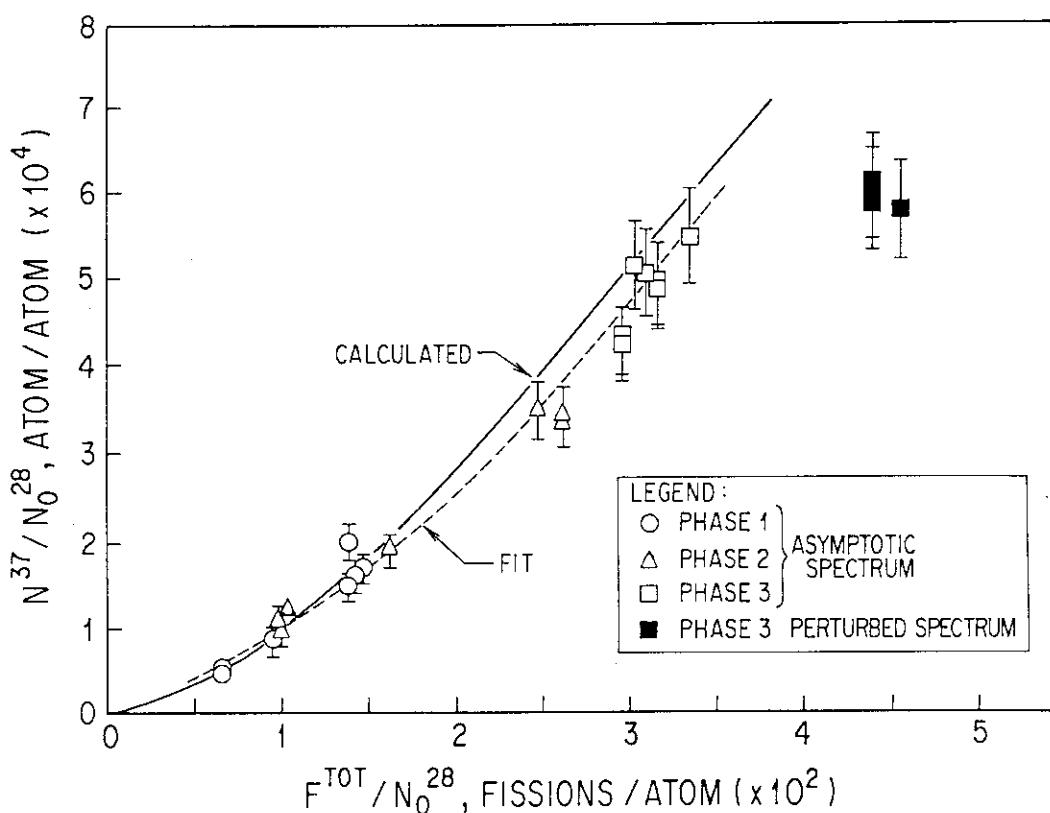


Fig. 3.1-13 Calculated and measured Np-237 as a function of accumulated fissions

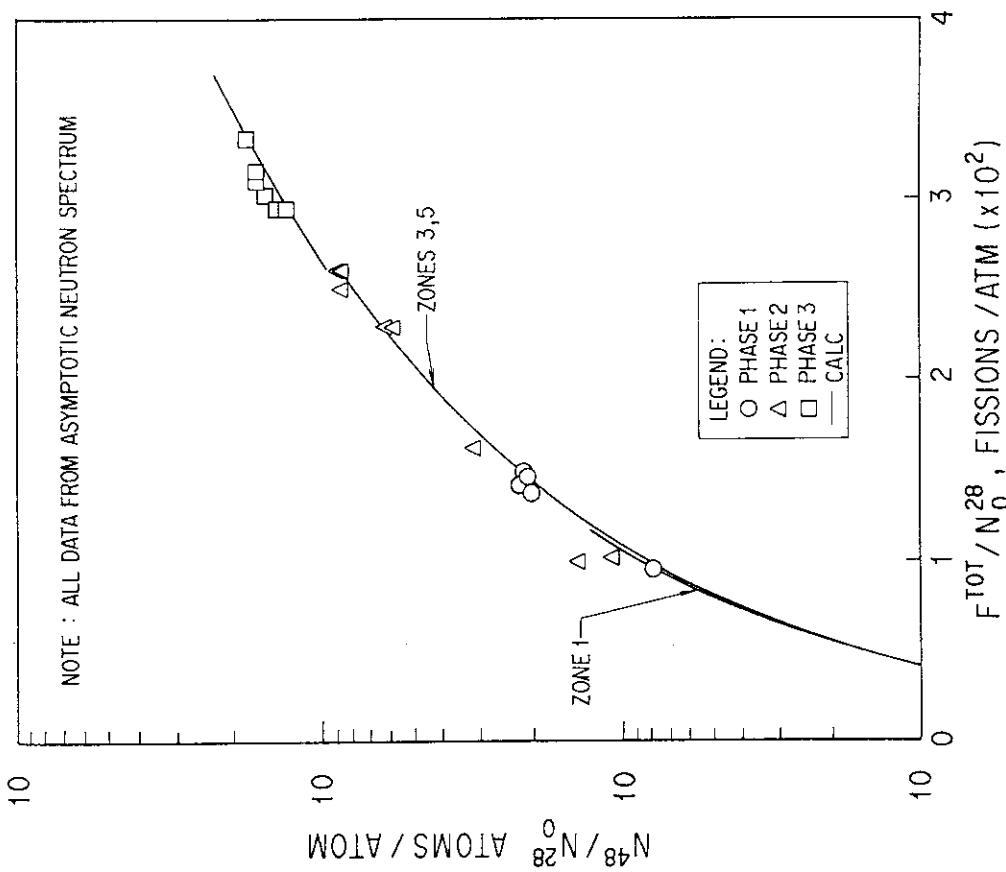


Fig. 3.1-14 Calculated and measured Pu-238 concentration as a function of accumulated fissions

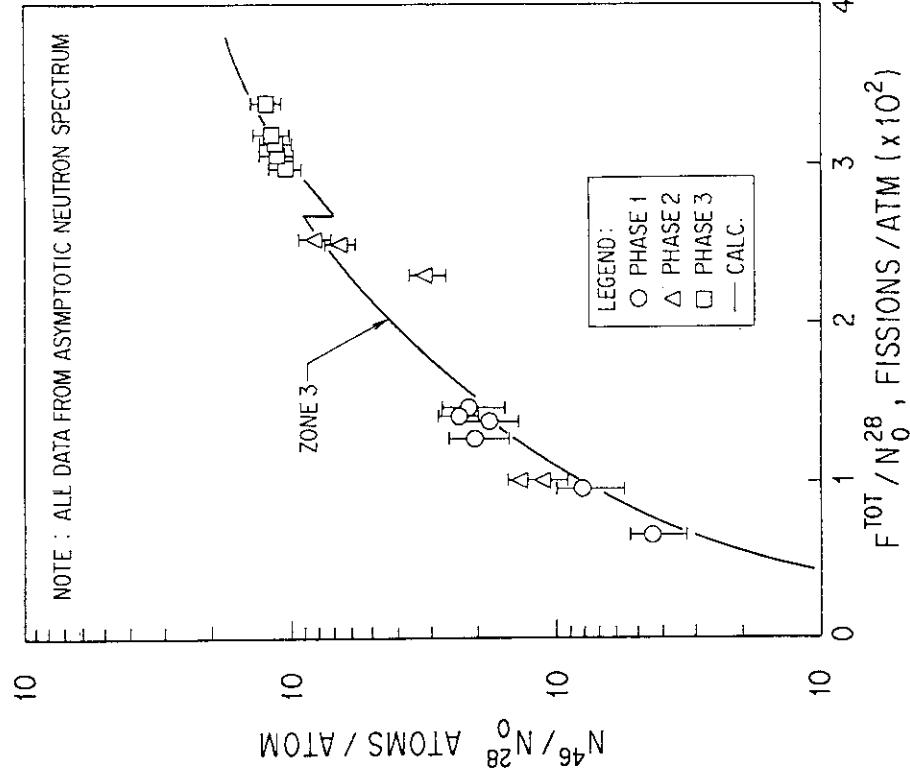


Fig. 3.1-15 Calculated and measured Pu-236 concentration as a function of accumulated fissions

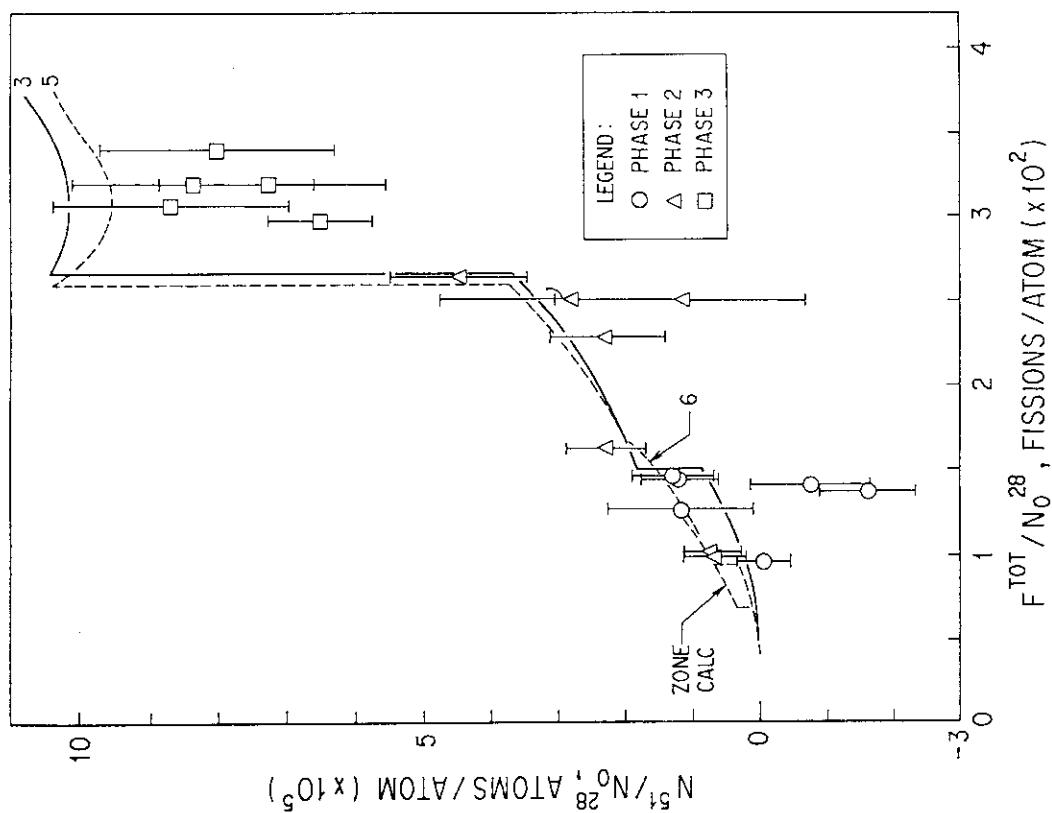


Fig. 3.1-17 Calculated and measured Am-241 concentration as a function of accumulated fissions

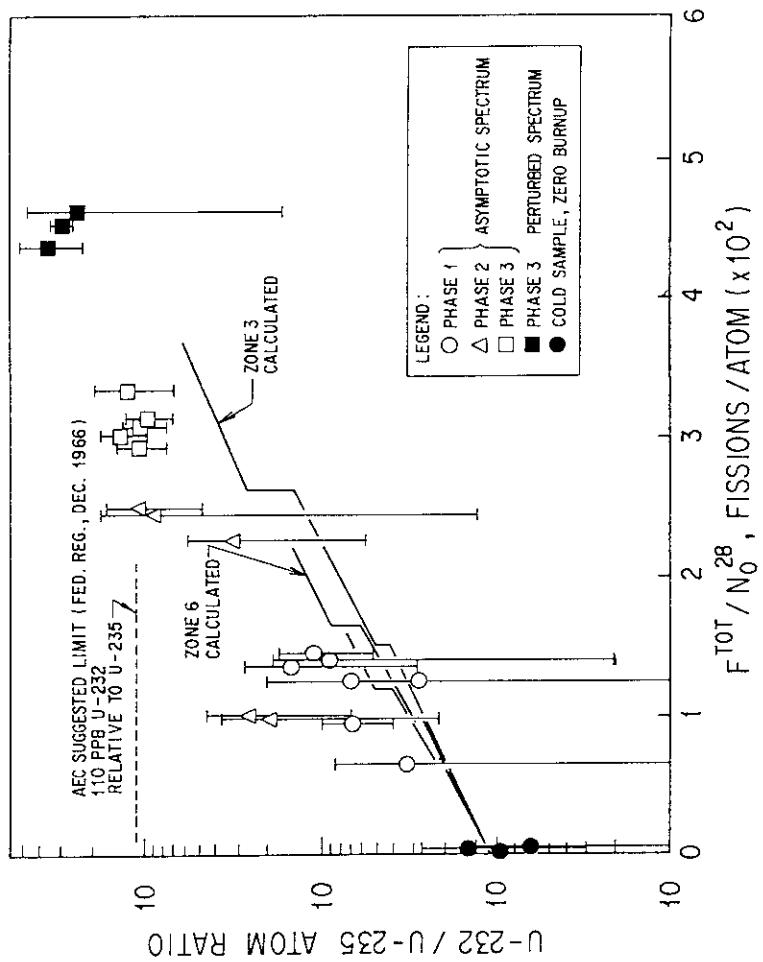


Fig. 3.1-16 Calculated and measured U-232 concentration versus total fissions

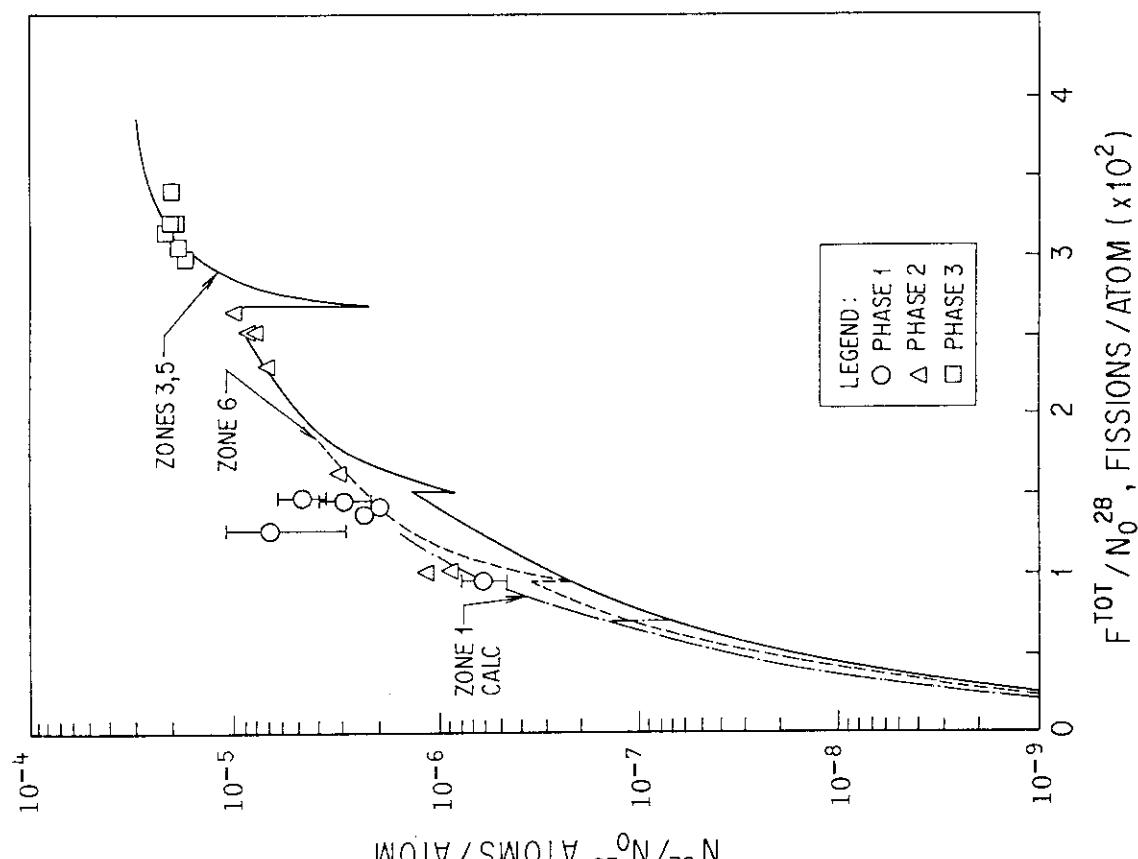


Fig. 3.1-18 Calculated and measured Am-243 concentration as a function of accumulated fissions

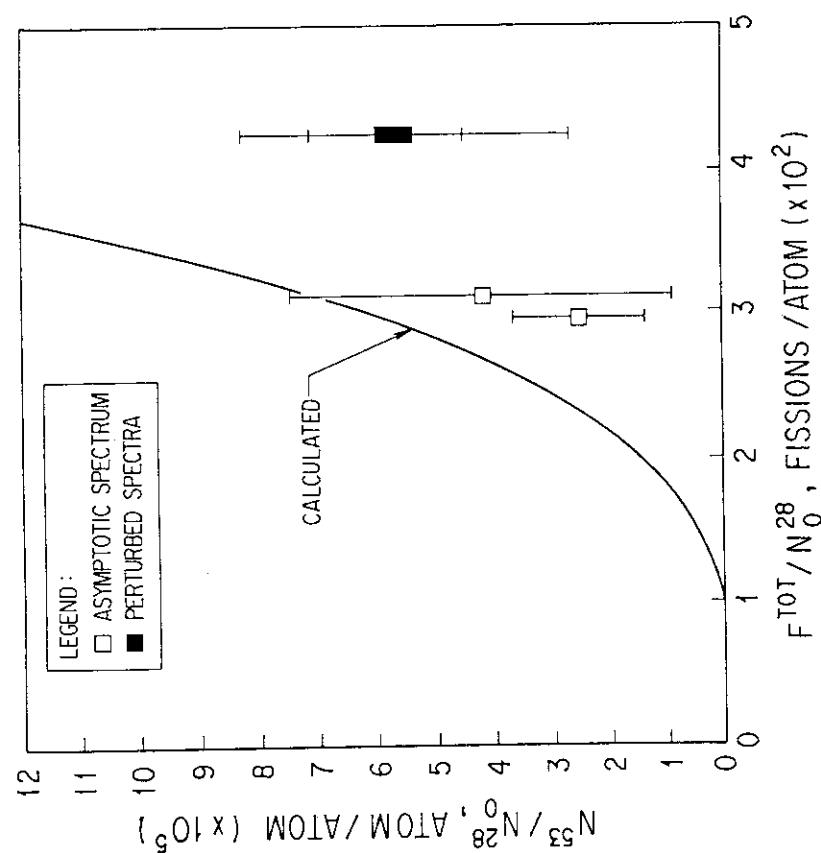


Fig. 3.1-19 Calculated and measured Cm-242 concentration as a function of accumulated fissions

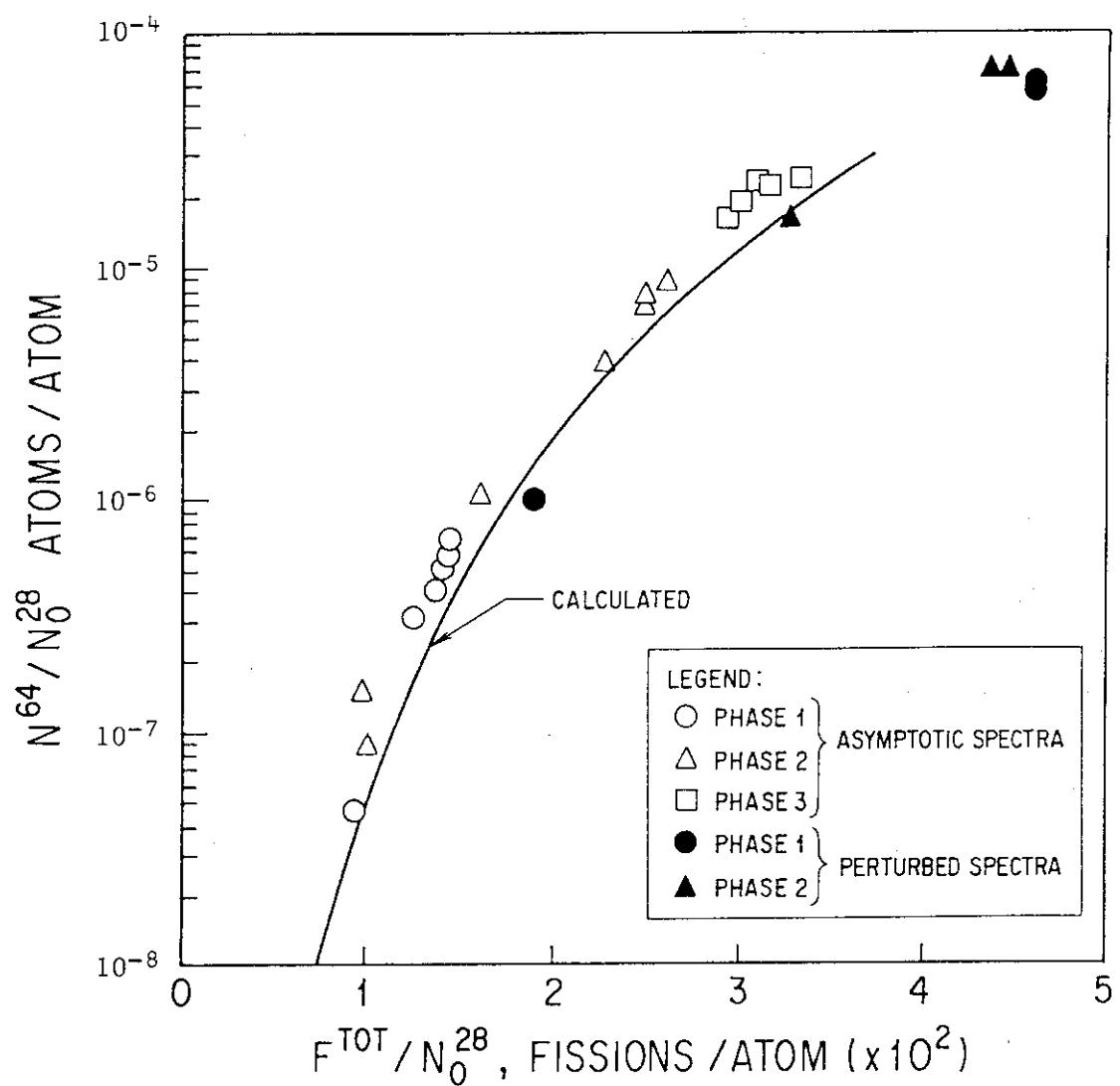


Fig. 3.1-20 Calculated and measured Cm-244 concentration as a function of accumulated fissions

3.2 Trino Vercellese炉(PWR)

Trino vercellese炉の測定はIspraとKarlsruheの両研究所で行われた。測定の主な目的は、計算法を評価するために選ばれた燃料サンプルの燃焼度と同位体組成を測定することだった。ガンマスペクトロメトリーは主に¹³⁷Cs放射能の決定に用いられた。これから燃焼度が求められた。質量分析法ではU, Pu, Am及びNd, Krガス, Xeガスの濃度及び同位体組成が求められた。アルファスペクトロメトリーがPu, Am及びCmのいくつかの核種の放射能を決定するために用いられた。重元素同位体と¹⁴⁸Ndの濃度はそれぞれ種類の異なる燃焼度評価に使われた。

なお、本節で使用した図表は次の文献から転載した。

- 3) A. M. Besesti et.al: "Post-irradiation Analysis of Trino Vercellese Reactor Fuel Elements", EUR4909e(1972).
- 4) P. Barbero et.al: "Post-irradiation Examination of the Fuel Discharged from the Trino Vercellese Reactor after the 2nd Irradiation Cycle", Nuclear Science and Technology, EUR5605e(1977).

3.2.1 炉心構成と炉心性能

Trino Vercellese炉は1964年6月臨界となり、1964年10月～1967年4月までの第1サイクルで平均11.6GWd/tUの燃焼度を達成した。燃焼に伴う反応度補償は、制御棒の引き抜きと減速材中のボロン濃度制御で行う。Table 3.2-1に炉心構成と炉心性能を示す。また、炉心の構成図、燃料集合体寸法図及びサンプル燃料集合体をFig. 3.2-1に示す。炉心は、第1サイクルでは全ての位置に燃料集合体が装荷されており、第2サイクルではX印の位置にダミー燃料集合体が装荷されている。

3.2.2 燃焼履歴とサンプリング燃料の配置

Table 3.2-2に第1サイクルの運転履歴を、サンプル燃料集合体をFig. 3.2-1に示す。サンプル集合体は4体、509-104(炉心位置L-7), 509-032(H-10), 509-049(G-7)及び509-069(C-5, D-4)である。Table 3.2-3に燃料集合体No. 509-069だけが第2サイクルまで照射され、その他3体は第1サイクルのみの照射履歴をもつ。燃料集合体No. 509-069の照射履歴をTable 3.2-3に示す。また、第1及び第2サイクルの運転履歴をFig. 3.2-2及びFig. 3.2-3に示す。

サンプル燃料の位置はFig. 3.2-1に図示されている。また、軸方向サンプリング位置は、軸方向に燃料棒を10等分する9断面の位置が上から順に1～9と番号付けされて示される。燃料サンプルの位置及び計算された燃焼度はTable 3.2-4に示す。

3.2.3 核種組成データ

測定はIspraとKarlsruheの2つの研究所で行われた。

Table 3.2-5に3種類の方法で測定された燃焼度を示す。Teoreticalは運転管理データを用いて計算した値である。Table 3.2-6にFP核種の放射能を、Table 3.2-7にFPガス(Kr, Xe)の同位体組成を示す。Table 3.2-8に²³⁹Pu及び¹⁴⁸Ndの²³⁸Uに対する比またはPu/U比を示す。UとPuの同位体組成をTable 3.2-9に、U同位体の蓄積、減損をTable 3.2-10に示す。また、Pu同位体の初期Uに対する比をTable 3.2-11に、AmとCmの初期Uに対する比をTable 3.2-12に示す。

Fig. 3.2-4～Fig. 3.2-10に核種間の相関を示す。また、Fig. 3.2-11～Fig. 3.2-13に燃焼に伴う核種の減損または生成量を示す。

Table 3.2-1 Core Composition and Performance(Trino Vercellese)

| Core Type | Cycle I | Cycle II | Core Type | Cycle I | Cycle II | | |
|--|--|--|--|---|------------------------------|---|---|
| Fuel Pellet UO ₂ density Linear density Diameter Length of pellet stack in fuel rod Clad-pellet clearance | (g/cm ³) (g/cm) (cm) (cm) (cm) (cm) | 6.6 0.89 0.89 264.1 0.006 | 6.6 0.89 264.1 0.006 | Cruciform Fuel Assembly Number of fuel rods Fuel length Rod outer diameter UO ₂ weight Initial enrichment | (cm) (cm) (kg) (%) | 26 240.3 1.092 44.0 2.72 | 26 240.3 1.092 44.0 2.72 |
| Fuel Clad | | | Control Rod Absorbing material | | | Ag-In-Cd | Ag-In-Cd |
| Outside diameter Inside diameter Wall thickness Material | (cm) (cm) (cm) SUS304 | 0.9786 0.902 0.0383 SUS304 | 0.9786 0.902 0.0383 SUS304 | Core Equivalent diameter Active height No. of square assemblies No. of cruciform assemblies No. of control rods | (cm) (cm) (cm) | 249.9 264.9 120 52 28 42,321 | 240.0 264.9 112 52 28 39,626 |
| Square Fuel Assembly Rod array Number of rods Fuel rod pitch Side of square | 15 × 15 208 1.303 | 15 × 15 208 1.303 | 15 × 15 208 1.303 | UO ₂ in square assemblies(kg) UO ₂ in cruciform assemblies(kg) | (kg) | 2,313 44,634 39,873 | 2,313 41,939 36,968 |
| cross section Total length UO ₂ weight Initial enrichent (reloaded assembly+) Channel material Channel mat. thickness | (cm) (cm) (kg) (%) 3.90 SUS304 | 20.0 320.88 353.81 2.72/3.13/ 3.90 3.90/4.00+ SUS304 | 20.0 320.88 353.81 2.72/3.13/ 3.90 3.90/4.00+ SUS304 | Total UO ₂ weight Total U weight Core Thermo-hydraulic Characteristics | (kg) (kg) (kg) | 2,313 44,634 39,873 | 2,313 41,939 36,968 |
| | | | Power | (MWth) | 825 | 825 | |
| | | | Coolant pressure Coolant temperature(ave., °C) (inlet, °C) (outlet, °C) | (kg/cm ²) (°C) (°C) | 140 282 266.5 297.5 | 140 282 266.5 297.5 | |

Table 3.2-2 Summary of cycle 1 operation

| Period | I | II | III |
|---|-----------------|-----------------|-----------------|
| Date | 23.10.64-5.6.65 | 31.8.65-20.5.66 | 11.7.66-28.4.67 |
| Max. power level (MWth) | 615 | 825 | 825 |
| Coolant avg. temp. (°C) | 282 | 278 | 278 |
| Control group insertion | 30% | 4% | 4% |
| Approx. boron concentration (ppm) | 1300 ÷ 1050 | 1150 ÷ 650 | 650 ÷ 0 |
| Core burnup (MWd/t(U)) | 2260 | 4085 | 5245 |

Table 3.2-3 Irradiation history of the fuel assembly
No. 509-069

| Periods | Days | Core Burn-up MWD/MTU | Cycle Operation | Coolant Avg. Temp. |
|----------------------|------|-------------------------|--------------------|-----------------------|
| 23.10.64 05.06.65 | 226 | 2.726 | | |
| 06.06.65 30.08.65 | 86 | - | | |
| 31.08.65 20.05.66 | 263 | 4.927 | FIRST | 278°C |
| 21.05.66 10.07.66 | 51 | - | | |
| 11.07.66 28.04.67 | 292 | 6.327 | | |
| 29.04.67 19.05.70 | 1117 | - | SHUT- DOWN | |
| 20.05.70 09.07.71 | 416 | 7.720 | SECOND | 269°C |

Table 3.2-4 Sampling Position and their Burnup (MWd/tU)

| 509-049 2.719 w% | | | | 509-032 3.13 w% | | | | 509-104 3.897 w% | | | | |
|------------------|------------|--------|--------|-----------------|--------------------------------|------------------------|------------|--------------------------------|------------------------|------------|---------------------------|-------|
| Position | I | K | I | K | I | K | I | K | I | K | I | K |
| Top 1 | 8,080 | | 8,970 | | 8,230 | 8,230 | 7,180 | | | | | 3,420 |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | 14,080 | 14,080 | 14,570 | | | | 15,170 | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | | | | 14,980 | 15,290 | 15,690 | | 17,180 | | 17,730 | |
| 8 | | | | | | | | | | | | |
| Bottom 9 | 10,070 | 10,070 | L5 | J9 | 11,000 | 11,900 | | 11,400 | | 12,220 | | |
| RODS | | | | | A1 | A1 | E11 | H9 | H9 | 015 | M11 | A12 |
| NEUTRON SPECTRUM | Asymptotic | | | | Intermediate (near water hole) | Perturbed (corner rod) | Asymptotic | Intermediate (near water hole) | Perturbed (corner rod) | Asymptotic | Perturbed (core edge rod) | A12 |

SELECTED FUEL SAMPLES (TRINO VERCSELSE PWR)

| 509-032 3.13 w% | | | | | | | |
|-----------------|------------|--------|--------|------------|--------|------------------------|--------------------------------|
| I | K | I | K | I | K | I | K |
| | | | 16,200 | | | | 19,700 |
| | | | | 22,200 | 22,200 | | |
| 23,000 | 22,500 | | 23,300 | 23,300 | | 23,000 | |
| | | | 23,200 | | | | 24,200 |
| 23,100 | 23,100 | 22,600 | | 23,400 | 23,400 | 23,100 | |
| 19,800 | | | | | 23,100 | | 24,200 |
| E5 | E5 | L5 | L5 | E11 | E11 | L11 | A1 |
| Asymptotic | Asymptotic | | | Asymptotic | | Perturbed (corner rod) | Intermediate (near water hole) |

Table 3.2-5 Burnup Values (MWD/MTU) Obtained by Independent Experimental Techniques

| FUEL ELEMENT | SAMPLE | LAB. | Nd-148 | Cs-137 Destructive | Cs-137 Non-destructive | Theoretical |
|--------------------|--------|-----------|--------|--------------------|------------------------|-------------|
| 509-049 2.719w% | L5 1 | Ispra | | 7,822 | 7,987 | 8,080 |
| | L5 4 | Ispra | 14,155 | 14,099 | 14,645 | 14,080 |
| | L5 4 | Karlsruhe | 14,490 | 13,883 | | 14,080 |
| | L5 9 | Ispra | | 10,478 | 11,252 | 10,070 |
| | L5 9 | Karlsruhe | 10,187 | 10,444 | | 10,070 |
| | J9 1 | Ispra | 8,713 | 8,307 | 8,584 | 8,970 |
| | J9 4 | Ispra | 14,770 | 14,644 | 15,024 | 14,570 |
| | J9 7 | Ispra | | | 15,442 | 14,980 |
| | J9 7 | Karlsruhe | 15,193 | 15,007 | | 14,980 |
| | J9 9 | Ispra | | | 10,706 | 11,000 |
| | J9 9 | Karlsruhe | 11,127 | 11,142 | | 11,000 |
| | A1 1 | Ispra | 8,895 | 8,879 | 8,509 | 8,230 |
| | A1 1 | Karlsruhe | 7,814 | 7,716 | | 8,230 |
| | A1 7 | Ispra | | 16,146 | 16,531 | 15,290 |
| | A1 7 | Karlsruhe | 15,506 | 15,740 | | 15,290 |
| | A1 9 | Ispra | 12,053 | 11,860 | 11,324 | 11,900 |
| 509-032 3.13w% | E11 1 | Ispra | 7,243 | 7,415 | 7,430 | 7,180 |
| | E11 4 | Ispra | 15,377 | 15,156 | 14,697 | 15,170 |
| | E11 7 | Ispra | 15,898 | 15,477 | 15,251 | 15,690 |
| | E11 9 | Ispra | 11,529 | 11,226 | 12,119 | 11,400 |
| | H9 4 | Ispra | | | 16,719 | 16,320 |
| | H9 4 | Karlsruhe | 16,556 | 16,400 | | 16,320 |
| | H9 7 | Ispra | 17,450 | 17,064 | 16,885 | 17,180 |
| | H9 9 | Ispra | 12,366 | 12,219 | 12,415 | 12,220 |
| | O15 7 | Ispra | 17,995 | 17,715 | 18,613 | 17,730 |
| | M11 7 | Ispra | 11,912 | 12,035 | 12,606 | 11,920 |
| 509-104 3.897w% | M11 7 | Karlsruhe | 12,172 | 12,242 | | 11,920 |
| | A12 1 | Ispra | 3,435 | 3,717 | 3,236 | 3,420 |
| | A12 1 | Ispra | 7,605 | 7,411 | 7,327 | 7,550 |
| | | | | | | |
| 509-069 3.13w% | E5 4 | Ispra | 23,867 | 23,715 | 22,640 | 23,000 |
| | E5 7 | Ispra | | 24,693 | 23,380 | 23,100 |
| | E5 7 | Karlsruhe | 24,548 | 24,683 | | 23,100 |
| | E5 9 | Ispra | 19,208 | 19,254 | 19,250 | 19,800 |
| | L5 4 | Ispra | 24,330 | 23,988 | 24,070 | 22,500 |
| | L5 7 | Ispra | | 24,313 | 24,230 | 22,600 |
| | E11 1 | Ispra | | 12,859 | 15,030 | 16,200 |
| | E11 2 | Ispra | | 20,628 | 21,200 | 22,200 |
| | E11 2 | Karlsruhe | 20,602 | 21,296 | | 22,200 |
| | E11 4 | Ispra | | 23,557 | 23,990 | 23,300 |
| | E11 4 | Karlsruhe | 23,718 | 23,969 | | 23,300 |
| | E11 5 | Ispra | 24,518 | 24,250 | | 23,200 |
| | E11 7 | Ispra | | 23,953 | 22,822 | 23,400 |
| | E11 7 | Karlsruhe | 24,304 | 25,095 | | 23,400 |
| | E11 8 | Karlsruhe | 23,406 | 23,818 | 21,840 | 23,100 |
| | E11 9 | Karlsruhe | 19,250 | 20,060 | 19,150 | 20,100 |
| | L11 4 | Karlsruhe | 23,928 | 24,050 | 25,770 | 23,000 |
| | L11 7 | Ispra | 24,023 | 24,471 | 25,290 | 23,100 |
| | L11 7 | Karlsruhe | 24,700 | 24,532 | | 23,100 |
| | A1 1 | Ispra | | 15,170 | 16,320 | 19,700 |
| | A1 7 | Karlsruhe | 26,884 | 27,758 | 27,090 | 25,600 |
| | J9 4 | Ispra | | 24,849 | 25,030 | 24,200 |
| | J9 7 | Karlsruhe | 25,258 | 25,386 | 25,340 | 24,200 |

Table 3.2-6 Specific Activities of Fission Products dis/sec/g
Final Uranium at Reactor Shut-down and Activity Ratios

| FUEL ELEMENT | SAMPLE | LAB. | Ce-144 x10E10 | Ru-106 x10E9 | Cs-137 x10E9 | Cs-134 x10E9 | Eu-154 x10E8 | Cs-134 /Cs-137 | Eu-154 /Cs-137 x10E-2 |
|--------------------|--------|-----------|------------------|-----------------|-----------------|-----------------|-----------------|----------------|--------------------------|
| 509-049 2.719w% | L5 1 | Ispra | 1.587 | 3.848 | .947 | .507 | | .535 | |
| | L5 4 | Ispra | 2.475 | 8.214 | 1.732 | 1.580 | | .912 | |
| | L5 4 | Karlsruhe | | | | | | | |
| | L5 9 | Ispra | 1.965 | 5.513 | 1.277 | .855 | | .670 | |
| | L5 9 | Karlsruhe | | | | | | | |
| | J9 1 | Ispra | 1.687 | 4.144 | 1.010 | .585 | | .579 | |
| | J9 4 | Ispra | 2.549 | 8.769 | 1.798 | 1.698 | | .944 | |
| | J9 7 | Ispra | | | | | | | |
| | J9 7 | Karlsruhe | | | | | | | |
| | J9 9 | Ispra | | | | | | | |
| | J9 9 | Karlsruhe | | | | | | | |
| | A1 1 | Ispra | 1.795 | 4.514 | 1.080 | .611 | | .566 | |
| | A1 1 | Karlsruhe | | | | | | | |
| | A1 7 | Ispra | 2.731 | 9.842 | 1.987 | 1.913 | | .963 | |
| | A1 7 | Karlsruhe | | | | | | | |
| | A1 9 | Ispra | 2.257 | 6.549 | 1.450 | 1.062 | | .732 | |
| 509-032 3.13w% | E11 1 | Ispra | 1.621 | 3.119 | .899 | .455 | | .506 | |
| | E11 4 | Ispra | 2.716 | 8.029 | 1.876 | 1.765 | | .941 | |
| | E11 7 | Ispra | 2.660 | 8.584 | 1.902 | 1.869 | | .983 | |
| | E11 9 | Ispra | 2.098 | 5.846 | 1.369 | 1.021 | | .746 | |
| | H9 4 | Ispra | | | | | | | |
| | H9 4 | Karlsruhe | | | | | | | |
| | H9 7 | Ispra | 2.912 | 9.102 | 2.102 | 2.105 | | 1.001 | |
| | H9 9 | Ispra | 2.375 | 6.364 | 1.491 | 1.129 | | .757 | |
| | O15 7 | Ispra | 3.067 | 9.250 | 2.183 | 2.253 | | 1.032 | |
| | | | | | | | | | |
| 509-104 3.897w% | M11 7 | Ispra | 2.179 | 5.291 | 1.469 | 1.029 | | .700 | |
| | M11 7 | Karlsruhe | | | | | | | |
| | A12 1 | Ispra | .881 | 1.092 | .444 | .082 | | .185 | |
| | A12 1 | Ispra | 1.428 | 2.342 | .895 | .302 | | .337 | |
| 509-069 3.13w% | E5 4 | Ispra | | | 2.788 | 2.939 | 1.765 | 1.054 | 6.332 |
| | E5 7 | Ispra | | | 2.909 | 3.054 | 1.919 | 1.050 | 6.596 |
| | E5 7 | Karlsruhe | | | | | | | |
| | E5 9 | Ispra | | | 2.248 | 1.965 | 1.149 | .974 | 5.111 |
| | L5 4 | Ispra | | | 2.821 | 2.939 | 1.768 | 1.042 | 6.267 |
| | L5 7 | Ispra | | | 2.862 | 3.005 | 1.843 | 1.050 | 6.461 |
| | E11 1 | Ispra | | | 1.486 | .941 | .517 | .633 | 3.479 |
| | E11 2 | Ispra | | | 2.418 | 2.312 | 1.398 | .956 | 5.782 |
| | E11 2 | Karlsruhe | | | | | | | |
| | E11 4 | Ispra | | | 2.775 | 2.914 | 1.779 | 1.050 | 6.411 |
| | E11 4 | Karlsruhe | | | | | | | |
| | E11 5 | Ispra | | | 2.864 | 3.030 | 1.568 | 1.058 | 5.475 |
| | E11 7 | Ispra | | | 2.818 | 2.987 | 1.650 | 1.060 | 5.855 |
| | E11 7 | Karlsruhe | | | | | | | |
| | E11 8 | Karlsruhe | | | | | | | |
| | E11 9 | Karlsruhe | | | | | | | |
| | L11 4 | Karlsruhe | | | | | | | |
| | L11 7 | Ispra | | | 2.881 | 3.048 | 1.718 | 1.058 | 5.963 |
| | L11 7 | Karlsruhe | | | | | | | |
| | A1 1 | Ispra | | | 1.765 | 1.248 | .568 | .707 | 3.218 |
| | A1 7 | Karlsruhe | | | | | | | |
| | J9 4 | Ispra | | | 2.927 | 3.132 | 1.686 | 1.070 | 5.760 |
| | J9 7 | Karlsruhe | | | | | | | |

Table 3.2-7 Isotopic Ratios of Fission Gases

| FUEL ELEMENT | SAMPLE | LAB. | Krypton | | | Xenon | | |
|--------------------|--------|-----------|---------|-------|-------|---------|---------|---------|
| | | | 83/86 | 84/86 | 85/86 | 131/134 | 132/134 | 136/134 |
| 509-049 2.719w% | L5 1 | Ispra | | | | | | |
| | L5 4 | Ispra | | | | | | |
| | L5 4 | Karlsruhe | .2571 | .5639 | .0947 | .3281 | .6619 | 1.4062 |
| | L5 9 | Ispra | | | | | | |
| | L5 9 | Karlsruhe | .2672 | .5665 | .1082 | .3406 | .6393 | 1.3510 |
| | J9 1 | Ispra | | | | | | |
| | J9 4 | Ispra | | | | | | |
| | J9 7 | Ispra | | | | | | |
| | J9 7 | Karlsruhe | .2550 | .5628 | .1043 | .3295 | .6660 | 1.4292 |
| | J9 9 | Ispra | | | | | | |
| | J9 9 | Karlsruhe | .2613 | .5555 | .1063 | .3416 | .6396 | 1.3659 |
| | A1 1 | Ispra | | | | | | |
| | A1 1 | Karlsruhe | .2667 | .5478 | .1084 | .3523 | .6170 | 1.2953 |
| | A1 7 | Ispra | | | | | | |
| | A1 7 | Karlsruhe | .2552 | .5716 | .1048 | .3240 | .6656 | 1.4476 |
| | A1 9 | Ispra | | | | | | |
| 509-032 3.13w% | E11 1 | Ispra | | | | | | |
| | E11 4 | Ispra | | | | | | |
| | E11 7 | Ispra | | | | | | |
| | E11 9 | Ispra | | | | | | |
| | H9 4 | Ispra | | | | | | |
| | H9 4 | Karlsruhe | .2547 | .5649 | .1057 | .3248 | .6659 | 1.4025 |
| | H9 7 | Ispra | | | | | | |
| | H9 9 | Ispra | | | | | | |
| | O15 7 | Ispra | | | | | | |
| | | | | | | | | |
| 509-104 3.897w% | M11 7 | Ispra | | | | | | |
| | M11 7 | Karlsruhe | .2657 | .5520 | .1051 | .3387 | .6334 | 1.2800 |
| | A12 1 | Ispra | | | | | | |
| | A12 1 | Ispra | | | | | | |
| 509-069 3.13w% | E5 4 | Ispra | | | | | | |
| | E5 7 | Ispra | | | | | | |
| | E5 7 | Karlsruhe | .2456 | .5881 | | .2957 | .7001 | 1.4113 |
| | E5 9 | Ispra | | | | | | |
| | L5 4 | Ispra | | | | | | |
| | L5 7 | Ispra | | | | | | |
| | E11 1 | Ispra | | | | | | |
| | E11 2 | Ispra | | | | | | |
| | E11 2 | Karlsruhe | .2518 | .5780 | | .3106 | .6937 | 1.3616 |
| | E11 4 | Ispra | | | | | | |
| | E11 4 | Karlsruhe | .2589 | .5950 | | .3063 | .7086 | 1.3920 |
| | E11 5 | Ispra | | | | | | |
| | E11 7 | Ispra | | | | | | |
| | E11 7 | Karlsruhe | .2459 | .5881 | | .3002 | .7092 | 1.3998 |
| | E11 8 | Karlsruhe | .2480 | .5856 | | .3051 | .7079 | 1.3828 |
| | E11 9 | Karlsruhe | .2534 | .5754 | | .3185 | .6840 | 1.3398 |
| | L11 4 | Karlsruhe | .2478 | .5875 | | .3001 | .7072 | 1.3884 |
| | L11 7 | Ispra | | | | | | |
| | L11 7 | Karlsruhe | .2464 | .5873 | | .3012 | .7114 | 1.3961 |
| | A1 1 | Ispra | | | | | | |
| | A1 7 | Karlsruhe | .2368 | .5932 | | .2927 | .7182 | 1.4400 |
| | J9 4 | Ispra | | | | | | |
| | J9 7 | Karlsruhe | .2438 | .5913 | | .3002 | .7126 | 1.4059 |

Table 3.2-8 Atom Ratios of Plutonium, Neodymium and Uranium from Mass Spectrometry

| FUEL ELEMENT | SAMPLE | LAB. | Nd-148 /U-238 ($\times 10E-4$) | Pu-239 /U-238 ($\times 10E-3$) | Total Pu/U Mass Ratio ($\times 10E-3$) |
|--------------------|--------|-----------|-------------------------------------|-------------------------------------|---|
| 509-049 2.719w% | L5 1 | Ispra | | | 4.362 |
| | L5 4 | Ispra | | | 6.895 |
| | L5 4 | Karlsruhe | | | 6.857 |
| | L5 9 | Ispra | | | 5.179 |
| | L5 9 | Karlsruhe | | | 5.316 |
| | J9 1 | Ispra | | | 4.437 |
| | J9 4 | Ispra | | | 6.698 |
| | J9 7 | Ispra | | | |
| | J9 7 | Karlsruhe | | | 6.921 |
| | J9 9 | Ispra | | | |
| | J9 9 | Karlsruhe | | | 5.479 |
| | A1 1 | Ispra | | | 4.412 |
| | A1 1 | Karlsruhe | | | 4.183 |
| | A1 7 | Ispra | | | 6.913 |
| | A1 7 | Karlsruhe | | | 7.016 |
| | A1 9 | Ispra | | | 5.464 |
| 509-032 3.13w% | E11 1 | Ispra | | | 4.131 |
| | E11 4 | Ispra | | | 7.151 |
| | E11 7 | Ispra | | | 7.157 |
| | E11 9 | Ispra | | | 5.638 |
| | H9 4 | Ispra | | | |
| | H9 4 | Karlsruhe | | | 7.234 |
| | H9 7 | Ispra | | | 7.355 |
| | H9 9 | Ispra | | | 5.735 |
| | O15 7 | Ispra | | | 7.168 |
| | | | | | |
| 509-104 3.897w% | M11 7 | Ispra | | | 5.601 |
| | M11 7 | Karlsruhe | | | 5.657 |
| | A12 1 | Ispra | | | 1.577 |
| | A12 1 | Ispra | | | 2.920 |
| 509-069 3.13w% | E5 4 | Ispra | 4.52 | 6.26 | |
| | E5 7 | Ispra | | 6.30 | |
| | E5 7 | Karlsruhe | 4.65 | 6.26 | |
| | E5 9 | Ispra | 3.65 | 5.51 | |
| | L5 4 | Ispra | 4.59 | 6.36 | |
| | L5 7 | Ispra | | 6.28 | |
| | E11 1 | Ispra | | 4.76 | |
| | E11 2 | Ispra | | 6.02 | |
| | E11 2 | Karlsruhe | 3.90 | 6.01 | |
| | E11 4 | Ispra | | 6.14 | |
| | E11 4 | Karlsruhe | 4.50 | 6.22 | |
| | E11 5 | Ispra | 4.75 | 6.30 | |
| | E11 7 | Ispra | | 6.49 | |
| | E11 7 | Karlsruhe | 4.61 | 6.24 | |
| | E11 8 | Karlsruhe | 4.44 | 6.19 | |
| | E11 9 | Karlsruhe | 3.64 | 5.88 | |
| | L11 4 | Karlsruhe | 4.54 | 6.36 | |
| | L11 7 | Ispra | 4.56 | 6.31 | |
| | L11 7 | Karlsruhe | 4.68 | 6.26 | |
| | A1 1 | Ispra | | 4.86 | |
| | A1 7 | Karlsruhe | 5.10 | 5.85 | |
| | J9 4 | Ispra | | 6.11 | |
| | J9 7 | Karlsruhe | 4.79 | 6.11 | |

Table 3.2-9 Atom Ratios of Uranium and Plutonium from Mass Spectrometry

| FUEL ELEMENT | SAMPLE | LAB. | U ($\times 10E-2$) | | Pu ($\times 10E-1$) | | | |
|--------------------|--------|-----------|----------------------|---------|-----------------------|---------|---------|---------|
| | | | 235/239 | 236/238 | Date | 240/239 | 241/239 | 242/239 |
| 509-049 2.719w% | L5 1 | Ispra | 2.068 | .170 | | 1.421 | .466 | .043 |
| | L5 4 | Ispra | 1.597 | .256 | | 2.218 | .975 | .166 |
| | L5 4 | Karlsruhe | 1.573 | .254 | | 2.230 | 1.006 | .177 |
| | L5 9 | Ispra | 1.844 | .221 | | 1.758 | .666 | .080 |
| | L5 9 | Karlsruhe | 1.823 | .214 | | 1.786 | .686 | .086 |
| | J9 1 | Ispra | 1.945 | .186 | | 1.546 | .522 | .053 |
| | J9 4 | Ispra | 1.466 | .263 | | 2.423 | 1.064 | .211 |
| | J9 7 | Ispra | | | | | | |
| | J9 7 | Karlsruhe | 1.463 | .270 | | 2.417 | 1.067 | .213 |
| | J9 9 | Ispra | | | | | | |
| | J9 9 | Karlsruhe | 1.748 | .224 | | 1.931 | .740 | .103 |
| | A1 1 | Ispra | 1.938 | .185 | | 1.343 | .578 | .064 |
| | A1 1 | Karlsruhe | 2.015 | .181 | | 1.512 | .478 | .045 |
| | A1 7 | Ispra | 1.409 | .281 | | 2.592 | 1.166 | .250 |
| | A1 7 | Karlsruhe | 1.428 | .281 | | 2.555 | 1.153 | .267 |
| | A1 9 | Ispra | 1.698 | .233 | | 2.020 | .805 | .115 |
| 509-032 3.13w% | E11 1 | Ispra | 2.451 | .171 | | 1.265 | .405 | .034 |
| | E11 4 | Ispra | 1.831 | .299 | | 2.115 | .962 | .162 |
| | E11 7 | Ispra | 1.760 | .289 | | 2.163 | .974 | .179 |
| | E11 9 | Ispra | 2.129 | .263 | | 1.747 | .690 | .085 |
| | H9 4 | Ispra | | | | | | |
| | H9 4 | Karlsruhe | 1.773 | .315 | | 2.332 | 1.079 | .205 |
| | H9 7 | Ispra | 1.730 | .320 | | 2.372 | 1.094 | .209 |
| | H9 9 | Ispra | 2.020 | .255 | | 1.867 | .760 | .100 |
| | O15 7 | Ispra | 1.593 | .328 | | 2.600 | 1.157 | .257 |
| | | | | | | | | |
| 509-104 3.897w% | M11 7 | Ispra | 2.811 | .288 | | 1.555 | .627 | .068 |
| | M11 7 | Karlsruhe | 2.858 | .292 | | 1.563 | .629 | .067 |
| | A12 1 | Ispra | 3.700 | .124 | | .630 | .080 | .003 |
| | A12 1 | Ispra | 3.270 | .204 | | 1.154 | .265 | .018 |
| 509-069 3.13w% | E5 4 | Ispra | 1.376 | .374 | 19.11.74 | 2.946 | 1.503 | .397 |
| | E5 7 | Ispra | 1.297 | .378 | 20.11.74 | 2.964 | 1.507 | .421 |
| | E5 7 | Karlsruhe | 1.310 | .375 | 11.11.74 | 2.979 | 1.498 | .418 |
| | E5 9 | Ispra | 1.609 | .346 | 25.11.74 | 2.512 | 1.192 | .254 |
| | L5 4 | Ispra | 1.384 | .369 | 02.07.75 | 2.915 | 1.442 | .398 |
| | L5 7 | Ispra | 1.317 | .380 | 21.11.74 | 2.991 | 1.511 | .415 |
| | E11 1 | Ispra | 2.055 | .258 | 10.12.74 | 1.836 | .753 | .100 |
| | E11 2 | Ispra | 1.521 | .343 | 10.12.74 | 2.626 | 1.292 | .289 |
| | E11 2 | Karlsruhe | 1.536 | .360 | 11.11.74 | 2.642 | 1.317 | .302 |
| | E11 4 | Ispra | 1.313 | .374 | 11.04.75 | 2.937 | 1.447 | .408 |
| | E11 4 | Karlsruhe | 1.349 | .393 | 06.11.74 | 2.960 | 1.488 | .411 |
| | E11 5 | Ispra | 1.309 | .384 | 07.04.75 | 2.972 | 1.448 | .398 |
| | E11 7 | Ispra | 1.307 | .384 | 09.04.75 | 2.994 | 1.443 | .423 |
| | E11 7 | Karlsruhe | 1.327 | .389 | 08.11.74 | 2.991 | 1.504 | .424 |
| | E11 8 | Karlsruhe | 1.345 | .381 | 18.11.74 | 2.907 | 1.481 | .387 |
| | E11 9 | Karlsruhe | 1.589 | .343 | 19.11.74 | 2.498 | 1.182 | .259 |
| | L11 4 | Karlsruhe | 1.369 | .399 | 18.02.75 | 2.936 | 1.461 | .403 |
| | L11 7 | Ispra | 1.315 | .367 | 25.05.75 | 3.004 | 1.451 | .432 |
| | L11 7 | Karlsruhe | 1.300 | .370 | 18.02.75 | 2.997 | 1.494 | .428 |
| | A1 1 | Ispra | 1.844 | .289 | 27.05.75 | 2.185 | .912 | .154 |
| | A1 7 | Karlsruhe | 1.106 | .399 | 08.11.74 | 3.376 | 1.740 | .599 |
| | J9 4 | Ispra | 1.283 | .387 | 18.05.75 | 3.102 | 1.523 | .460 |
| | J9 7 | Karlsruhe | 1.254 | .392 | 13.02.75 | 3.134 | 1.554 | .479 |

Table 3.2-10 Buildup and Depletion of Uranium Isotopes
(kg/MTU initial)

| FUEL ELEMENT | SAMPLE | LAB. | U-235 Depletion | U-236 Build up | U-238 Depletion |
|--------------------|--------|-----------|-----------------|----------------|-----------------|
| 509-049 2.719w% | L5 1 | Ispra | 7.47 | 1.43 | |
| | L5 4 | Ispra | 12.05 | 2.24 | |
| | L5 4 | Karlsruhe | 12.28 | 2.22 | |
| | L5 9 | Ispra | 9.64 | 1.92 | |
| | L5 9 | Karlsruhe | 9.84 | 1.85 | |
| | J9 1 | Ispra | 8.65 | 1.58 | |
| | J9 4 | Ispra | 13.29 | 2.31 | |
| | J9 7 | Ispra | 13.33 | 2.37 | |
| | J9 7 | Karlsruhe | | | |
| | J9 9 | Ispra | 10.56 | 1.94 | |
| | J9 9 | Karlsruhe | | | |
| | A1 1 | Ispra | 8.71 | 1.57 | |
| | A1 1 | Karlsruhe | | | |
| | A1 7 | Ispra | 13.85 | 2.48 | |
| | A1 7 | Karlsruhe | 13.67 | 2.48 | |
| | A1 9 | Ispra | 11.04 | 2.03 | |
| | | | | | |
| 509-032 3.13w% | E11 1 | Ispra | 8.01 | 1.43 | |
| | E11 4 | Ispra | 14.02 | 2.64 | |
| | E11 7 | Ispra | 14.69 | 2.54 | |
| | E11 9 | Ispra | 11.13 | 2.30 | |
| | H9 4 | Ispra | 14.58 | 2.79 | |
| | H9 4 | Karlsruhe | | | |
| | H9 7 | Ispra | 14.99 | 2.83 | |
| | H9 9 | Ispra | 12.41 | 2.21 | |
| | O15 7 | Ispra | 16.28 | 2.91 | |
| | | | | | |
| 509-104 3.897w% | M11 7 | Ispra | 12.56 | 2.52 | |
| | M11 7 | Karlsruhe | 12.13 | 2.56 | |
| | A12 1 | Ispra | 3.95 | | |
| | A12 1 | Ispra | 8.09 | | |
| | | | | | |
| 509-069 3.13w% | E5 4 | Ispra | 18.39 | 3.53 | 19.13 |
| | E5 7 | Ispra | 19.15 | 3.56 | 20.40 |
| | E5 7 | Karlsruhe | 19.03 | 3.53 | 19.51 |
| | E5 9 | Ispra | 16.16 | 3.27 | 15.11 |
| | L5 4 | Ispra | 18.33 | 3.48 | 19.64 |
| | L5 7 | Ispra | 18.99 | 3.57 | 21.09 |
| | E11 1 | Ispra | 11.84 | 2.45 | 9.61 |
| | E11 2 | Ispra | 17.00 | 3.24 | 16.24 |
| | E11 2 | Karlsruhe | 16.88 | 3.39 | 16.75 |
| | E11 4 | Ispra | 18.98 | 3.53 | 18.54 |
| | E11 4 | Karlsruhe | 18.66 | 3.70 | 19.34 |
| | E11 5 | Ispra | 19.03 | 3.62 | 19.58 |
| | E11 7 | Ispra | 19.04 | 3.62 | 18.58 |
| | E11 7 | Karlsruhe | 18.87 | 3.66 | 19.66 |
| | E11 8 | Karlsruhe | 18.68 | 3.59 | 18.55 |
| | E11 9 | Karlsruhe | 16.33 | 3.24 | 14.50 |
| | L11 4 | Karlsruhe | 18.48 | 3.76 | 19.80 |
| | L11 7 | Ispra | 18.98 | 3.45 | 19.48 |
| | L11 7 | Karlsruhe | 19.12 | 3.48 | 20.72 |
| | A1 1 | Ispra | 13.87 | 2.74 | 11.88 |
| | A1 7 | Karlsruhe | 20.95 | 3.75 | 20.16 |
| | J9 4 | Ispra | 19.29 | 3.64 | 20.36 |
| | J9 7 | Karlsruhe | 19.55 | 3.69 | 19.85 |

Table 3.2-11 Buildup of Plutonium Isotopes (kg/MTU initial)

| FUEL ELEMENT | SAMPLE | LAB. | Pu-238 | Pu-239 | Pu-240 | Pu-241 | Pu-242 | Total Pu |
|--------------------|--------|-----------|--------|--------|--------|--------|--------|----------|
| 509-049 2.719w% | L5 1 | Ispra | | 3.608 | .515 | .204 | | 4.327 |
| | L5 4 | Ispra | | 5.041 | 1.123 | .596 | | 6.760 |
| | L5 4 | Karlsruhe | | 4.991 | 1.118 | .609 | | 6.718 |
| | L5 9 | Ispra | | 4.072 | .719 | .329 | | 5.120 |
| | L5 9 | Karlsruhe | | 4.159 | .746 | .346 | | 5.251 |
| | J9 1 | Ispra | | 3.606 | .560 | .228 | | 4.394 |
| | J9 4 | Ispra | | 4.769 | 1.160 | .615 | | 6.544 |
| | J9 7 | Ispra | | 4.926 | 1.196 | .637 | | 6.759 |
| | J9 7 | Karlsruhe | | | | | | |
| | J9 9 | Ispra | | 4.134 | .802 | .371 | | 5.307 |
| | J9 9 | Karlsruhe | | | | | | |
| | A1 1 | Ispra | | 3.537 | .585 | .248 | | 4.370 |
| | A1 1 | Karlsruhe | | | | | | |
| | A1 7 | Ispra | | 4.806 | 1.251 | .679 | | 6.736 |
| | A1 7 | Karlsruhe | | 4.889 | 1.254 | .683 | | 6.826 |
| | A1 9 | Ispra | | 4.141 | .840 | .404 | | 5.385 |
| 509-032 3.13w% | E11 1 | Ispra | | 3.483 | .442 | .171 | | 4.096 |
| | E11 4 | Ispra | | 5.266 | 1.118 | .614 | | 6.998 |
| | E11 7 | Ispra | | 5.234 | 1.137 | .618 | | 6.989 |
| | E11 9 | Ispra | | 4.418 | .775 | .369 | | 5.562 |
| | H9 4 | Ispra | | 5.172 | 1.211 | .676 | | 7.059 |
| | H9 4 | Karlsruhe | | | | | | |
| | H9 7 | Ispra | | 5.234 | 1.247 | .694 | | 7.175 |
| | H9 9 | Ispra | | 4.446 | .834 | .409 | | 5.689 |
| | O15 7 | Ispra | | 4.968 | 1.297 | .697 | | 6.962 |
| | | | | | | | | |
| 509-104 3.897w% | M11 7 | Ispra | | 4.647 | .723 | .350 | | 5.720 |
| | M11 7 | Karlsruhe | | 4.525 | .710 | .345 | | 5.580 |
| | A12 1 | Ispra | | 1.464 | | | | 1.464 |
| | A12 1 | Ispra | | 2.525 | | | | 2.525 |
| 509-069 3.13w% | E5 4 | Ispra | .117 | 5.95 | 1.76 | 1.05 | .240 | 9.117 |
| | E5 7 | Ispra | .116 | 5.99 | 1.78 | 1.06 | .255 | 9.201 |
| | E5 7 | Karlsruhe | .115 | 5.97 | 1.79 | 1.05 | .253 | 9.178 |
| | E5 9 | Ispra | .063 | 5.27 | 1.33 | .73 | .135 | 7.529 |
| | L5 4 | Ispra | .110 | 6.06 | 1.77 | 1.06 | .244 | 9.244 |
| | L5 7 | Ispra | .114 | 5.97 | 1.79 | 1.06 | .250 | 9.184 |
| | E11 1 | Ispra | .025 | 4.58 | .84 | .40 | .046 | 5.891 |
| | E11 2 | Ispra | .080 | 5.76 | 1.52 | .88 | .168 | 8.408 |
| | E11 2 | Karlsruhe | .081 | 5.75 | 1.52 | .89 | .176 | 8.417 |
| | E11 4 | Ispra | .109 | 5.86 | 1.75 | 1.02 | .240 | 8.978 |
| | E11 4 | Karlsruhe | .109 | 5.93 | 1.76 | 1.04 | .247 | 9.086 |
| | E11 5 | Ispra | .117 | 6.01 | 1.79 | 1.04 | .240 | 9.197 |
| | E11 7 | Ispra | .120 | 6.19 | 1.86 | 1.07 | .260 | 9.500 |
| | E11 7 | Karlsruhe | .114 | 5.95 | 1.79 | 1.05 | .255 | 9.159 |
| | E11 8 | Karlsruhe | .119 | 5.91 | 1.72 | 1.03 | .232 | 9.011 |
| | E11 9 | Karlsruhe | .068 | 5.63 | 1.41 | .78 | .147 | 8.035 |
| | L11 4 | Karlsruhe | .106 | 6.06 | 1.79 | 1.05 | .247 | 9.253 |
| | L11 7 | Ispra | .118 | 6.02 | 1.82 | 1.05 | .260 | 9.268 |
| | L11 7 | Karlsruhe | .114 | 5.97 | 1.80 | 1.06 | .258 | 9.202 |
| | A1 1 | Ispra | .035 | 4.67 | 1.02 | .51 | .073 | 6.308 |
| | A1 7 | Karlsruhe | .132 | 5.56 | 1.89 | 1.14 | .338 | 9.060 |
| | J9 4 | Ispra | .120 | 5.82 | 1.81 | 1.07 | .270 | 9.090 |
| | J9 7 | Karlsruhe | .134 | 5.83 | 1.84 | 1.08 | .282 | 9.166 |

Table 3.2-12 Buildup of Curium and Americium Isotopes
(atom/10E6 initial heavy atoms)

| FUEL ELEMENT | SAMPLE | LAB. | Am-242 /Am-241 ($\times 10E-2$) | Am-243 /Am-241 ($\times 10E-1$) | Cm-242 | Cm-244 | Am-241 | Am-242 | Am-243 | |
|--------------------|---|---|-----------------------------------|---|---|--|---|--|--|--|
| 509-049 2.719w% | L5 1 L5 4 L5 4 L5 9 L5 9 J9 1 J9 4 J9 7 J9 7 J9 9 J9 9 A1 1 A1 1 A1 7 A1 7 A1 9 | Ispra Ispra Karlsruhe Ispra Karlsruhe Ispra Ispra Ispra Karlsruhe Ispra Karlsruhe Ispra Karlsruhe Ispra Karlsruhe Ispra | | .3510 .2820 .2710 .3230 .3400 | .6886 .3585 .8032 .1793 .8806 | | | | | |
| 509-032 3.13w% | E11 1 E11 4 E11 7 E11 9 H9 4 H9 4 H9 7 H9 9 O15 7 | Ispra Ispra Ispra Ispra Ispra Karlsruhe Ispra Ispra Ispra | | .2390 | .8006 | | | | | |
| 509-104 3.897w% | M11 7 M11 7 A12 1 A12 1 | Ispra Karlsruhe Ispra Ispra | .2050 | .3050 | | | | | | |
| 509-069 3.13w% | E5 4 E5 7 E5 7 E5 9 L5 4 L5 7 E11 1 E11 2 E11 2 E11 4 E11 4 E11 5 E11 7 E11 7 E11 8 E11 9 L11 4 L11 7 L11 7 A1 1 A1 7 J9 4 J9 7 | Ispra Ispra Karlsruhe Ispra Ispra Ispra Ispra Ispra Karlsruhe Ispra Karlsruhe Ispra Ispra Ispra Karlsruhe Ispra Karlsruhe Ispra Ispra Karlsruhe Ispra | | .8210 | 1.7300 1.1600 1.2800 1.7990 1.5900 1.5900 1.7200 1.5800 1.0900 1.6100 1.5900 1.6500 7.4 29.5 25.1 13.20 10.43 28.0 | 22.8 24.3 25.1 13.7 24.8 24.4 1.0 17.0 17.8 23.6 24.3 25.3 26.2 26.2 24.1 17.1 27.5 24.3 24.2 7.4 29.5 25.1 13.20 10.43 28.0 | 8.74 9.07 9.31 2.48 9.29 8.57 .10 4.35 4.77 9.03 8.56 9.67 10.03 9.29 7.40 3.55 8.93 9.79 9.20 .86 13.20 10.43 9.43 | 219.4 241.3 150.6 240.1 295.1 83.3 172.6 1.35 1.38 206.2 2.09 304.9 2.73 297.2 2.22 2.14 2.06 1.93 1.94 2.37 82.7 1.93 209.3 2.05 | 2.40 45.2 1.35 23.2 1.38 23.7 2.09 44.4 2.73 53.8 2.22 44.9 2.14 42.8 2.06 29.5 1.93 43.6 1.94 38.5 2.37 44.7 1.93 59.8 | |

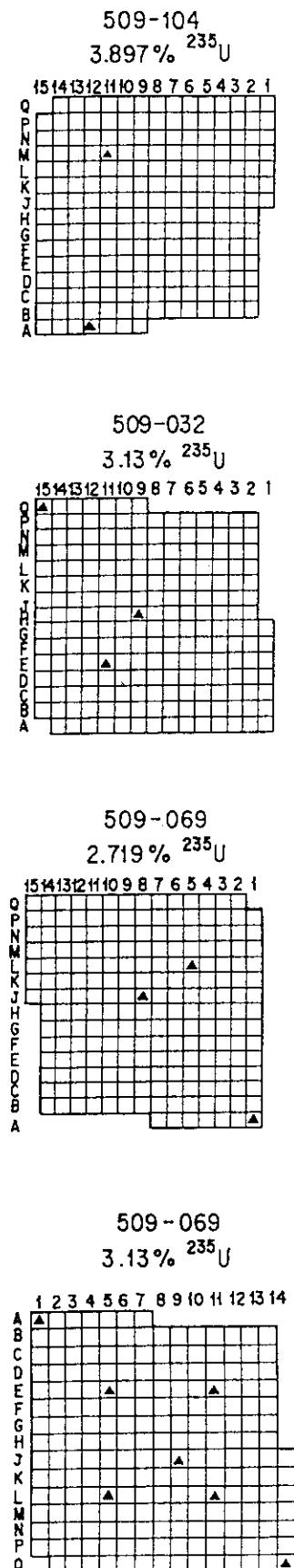
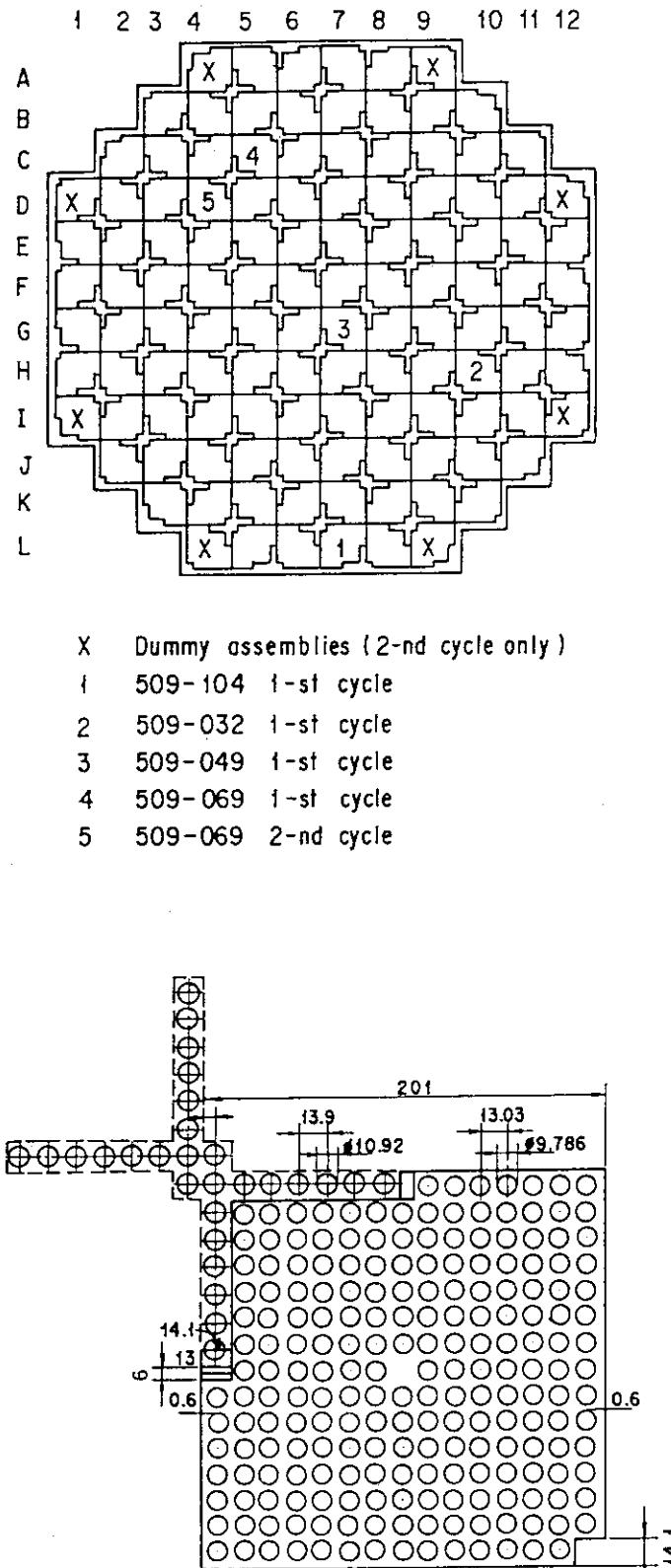


Fig. 3.2-1 Core configuration of Trino Vercellese core

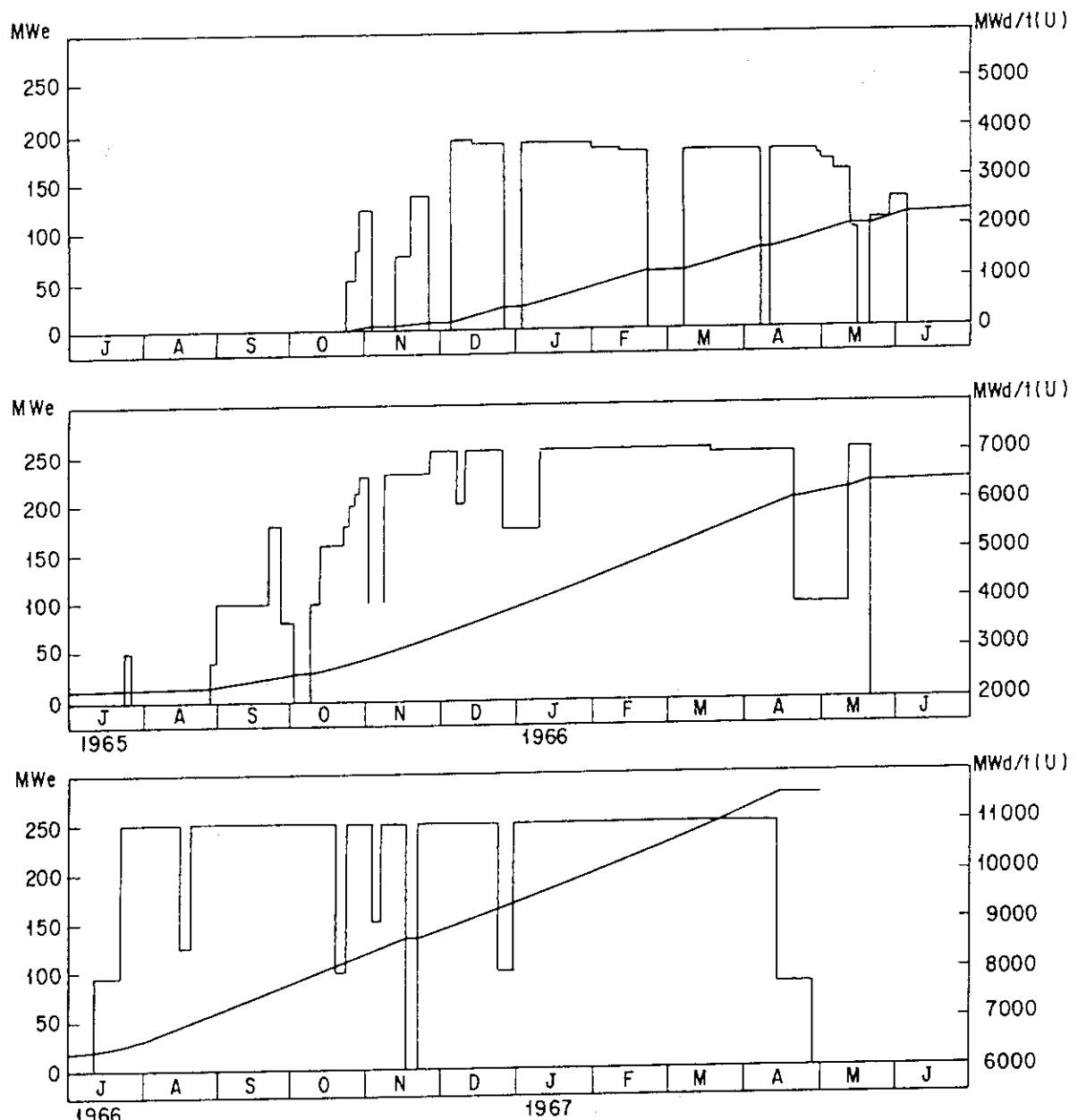


Fig. 3.2-2 Load diagram and cumulative burn-up

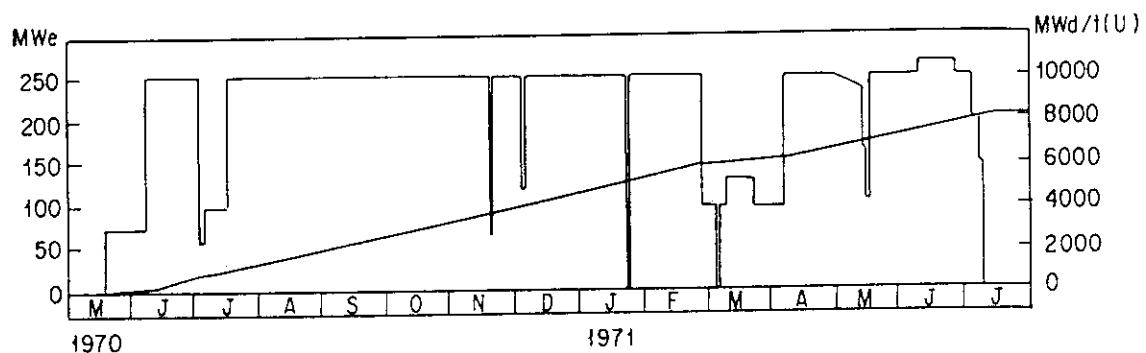


Fig. 3.2-3 Load diagram and cumulative burn-up during the 2nd irradiation cycle of the Trino Vercellese reactor

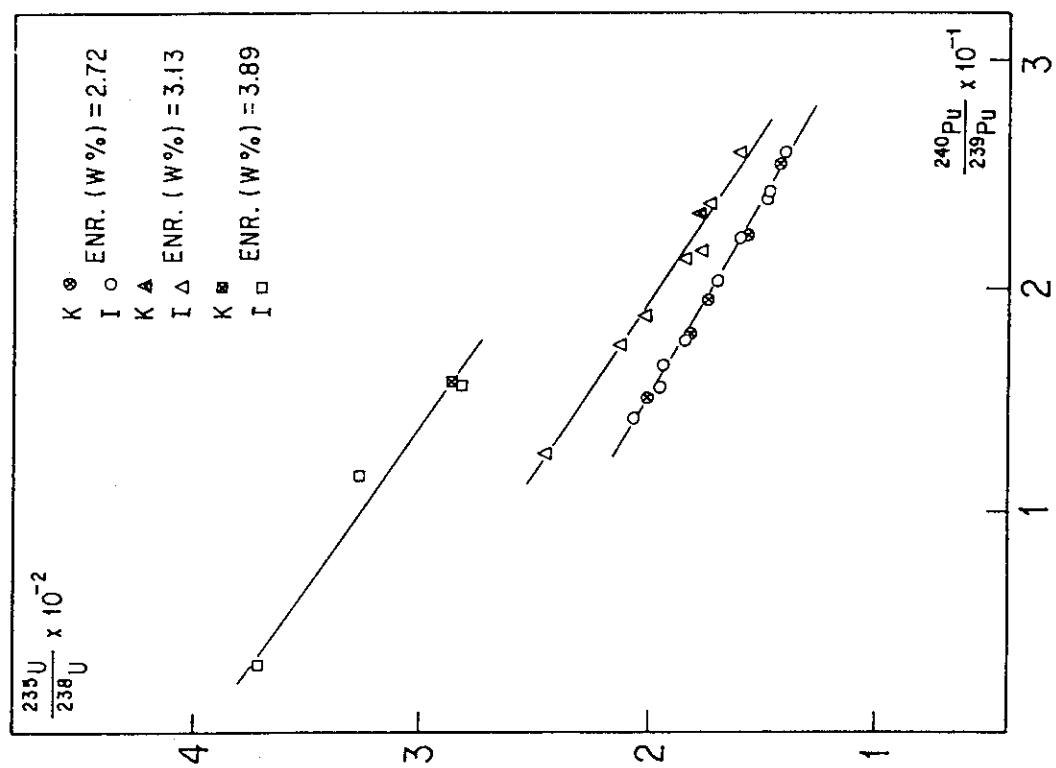


Fig. 3.2-5 Correlation between U-235 and
Pu-240/Pu-239

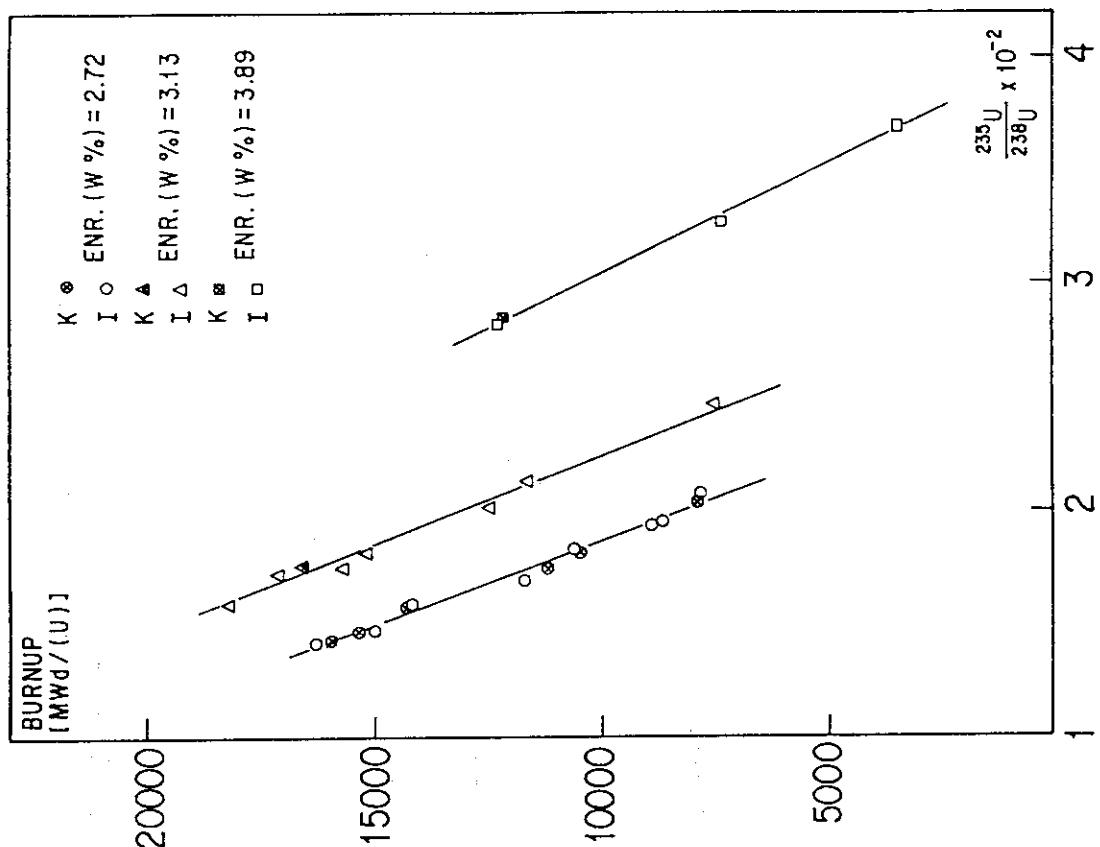


Fig. 3.2-4 Correlation between burnup and
U-235/U-238

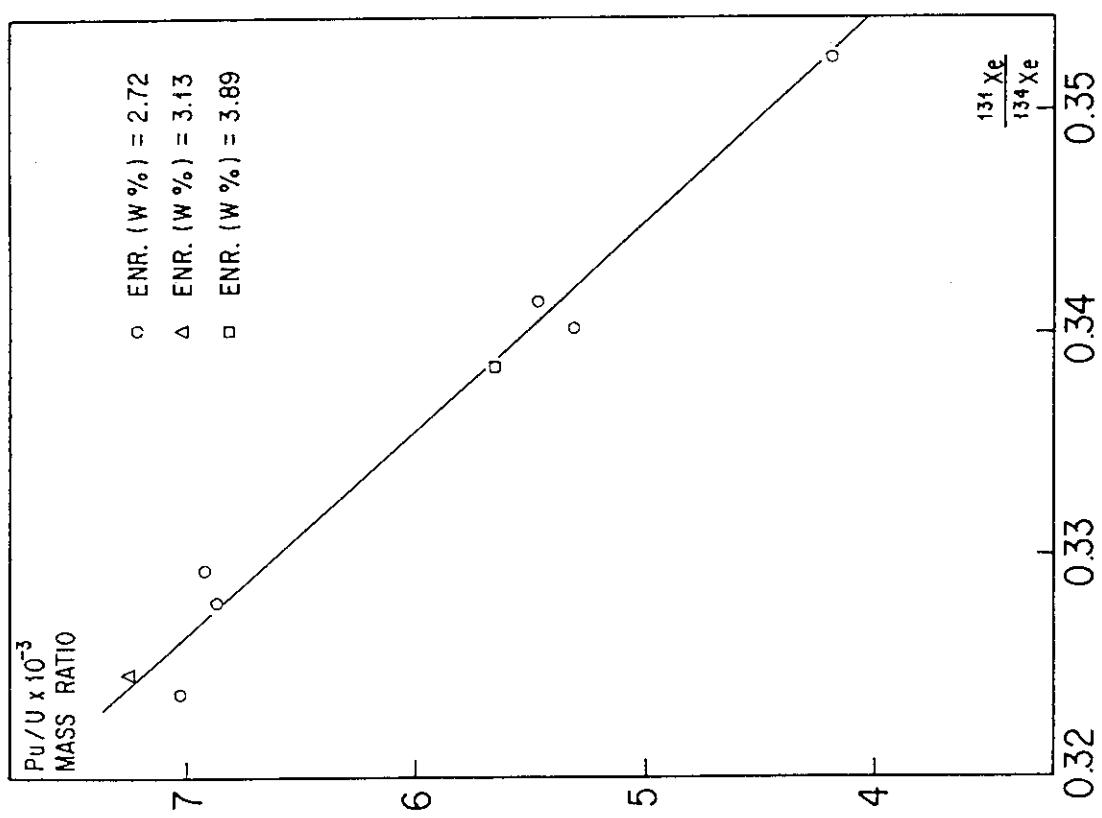


Fig. 3.2-7 Correlation between Pu/U and $\text{Xe-131}/\text{Xe-134}$

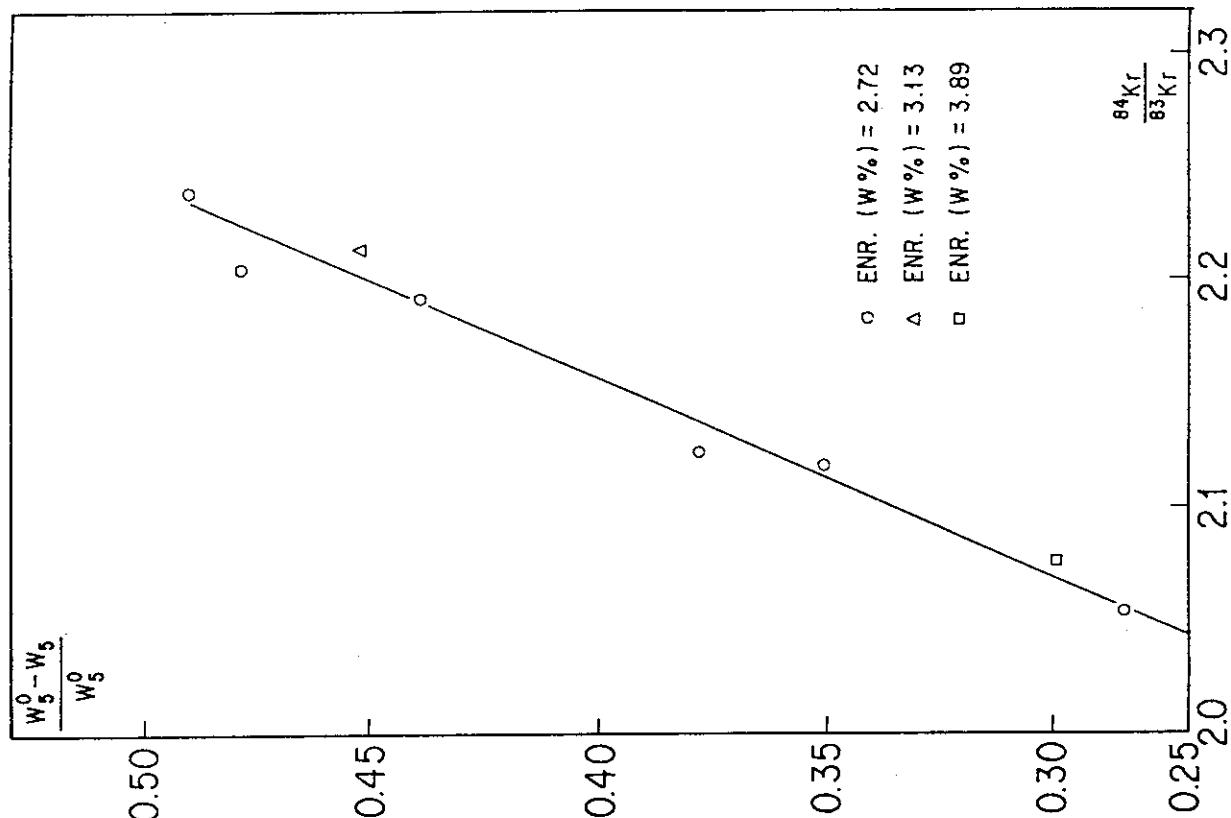


Fig. 3.2-6 Correlation between uranium depletion and $\text{Kr-84}/\text{Kr-83}$

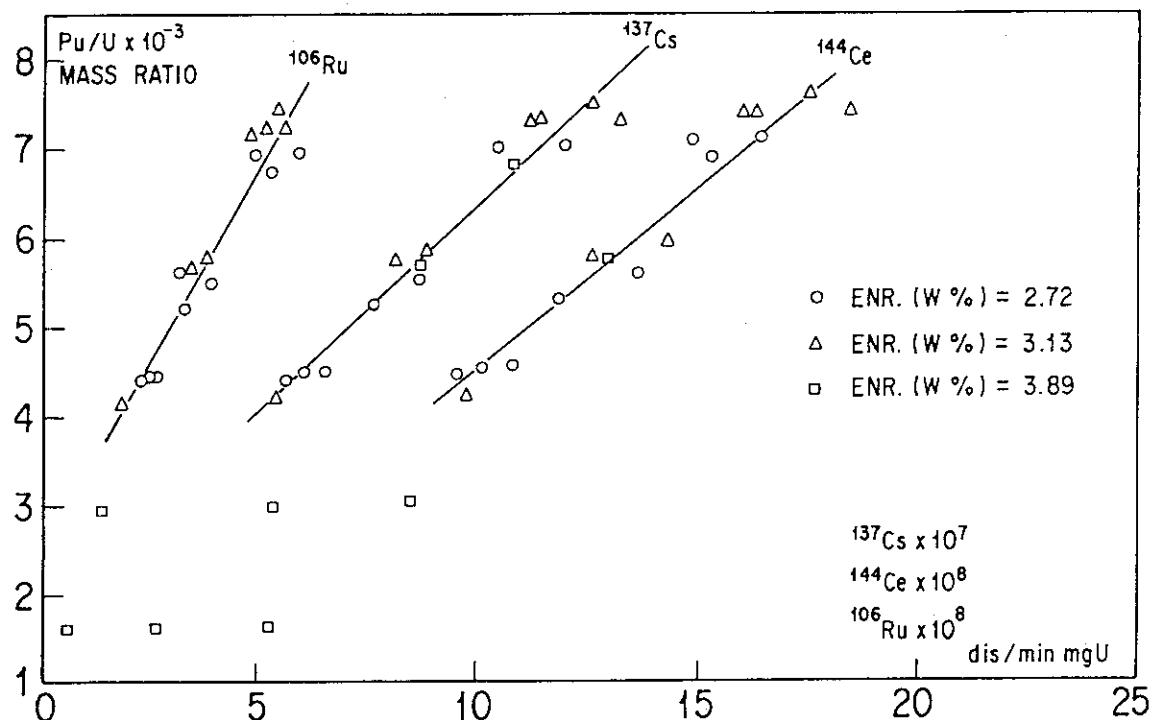


Fig. 3.2-8 Correlation between Pu/U and Cs-137, Ce-144, Ru-106 specific activities

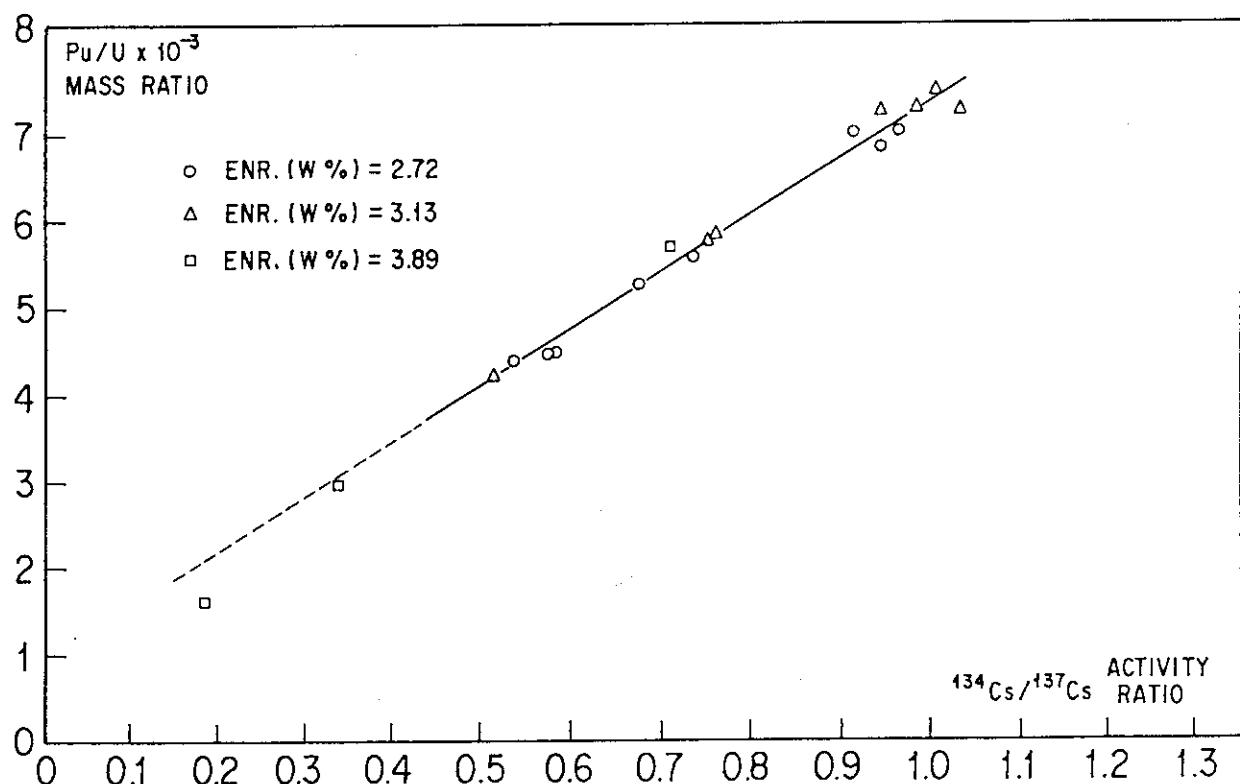


Fig. 3.2-9 Correlation between Pu/U and Cs-134/Cs-137 activity ratio

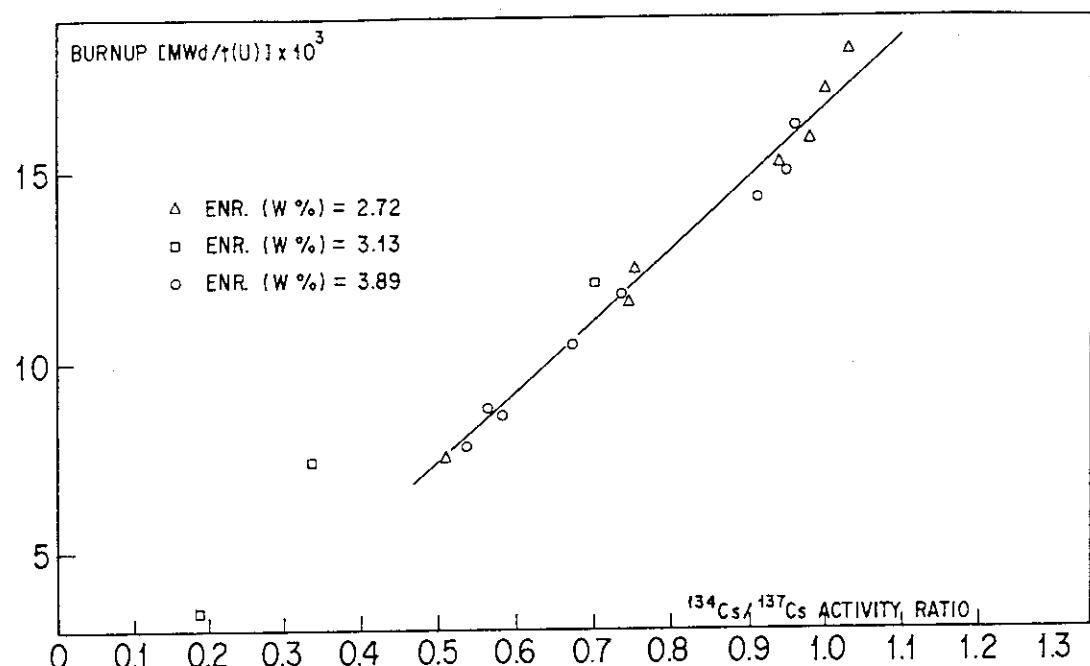


Fig. 3.2-10 Correlation between burnup and $^{134}\text{Cs}/^{137}\text{Cs}$ activity ratio

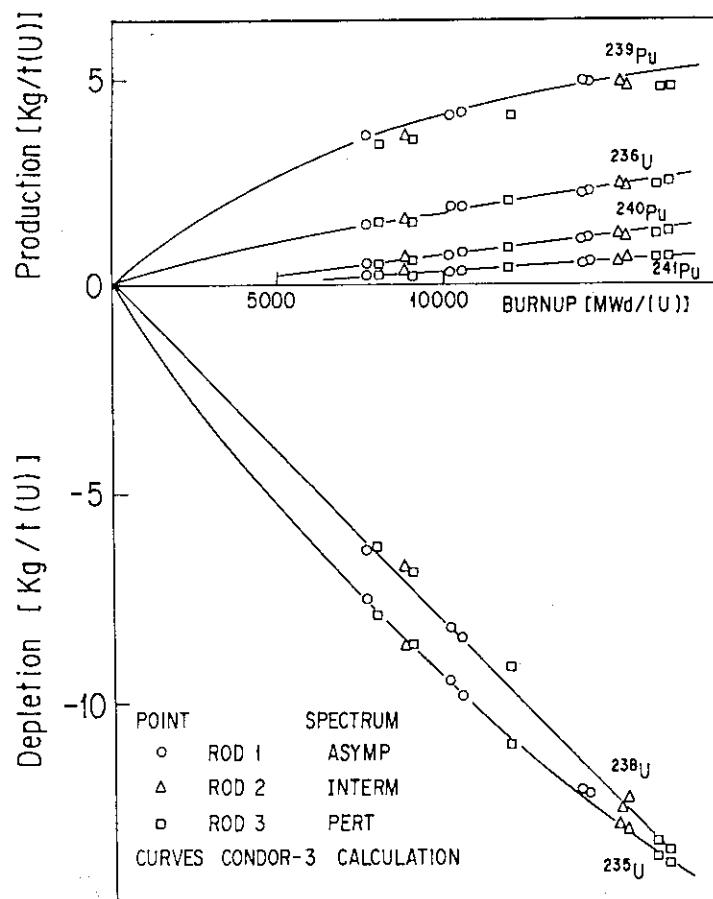


Fig. 3.2-11 Isotopic production and depletion vs. burnup for the inner core region

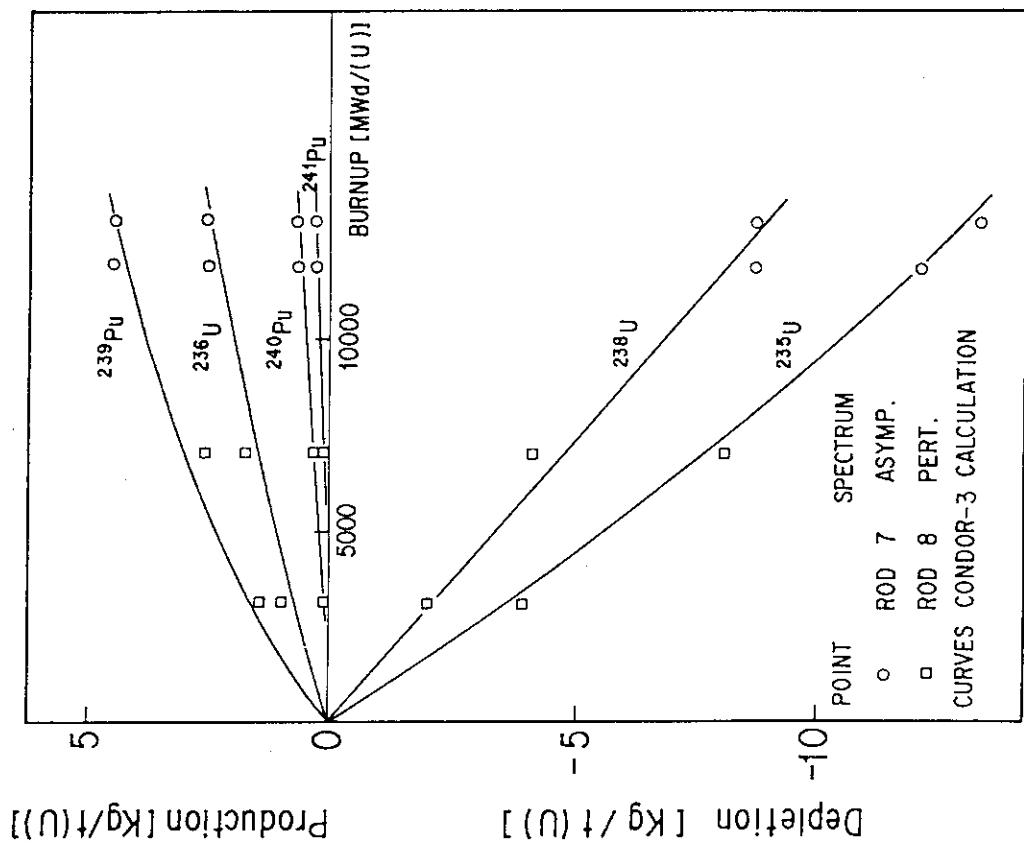


Fig. 3.2-13 Isotopic production and depletion vs. burnup for the outer core region

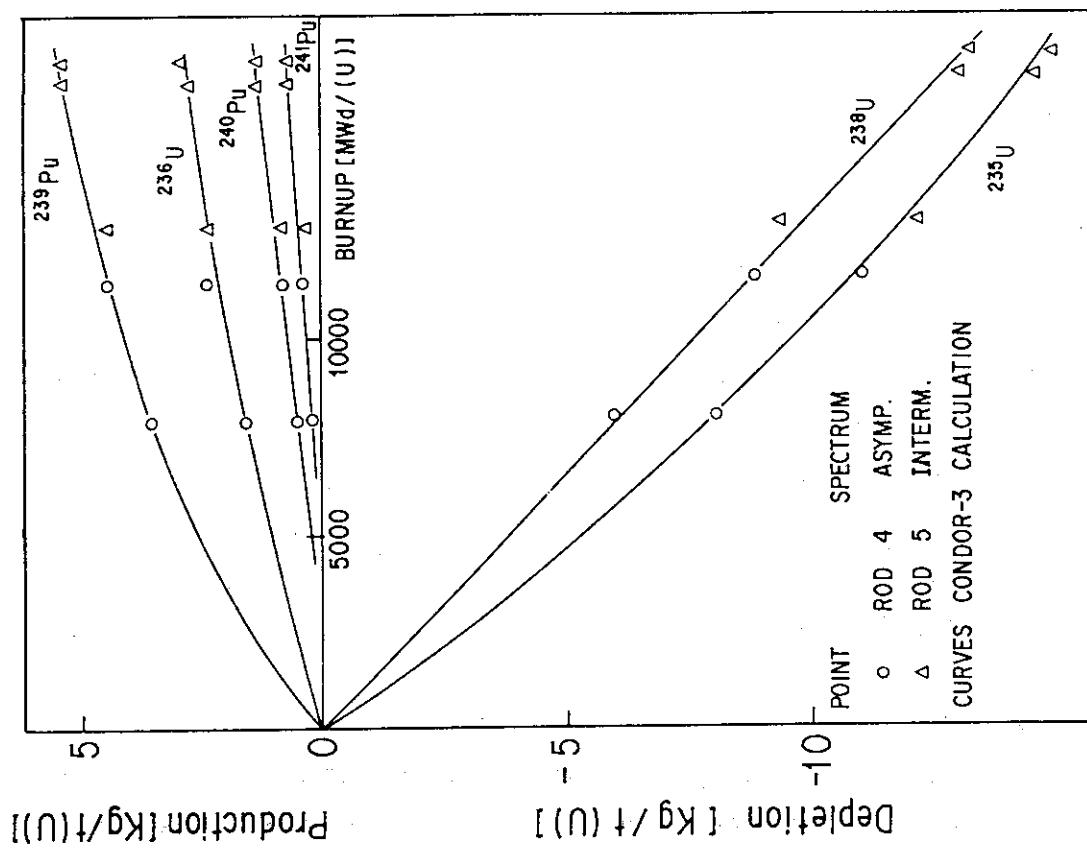


Fig. 3.2-12 Isotopic production and depletion vs. burnup for the intermediate core region

3.3 Obrigheim炉(PWR)

Obrigheim炉の2つの燃料集合体 BE124とBE210が照射後試験のために第5サイクルの終わりに取り出された。この計画はベンチマーク実験の一環として Ispra研究所とKarlsruhe研究所の共同研究センターのもとで実行された。その目的は、核計算の精度検証に使用するデータを得るために燃料サンプルの燃焼度と同位体組成を測定することにあった。

この試験で測定された燃焼度と同位体組成の値の精度を確認するため3つの手順が適用された。第一は、同じ量の測定に異なった方法を用いること。これが燃焼度の値に適用され、燃焼度は¹³⁷Csと¹⁴⁸Ndの2つの方法で決定された。第二に、異なる研究所の結果を比較すること。このため、4組の隣接するペレットが Ispra研究所とKarlsruhe研究所で分析された。第三に、Isotopic Correlation Techniqueを用いること。

同様の照射後試験がGarigliano炉、Trino Vercellese炉及び Gundremmingen炉から取り出された燃料に対して行われた。

なお、本節で使用された図表は下記の文献から転載したものである。

5) P. Barbero et.al: "Post-irradiation Analysis of Obrigheim PWR Spent Fuel", Nuclear Science and Technology, Vol. 2, No. 1(1980), pp. 129-177

3.3.1 炉心構造と炉心性能

Obrigheim炉は定格電気出力350MWeのPWRである。Table 3.3-1に炉心構成と炉心性能を示す。また、炉心の構成図及び燃料集合体図をFig. 3.3-1に示す。

3.3.2 燃焼履歴とサンプリング燃料の配置

6つの試験燃料棒がBE124(平均燃焼度29,000MWd/t)とBE210(平均燃焼度30,000MWd/t)の2つの燃料集合体から選び出された。初期濃縮度はそれぞれ3.00wt%²³⁵U, 2.83wt%²³⁵Uであった。原子炉の運転履歴をFig. 3.3-2に示す。また、Table 3.3-2にサンプル燃料集合体の燃焼履歴を示す。Fig. 3.3-3に照射サイクル毎のサンプル燃料集合体の炉心内位置を示す。

サンプル燃料棒の位置及び軸方向サンプリング位置はFig. 3.3-4に図示されている。サンプル燃料棒は集合体 BE124から4本、D1, E3, G7及びM14, BE210から2本、G14及びK14が選ばれた。軸方向サンプリング位置は燃料棒の下方からP1, P2, P3, P4およびP5(BE124), P1, P3(1), P4(1), P5(1)及びP5(2)(BE124)と名付られた。

3.3.3 核種組成データ

測定はIspraとKarlsruheの2つの研究所で行われた。Ispraでは17サンプルが分析され、Karlsruheでは6サンプルに加えてクロスチェックのための4サンプルが分析された。サンプリン

グされた位置と測定された燃焼度は中性子スペクトルとともにTable 3.3-3に示す。G7P1のサンプルの燃焼度はIspraとKarlsruheの2つの研究所で測定されたが、後に述べる理由でKarlsruheのデータは信頼性がないとして除外された。

^{148}Nd 法、非破壊の ^{137}Cs 法及び破壊の ^{137}Cs 法で決定した燃焼度を運転管理データをもとに計算した値とともにTable 3.3-4に示す。G7P1のサンプルの燃焼度はIspraにおいて3つの方法を用いて測定され、3方法による値がひじょうに良い一致を示した。しかし、Karlsruheの測定値はこれと著しく異なり(Ispraに比べて30%高い)、クロスチェックされた他の3つのサンプルにおける研究所間の値の差(1.4%)と比べても異常な差であった。そこで、Karlsruheの測定には信頼性がないと考えられた。また、サンプルK14P1の値は ^{148}Nd 法と ^{137}Cs 法で約11%の差を示したが、これはサンプル切断図でFPの移動が生じたものと考えられた。

Table 3.3-5にUとPuの同位体比及び $^{148}\text{Nd}/^{238}\text{U}$ を示す。ここでも、G7P1サンプルのKarlsruheの値はIspraの値に比べて大きい。これは、燃焼度の評価が異なるためである。

Table 3.3-6及びTable 3.3-7に、燃焼に伴うU同位体の減損または生成量及びPu同位体の生成量をそれぞれに示す。

Table 3.3-8に初期Uに対するAm及びCm同位体の生成量を示す。

Fig. 3.3-5およびFig. 3.3-6にCm及びAmの燃焼に伴う変化を示す。 ^{241}Am の測定データは2つのグループに分けて整理された。AグループはIspraの質量分析とKarlsruheのアルファスペクトロメトリーが成されたもの、BグループはIspraでのアルファスペクトロメトリーだけの測定データであり(Table 3.3-8には(a), (b)で示した)、2つのグループは異なった傾向を示している。Aグループのデータは、異なる研究所で異なる方法で得られたことを考慮すると、高い信頼性を持っていると考えられる。また、RIBOTコードによる計算結果もこの結論を指示している。

^{242}Cm のデータも似たような状況を示している。Karlsruheの測定値は全てIspraの測定値より高い。RIBOTコードによるチェック計算結果はKarlsruheの測定に系統的なエラーが存在することを示唆した。

これと対称的に ^{244}Cm のデータは、E3P2サンプルを除いてKarlsruheとIspraの両方のデータが一つの線上にのった。

Table 3.3-9にFPガス(Kr, Xe)の同位体組成を示す。

Table 3.3-10に最終 ^{238}U に対する ^{148}Nd , ^{137}Cs , ^{239}Pu の原子数比およびPu/Uを示す。

Table 3.3-11に ^{137}Cs , ^{134}Cs および ^{154}Eu の比放射能を示す。

Table 3.3-1 Core Composition and Performance(Obrigheim)

| | | | | |
|---------------------------------------|----------------------|-------------|--|----------|
| Fuel Pellet | | | Control Rod | |
| UO ₂ density | (g/cm ³) | 6.68/6.52 | Absorbing material | Ag-In-Cd |
| Linear density | (g/cm) | 0.904 | Core | |
| Diameter | (cm) | | Equivalent diameter (cm) | 250.0 |
| Length of pellet stack in fuel rod | (cm) | 295.6 | Active height (cm) | 275.0 |
| Clad-pellet clearance | (cm) | 0.0139 | No. of square assemblies | 121 |
| Fuel Clad | | | No. of control rods | 32 |
| Outside diameter | (cm) | 1.076 | UO ₂ in square assemblies(kg) | |
| Inside diameter | (cm) | 0.9318 | Total UO ₂ weight (kg) | 39,930 |
| Wall thickness | (cm) | 0.06885 | Total U weight (kg) | 35,200 |
| Material | | Zircaloy-4 | Core Thermo-hydraulic Characteristics | |
| Square Fuel Assembly | | | Power (MWth) | 907.5 |
| Rod array | | 14 × 14 | (MWe) | 350 |
| Number of rods | | 180 | Coolant pressure (kg/cm ²) | 147.8 |
| Fuel rod pitch | (cm) | 1.430 | Coolant temperature(ave., °C) (inlet, °C) | 283 |
| Side of square cross section | (cm) | 20.0 | (outlet, °C) | 313 |
| Total length | (cm) | 317.0 | | |
| UO ₂ weight | (kg) | 221.83 | | |
| Initial enrichment | (%) | 2.5/2.8/3.1 | | |
| Channel material | | Zircaloy-4 | | |
| Channel mat. thickness | (cm) | | | |

Table 3.3-2 Irradiation History of the Obrigheim Fuel Element BE124 and BE210

| CYCLE OF OPERATION | PERIODS | DAYS (a) | BURNUP (MWD/MTU) | | | |
|--------------------|----------------------|----------|------------------|--------|----------|--------|
| | | | POSITION | BE 124 | POSITION | BE 210 |
| Second | 30.09.70 12.08.71 | 258 | G-1 | 6,600 | | |
| Shut-down | 13.08.71 29.09.71 | 48 | | | | |
| Third | 30.09.71 07.09.72 | 295 | | | D-11 | 9,900 |
| Shut-down | 08.09.72 04.10.72 | 27 | | | | |
| Fourth | 05.10.72 01.09.73 | 283 | D-7 | 18,600 | J-5 | 21,300 |
| Shut-down | 02.09.73 24.09.73 | 23 | | | | |
| Fifth | 25.09.73 16.08.74 | 229 | D-4 | 29,000 | G-3 | 30,100 |

Table 3.3-3 Burnup of Selected Fuel Samples in Obriheim PWR

| | Fuel Element BE 124 | | | | Fuel Element BE 210 | | | |
|------------------|--------------------------------------|--------------------------------|------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|
| | I | K | I | K | I | K | I | K |
| P5(2585) | | 22800 | | | 25800 | | | |
| P5(2)(2547) | | | | | | | 24200 | |
| P5(1)(2426) | | | | | | | 30100 | |
| P4(2315) | | 30900 | 30900 | 27700 | | | 24900 | |
| P4(1)(2206) | | | | | 35600 | | | 32900 |
| P3(1435) | 33700 | 36200 | 31300 | 31300 | 29400 | | | |
| P3(1)(1328) | | | | | | 37500 | 37500 | |
| P2(315) | 28000 | | 35100 | 25800 | | | | 36600 |
| P1(150) | 21200 | 20200 | 17100 | | 15600 | | | |
| RODS | D1 | D1 | E2 | E2 | G7 | M14 | G14 | K14 |
| NEUTRON SPECTRUM | Perturbed (Close to the Assy's edge) | Intermediate (Near water hole) | Asymptotic | Perturbed (Close to the Assy's edge) |

SELECTED FUEL SAMPLES (OBRIGHEIM PWR)

Table 3.3-4 Burnup Values Obtained by Means of Three Independent Experimental Methods(MWD/MTU)

| FUEL ELEMENT | SAMPLES | LAB. | Nd-148 | Cs-137 Destructive | Cs-137 Non-destructive | Theoretical |
|-------------------|-----------|-----------|--------|--------------------|------------------------|-------------|
| BE 124 3.00 w% | D1 P1 | Karlsruhe | 21,170 | | 19,520 | 21,200 |
| | D1 P2 | Ispra | | | 27,910 | 28,000 |
| | D1 P3 | Ispra | 33,750 | 33,160 | 33,760 | 33,700 |
| | E3 P1 | Ispra | 20,180 | 19,540 | 19,420 | 20,200 |
| | E3 P2 | Karlsruhe | 35,100 | | 29,350 | 35,100 |
| | E3 P3 | Ispra | 36,260 | 35,220 | 35,510 | 36,200 |
| | E3 P4 | Ispra | 30,890 | 30,640 | 28,140 | 30,900 |
| | E3 P4 | Karlsruhe | 30,940 | | | 30,900 |
| | E3 P5 | Ispra | 22,860 | 22,570 | 22,920 | 22,800 |
| | G7 P1 | Ispra | 17,130 | 16,970 | 17,490 | 17,100 |
| | G7 P1 | Karlsruhe | 22,700 | | | |
| | G7 P2 | Ispra | 25,830 | 24,880 | 26,240 | 25,800 |
| | G7 P3 | Ispra | 31,500 | 31,400 | 31,920 | 31,300 |
| | G7 P3 | Karlsruhe | 31,140 | | | 31,300 |
| | G7 P4 | Ispra | 27,710 | 27,420 | 29,460 | 27,700 |
| | G7 P5 | Karlsruhe | 25,810 | | 28,830 | 25,800 |
| BE 210 2.83 w% | M14 P1 | Karlsruhe | 15,600 | | 15,790 | 15,600 |
| | M14 P3 | Ispra | 29,360 | 28,800 | 27,200 | 29,400 |
| | M14 P4 | Karlsruhe | 24,900 | | 27,460 | 24,900 |
| | G14 P3(1) | Ispra | 38,100 | 37,720 | 36,290 | 37,500 |
| | G14 P3(1) | Karlsruhe | 36,880 | | | 37,500 |
| | G14 P4(1) | Ispra | 35,640 | 35,480 | 36,070 | 35,600 |
| | G14 P5(1) | Ispra | 30,160 | 30,660 | 31,870 | 30,100 |
| | G14 P5(2) | Ispra | 24,220 | 24,400 | 26,060 | 24,200 |
| | K14 P1 | Ispra | 25,450 | 22,900 | 22,460 | 25,500 |
| | K14 P3(1) | Ispra | 36,670 | 35,990 | 35,120 | 36,600 |
| | K14 P4(1) | Karlsruhe | 32,900 | | 34,630 | 32,900 |

Table 3.3-5 Atom Ratios of U and Pu from Mass Spectrometry
in Obrigheim PWR

| FUEL ELEMENT | SAMPLES | LAB. | U ($\times 10E-2$) | | Pu ($\times 10E-1$) | | |
|-------------------|-----------|-----------|----------------------|---------|-----------------------|---------|---------|
| | | | 235/238 | 236/238 | Date | 240/239 | 241/239 |
| BE 124 3.00 w% | D1 P1 | Karlsruhe | 1.438 | .313 | 17.07.78 | 3.021 | 1.183 |
| | D1 P2 | Ispra | .998 | .396 | 05.04.78 | 4.046 | 1.776 |
| | D1 P3 | Ispra | .742 | .431 | 12.04.78 | 4.686 | 2.133 |
| | E3 P1 | Ispra | 1.337 | .297 | 08.07.77 | 3.165 | 1.259 |
| | E3 P2 | Karlsruhe | .897 | .4 | 17.07.78 | 4.298 | 1.818 |
| | E3 P3 | Ispra | .653 | .441 | 22.07.77 | 5.041 | 2.287 |
| | E3 P4 | Ispra | .798 | .408 | 16.07.77 | 4.481 | 2.059 |
| | E3 P4 | Karlsruhe | .83 | .412 | 17.07.78 | 4.548 | 2.007 |
| | E3 P5 | Ispra | 1.258 | .383 | 04.10.77 | 3.475 | 1.549 |
| | G7 P1 | Ispra | 1.607 | .308 | 13.12.77 | 2.722 | 1.096 |
| | G7 P1 | Karlsruhe | 1.516 | .306 | 17.07.78 | 2.8 | 1.102 |
| | G7 P2 | Ispra | 1.146 | .408 | 19.12.77 | 3.778 | 1.665 |
| | G7 P3 | Ispra | .813 | .42 | 30.03.78 | 4.539 | 2.01 |
| M14 | G7 P3 | Karlsruhe | .794 | .42 | 17.07.78 | 4.524 | 1.991 |
| | G7 P4 | Ispra | 1.077 | .43 | 19.12.77 | 4.005 | 1.844 |
| | G7 P5 | Karlsruhe | 1.064 | .378 | 17.07.78 | 3.813 | 1.703 |
| | M14 P1 | Karlsruhe | 1.639 | .283 | 17.07.78 | 2.606 | .958 |
| | M14 P3 | Ispra | .936 | .405 | 18.04.78 | 4.138 | 1.865 |
| BE 210 2.83 w% | M14 P4 | Karlsruhe | 1.088 | .377 | 17.07.78 | 3.737 | 1.673 |
| | G14 P3(1) | Ispra | .542 | .416 | 11.11.77 | 5.455 | 2.452 |
| | G14 P3(1) | Karlsruhe | .47 | .412 | 17.07.78 | 5.451 | 2.363 |
| | G14 P4(1) | Ispra | .529 | .422 | 11.11.77 | 5.363 | 2.326 |
| | G14 P5(1) | Ispra | .667 | .388 | 13.12.77 | 4.81 | 2.122 |
| | G14 P5(2) | Ispra | .947 | .353 | 30.10.77 | 4.009 | 1.721 |
| | K14 P1 | Ispra | 1.066 | .341 | 06.04.78 | 3.759 | 1.636 |
| | K14 P3(1) | Ispra | .521 | .413 | 20.04.78 | 5.248 | 2.312 |
| | K14 P4(1) | Karlsruhe | .541 | .408 | 17.07.78 | 5.234 | 2.225 |
| | | | | | | | 1.441 |

Table 3.3-6 Buildup and Depletion of Uranium Isotopes
in Obrigheim PWR(kg/MTU initial)

| FUEL ELEMENT | SAMPLES | LAB. | U-235 Depletion | U-236 Build up | U-238 Depletion |
|-------------------|-----------|-----------|-----------------|----------------|-----------------|
| BE 124 3.00 w% | D1 P1 | Karlsruhe | 16.31 | 2.99 | 15.95 |
| | D1 P2 | Ispra | | | |
| | D1 P3 | Ispra | 23.07 | 4.06 | 25.32 |
| | E3 P1 | Ispra | 17.25 | 2.82 | 12.88 |
| | E3 P2 | Karlsruhe | 21.56 | 3.77 | 27.85 |
| | E3 P3 | Ispra | 23.91 | 4.12 | 27.01 |
| | E3 P4 | Ispra | 22.52 | 3.83 | 22.22 |
| | E3 P4 | Karlsruhe | 22.16 | 3.91 | 23.83 |
| | E3 P5 | Ispra | 18.15 | 3.62 | 16.59 |
| | G7 P1 | Ispra | 14.79 | 2.92 | 11.97 |
| | G7 P1 | Karlsruhe | 15.60 | 2.93 | 18.18 |
| | G7 P2 | Ispra | 19.24 | 3.85 | 19.21 |
| | G7 P3 | Ispra | 22.39 | 3.94 | 23.36 |
| | G7 P3 | Karlsruhe | 22.50 | 3.98 | 23.90 |
| M14 | G7 P4 | Ispra | 19.91 | 4.05 | 21.62 |
| | G7 P5 | Karlsruhe | 19.91 | 3.60 | 19.80 |
| | M14 P1 | Karlsruhe | 14.31 | 2.73 | 10.91 |
| | M14 P3 | Ispra | 21.22 | 3.81 | 21.73 |
| | M14 P4 | Karlsruhe | 19.67 | 3.60 | 18.85 |
| | | | | | |
| BE 210 2.83 w% | G14 P3(1) | Ispra | 23.25 | 3.89 | 29.38 |
| | G14 P3(1) | Karlsruhe | 23.89 | 3.87 | 28.78 |
| | G14 P4(1) | Ispra | 23.35 | 3.95 | 26.36 |
| | G14 P5(1) | Ispra | 22.03 | 3.66 | 20.99 |
| | G14 P5(2) | Ispra | 19.36 | 3.33 | 16.25 |
| | K14 P1 | Ispra | 18.27 | 3.22 | 18.86 |
| | K14 P3(1) | Ispra | 23.44 | 3.86 | 27.76 |
| | K14 P4(1) | Karlsruhe | 23.26 | 3.82 | 24.55 |

Table 3.3-7 Buildup of Plutonium Isotopes in Obrigheim PWR
(kg/MTU initial)

| FUEL ELEMENT | SAMPLES | LAB. | Pu-238 | Pu-239 | Pu-240 | Pu-241 | Pu-242 | Total Pu |
|-------------------|-----------|-----------|--------|--------|--------|--------|--------|----------|
| BE 124 3.00 w% | D1 P1 | Karlsruhe | .036 | 4.35 | 1.32 | .62 | .128 | 6.454 |
| | D1 P2 | Ispra | | | | | | |
| | D1 P3 | Ispra | .156 | 5.02 | 2.36 | 1.28 | .564 | 9.380 |
| | E3 P1 | Ispra | .041 | 4.28 | 1.36 | .62 | .139 | 6.440 |
| | E3 P2 | Karlsruhe | .104 | 4.62 | 1.99 | 1.02 | .380 | 8.114 |
| | E3 P3 | Ispra | .165 | 4.77 | 2.41 | 1.26 | .629 | 9.234 |
| | E3 P4 | Ispra | .125 | 4.94 | 2.22 | 1.18 | .464 | 8.929 |
| | E3 P4 | Karlsruhe | .103 | 4.91 | 2.24 | 1.19 | .488 | 8.931 |
| | E3 P5 | Ispra | .062 | 4.65 | 1.62 | .84 | .211 | 7.383 |
| | G7 P1 | Ispra | .031 | 4.26 | 1.16 | .55 | .099 | 6.100 |
| | G7 P1 | Karlsruhe | .039 | 4.39 | 1.23 | .59 | .112 | 6.361 |
| | G7 P2 | Ispra | .079 | 4.70 | 1.81 | .94 | .279 | 7.808 |
| | G7 P3 | Ispra | .138 | 4.99 | 2.27 | 1.20 | .478 | 9.076 |
| | G7 P3 | Karlsruhe | .145 | 5.04 | 2.29 | 1.21 | .500 | 9.194 |
| | G7 P4 | Ispra | .106 | 5.08 | 2.04 | 1.11 | .366 | 8.702 |
| | G7 P5 | Karlsruhe | .079 | 5.08 | 1.95 | 1.05 | .320 | 8.479 |
| BE 210 2.83 w% | M14 P1 | Karlsruhe | .025 | 3.98 | 1.04 | .46 | .075 | 5.581 |
| | M14 P3 | Ispra | .107 | 5.02 | 2.08 | 1.12 | .384 | 8.711 |
| | M14 P4 | Karlsruhe | .076 | 4.96 | 1.86 | 1.00 | .299 | 8.195 |
| | G14 P3(1) | Ispra | .190 | 4.52 | 2.47 | 1.30 | .773 | 9.253 |
| | G14 P3(1) | Karlsruhe | .139 | 4.60 | 2.52 | 1.32 | .787 | 9.366 |
| | G14 P4(1) | Ispra | .159 | 4.41 | 2.38 | 1.21 | .680 | 8.839 |
| K14 P1 | G14 P5(1) | Ispra | .114 | 4.36 | 2.11 | 1.09 | .494 | 8.168 |
| | G14 P5(2) | Ispra | .065 | 4.27 | 1.72 | .86 | .285 | 7.200 |
| | K14 P1 | Ispra | .065 | 4.60 | 1.74 | .90 | .264 | 7.569 |
| | K14 P3(1) | Ispra | .169 | 4.69 | 2.47 | 1.30 | .735 | 9.364 |
| | K14 P4(1) | Karlsruhe | .126 | 4.51 | 2.37 | 1.21 | .658 | 8.874 |

Table 3.3-8 Buildup of Am and Cm Isotopes in Obrigheim PWR
(kg/MTU initial)

| FUEL ELEMENT | SAMPLES | LAB. | Americium | | | Curium | |
|-------------------|-----------|-----------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|
| | | | 241 ($\times 10E-2$) | 242 ($\times 10E-4$) | 243 ($\times 10E-2$) | 242 ($\times 10E-3$) | 244 ($\times 10E-3$) |
| BE 124 3.00 w% | D1 P1 | Karlsruhe | 2.19(a) | | | 7.40 | 2.22 |
| | D1 P2 | Ispra | | | | 15.65 | 33.97 |
| | D1 P3 | Ispra | 6.08(b) | | | | |
| | E3 P1 | Ispra | 2.93(b) | | | 4.50 | 2.04 |
| | E3 P2 | Karlsruhe | | | | | 12.58 |
| | E3 P3 | Ispra | 9.00(b) | | | 14.79 | 41.62 |
| | E3 P4 | Ispra | 7.30(b) | | | 15.01 | 24.80 |
| | E3 P4 | Karlsruhe | | | | 33.17 | 22.18 |
| | E3 P5 | Ispra | 2.37(b) | | | 7.10 | 5.13 |
| | G7 P1 | Ispra | 1.40(a) | 2.88 | .086 | 2.94 | 1.04 |
| | G7 P1 | Karlsruhe | 2.21(a) | | | | 1.97 |
| | G7 P2 | Ispra | 2.48(a) | 4.94 | .390 | 8.58 | 9.49 |
| | G7 P3 | Ispra | 17.58(b) | | | 14.79 | 29.73 |
| | G7 P3 | Karlsruhe | | | | 27.15 | 26.73 |
| | G7 P4 | Ispra | 13.98(b) | | | 11.88 | 16.52 |
| | G7 P5 | Karlsruhe | | | | 19.56 | 10.68 |
| M14 P1 | M14 P1 | Karlsruhe | .67(a) | | | | 1.04 |
| | M14 P3 | Ispra | 9.39(b) | | | 11.30 | 17.99 |
| | M14 P4 | Karlsruhe | | | | 14.07 | 8.91 |
| BE 210 2.83 w% | G14 P3(1) | Ispra | 4.10(a) | 7.29 | 1.540 | 14.54 | 59.81 |
| | G14 P3(1) | Karlsruhe | | | | 47.03 | 45.94 |
| | G14 P4(1) | Ispra | 4.03(a) | 19.30 | 1.380 | 14.36 | 47.15 |
| | G14 P5(1) | Ispra | 5.53(b) | 12.07 | .420 | 11.70 | 22.07 |
| | G14 P5(2) | Ispra | 2.77(a) | 7.10 | .360 | 7.56 | 6.95 |
| | K14 P1 | Ispra | 2.52(a) | | | 8.13 | 6.53 |
| | K14 P3(1) | Ispra | 7.49(b) | 7.57 | 1.400 | 17.75 | 52.59 |
| | K14 P4(1) | Karlsruhe | | | | 33.10 | 31.68 |

Table 3.3-9 Isotopic Ratios of Fission Gass in Obrigheim PWR

| FUEL ELEMENT | SAMPLES | LAB. | Krypton | | | Xenon | | | |
|-------------------|-----------|-----------|---------|-------|-------|---------|---------|---------|---------|
| | | | 83/86 | 84/86 | 85/86 | 130/134 | 131/134 | 132/134 | 136/134 |
| BE 124 3.00 w% | D1 P1 | Karlsruhe | .134 | .305 | .055 | .0024 | .335 | .685 | 1.412 |
| | D1 P2 | Ispra | | | | | | | |
| | D1 P3 | Ispra | | | | | | | |
| | E3 P1 | Ispra | | | | | | | |
| | E3 P2 | Karlsruhe | .233 | .613 | .100 | .0046 | .306 | .734 | 1.520 |
| | E3 P3 | Ispra | | | | | | | |
| | E3 P4 | Ispra | | | | | | | |
| | E3 P4 | Karlsruhe | .231 | .611 | .105 | .0049 | .296 | .625 | 1.518 |
| | E3 P5 | Ispra | | | | | | | |
| | G7 P1 | Ispra | | | | | | | |
| M14 | G7 P1 | Karlsruhe | .255 | .573 | .104 | .0024 | .333 | .656 | 1.400 |
| | G7 P2 | Ispra | | | | | | | |
| | G7 P3 | Ispra | | | | | | | |
| | G7 P3 | Karlsruhe | .229 | .613 | .104 | .0049 | .294 | .757 | 1.534 |
| | G7 P4 | Ispra | | | | | | | |
| | G7 P5 | Karlsruhe | .245 | .602 | .107 | .0036 | .304 | .723 | 1.487 |
| | M14 P1 | Karlsruhe | .257 | .567 | .106 | .0020 | .339 | .649 | 1.375 |
| | M14 P3 | Ispra | | | | | | | |
| | M14 P4 | Karlsruhe | .241 | .594 | .105 | .0036 | .303 | .700 | 1.419 |
| | | | | | | | | | |
| BE 210 2.83 w% | G14 P3(1) | Ispra | | | | | | | |
| | G14 P3(1) | Karlsruhe | .212 | .631 | .104 | .0065 | .275 | .761 | 1.585 |
| | G14 P4(1) | Ispra | | | | | | | |
| | G14 P5(1) | Ispra | | | | | | | |
| | G14 P5(2) | Ispra | | | | | | | |
| K14 | P1 | Ispra | | | | | | | |
| | P3(1) | Ispra | | | | | | | |
| | P4(1) | Karlsruhe | .241 | .594 | .105 | .0036 | .030 | .700 | 1.491 |

Table 3.3-10 Atoms Ratios Nd, Cs and Pu Referred to Final U
in Obrigheim PWR

| FUEL ELEMENT | SAMPLES | LAB. | Nd148/U238 ($\times 10E-4$) | Cs137/U238 ($\times 10E-3$) | Pu239/U238 ($\times 10E-3$) | Total Pu/U Mass Ratio ($\times 10E-3$) |
|-------------------|-----------|-----------|----------------------------------|----------------------------------|----------------------------------|---|
| BE 124 3.00 w% | D1 P1 | Karlsruhe | 4.01 | | 4.54 | 6.65 |
| | D1 P2 | Ispra | | 1.88 | | |
| | D1 P3 | Ispra | 6.46 | 2.33 | 5.29 | 9.82 |
| | E3 P1 | Ispra | 3.81 | 1.35 | 4.45 | 6.62 |
| | E3 P2 | Karlsruhe | 6.73 | | 4.88 | 8.50 |
| | E3 P3 | Ispra | 6.96 | 2.48 | 5.04 | 9.69 |
| | E3 P4 | Ispra | 5.89 | 2.15 | 5.19 | 9.30 |
| | E3 P4 | Karlsruhe | 5.91 | | 5.17 | 9.31 |
| | E3 P5 | Ispra | 4.34 | 2.36 | 4.86 | 7.63 |
| | G7 P1 | Ispra | 3.23 | 1.77 | 4.42 | 6.25 |
| | G7 P1 | Karlsruhe | 4.31 | | 4.59 | 6.56 |
| | G7 P2 | Ispra | 4.91 | 2.59 | 4.92 | 8.09 |
| | G7 P3 | Ispra | 6.02 | 3.28 | 5.25 | 9.47 |
| | G7 P3 | Karlsruhe | 5.95 | | 5.31 | 9.60 |
| | G7 P4 | Ispra | 5.29 | 2.86 | 5.33 | 9.03 |
| | G7 P5 | Karlsruhe | 4.91 | | 5.33 | 8.80 |
| M14 | M14 P1 | Karlsruhe | 2.94 | | 4.13 | 5.17 |
| | M14 P3 | Ispra | 5.60 | 3.01 | 5.27 | 9.07 |
| | M14 P4 | Karlsruhe | 4.73 | | 5.19 | 8.49 |
| BE 210 2.83 w% | G14 P3(1) | Ispra | 7.31 | 3.94 | 4.77 | 9.73 |
| | G14 P3(1) | Karlsruhe | 7.09 | | 4.86 | 9.85 |
| | G14 P4(1) | Ispra | 6.82 | 3.70 | 4.65 | 8.84 |
| | G14 P5(1) | Ispra | 5.74 | 3.20 | 4.57 | 8.17 |
| | G14 P5(2) | Ispra | 4.59 | 2.55 | 4.46 | 7.21 |
| | K14 P1 | Ispra | 4.83 | 2.39 | 4.81 | 7.57 |
| | K14 P3(1) | Ispra | 7.03 | 3.75 | 4.94 | 9.36 |
| | K14 P4(1) | Karlsruhe | 6.28 | | 4.74 | 9.28 |

Table 3.3-11 Specific Activities of Fission Products and Activity Ratios in Obrigheim PWR at Reactor Shutdown (dps/g of final uranium)

| FUEL ELEMENT | SAMPLES | LAB. | Cs-137 ($\times 10^9$) | Cs-134 ($\times 10^9$) | Eu-154 ($\times 10^8$) | Cs-134/ Cs-137 | Eu-154/ Cs-137 ($\times 10^{-2}$) |
|-------------------|-----------|-----------|-----------------------------|-----------------------------|-----------------------------|-------------------|---|
| BE 124 3.00 w% | D1 P1 | Karlsruhe | | | | | |
| | D1 P2 | Ispra | 3.308 | 4.287 | 1.916 | 1.296 | 5.790 |
| | D1 P3 | Ispra | 4.097 | 6.512 | 2.652 | 1.590 | 6.470 |
| | E3 P1 | Ispra | 2.372 | 2.115 | .779 | .892 | 3.284 |
| | E3 P2 | Karlsruhe | | | | | |
| | E3 P3 | Ispra | 4.361 | 6.926 | 2.555 | 1.588 | 5.859 |
| | E3 P4 | Ispra | 3.774 | 5.568 | 2.147 | 1.475 | 5.689 |
| | E3 P4 | Karlsruhe | | | | | |
| | E3 P5 | Ispra | 2.751 | 3.084 | 1.186 | 1.121 | 4.311 |
| | G7 P1 | Ispra | 2.053 | 1.714 | .547 | .835 | 2.664 |
| BE 210 2.83 w% | G7 P1 | Karlsruhe | | | | | |
| | G7 P2 | Ispra | 3.041 | 3.749 | 1.653 | 1.233 | 5.436 |
| | G7 P3 | Ispra | 3.871 | 5.940 | 2.481 | 1.534 | 6.411 |
| | G7 P3 | Karlsruhe | | | | | |
| | G7 P4 | Ispra | 3.356 | 4.752 | 1.999 | 1.412 | 5.941 |
| | G7 P5 | Karlsruhe | | | | | |
| | M14 P1 | Karlsruhe | | | | | |
| | M14 P3 | Ispra | 3.539 | 5.068 | 2.102 | 1.432 | 5.940 |
| | M14 P4 | Karlsruhe | | | | | |
| | G14 P3(1) | Ispra | 4.665 | 7.597 | 2.743 | 1.628 | 5.880 |
| BE 210 2.83 w% | G14 P3(1) | Karlsruhe | | | | | |
| | G14 P4(1) | Ispra | 4.376 | 6.842 | 2.609 | 1.564 | 5.962 |
| | G14 P5(1) | Ispra | 3.758 | 5.091 | 2.079 | 1.355 | 5.532 |
| | G14 P5(2) | Ispra | 2.968 | 3.244 | 1.338 | 1.093 | 4.508 |
| | K14 P1 | Ispra | 2.782 | 3.236 | 1.364 | 1.163 | 4.900 |
| | K14 P3(1) | Ispra | 4.438 | 7.353 | 2.909 | 1.657 | 6.554 |
| BE 210 2.83 w% | K14 P4(1) | Karlsruhe | | | | | |

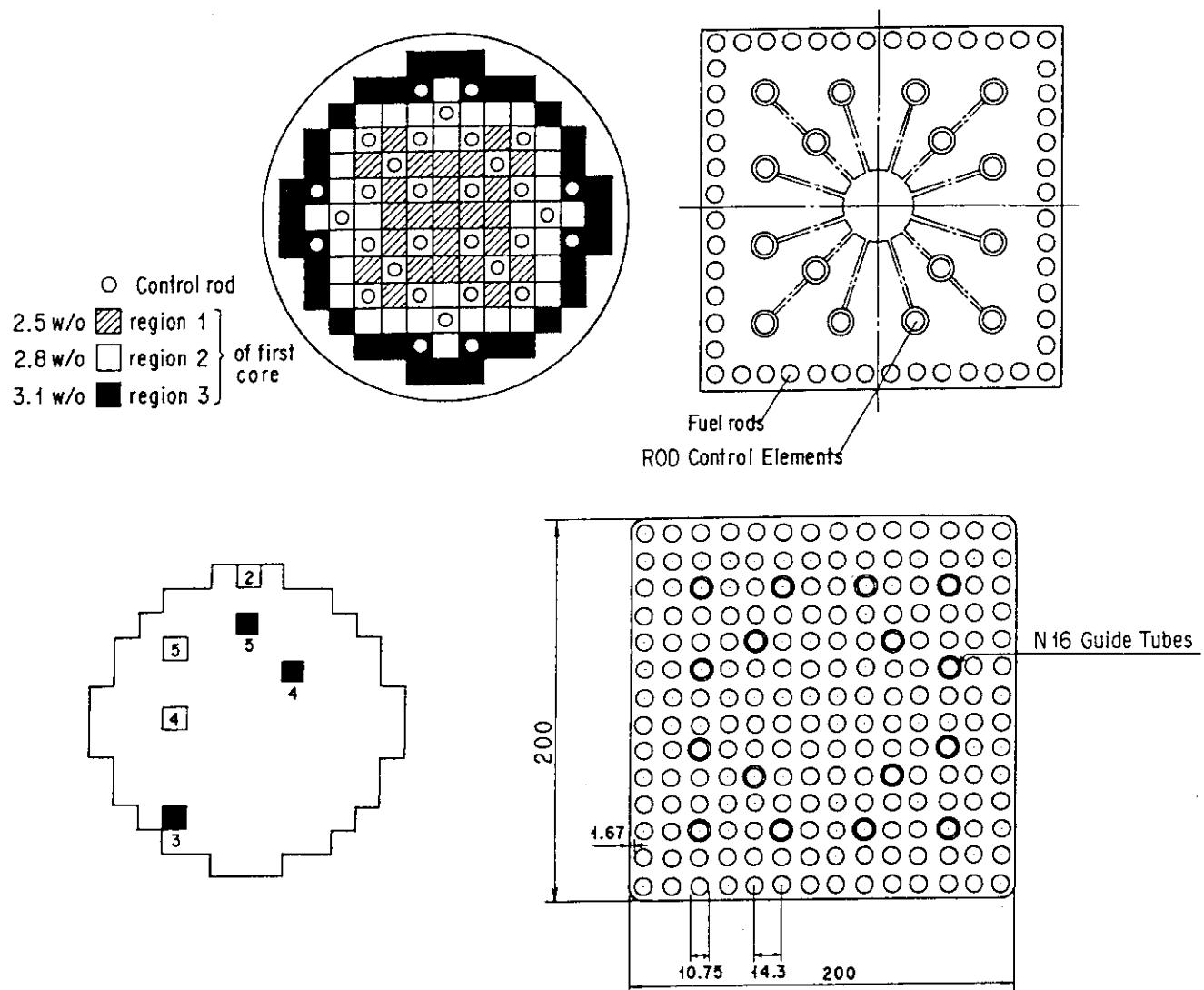
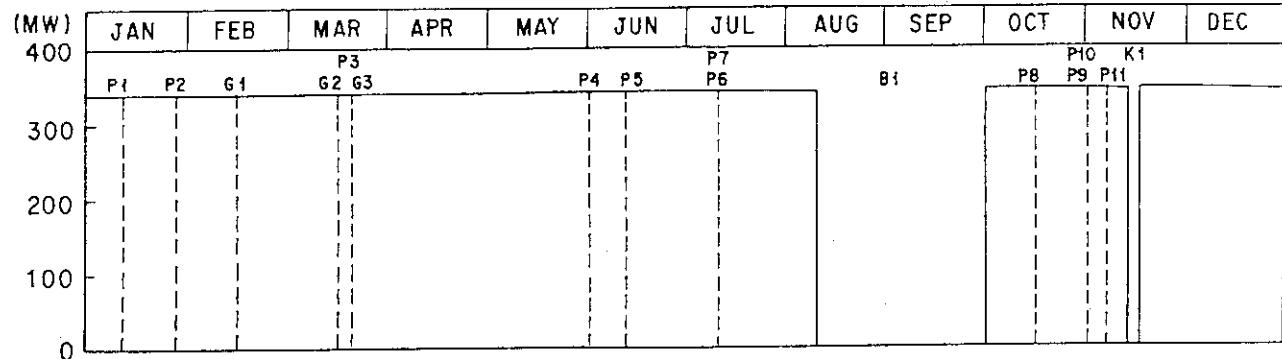
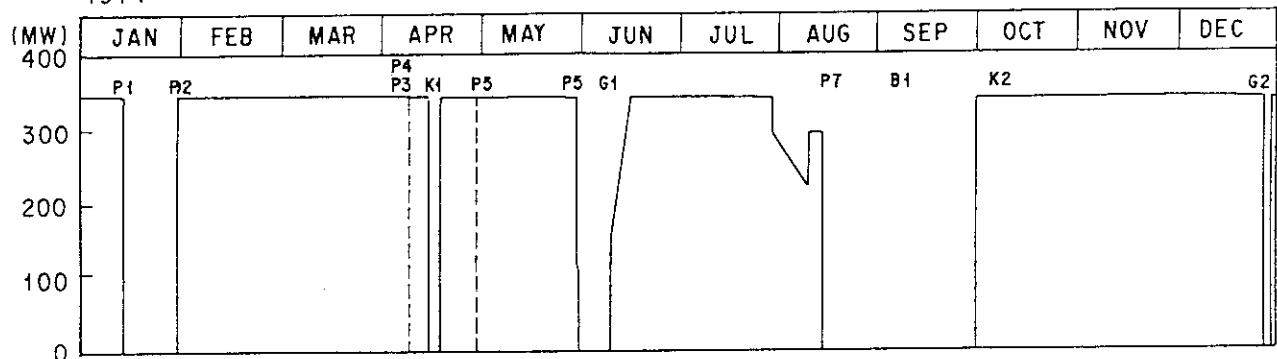


Fig. 3.3-1 Configuration of Obrigheim core

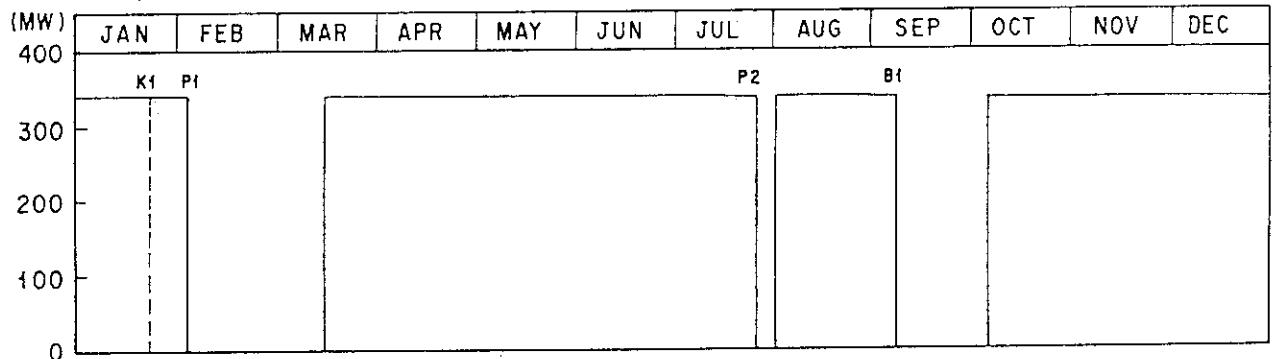
1970



1971



1972



1973

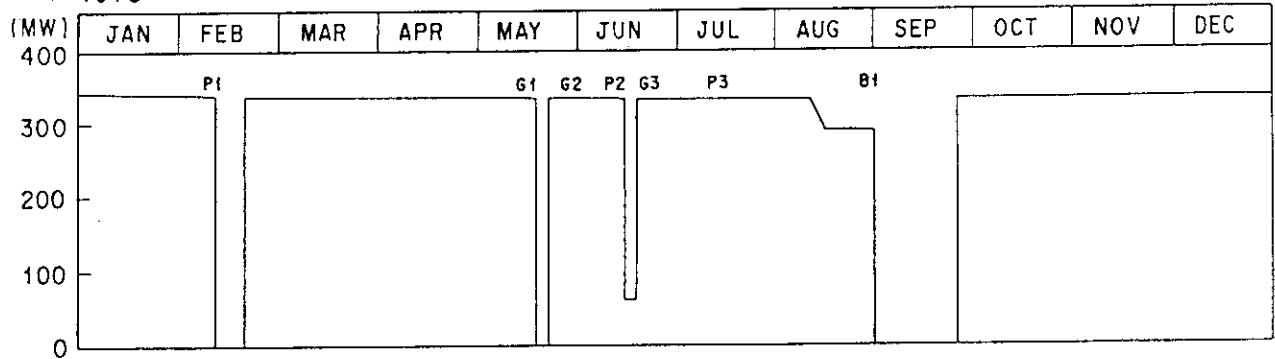


Fig. 3.3-2 Operating history of Obrigheim core

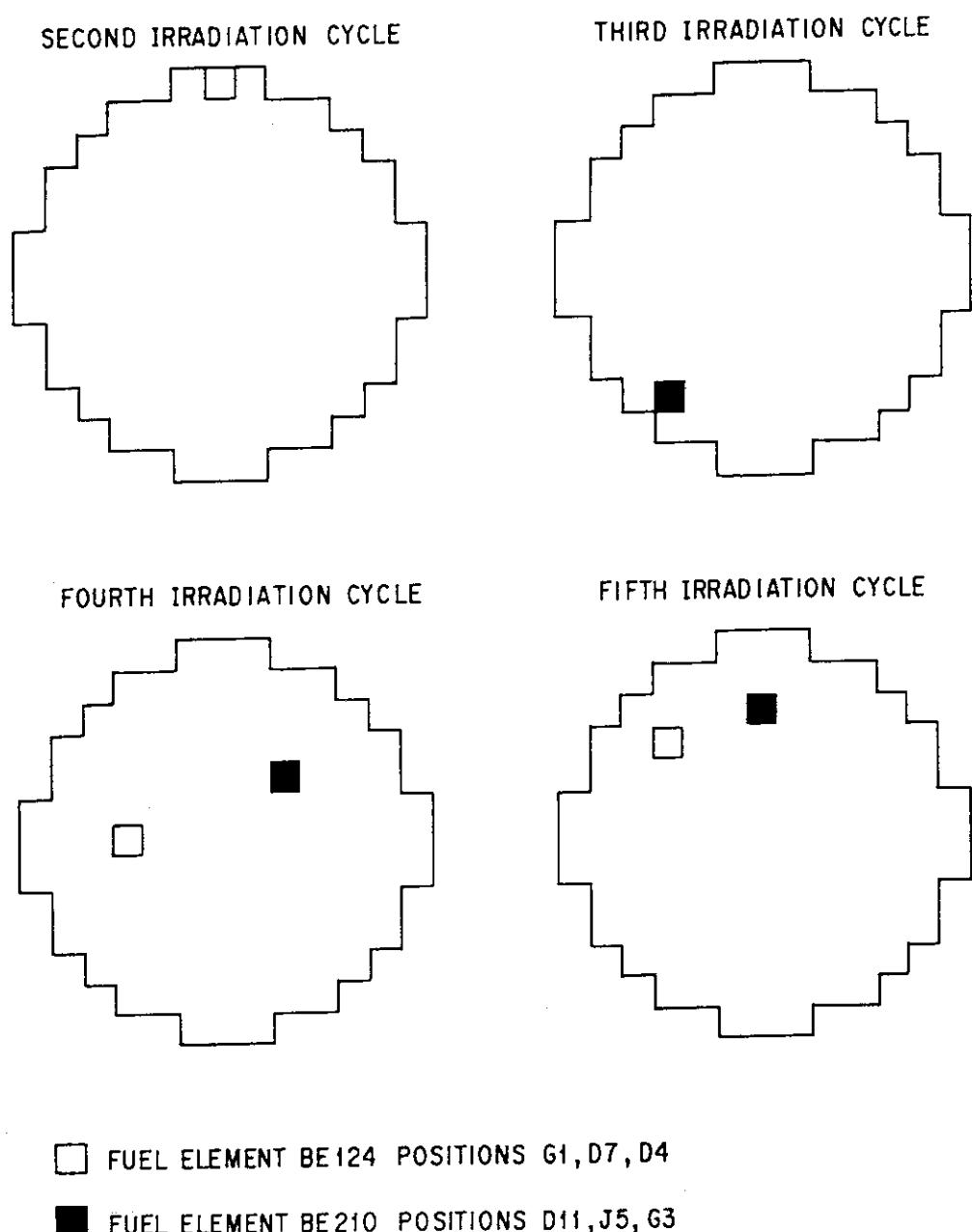
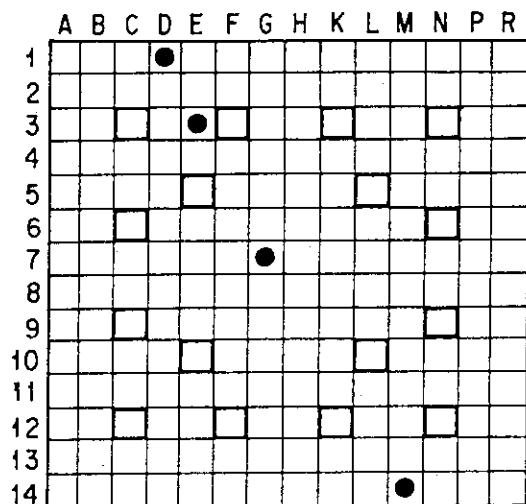
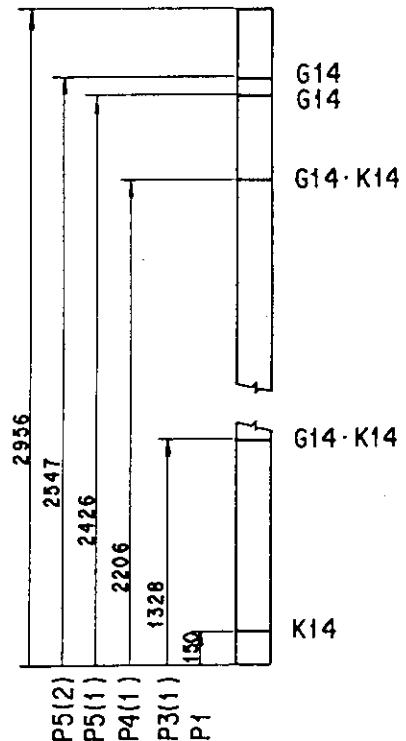
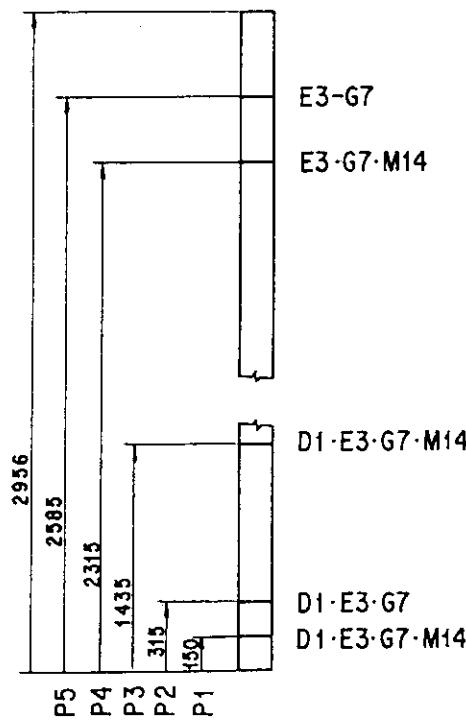
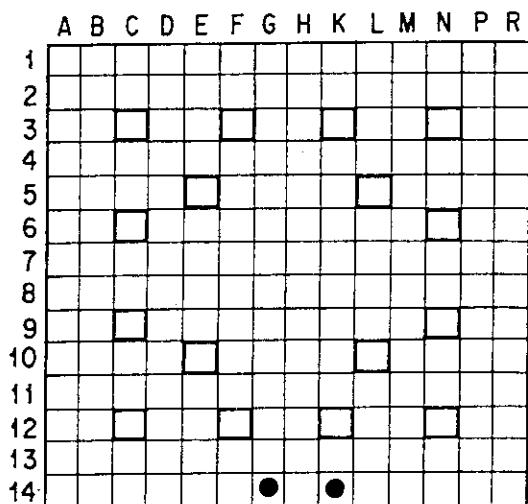
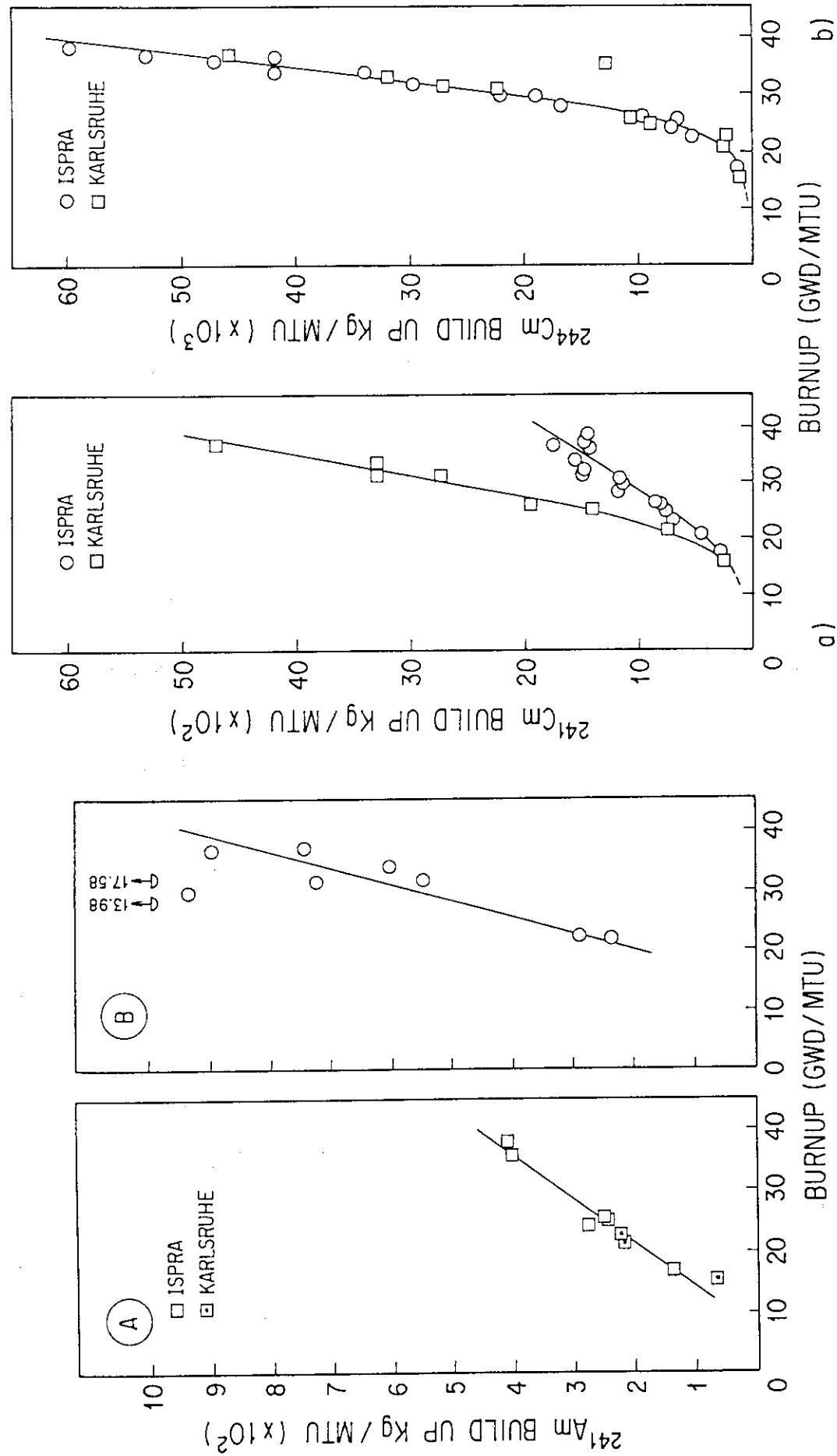


Fig. 3.3-3 Schematic core maps of the Obrigheim during different irradiation cycles.
The position of the elements BE-124 and BE-210 are indicated.

BE124·3.00 wt% ^{235}U BE210·2.83 wt% ^{235}U 

● SELECTED ROD

Fig. 3.3-4 Cutting positions of the Obrigheim reactor fuel samples selected for analysis

Fig. 3.3-5 ^{241}Am build up plotted against burnupFig. 3.3-6 ^{241}Cm isotopes build up plotted against burnup

3.4 Garigliano炉(BWR)

Garigliano炉の照射後試験は発電用軽水路のプルトニウム・リサイクルの研究の一環として行われた。その主な目的は適当な計算方法を用いてプルトニウムを含む燃料要素の設計限界を明らかにすることであった。そのため、計算方法および計算コードの検証ができるよう膨大な測定が実施された。また、照射後の燃焼度および同位体含有率の測定は、プルトニウム燃料集合体の設計で用いられると期待される高いプルトニウム含有率をもつ照射済燃料集合体について実施された。

なお、本節に使用した図表は下記の文献から転載したものである。

- 6) A. Aeijemma et.al: "Experimental and Theoretical Determination of Burnup and Heavy Isotope Content in a Fuel Assembly Irradiated in the Garigliano Boiling Water Reactor", EUR4638e(1971).
- 8) S. Guardini et.al: "Benchmark Reference Data on Post-irradiation Analysis of Light Water Reactor Fuel Samples", EUR7879EN(1982).

3.4.1 炉心構成と炉心性能

Table 3.4-1 炉心構成と炉心性能を示す。また、炉心の構成図および燃料集合体図をFig. 3.4-1に示す。運転サイクル Cycle I では 9×9 の燃料棒配列をもつ燃料集合体が装荷され、Cycle II では 8×8 の燃料棒配列をもつ燃料集合体が装荷された。 9×9 配列の燃料集合体内の初期濃縮度分布をFig. 3.4-2に示す。

3.4.2 燃焼履歴とサンプリング燃料の配置

試験燃料として、Cycle I からの燃料集合体A-106の1体、Cycle II から燃料集合体SA-13の1体合計2体が選ばれた。

Fig. 3.4-3 にサンプル燃料 A-106の照射履歴を示す。Fig. 3.4-1 およびFig. 3.4-4 に照射中の A-106の炉心内位置を図示する。また、測定された燃料棒の燃料集合体内位置をFig. 3.4-5 に示す。この図で x印がサンプル燃料棒を示す。全部で18本の燃料棒が選ばれた。

燃料集合体SA-13はCycle IIで照射されたが、その炉心内位置をFig. 3.4-1 に示す。

各サンプル燃料の軸方向サンプリング位置、SA-13の初期濃縮度分布およびサンプル燃料棒位置をFig. 3.4-6 に示す。SA-13のサンプル燃料棒は1本である。

A-106から選ばれたサンプル燃料棒は全てlevel CおよびDから切断されてサンプリングされた。

3.4.3 核種組成データ

測定はIspraとKarlsruheの2つの研究所で行われた。

まず、A-106の測定について述べる。

level C および Dに於ける (Ru/Rh), Csおよび (Ce/Pr)の放射能をTable 3.4-2 およびTable 3.4-2 およびTable 3.4-3 に示す。

核種組成測定のサンプルは18本の燃料棒全てLevel Cから取られた。

Table 3.4-4 に非破壊測定の¹³⁷Cs法, 破壊測定の¹³⁷Cs法およびHE (U, Puの同位体の生成消滅から重元素総燃焼量F_T)を算出する; Heavy Element)法の3つ方法による燃焼度測定の結果を示す。また, 破壊測定法のうち¹³⁷Cs法と¹⁴⁸Nd法による燃焼度の値を比較した結果をTable 3.4-5 に示す。さらに, 非破壊の¹³⁷Cs法とHE法による燃焼度との関係についてTable 3.4-6 に示す。

Table 3.4-7 にU, Puの同位体の含有量を初期U量に対する比として示す。その各同位体含有率の燃料集合体内分布をFig. 3.4-7 ~ Fig. 3.4-13に示す。またU, Pu, AmおよびNdの同位体比をTable 3.4-8 に示す。

Kr, Xeの同位体比をTable 3.4-9 に示す。また, (⁸⁴Kr/⁸³Kr)と重元素総燃焼量F_T, U減損量の初期Uに対する原子個数%との関係をFig. 3.4-14に示す。さらに(⁸³Kr/⁸⁴Kr)と重元素総燃焼量F_T, ²³⁵U燃焼量F₅およびU減損量の初期Uに対する原子個数%との関係をFig. 3.4-15に示す。²⁴⁰Pu/²³⁹Puと²³⁵U/²³⁸Uとの関係をFig. 3.4-16に, ²³⁶U/²³⁸Uと²³⁵U/²³⁸Uとの関係をFig. 3.4-17に示す。また, ²³⁶U/²³⁸Uと総燃焼量F_Tとの関係をFig. 3.4-18に示す。

Table 3.4-10 にアルファ放出核種のアルファ放射能を, Table 3.4-11 に¹⁴⁸Nd, ²³⁸U および²³⁹Puの同位体濃度を示す。

つぎに, サンプル燃料集合体 SA-13の測定について述べる。サンプル燃料棒はE6燃料棒1本である。軸方向サンプリング位置はFig. 3.4-6 に示す通りである。

U同位体の最終²³⁸Uに対する比をTable 3.4-12に, Pu同位体の最終²³⁸Uに対する比をTable 3.4-13に示す。また, ¹⁴⁸Ndおよび¹³⁷Csの最終²³⁸Uに対する比をTable 3.4-14に, AmおよびCm同位体の最終²³⁸Uに対する比をTable 3.4-15に示す。

初期U量に対するU同位体の蓄積, 減損をTable 3.4-16に, 初期U量に対するPu同位体の蓄積をTable 3.4-17に示す。また, 初期U量に対するAmおよびCm同位体の蓄積をTable 3.4-18に示す。

Table 3.4-19 に¹⁴⁸Ndおよび¹³⁷Csから算出された燃焼度をF_TおよびMWD/MTUで示す。

Table 3.4-1 Core Composition and Performance(Garigliano)

| | Cycle Number | Cycle I | Cycle II | Cycle Number | Cycle I | Cycle II |
|---------------------------------------|----------------------|------------|------------|---|-------------------------|----------|
| Fuel Pellet | | | | Control Rod Absorbing material | | |
| UO ₂ density | (g/cm ³) | 11.4 | 13.37 | B ₄ C Powder | B ₄ C Powder | |
| Linear density | (g/cm) | 1.191 | 1.290 | | | |
| Diameter | (cm) | | | Core | | |
| Length of pellet stack in fuel rod | (cm) | 267.72 | 271.8 | Equivalent diameter (cm) | 291.084 | 291.084 |
| Clad-pellet clearance | (cm) | 0.0063 | 0.014 | Active height (cm) | 267.72 | 271.8 |
| Fuel Clad | | | | No. of square assemblies | 208 | 208 |
| Outside diameter | (cm) | 1.356 | 1.506 | No. of control rods | 89 | 89 |
| Inside diameter | (cm) | 1.2036 | 1.318 | UO ₂ in square assemblies(kg) | | |
| Wall thickness | (cm) | 0.0762 | 0.094 | Total UO ₂ weight(kg) | 51,609 | 51,609 |
| Material | Zircaloy-2 | Zircaloy-2 | Zircaloy-2 | Total U weight(kg) | 45,492 | 45,492 |
| Square Fuel Assembly | | | | Core Thermo-hydraulic Characteristics | | |
| Rod array | 9 × 9 | 8 × 8 | | Power | 506 | 506 |
| Number of rods | 81 | 64 | | (MWth) | | |
| Fuel rod pitch | (cm) | 1.73 | 1.93 | (MW _e) | | |
| Side of square cross section | (cm) | 16.144 | 16.144 | Coolant pressure (kg/cm ²) | 181.26 | 181.26 |
| Total length | (cm) | 327.5 | 327.5 | Coolant temperature(ave., °C) | 285 | 285 |
| UO ₂ weight | (kg) | 240.12 | 231.52 | (inlet, °C) | | |
| Initial enrichment | (%) | 1.6/2.1 | 1.83/2.41 | (outlet, °C) | | |
| Channel material | SUS304 | Zircaloy-2 | | | | |
| Channel mat. thickness | (cm) | 0.152 | 0.203 | | | |

Table 3.4-2 Activities Measured at Level C

| Rod | Counts, cps | | |
|-----|------------------------|---------------|-------------------------|
| | (Ru/Rh) (*) 512 keV | Cs 662 keV | (Ce/Pr) (*) 2186 keV |
| A-1 | 75.12 | 164.90 | 1.453 |
| B-1 | 67.08 | 148.29 | 1.357 |
| C-1 | 60.43 | 158.59 | 1.388 |
| D-1 | 63.08 | 159.29 | 1.465 |
| E-1 | 64.36 | 164.15 | 1.470 |
| J-1 | 92.45 | 196.24 | 1.661 |
| A-2 | 63.17 | 146.33 | 1.339 |
| B-2 | 60.66 | 159.68 | 1.435 |
| C-2 | 55.61 | 148.30 | 1.352 |
| D-2 | 55.69 | 143.65 | 1.306 |
| H-2 | 68.50 | 179.60 | 1.586 |
| A-3 | 61.23 | 158.14 | 1.424 |
| B-3 | 56.16 | 146.55 | 1.356 |
| C-3 | 53.23 | 141.37 | 1.302 |
| D-3 | 52.99 | 139.24 | 1.286 |
| E-3 | 54.17 | 139.43 | 1.240 |
| A-4 | 61.72 | 160.16 | 1.455 |
| D-4 | 50.48 | 131.67 | 1.209 |
| A-5 | 66.38 | 165.99 | 1.549 |
| C-5 | 55.55 | 143.77 | 1.322 |
| E-5 | 43.03 | 112.82 | 0.996 |
| B-6 | 61.80 | 157.38 | 1.412 |
| D-6 | 53.94 | 142.98 | 1.278 |
| C-7 | 59.41 | 155.26 | 1.416 |
| D-7 | 47.45 | 124.71 | 0.861 |
| G-7 | 62.21 | 160.87 | 1.459 |
| A-8 | 95.11 | 187.15 | 1.636 |
| B-8 | 72.03 | 185.16 | 1.716 |
| H-8 | 74.50 | 190.79 | 1.680 |
| A-9 | 102.98 | 214.39 | 1.827 |
| B-9 | 88.27 | 185.92 | 1.638 |
| C-9 | 81.02 | 201.91 | 1.842 |
| D-9 | 79.77 | 191.18 | 1.827 |
| J-9 | 88.19 | 175.51 | 1.533 |

(*) Counts referred to November 18, 1968

Table 3.4-3 Activities Measured at Level D

| Rod | Counts, cps | | |
|-----|------------------------|---------------|-------------------------|
| | (Ru/Rh) (*) 512 keV | Cs 662 keV | (Ce/Pr) (*) 2186 keV |
| A-1 | 37.69 | 94.48 | 0.774 |
| B-1 | 35.30 | 96.12 | 0.815 |
| C-1 | 32.54 | 101.75 | 0.856 |
| D-1 | 32.05 | 101.03 | 0.839 |
| E-1 | 33.41 | 96.56 | 0.785 |
| J-1 | 46.48 | 119.68 | 0.989 |
| A-2 | 33.71 | 92.84 | 0.744 |
| B-2 | 30.35 | 98.10 | 0.796 |
| C-2 | 28.05 | 89.50 | 0.707 |
| D-2 | 27.76 | 89.04 | 0.736 |
| H-2 | 33.05 | 106.11 | 0.882 |
| A-3 | 31.74 | 99.65 | 0.731 |
| B-3 | 28.04 | 89.21 | 0.785 |
| C-3 | 28.26 | 88.57 | 9.717 |
| D-3 | 25.73 | 83.11 | 0.647 |
| E-3 | 26.20 | 82.35 | 0.648 |
| A-4 | 30.83 | 96.81 | 0.794 |
| D-4 | 25.58 | 81.28 | 0.657 |
| A-5 | 32.59 | 100.51 | 0.827 |
| C-5 | 26.12 | 82.31 | 0.667 |
| E-5 | 25.26 | 78.70 | 0.654 |
| B-6 | 27.96 | 89.22 | 0.705 |
| D-6 | 26.59 | 81.51 | 0.671 |
| C-7 | 28.10 | 89.72 | 0.735 |
| D-7 | 27.81 | 85.74 | 0.688 |
| G-7 | 29.74 | 92.20 | 0.749 |
| A-8 | 41.72 | 109.01 | 0.893 |
| B-8 | 34.62 | 110.70 | 0.915 |
| H-8 | 36.18 | 114.74 | 0.940 |
| A-9 | 49.57 | 125.45 | 0.958 |
| B-9 | 44.39 | 11.12 | 0.914 |
| C-9 | 39.32 | 118.97 | 1.032 |
| D-9 | 37.70 | 113.46 | 0.936 |
| J-9 | 51.44 | 123.17 | 1.011 |

(*) Counts referred to January 10, 1969

Table 3.4-4 Comparison of the Burn-up Distribution Obtained with Three Different Techniques

| Rod | B^1_{rel} | B^2_{rel} | B^3_{rel} | Rod | B^1_{rel} | B^2_{rel} | B^3_{rel} |
|-----|-------------|-------------|-------------|-----|-------------|-------------|-------------|
| A-1 | 0.991 | 0.982 | 0.967 | D-2 | 0.863 | 0.870 | 0.866 |
| A-3 | 0.950 | 0.968 | 0.960 | D-4 | 0.791 | 0.822 | 0.808 |
| A-5 | 0.997 | 1.000 | 0.969 | E-1 | 0.986 | 0.977 | 0.990 |
| A-9 | 1.288 | 1.287 | 1.287 | E-5 | 0.688 | 0.816 | 0.809 |
| B-1 | 0.891 | 0.892 | 0.898 | G-7 | 0.966 | 0.941 | 0.963 |
| B-2 | 0.959 | 0.931 | 0.940 | H-2 | 1.079 | 1.069 | 1.093 |
| B-8 | 1.112 | 1.119 | 1.111 | H-8 | 1.146 | 1.128 | 1.160 |
| C-1 | 0.953 | 0.978 | 0.977 | J-1 | 1.179 | 1.196 | 1.177 |
| C-3 | 0.849 | 0.839 | 0.835 | J-9 | 1.070 | 1.298 | 1.314 |

 B^1_{rel} from cps of Cs-137

$$\sigma[(B^2_{rel} - B^1_{rel})/B^1_{rel}] = \pm 1.8\%$$

 B^2_{rel} from Ci/g of Cs-137 B^3_{rel} from % F_T

$$\sigma[(B^3_{rel} - B^1_{rel})/B^1_{rel}] = \pm 1.5\%$$

Table 3.4-5 Comparison between the Burn-up Values Obtained with the Two Destructive Techniques Based on Cs-137 Activity and Nd-148 Concentration

| Rod | B^1 | B^2 | $B^1 - B^2 / B^2 \times 100$ | Rod | B^1 | B^2 | $B^1 - B^2 / B^2 \times 100$ |
|-----|--------|--------|------------------------------|-----|--------|--------|------------------------------|
| A-1 | 10,355 | 10,183 | +1.66 | C-3 | 8,939 | 8,702 | +2.65 |
| B-1 | 9,619 | 9,252 | +3.81 | D-4 | 8,653 | 8,517 | +1.57 |
| C-1 | 10,465 | 10,138 | +3.12 | A-5 | 10,373 | 10,369 | +0.04 |
| E-1 | 10,603 | 10,125 | +4.51 | E-5 | 8,736 | 8,517 | +2.51 |
| J-1 | 12,599 | 12,403 | +1.56 | G-7 | 10,309 | 9,752 | +5.40 |
| B-2 | 10,060 | 9,659 | +3.98 | B-8 | 11,890 | 11,597 | +2.46 |
| D-2 | 9,270 | 9,017 | +2.73 | H-8 | 12,424 | 11,696 | +5.86 |
| H-2 | 11,706 | 11,081 | +5.34 | A-9 | 13,785 | 13,344 | +3.20 |
| A-3 | 10,281 | 10,039 | +2.35 | J-9 | 14,180 | 13,547 | +4.46 |

 B^1 obtained from F_T in MWd/MTU B^2 obtained from Ci/g of Cs-137 in MWd/MTU

Table 3.4-6 Correlation of Burn-ups as Obtained from F_T (%)
with Cs-137 (cps) Non-destructive Gamma Spectrometry

| Rod | F_T (%) | B from F_T (Mwd/ MTU) | Cs-137 (cps) | $\frac{B}{Cs-137}$ | B from Cs-137 (Mwd/ MTU) | Rod | Cs-137 (cps) | B from Cs-137 (Mwd/ MTU) |
|------------|--------------|----------------------------------|-----------------|--------------------|-----------------------------------|-----|-----------------|-----------------------------------|
| A-1 | 1.126 | 10,355 | 164.90 | 62.796 | 10,608 | D-1 | 159.29 | 10,248 |
| B-1 | 1.046 | 9,619 | 148.29 | 64.866 | 9,540 | A-2 | 146.33 | 9,414 |
| C-1 | 1.138 | 10,465 | 158.59 | 65.988 | 10,202 | C-2 | 148.30 | 9,541 |
| E-1 | 1.153 | 10,603 | 164.15 | 64.593 | 10,560 | B-3 | 146.55 | 9,428 |
| J-1 | 1.370 | 12,599 | 196.24 | 64.202 | 12,625 | D-3 | 139.24 | 8,958 |
| B-2 | 1.094 | 10,060 | 159.68 | 63.001 | 10,273 | E-3 | 139.43 | 8,970 |
| D-2 | 1.008 | 9,270 | 143.65 | 64.532 | 9,241 | A-4 | 160.16 | 10,304 |
| H-2 | 1.273 | 11,706 | 179.60 | 65.178 | 11,554 | C-5 | 143.77 | 9,249 |
| A-3 | 1.118 | 10,281 | 158.14 | 65.012 | 10,174 | B-6 | 157.38 | 10,125 |
| C-3 | 0.972 | 8,939 | 141.37 | 63.231 | 9,095 | D-6 | 142.98 | 9,198 |
| D-4 | 0.941 | 8,653 | 131.67 | 65.717 | 8,471 | C-7 | 155.26 | 9,988 |
| A-5 | 1.128 | 10,373 | 165.99 | 62.492 | 10,679 | D-7 | 124.71 | 8,023 |
| G-7 | 1.121 | 10,309 | 160.87 | 64.083 | 10,349 | A-8 | 187.15 | 12,040 |
| B-8 | 1.293 | 11,890 | 185.16 | 64.215 | 11,912 | B-9 | 185.92 | 11,961 |
| H-8 | 1.351 | 12,424 | 190.79 | 65.119 | 12,274 | C-9 | 201.91 | 12,989 |
| A-9 | 1.499 | 13,785 | 214.39 | 64.299 | 13,792 | D-9 | 191.18 | 12,299 |
| mean value | | | | 64.333 | | | | |

$$\sigma = \pm 1.548\%$$

Table 3.4-7 Theoretical-Experimental Comparison of Uranium and Plutonium Isotope Content

| Sample | A ₁ | A ₃ | A ₅ | A ₉ | B ₁ | B ₂ | B ₈ | C ₁ | C ₃ | D ₂ | D ₄ | E ₁ | E ₅ | G ₇ | H ₂ | H ₈ | J ₁ | J ₉ |
|------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| U-235 × 10 ⁻³ | 7.70 | 12.35 | 11.85 | 5.55 | 8.51 | 12.31 | 10.50 | 12.25 | 13.48 | 12.97 | 13.32 | 12.04 | 13.35 | 11.99 | 10.96 | 10.36 | 6.31 | 5.41 |
| | 7.40 | 11.73 | 11.68 | 4.74 | 8.00 | 12.02 | 10.43 | 11.73 | 12.67 | 12.44 | 12.85 | 11.68 | 12.75 | 11.58 | 10.43 | 10.06 | 5.88 | 4.58 |
| | -5.00 | -5.29 | -1.46 | -17.09 | -6.38 | -2.41 | -0.67 | -4.43 | -6.39 | -4.26 | -3.66 | -3.08 | -4.71 | -3.54 | -5.08 | -2.98 | -7.31 | -18.12 |
| U-236 × 10 ⁻³ | 1.61 | 1.87 | 1.73 | 1.84 | 1.42 | 1.89 | 1.99 | 1.88 | 1.68 | 1.73 | 1.72 | 1.90 | 1.64 | 1.83 | 1.95 | 2.00 | 1.80 | 1.91 |
| | 1.48 | 1.68 | 1.69 | 1.70 | 1.40 | 1.64 | 1.86 | 1.68 | 1.56 | 1.59 | 1.54 | 1.69 | 1.55 | 1.72 | 1.86 | 1.91 | 1.70 | 1.72 |
| | -8.78 | -11.31 | -2.37 | -1.63 | -1.41 | -15.24 | -6.99 | -11.91 | -7.69 | -8.80 | -11.69 | -12.43 | -5.81 | -6.39 | -4.84 | -4.71 | -5.88 | -4.94 |
| U-238 | 0.9739 | 0.9693 | 0.9697 | 0.9720 | 0.9742 | 0.9696 | 0.9653 | 0.9692 | 0.9697 | 0.9698 | 0.9701 | 0.9690 | 0.9701 | 0.9693 | 0.9690 | 0.9685 | 0.9725 | 0.9714 |
| | 0.9758 | 0.9715 | 0.9714 | 0.9736 | 0.9758 | 0.9715 | 0.9707 | 0.9715 | 0.9715 | 0.9715 | 0.9714 | 0.9714 | 0.9713 | 0.9709 | 0.9707 | 0.9705 | 0.9747 | 0.9735 |
| | +0.19 | +0.23 | +0.18 | +0.16 | +0.20 | +0.14 | +0.24 | +0.18 | +0.17 | +0.13 | +0.25 | +0.12 | +0.16 | +0.18 | +0.18 | +0.21 | +0.23 | +0.22 |
| Pu-239 × 10 ⁻³ | 3.725 | 3.884 | 3.977 | 3.439 | 3.859 | 3.857 | 3.685 | 3.929 | 4.148 | 4.028 | 4.181 | 4.058 | 4.221 | 4.167 | 3.820 | 3.855 | 3.663 | 3.518 |
| | 2.866 | 3.062 | 3.139 | 2.665 | 3.046 | 3.159 | 3.007 | 3.062 | 3.491 | 3.404 | 3.680 | 3.139 | 3.739 | 3.417 | 3.007 | 2.993 | 2.551 | 2.639 |
| | -29.97 | -26.84 | -21.07 | -29.04 | -26.69 | -22.10 | -18.40 | -22.07 | -18.82 | -18.33 | -13.61 | -29.28 | -12.89 | -21.95 | -27.04 | -28.80 | -43.59 | -33.31 |
| Pu-240 × 10 ⁻³ | 1.1170 | 0.9190 | 0.9350 | 1.4200 | 1.0100 | 0.8790 | 1.0640 | 0.9190 | 0.8070 | 0.8090 | 0.7640 | 0.9340 | 0.7700 | 0.9410 | 1.0280 | 1.1330 | 1.3240 | 1.4740 |
| | 1.2182 | 0.9887 | 0.9961 | 1.6063 | 1.1100 | 0.9444 | 1.1491 | 0.9887 | 0.8479 | 0.8815 | 0.8147 | 0.9961 | 0.8235 | 0.9943 | 1.1491 | 1.2022 | 1.4923 | 1.6400 |
| | +8.29 | +7.05 | +6.13 | +11.58 | +9.01 | +6.88 | +7.40 | +7.05 | +4.82 | +8.22 | +6.22 | +6.23 | +6.50 | +5.36 | +10.54 | +5.76 | +11.28 | +10.12 |
| Pu-241 × 10 ⁻³ | 0.4394 | 0.3722 | 0.3847 | 0.5946 | 0.4030 | 0.3506 | 0.4036 | 0.3761 | 0.3360 | 0.3383 | 0.3311 | 0.3909 | 0.3336 | 0.3894 | 0.4130 | 0.4360 | 0.5497 | 0.5840 |
| | 0.4119 | 0.3670 | 0.3806 | 0.5211 | 0.4071 | 0.3661 | 0.4171 | 0.3670 | 0.3745 | 0.3765 | 0.3869 | 0.4006 | 0.4235 | 0.4171 | 0.4341 | 0.4411 | 0.5253 | |
| | -6.68 | -1.42 | -1.08 | -5.47 | +1.01 | +4.23 | +3.24 | -2.48 | +10.28 | +10.15 | +14.42 | -2.70 | +1.65 | +8.05 | +0.98 | -0.44 | -24.62 | -11.17 |
| Pu-242 × 10 ⁻³ | 0.0861 | 0.0544 | 0.0555 | 0.1649 | 0.0676 | 0.0494 | 0.0735 | 0.0561 | 0.0384 | 0.0411 | 0.0364 | 0.0559 | 0.0359 | 0.0542 | 0.0693 | 0.0827 | 0.1407 | 0.1820 |
| | 0.0809 | 0.0533 | 0.0548 | 0.1430 | 0.0702 | 0.0495 | 0.0727 | 0.0533 | 0.0422 | 0.0450 | 0.0405 | 0.0548 | 0.0421 | 0.0577 | 0.0727 | 0.0801 | 0.1212 | 0.1515 |
| | -6.43 | -2.06 | -1.28 | -15.31 | +3.70 | +0.20 | -1.10 | -5.25 | +9.00 | +8.67 | +10.12 | -2.01 | +14.73 | +6.07 | +4.68 | -3.25 | -16.09 | -20.10 |

* Experimental value

** Theoretical value

*** (T - E/T) × 100

— Values calculated by two-group BURNY

Table 3.4-8 Isotope Mass Ratio of Uranium, Plutonium, Americium and Neodymium (1/2)

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| Sample No. | Uranium | | | Plutonium | | | Americium | | | Neodymium | |
|---|----------------------------------|---|---|---|------------------------------------|------------------------------------|--------------------------------------|--------------------------------------|--|--|--|
| | R ⁵ (U-235/U-238) | R ₆ (U-236/U-238) | R' ⁰ (Pu-240/Pu-238) | R' ¹ (Pu-241/Pu-239) | R' ² (Pu-242/Pu-239) | R' ² (Am-242/Am-241) | R' ²⁴² (Am-242/Am-241) | R' ²⁴³ (Am-243/Am-241) | R' ²⁴³ (Corr. Nd-148/Nd-150) | R' ¹⁴⁸ (Corr. Nd-148/Nd-150) | |
| A-1 0.00800 ± 0.20 0.00796 ± 0.32 | 0.00163 ± 0.85 0.00166 ± 0.95 | 0.3009 ± 0.13 0.2988 ± 0.15 0.2998 ± 0.13 | 0.1057 ± 0.22 0.1062 ± 0.32 0.1060 ± 0.34 | 0.0227 ± 0.62 0.0232 ± 0.48 0.0235 ± 0.78 | n.m. n.m. | n.m. n.m. | 2.1752 ± 0.30 2.1677 ± 0.40 | 2.1714 ± 0.40 | 2.1714 ± 0.40 | | |
| A-3 0.01279 ± 0.57 0.01271 ± 0.68 | 0.00196 ± 1.46 0.00190 ± 1.30 | 0.2998 ± 0.20 0.2365 ± 0.24 | 0.1060 ± 0.40 0.0848 ± 0.27 | 0.0231 ± 0.80 0.0139 ± 0.35 | n.m. n.m. | n.m. n.m. | 2.2132 ± 0.15 2.2037 ± 0.31 | 2.2085 ± 0.30 | 2.2085 ± 0.30 | | |
| A-5 0.01213 ± 0.61 0.01232 ± 0.41 | 0.00178 ± 0.72 0.00179 ± 1.20 | 0.2365 ± 0.30 0.2351 ± 0.30 0.2354 ± 0.14 | 0.0850 ± 0.40 0.0842 ± 0.18 0.0842 ± 0.30 | 0.0140 ± 0.60 0.0140 ± 0.94 0.0139 ± 0.54 | n.m. n.m. 0.00667 | 0.0650 0.0650 | 2.1736 ± 0.44 2.1791 ± 0.72 | 2.1791 ± 0.72 | 2.1791 ± 0.72 | | |
| A-9 0.00573 ± 0.55 0.00570 ± 0.28 | 0.00189 ± 1.10 0.00189 ± 1.00 | 0.4137 ± 0.21 0.4123 ± 0.29 | 0.1392 ± 0.10 0.1392 ± 0.31 | 0.0480 ± 0.27 0.0480 ± 0.40 | 0.00314 0.00314 | 0.1713 0.1713 | 2.1800 ± 0.42 2.1865 ± 0.61 | 2.1865 ± 0.61 | 2.1865 ± 0.61 | | |
| B-1 0.00868 ± 0.52 0.00880 ± 1.05 | 0.00145 ± 0.45 0.00147 ± 0.85 | 0.2619 ± 0.18 0.2615 ± 0.37 | 0.0928 ± 0.19 0.0930 ± 0.16 | 0.0175 ± 0.81 0.0175 ± 0.54 | 0.00314 ± 2.40 0.01550 | 0.0815 0.0815 | 2.1626 ± 0.48 2.1515 ± 0.48 | 2.1515 ± 0.48 | 2.1515 ± 0.48 | | |
| B-2 0.01283 ± 0.49 0.01257 ± 0.21 | 0.00202 ± 2.20 0.00187 ± 1.60 | 0.2279 ± 0.19 0.2280 ± 0.21 | 0.0812 ± 0.42 0.0818 ± 0.31 | 0.0175 ± 0.80 0.0175 ± 0.54 | 0.01550 ± 1.50 0.01550 ± 1.50 | 0.0815 ± 0.80 0.0815 ± 0.80 | 2.1832 ± 0.70 2.1713 ± 1.10 | 2.1713 ± 1.10 | 2.1713 ± 1.10 | | |
| B-8 0.01080 ± 0.58 0.01086 ± 0.79 | 0.00203 ± 1.00 0.00207 ± 0.93 | 0.2890 ± 0.20 0.2884 ± 0.15 | 0.0974 ± 0.21 0.0974 ± 0.30 | 0.0128 ± 1.20 0.0200 ± 0.90 | 0.00665 ± 3.10 0.00665 ± 3.10 | 0.0773 0.0773 | 2.1626 ± 0.48 2.2257 ± 0.50 | 2.2257 ± 0.50 | 2.2257 ± 0.50 | | |
| C-1 0.01260 ± 0.80 0.01270 ± 0.39 | 0.00200 ± 2.40 0.00186 ± 1.09 | 0.2329 ± 0.31 0.2347 ± 0.21 | 0.0847 ± 0.51 0.0850 ± 0.46 | 0.0143 ± 1.30 0.0143 ± 1.00 | n.m. n.m. | n.m. n.m. | 2.2364 ± 0.42 2.2275 ± 0.70 | 2.2275 ± 0.70 | 2.2275 ± 0.70 | | |
| C-3 0.01404 ± 0.48 0.01375 ± 0.78 | 0.00172 ± 1.00 0.00173 ± 1.30 | 0.1948 ± 0.22 0.1945 ± 0.30 | 0.0736 ± 0.42 0.0731 ± 0.40 | 0.0093 ± 0.60 0.0092 ± 0.72 | n.m. n.m. | n.m. n.m. | 2.1119 ± 0.40 2.1954 ± 0.50 | 2.1954 ± 0.50 | 2.1954 ± 0.50 | | |
| C-3 0.01390 ± 0.80 | 0.00172 ± 1.40 | 0.1946 ± 0.30 | 0.0733 ± 0.40 | 0.0093 ± 0.90 | 2.1932 ± 0.50 | 2.1932 ± 0.50 | 2.1932 ± 0.50 | 2.1932 ± 0.50 | 2.1932 ± 0.50 | | |

Table 3.4-8 (continued, 2/2)

| Sample No. | Uranium | | | Plutonium | | | Americium | | | Neodymium | |
|------------|---------------------|---------------------|------------------------|------------------------|------------------------|--------------------------|--------------------------|--------------------------|--------------------------|---------------------|-------|
| | R5 (U-225/U-238) | R6 (U-236/U-238) | R'0 (Pu-240/Pu-239) | R'1 (Pu-241/Pu-239) | R'2 (Pu-242/Pu-239) | R'242 (Am-242/Am-241) | R'243 (Am-243/Am-241) | R'243 (Am-243/Am-241) | R'243 (Am-243/Am-241) | Corr. Nd-148/Nd-150 | R'148 |
| D-2 | 0.01343 ± 0.25 | 0.00186 ± 1.20 | 0.2007 ± 0.15 | 0.0732 ± 0.31 | 0.0102 ± 0.82 | | | | | 2.2168 ± 0.32 | |
| | 0.01333 ± 0.36 | 0.00171 ± 1.40 | 0.2011 ± 0.22 | 0.0733 ± 0.25 | 0.0102 ± 1.20 | 0.00433 | 0.0541 | | | 2.1515 ± 0.41 | |
| D-4 | 0.01338 ± 0.40 | 0.00178 ± 1.60 | 0.2009 ± 0.20 | 0.0732 ± 0.30 | 0.0102 ± 1.30 | 0.00433 ± 2.10 | 0.0541 | | | 2.2042 ± 0.25 | |
| | 0.01372 ± 0.21 | 0.00176 ± 0.50 | 0.1828 ± 0.18 | 0.0714 ± 0.34 | 0.0089 ± 1.50 | | | | | 2.1860 ± 0.31 | |
| D-5 | 0.01374 ± 0.24 | 0.00179 ± 0.80 | 0.1826 ± 0.20 | 0.0710 ± 0.28 | 0.0085 ± 1.40 | | | | | 2.2008 ± 0.30 | |
| | 0.01373 ± 0.30 | 0.00177 ± 0.80 | 0.1827 ± 0.20 | 0.0712 ± 0.40 | 0.0087 ± 1.80 | | | | | 2.1978 ± 0.45 | |
| E-1 | 0.01225 ± 1.20 | 0.00192 ± 2.10 | 0.2304 ± 0.27 | 0.0844 ± 0.16 | 0.0139 ± 0.59 | n.m. | | | | 2.2095 ± 0.49 | |
| | 0.01261 ± 1.30 | 0.00201 ± 1.80 | 0.2300 ± 0.25 | 0.0840 ± 0.35 | 0.0137 ± 0.62 | | | | | 2.1978 ± 0.45 | |
| E-2 | 0.01243 ± 1.50 | 0.00196 ± 2.30 | 0.2302 ± 0.30 | 0.0842 ± 0.40 | 0.0138 ± 0.70 | | | | | 2.2036 ± 0.50 | |
| | 0.01369 ± 0.37 | 0.00166 ± 1.01 | 0.1830 ± 0.25 | 0.0713 ± 0.31 | 0.0085 ± 0.73 | | | | | 2.2029 ± 0.25 | |
| E-5 | 0.01383 ± 0.40 | 0.00171 ± 1.15 | 0.1819 ± 0.18 | 0.0705 ± 0.15 | 0.0084 ± 0.68 | | | | | 2.2165 ± 0.35 | |
| | 0.01376 ± 0.32 | 0.00164 ± 1.09 | 0.1820 ± 0.28 | 0.0710 ± 0.16 | 0.0085 ± 0.76 | 0.00518 | 0.0584 | | | 2.2097 ± 0.40 | |
| G-7 | 0.01246 ± 0.40 | 0.00169 ± 1.30 | 0.1825 ± 0.30 | 0.0709 ± 0.30 | 0.0085 ± 0.90 | 0.00518 ± 2.90 | 0.0584 | 0.80 | | 2.1564 ± 0.47 | |
| | 0.01234 ± 0.24 | 0.00187 ± 1.20 | 0.2262 ± 0.20 | 0.0848 ± 0.32 | 0.0132 ± 1.10 | | | | | 2.1590 ± 0.30 | |
| H-2 | 0.01237 ± 0.30 | 0.00189 ± 1.20 | 0.2258 ± 0.20 | 0.0846 ± 0.40 | 0.0130 ± 1.20 | | | | | 2.1577 ± 0.40 | |
| | 0.01126 ± 0.77 | 0.00203 ± 1.00 | 0.2254 ± 0.15 | 0.0843 ± 0.38 | 0.0129 ± 0.92 | n.m. | | | | 2.2272 ± 0.31 | |
| H-3 | 0.01136 ± 0.79 | 0.00201 ± 1.60 | 0.2690 ± 0.15 | 0.0939 ± 0.35 | 0.0132 ± 1.10 | | | | | 2.2186 ± 0.43 | |
| | 0.01131 ± 0.90 | 0.00201 ± 1.60 | 0.2691 ± 0.20 | 0.0943 ± 0.40 | 0.0181 ± 1.10 | 0.00441 | 0.0827 | | | 2.2229 ± 0.40 | |
| H-8 | 0.01070 ± 1.00 | 0.00199 ± 1.90 | 0.2943 ± 0.25 | 0.1029 ± 0.50 | 0.0215 ± 1.10 | | | | | 2.2150 ± 0.20 | |
| | 0.01062 ± 0.84 | 0.00208 ± 1.70 | 0.2933 ± 0.42 | 0.1020 ± 0.40 | 0.0214 ± 1.10 | | | | | 2.2005 ± 0.18 | |
| J-1 | 0.01066 ± 1.10 | 0.00203 ± 2.20 | 0.2938 ± 0.40 | 0.1025 ± 0.60 | 0.0215 ± 1.30 | | | | | 2.2178 ± 0.30 | |
| | 0.00652 ± 0.28 | 0.00188 ± 0.90 | 0.3615 ± 0.11 | 0.1321 ± 0.40 | 0.0386 ± 0.84 | | | | | 2.1525 ± 0.20 | |
| J-9 | 0.00649 ± 0.40 | 0.00185 ± 1.30 | 0.3613 ± 0.20 | 0.1314 ± 0.50 | 0.0384 ± 1.00 | | | | | 2.1437 ± 0.16 | |
| | 0.00556 ± 0.50 | 0.00196 ± 1.31 | 0.4189 ± 0.21 | 0.1485 ± 0.20 | 0.0516 ± 0.42 | | | | | 2.1481 ± 0.30 | |
| J-10 | 0.00555 ± 0.61 | 0.00200 ± 1.20 | 0.4194 ± 0.19 | 0.1496 ± 0.31 | 0.0515 ± 0.34 | n.m. | | | | 2.1372 ± 0.29 | |
| | 0.00560 ± 0.45 | 0.00195 ± 1.25 | 0.4206 ± 0.19 | 0.1489 ± 0.18 | 0.0522 ± 0.38 | | | | | 2.1541 ± 0.16 | |
| J-11 | 0.00557 ± 0.60 | 0.00197 ± 1.50 | 0.4192 ± 0.20 | 0.1491 ± 0.30 | 0.0518 ± 0.50 | | | | | 2.1553 ± 0.30 | |

Table 3.4-9 Isotope Mass Ratios of Krypton and Xenon

| Sample No. | Kr 83/86 | Kr 84/86 | Kr 85/86 | Xe 131/134 | Xe 132/134 | Xe 136/134 |
|------------|---------------|---------------|---------------|---------------|---------------|---------------|
| A-1 | 0.2626 ± 0.15 | 0.5763 ± 0.25 | 0.1185 ± 0.21 | 0.3544 ± 0.15 | 0.6678 ± 0.20 | 1.4310 ± 0.10 |
| A-3 | 0.2633 ± 0.63 | 0.5671 ± 0.89 | 0.1153 ± 1.13 | 0.3488 ± 0.30 | 0.6501 ± 0.18 | 1.3712 ± 0.34 |
| A-9 | 0.2445 ± 0.22 | 0.5902 ± 0.43 | 0.1143 ± 0.52 | 0.3385 ± 0.28 | 0.6824 ± 0.13 | 1.5175 ± 0.17 |
| B-1 | 0.2694 ± 1.52 | 0.5923 ± 0.72 | 0.1163 ± 0.77 | 0.3512 ± 0.38 | 0.6654 ± 0.29 | 1.4232 ± 0.24 |
| B-2 | 0.2682 ± 0.39 | 0.5698 ± 0.17 | 0.1172 ± 0.10 | 0.3509 ± 0.33 | 0.6550 ± 0.28 | 1.3580 ± 0.25 |
| B-8 | 0.2561 ± 1.19 | 0.5707 ± 0.49 | 0.1135 ± 0.59 | 0.3433 ± 0.49 | 0.6614 ± 0.64 | 1.4130 ± 0.29 |
| C-1 | 0.2641 ± 0.28 | 0.5671 ± 0.39 | 0.1111 ± 0.78 | 0.3496 ± 0.30 | 0.6531 ± 0.37 | 1.3680 ± 0.62 |
| C-3 | 0.2706 ± 0.40 | 0.5687 ± 0.40 | 0.1188 ± 0.50 | 0.3486 ± 0.50 | 0.6517 ± 0.40 | 1.3040 ± 0.20 |
| D-2 | 0.2696 ± 0.75 | 0.5679 ± 0.36 | 0.1099 ± 0.78 | 0.3494 ± 0.53 | 0.6524 ± 0.39 | 1.3270 ± 0.27 |
| D-4 | 0.2703 ± 0.50 | 0.5650 ± 0.40 | 0.1178 ± 0.80 | 0.3486 ± 0.30 | 0.6491 ± 0.40 | 1.2936 ± 0.30 |
| E-1 | 0.2653 ± 0.60 | 0.5732 ± 0.40 | 0.1124 ± 0.90 | 0.3478 ± 0.50 | 0.6566 ± 0.60 | 1.3636 ± 0.40 |
| E-6 | 0.2632 ± 0.46 | 0.5678 ± 0.14 | 0.1152 ± 0.30 | 0.3464 ± 0.37 | 0.6553 ± 0.23 | 1.3670 ± 0.18 |
| G-7 | 0.2696 ± 0.40 | 0.5702 ± 0.30 | 0.1181 ± 0.30 | 0.3491 ± 0.40 | 0.6588 ± 0.20 | 1.3490 ± 0.20 |
| H-2 | 0.2601 ± 0.72 | 0.5681 ± 0.28 | 0.1136 ± 0.84 | 0.3423 ± 0.35 | 0.6610 ± 0.22 | 1.3980 ± 0.29 |
| H-8 | 0.2622 ± 0.60 | 0.5855 ± 0.30 | 0.1187 ± 0.70 | 0.3473 ± 0.30 | 0.6670 ± 0.20 | 1.4040 ± 0.20 |
| J-1 | 0.2567 ± 0.92 | 0.5959 ± 1.57 | 0.1161 ± 1.63 | 0.3417 ± 0.24 | 0.6817 ± 0.17 | 1.4810 ± 0.24 |
| J-9 | 0.2481 ± 0.70 | 0.5966 ± 0.50 | 0.1179 ± 0.80 | 0.3365 ± 0.30 | 0.6857 ± 0.20 | 1.5380 ± 0.20 |

Table 3.4-10 Percent of Activity per Alpha-emitting Nuclides of Plutonium, Americium and Curium (1/2)

| Sample | Date of measurement | Before separation | | | | After separation | |
|--------|---------------------|-------------------|------------------|-------------|-------------|------------------|-------------|
| | | Pu239+240 % | Pu238+Am241 % | Cm242 % | Cm244 % | Pu239+240 % | Pu240 % |
| A-1 | 06.26.79 | 26.60 | 34.00 | 34.00 | 5.00 | 54.45 | 45.55 |
| | | 25.90 | 33.60 | 34.85 | 5.65 | 55.00 | 45.00 |
| | | 26.40 | 33.80 | 34.60 | 5.20 | 54.00 | 46.00 |
| | | 26.30 ± 1.3 | 33.80 ± 0.6 | 34.62 ± 0.6 | 5.28 ± 6.3 | 54.48 ± 0.9 | 45.52 ± 1.1 |
| A-3 | 10.09.69 | 34.80 | 41.80 | 17.20 | 6.20 | 56.55 | 43.45 |
| | | 34.40 | 41.50 | 17.70 | 6.40 | 56.20 | 43.80 |
| | | 34.70 | 42.10 | 16.70 | 6.50 | 57.00 | 43.00 |
| | | 34.63 ± 0.6 | 41.80 ± 0.7 | 17.20 ± 2.9 | 6.37 ± 2.4 | 56.58 ± 0.7 | 43.42 ± 0.9 |
| A-5 | 02.23.70 | 36.40 | 47.10 | 11.80 | 4.20 | 57.30 | 42.70 |
| | | 36.60 | 47.80 | 11.50 | 4.10 | 58.10 | 41.90 |
| | | 36.30 | 48.00 | 11.40 | 4.30 | 57.50 | 42.50 |
| | | 36.43 ± 0.4 | 47.80 ± 0.4 | 11.57 ± 1.8 | 4.20 ± 2.4 | 57.63 ± 0.7 | 42.37 ± 1.0 |
| A-9 | 02.23.70 | 27.80 | 46.40 | 14.90 | 10.90 | 47.90 | 52.10 |
| | | 28.30 | 45.60 | 15.30 | 10.80 | 47.80 | 52.20 |
| | | 28.10 | 45.40 | 15.10 | 11.40 | 48.10 | 51.90 |
| | | 28.07 ± 0.9 | 45.80 ± 1.1 | 15.10 ± 1.3 | 11.03 ± 2.9 | 47.93 ± 0.3 | 52.07 ± 0.3 |
| B-1 | 09.18.69 | 34.80 | 39.00 | 20.90 | 5.30 | 55.65 | 44.35 |
| | | 34.40 | 39.10 | 21.60 | 4.50 | 55.05 | 44.95 |
| | | 34.70 | 39.40 | 20.80 | 5.10 | 55.40 | 44.60 |
| | | 34.63 ± 0.6 | 39.17 ± 0.5 | 21.10 ± 2.0 | 5.10 ± 3.0 | 55.37 ± 0.5 | 44.63 ± 0.7 |
| B-2 | 07.15.69 | 32.43 | 38.10 | 22.89 | 6.58 | 56.20 | 43.80 |
| | | 32.82 | 38.51 | 22.81 | 5.86 | 55.45 | 44.55 |
| | | 32.95 | 38.28 | 22.56 | 6.21 | 55.84 | 44.16 |
| | | 32.73 ± 0.8 | 38.30 ± 0.5 | 22.75 ± 0.8 | 6.22 ± 5.7 | 55.83 ± 0.7 | 44.17 ± 0.8 |
| B-8 | 09.15.69 | 31.80 | 43.40 | 18.80 | 6.00 | 54.50 | 45.50 |
| | | 31.60 | 43.60 | 18.60 | 6.20 | 53.80 | 46.20 |
| | | 32.10 | 43.30 | 18.70 | 5.90 | 53.40 | 46.60 |
| | | 31.83 ± 0.8 | 43.44 ± 0.3 | 18.70 ± 0.5 | 6.03 ± 0.3 | 53.90 ± 1.0 | 46.10 ± 1.2 |
| C-1 | 10.08.69 | 35.10 | 41.50 | 18.00 | 5.40 | 55.55 | 44.45 |
| | | 35.90 | 41.50 | 17.40 | 5.20 | 55.60 | 44.40 |
| | | 35.50 | 41.70 | 17.50 | 5.30 | 55.55 | 44.45 |
| | | 35.50 ± 1.1 | 41.57 ± 0.3 | 17.63 ± 1.8 | 5.30 ± 1.9 | 55.57 ± 0.1 | 44.43 ± 0.1 |
| C-3 | 05.13.69 | 36.30 | 35.30 | 25.40 | 3.00 | 63.15 | 36.85 |
| | | 35.90 | 35.50 | 25.50 | 3.10 | 63.00 | 37.00 |
| | | 36.20 | 35.45 | 25.45 | 2.90 | 62.95 | 37.05 |
| | | 36.13 ± 0.6 | 35.42 ± 0.3 | 25.45 ± 0.2 | 3.00 ± 3.3 | 63.03 ± 0.8 | 36.96 ± 0.3 |

Table 3.4-10 (continued, 2/2)

| Sample | Date of measurement | Before separation | | | | After separation | |
|--------|---------------------|-------------------|---------------|-------------|-------------|------------------|-------------|
| | | Pu239+240 % | Pu238+Am241 % | Cm242 % | Cm244 % | Pu239+240 % | Pu240 % |
| D-2 | 02.17.70 | 38.90 | 45.20 | 10.40 | 5.50 | 59.60 | 40.40 |
| | | 39.70 | 44.40 | 10.40 | 5.50 | 59.40 | 40.60 |
| | | 39.50 | 45.00 | 9.70 | 5.80 | 59.90 | 40.10 |
| | | 39.37 ± 1.0 | 44.86 ± 0.9 | 10.17 ± 3.9 | 5.60 ± 3.1 | 59.63 ± 0.4 | 40.37 ± 0.6 |
| D-4 | 05.19.69 | 31.65 | 38.08 | 24.58 | 5.69 | 56.67 | 43.33 |
| | | 32.02 | 38.11 | 24.40 | 5.47 | 56.41 | 43.59 |
| | | 31.58 | 38.39 | 24.79 | 5.24 | 56.90 | 43.10 |
| | | 31.75 ± 0.7 | 38.19 ± 0.4 | 24.59 ± 0.8 | 5.47 ± 4.1 | 56.66 ± 0.5 | 43.34 ± 0.6 |
| E-1 | 01.27.70 | 38.20 | 47.50 | 10.90 | 3.40 | 57.10 | 42.90 |
| | | 37.90 | 47.40 | 11.30 | 3.40 | 56.40 | 43.60 |
| | | 38.50 | 47.10 | 10.70 | 3.70 | 57.00 | 43.00 |
| | | 38.20 ± 0.8 | 47.33 ± 0.4 | 10.97 ± 2.8 | 3.50 ± 4.9 | 56.83 ± 0.7 | 43.17 ± 0.9 |
| E-5 | 07.21.69 | 34.30 | 39.13 | 16.95 | 9.62 | 56.80 | 43.20 |
| | | 33.82 | 40.05 | 16.39 | 9.74 | 57.00 | 43.00 |
| | | 34.02 | 39.37 | 17.70 | 8.91 | 56.40 | 43.60 |
| | | 34.05 ± 0.7 | 39.52 ± 1.2 | 17.01 ± 3.8 | 9.42 ± 4.8 | 56.73 ± 0.5 | 43.27 ± 0.7 |
| G-7 | 05.12.69 | 31.94 | 36.30 | 28.05 | 3.71 | 56.00 | 44.00 |
| | | 31.93 | 36.51 | 27.81 | 3.75 | 56.40 | 43.60 |
| | | 32.03 | 36.84 | 27.26 | 3.87 | 56.80 | 43.20 |
| | | 31.96 ± 0.2 | 36.55 ± 0.7 | 27.71 ± 1.5 | 3.78 ± 2.2 | 56.40 ± 0.7 | 43.60 ± 0.9 |
| H-2 | 02.17.70 | 33.40 | 47.00 | 12.70 | 6.90 | 54.60 | 45.40 |
| | | 33.80 | 46.60 | 12.20 | 7.40 | 54.00 | 46.00 |
| | | 33.80 | 46.60 | 12.30 | 7.30 | 53.80 | 46.20 |
| | | 33.67 ± 0.7 | 46.73 ± 0.5 | 12.40 ± 2.1 | 7.20 ± 3.7 | 54.13 ± 0.7 | 45.87 ± 0.9 |
| H-8 | 05.06.69 | 27.45 | 35.50 | 27.33 | 9.72 | 54.90 | 45.10 |
| | | 27.27 | 35.98 | 27.07 | 9.68 | 54.60 | 45.40 |
| | | 27.53 | 35.92 | 27.26 | 9.29 | 54.00 | 46.00 |
| | | 27.42 ± 0.5 | 35.80 ± 0.7 | 27.22 ± 0.5 | 9.56 ± 2.5 | 54.50 ± 0.8 | 45.50 ± 1.0 |
| J-1 | 01.20.70 | 29.90 | 46.70 | 14.30 | 9.10 | 47.30 | 52.70 |
| | | 29.80 | 47.20 | 14.50 | 8.50 | 47.50 | 52.50 |
| | | 29.60 | 47.20 | 14.40 | 8.80 | 47.50 | 52.50 |
| | | 29.77 ± 0.5 | 47.03 ± 0.6 | 14.40 ± 0.9 | 8.80 ± 3.4 | 47.43 ± 0.2 | 52.57 ± 0.2 |
| J-9 | 07.09.69 | 22.62 | 35.80 | 31.39 | 10.19 | 45.95 | 54.05 |
| | | 22.61 | 35.69 | 31.60 | 10.10 | 45.42 | 54.58 |
| | | 22.79 | 35.37 | 32.09 | 9.75 | 45.48 | 54.52 |
| | | 22.68 ± 0.4 | 35.62 ± 0.6 | 31.69 ± 1.1 | 10.01 ± 2.3 | 45.62 ± 0.6 | 54.38 ± 0.5 |

Table 3.4-11 Isotopic Concentrations of Nd-148, U-238 and Pu-239

| Sample No. | $A(U-238) \times 10^{17}$ | $A(Pu-239) \times 10^{14}$ | $A(Nd-148) \times 10^{14}$ | Sample No. | $A(U-238) \times 10^{17}$ | $A(Pu-239) \times 10^{14}$ | $A(Nd-148) \times 10^{14}$ |
|------------|---------------------------|----------------------------|----------------------------|------------|---------------------------|----------------------------|----------------------------|
| | % | % | % | | % | % | % |
| A-1 | 5.6024 | 21.419 | 1.1024 | D-2 | 5.6123 | 23.281 | 0.9902 |
| | 5.5799 | 21.348 | 1.1047 | | 5.5738 | 23.180 | 0.9840 |
| | 5.5912 ± 0.20 | 21.384 ± 0.17 | 1.1036 ± 0.10 | | 5.5930 ± 0.34 | 23.231 ± 0.22 | 0.9886 ± 0.16 |
| A-3 | 5.3510 | | | D-4 | 5.5319 | 23.954 | 0.9149 |
| | 5.2882 | 21.4084 | 1.0493 | | 5.5731 | 23.906 | 0.9238 |
| | 5.4175 | 21.4840 | 1.0577 | | 5.5525 ± 0.37 | 23.930 ± 0.10 | 0.9193 ± 0.48 |
| A-5 | 5.1594 | 21.182 | 1.0193 | E-1 | 5.5739 | 23.401 | 1.1237 |
| | 5.1415 | | | | 5.5718 | 23.277 | 1.1312 |
| | 5.1504 ± 0.17 | 21.122 ± 0.28 | 1.0189 ± 0.03 | | 5.5728 ± 0.02 | 23.339 ± 0.27 | 1.1274 ± 0.23 |
| A-9 | 5.5701 | | | E-5 | | 24.387 | 0.9320 |
| | 5.5532 | 19.734 | 1.4690 | | 5.6171 | 24.247 | |
| | 5.5870 | 19.678 | 1.4522 | | 5.5763 | 24.321 | 0.9397 |
| | 5.5701 ± 0.30 | 19.706 ± 0.14 | 1.4606 ± 0.57 | | 5.5967 ± 0.36 | 24.318 ± 0.29 | 0.9358 ± 0.41 |
| B-1 | 5.6198 | 22.271 | 1.0209 | G-7 | 5.4672 | 23.577 | 1.0790 |
| | 5.6254 | 22.269 | 1.0323 | | 5.4999 | 23.571 | 1.0866 |
| | 5.6226 ± 0.05 | 22.270 ± 0.004 | 1.0266 ± 0.55 | | 5.4836 ± 0.30 | 23.574 ± 0.01 | 1.0827 ± 0.35 |
| B-2 | 5.5766 | 22.218 | 1.0820 | H-2 | 5.4717 | 21.514 | 1.2290 |
| | 5.5821 | 22.168 | 1.0711 | | 5.4581 | 21.574 | 1.2118 |
| | 5.5793 ± 0.05 | 22.193 ± 0.40 | 1.0741 ± 0.64 | | 5.4649 ± 0.12 | 21.544 ± 0.14 | 1.2204 ± 0.70 |
| B-8 | 5.6335 | 21.418 | 1.2765 | H-8 | 5.5095 | 21.730 | 1.3116 |
| | 5.6297 | 21.397 | | | 5.4644 | 21.954 | 1.3001 |
| | 5.6316 ± 0.03 | 21.408 ± 0.05 | 1.2815 ± 0.38 | | 5.4870 ± 0.40 | 21.842 ± 0.50 | 1.3059 ± 0.44 |
| C-1 | 4.9671 | 20.144 | 0.9933 | J-1 | 5.5611 | 20.999 | 1.3291 |
| | 4.9636 | 20.118 | 0.9895 | | 5.5542 | 20.870 | 1.3330 |
| | 4.9653 ± 0.03 | 20.131 ± 0.06 | 0.9914 ± 0.19 | | 5.5576 ± 0.06 | 20.934 ± 0.31 | 1.3310 ± 0.15 |
| C-3 | 5.5336 | 23.759 | 0.9439 | J-9 | 5.4778 | 19.805 | 1.4792 |
| | 5.5643 | 23.718 | 0.9499 | | 5.4906 | 19.860 | 1.4904 |
| | 5.5490 ± 0.28 | 23.738 ± 0.08 | 0.9495 ± 0.30 | | 5.4842 ± 0.12 | 19.860 ± 0.14 | 1.4848 ± 0.38 |

Table 3.4-12 U Isotopes Referred to Final ^{238}U Atoms

| Fuel Element | Sample | ^{235}U ($\times 10^2$) | ^{236}U ($\times 10^3$) |
|-----------------------------------|--------|------------------------------------|------------------------------------|
| INITIAL ENRICHMENT 2.41 wt% U-235 | | | |
| E6 | 1 | 1.856 | 1.365 |
| 3 | 1.721 | 1.651 | 1.649 |
| 5 | 1.688 | 1.680 | 1.650 |
| 7 | 1.680 | 1.578 | 1.438 |
| 10 | 1.680 | 1.438 | 1.236 |
| 16 | 1.882 | 1.944 | 2.054 |
| 13 | 1.944 | 2.054 | 0.970 |

Table 3.4-13 Pu Isotopes Referred to Final ^{238}U Atoms

| Fuel Element | Sample | ^{239}Pu ($\times 10^3$) | ^{240}Pu ($\times 10^4$) | ^{241}Pu ($\times 10^4$) | ^{242}Pu ($\times 10^6$) |
|-----------------------------------|--------|-------------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|
| INITIAL ENRICHMENT 2.41 wt% U-235 | | | | | |
| E6 | 1 | 2.438 | 3.278 | 0.946 | 6.397 |
| 3 | 3.483 | 5.806 | 1.895 | 16.193 | |
| 5 | 3.578 | 6.170 | 2.194 | 19.743 | |
| 7 | 3.442 | 5.944 | 2.148 | 22.973 | |
| 10 | 3.303 | 5.804 | 2.013 | 18.512 | |
| 16 | 3.352 | 4.525 | 1.624 | 11.086 | |
| 13 | 3.052 | 3.579 | 1.182 | 6.701 | |
| 11 | 2.461 | 2.281 | 0.613 | 2.566 | |

Table 3.4-14 Atom Ratios of ^{148}Nd and ^{137}Cs Referred to Final ^{238}U

| Fuel Element | Sample | ^{148}Nd ($\times 10^4$) | ^{137}Cs ($\times 10^4$) |
|-----------------------------------|--------|-------------------------------------|-------------------------------------|
| INITIAL ENRICHMENT 2.41 wt% U-235 | | | |
| E6 | 1 | 1.122 | 3.442 |
| 3 | 1.544 | 4.634 | |
| 5 | 1.615 | 5.871 | |
| 7 | 1.557 | 5.514 | |
| 10 | 1.001 | 5.126 | |
| 16 | 1.241 | 4.561 | |
| 13 | 1.039 | 3.801 | |
| 11 | 0.782 | 2.862 | |

Table 3.4-15 Am and Cm Isotopes Referred to Final ^{238}U Atoms

| Fuel Element | Sample | ^{241}Am ($\times 10^6$) | ^{244}Cm ($\times 10^8$) |
|-----------------------------------|--------|-------------------------------------|-------------------------------------|
| INITIAL ENRICHMENT 2.41 wt% U-235 | | | |
| E6 | 1 | 2.81 | 1.44 |
| 3 | 11.01 | 7.24 | |
| 5 | 22.41 | 12.31 | |
| 7 | 14.82 | 10.03 | |
| 10 | 5.61 | 6.72 | |
| 16 | 31.20 | 6.61 | |
| 13 | 4.76 | 2.43 | |
| 11 | - | 0.67 | |

Table 3.4-16 Buildup and Depletion of U Isotopes (kg/MTU Initial)

| Fuel Element | Sample | ^{235}U (a) | ^{236}U | ^{238}U (a) |
|---|--------|----------------------|------------------|----------------------|
| SA-13 INITIAL ENRICHMENT 2.41 wt% U-235 | E6 | 6.29 | 1.31 | 4.36 |
| | 3 | 7.64 | 1.58 | 7.56 |
| | 5 | 8.16 | 1.58 | 7.99 |
| | 7 | 8.02 | 1.58 | 7.43 |
| | 10 | 8.02 | 1.57 | 6.75 |
| | 16 | 6.09 | 1.38 | 7.08 |
| | 13 | 5.46 | 1.19 | 5.39 |
| | 11 | 4.38 | 0.93 | 3.77 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

(a) Depletion

Table 3.4-18 Buildup of Am and Cm Isotopes (kg/MTU Initial)

| Fuel Element | Sample | ^{241}Am ($\times 10^3$) | ^{244}Cm ($\times 10^5$) |
|---|--------|-------------------------------------|-------------------------------------|
| SA-13 INITIAL ENRICHMENT 2.41 wt% U-235 | E6 | 2.76 | 1.44 |
| | 3 | 10.79 | 7.18 |
| | 5 | 21.96 | 12.21 |
| | 7 | 14.5 | 9.96 |
| | 10 | 5.50 | 6.67 |
| | 16 | 30.6 | 6.56 |
| | 13 | 4.67 | 2.42 |
| | 11 | | 0.67 |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

Table 3.4-17 Buildup of Pu Isotopes (kg/MTU Initial)

| Fuel Element | Sample | ^{239}Pu | ^{240}Pu | ^{241}Pu | ^{242}Pu |
|---|--------|-------------------|-------------------|-------------------|-------------------|
| SA-13 INITIAL ENRICHMENT 2.41 wt% U-235 | E6 | 1 | 2.37 | 0.32 | 0.093 |
| | 3 | 3.38 | 0.57 | 0.18 | 0.016 |
| | 5 | 3.48 | 0.60 | 0.21 | 0.019 |
| | 7 | 3.35 | 0.58 | 0.21 | 0.023 |
| | 10 | 3.21 | 0.57 | 0.20 | 0.018 |
| | 16 | 3.26 | 0.44 | 0.159 | 0.011 |
| | 13 | 2.97 | 0.35 | 0.116 | 0.0066 |
| | 11 | 2.40 | 0.22 | 0.060 | 0.0025 |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Table 3.4-19 Burnup Values $F_T\%$ and MWD/MTU Obtained from ^{148}Nd and ^{137}Cs

| Fuel Element | Sample | ^{148}Nd | ^{137}Cs | MWD/MTU |
|---|--------|-------------------|-------------------|---------|
| SA-13 INITIAL ENRICHMENT 2.41 wt% U-235 | E6 | 1 | 0.63 | 0.53 |
| | 3 | 0.86 | 0.71 | 8,260 |
| | 5 | 0.90 | 0.89 | 8,640 |
| | 7 | 0.87 | 0.84 | 8,325 |
| | 10 | 0.85 | 0.79 | 8,143 |
| | 16 | 0.69 | 0.70 | 6,644 |
| | 13 | 0.58 | 0.58 | 5,578 |
| | 11 | 0.44 | 0.44 | 4,201 |
| | | | | 4,211 |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

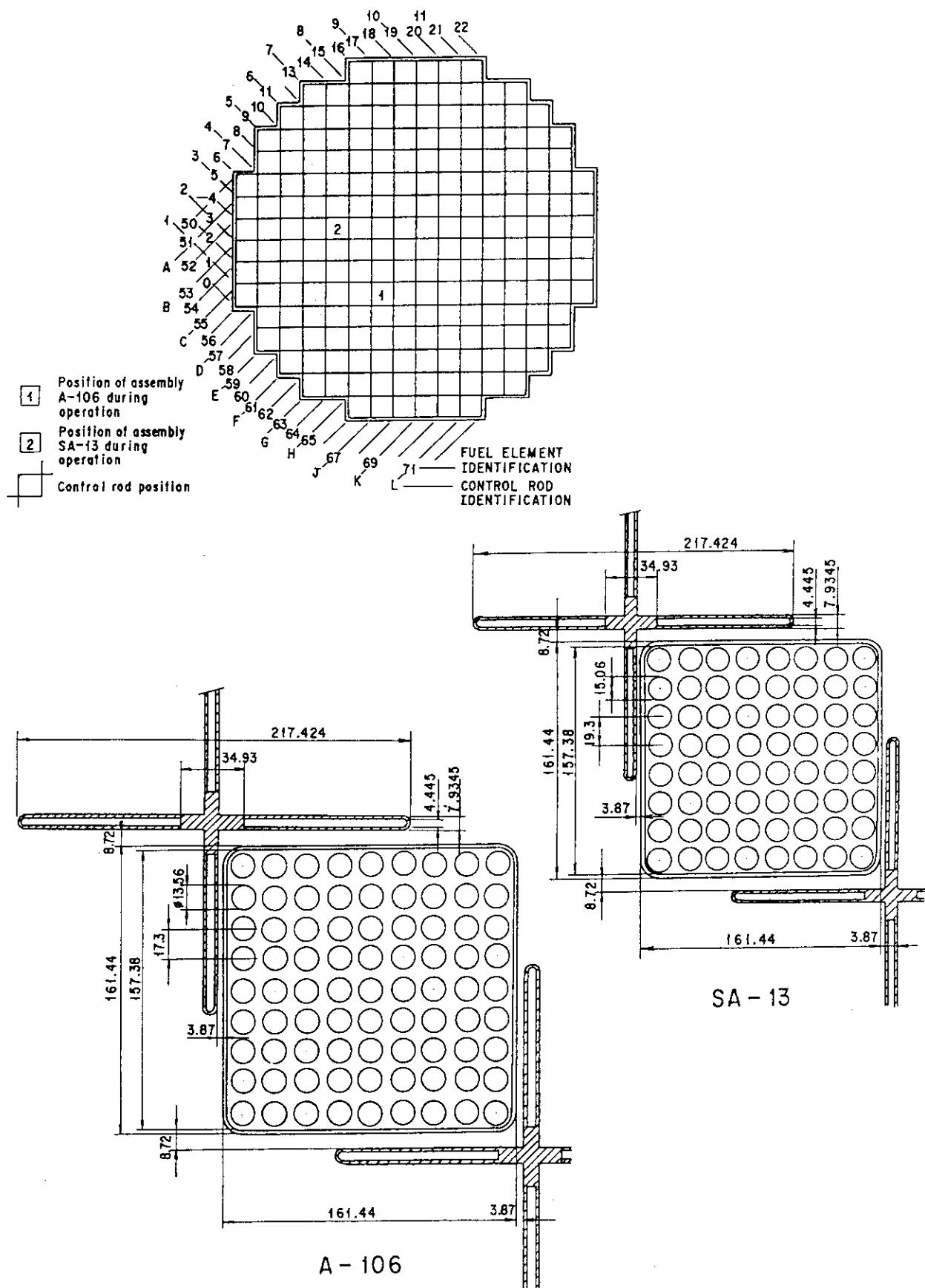
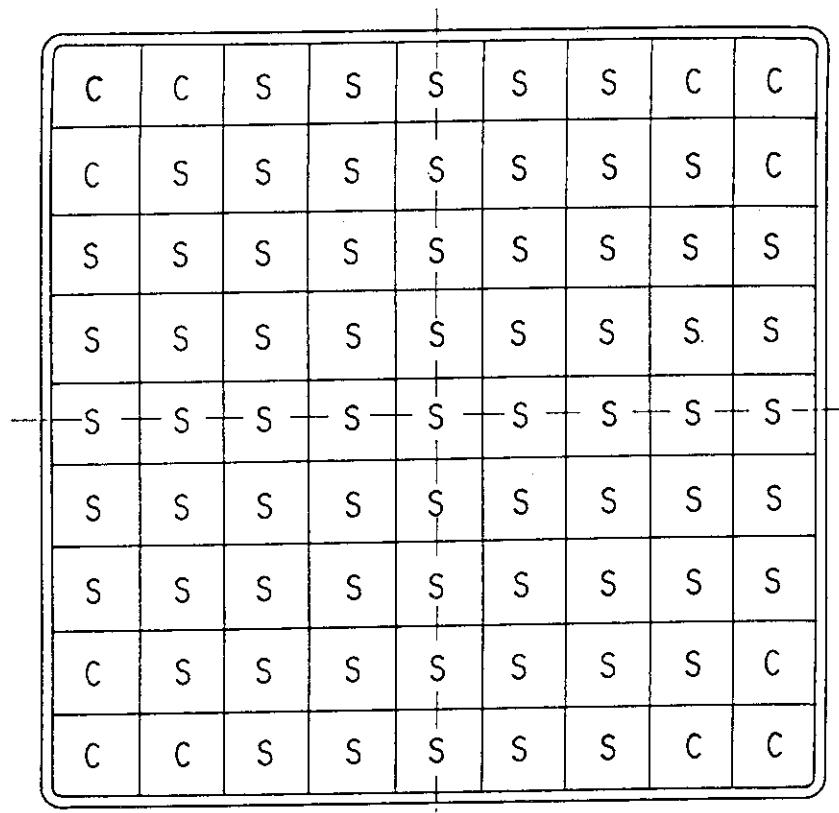


Fig. 3.4-1 Core configuration of Garigriano core



S = STANDARD ROD : ENRICHEMENT 2.1 %

C = CORNER ROD : ENRICHEMENT 1.6 %

Fig. 3.4-2 Enrichment distribution in the Cariglano
first core assembly

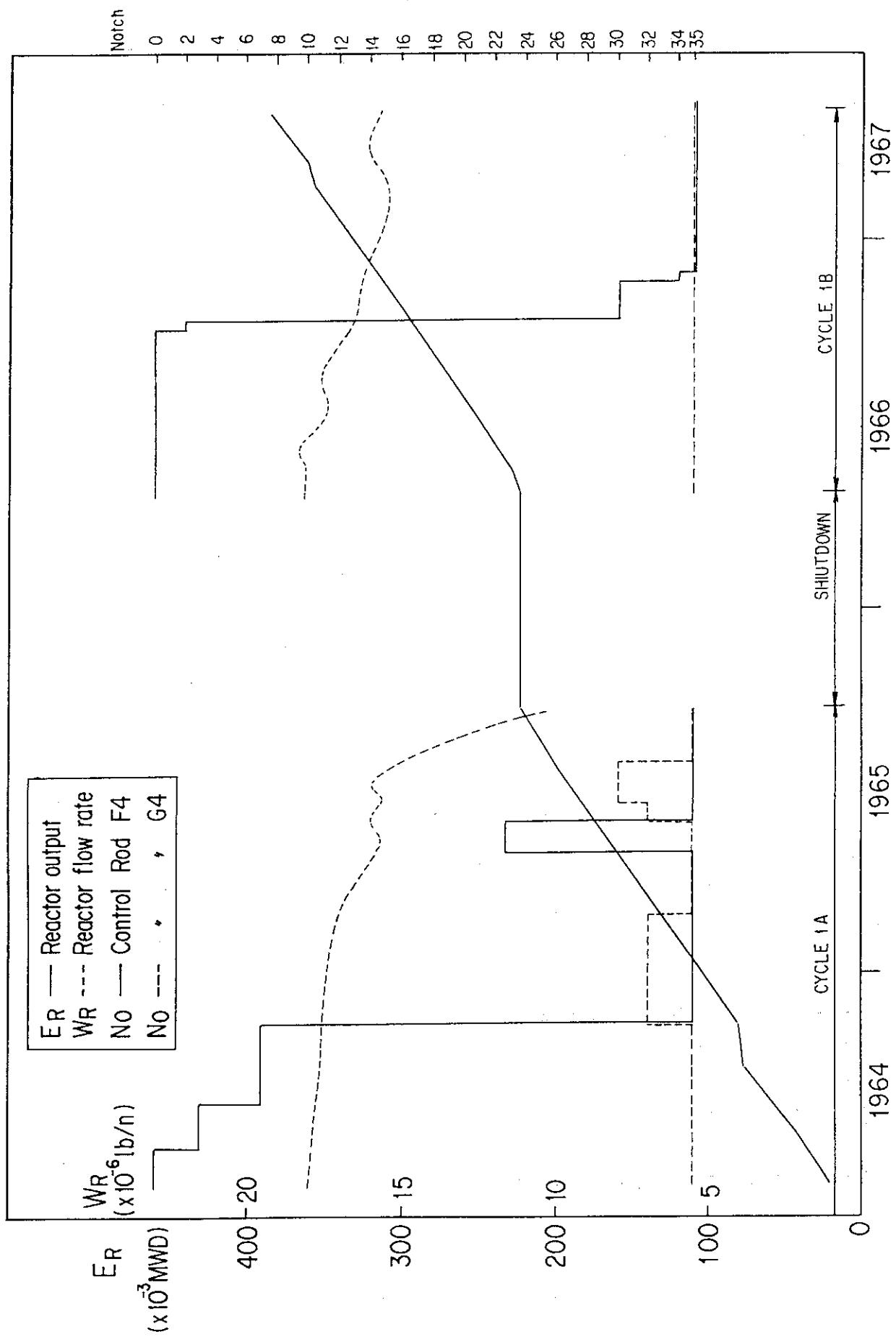
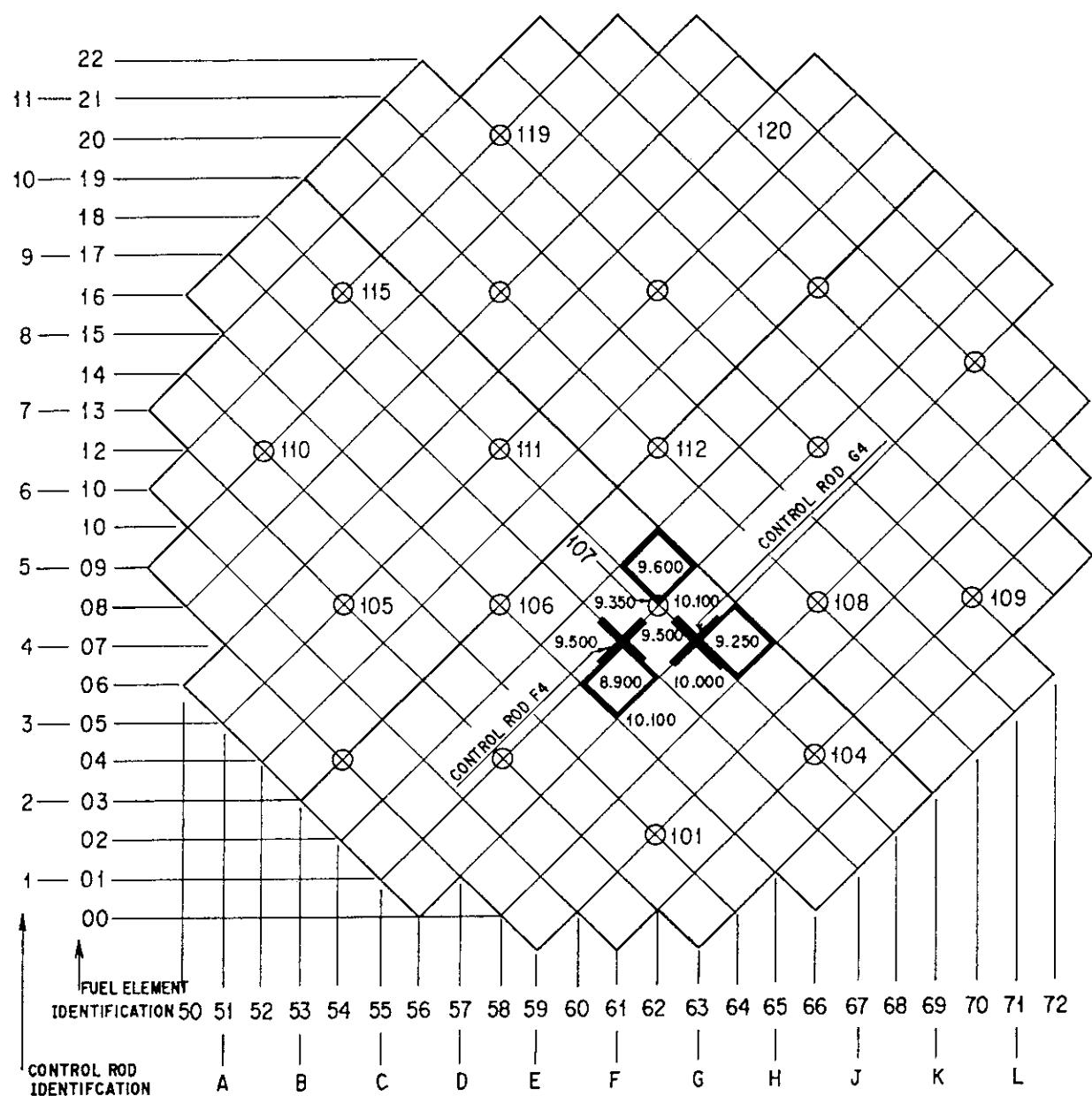


Fig. 3.4-3 Irradiation history of element A-106 in the Gariglano reactor



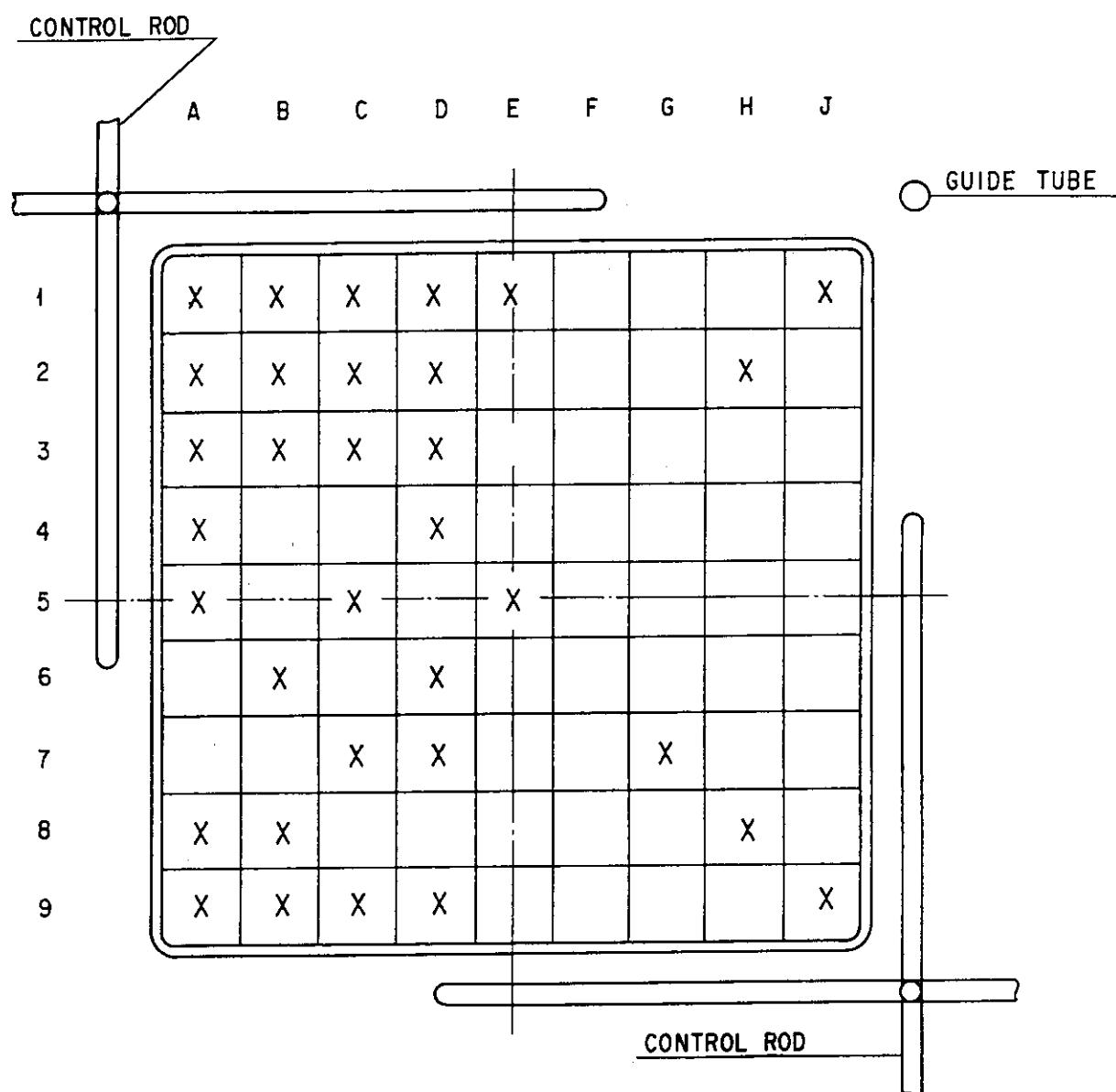
BURN-UP AT THE END OF CYCLE 1B

⊕ SS IN-CORE TUBE

SS CHANNEL

AVERAGE FUEL ASSEMBLY BURN-UP

Fig. 3.4-4 Position of assembly A-106 in the core during operation



ORIENTATION OF ASSEMBLY A-106

Fig. 3.4-5 Rods of element A-106 selected for the program

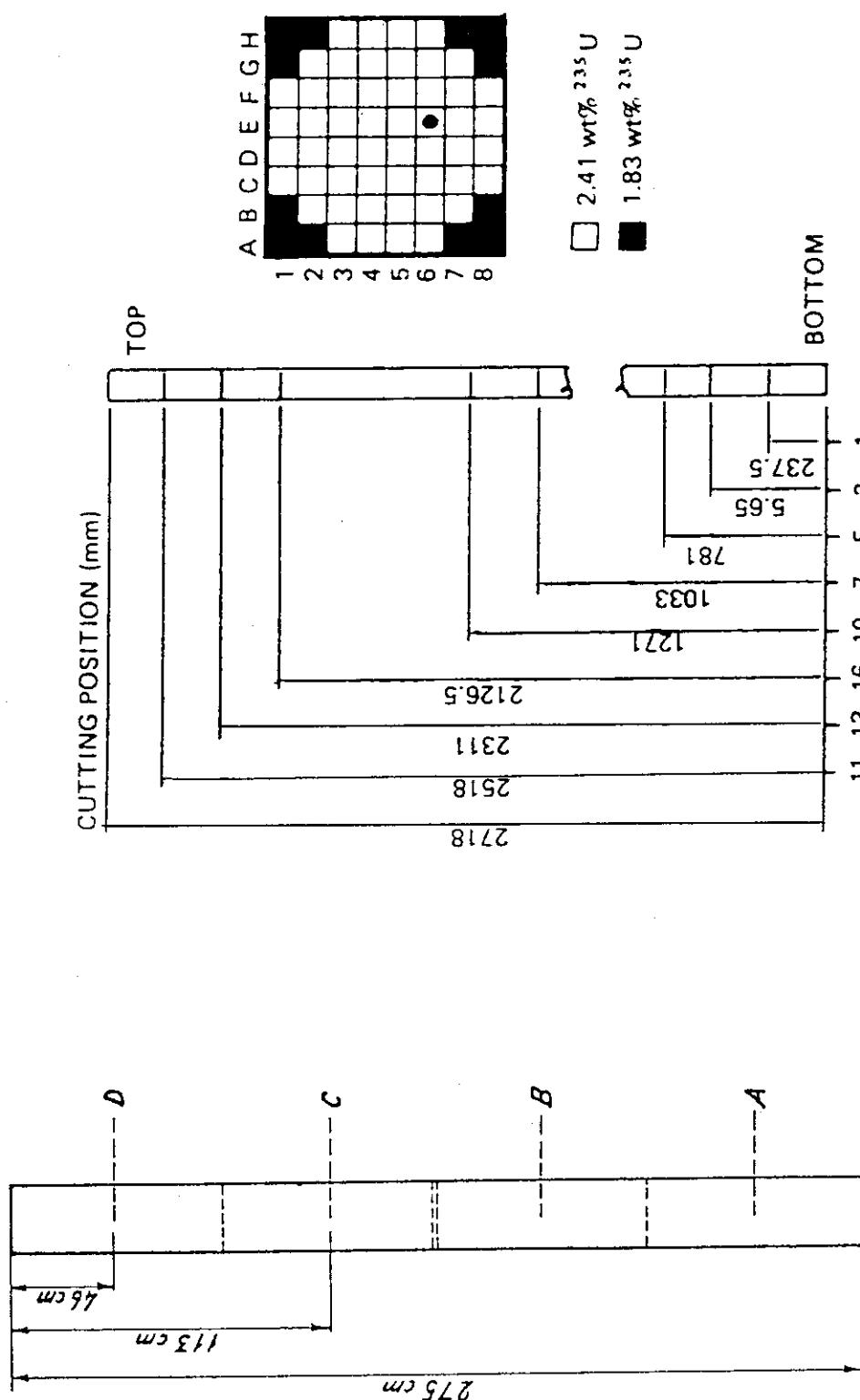
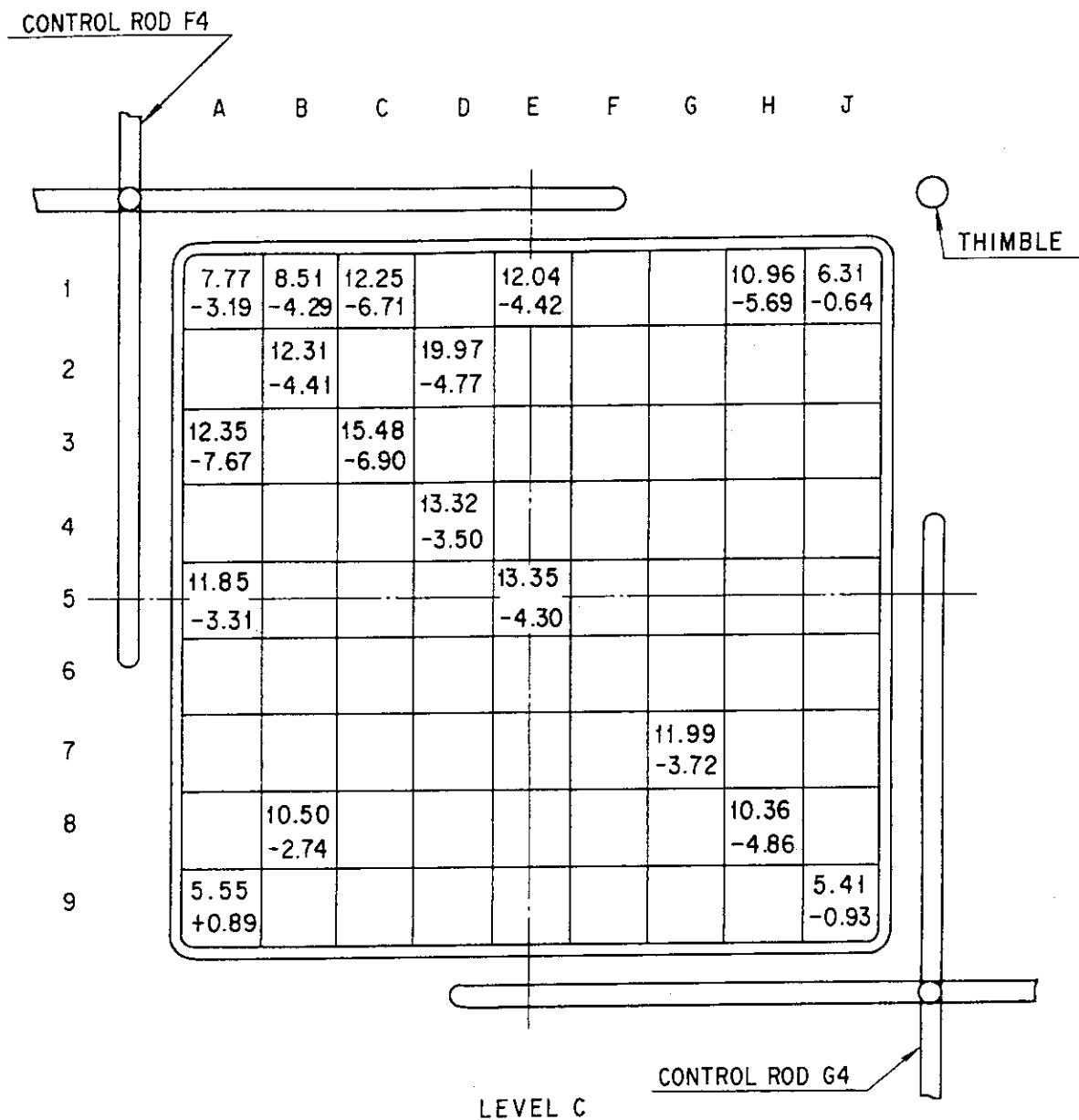
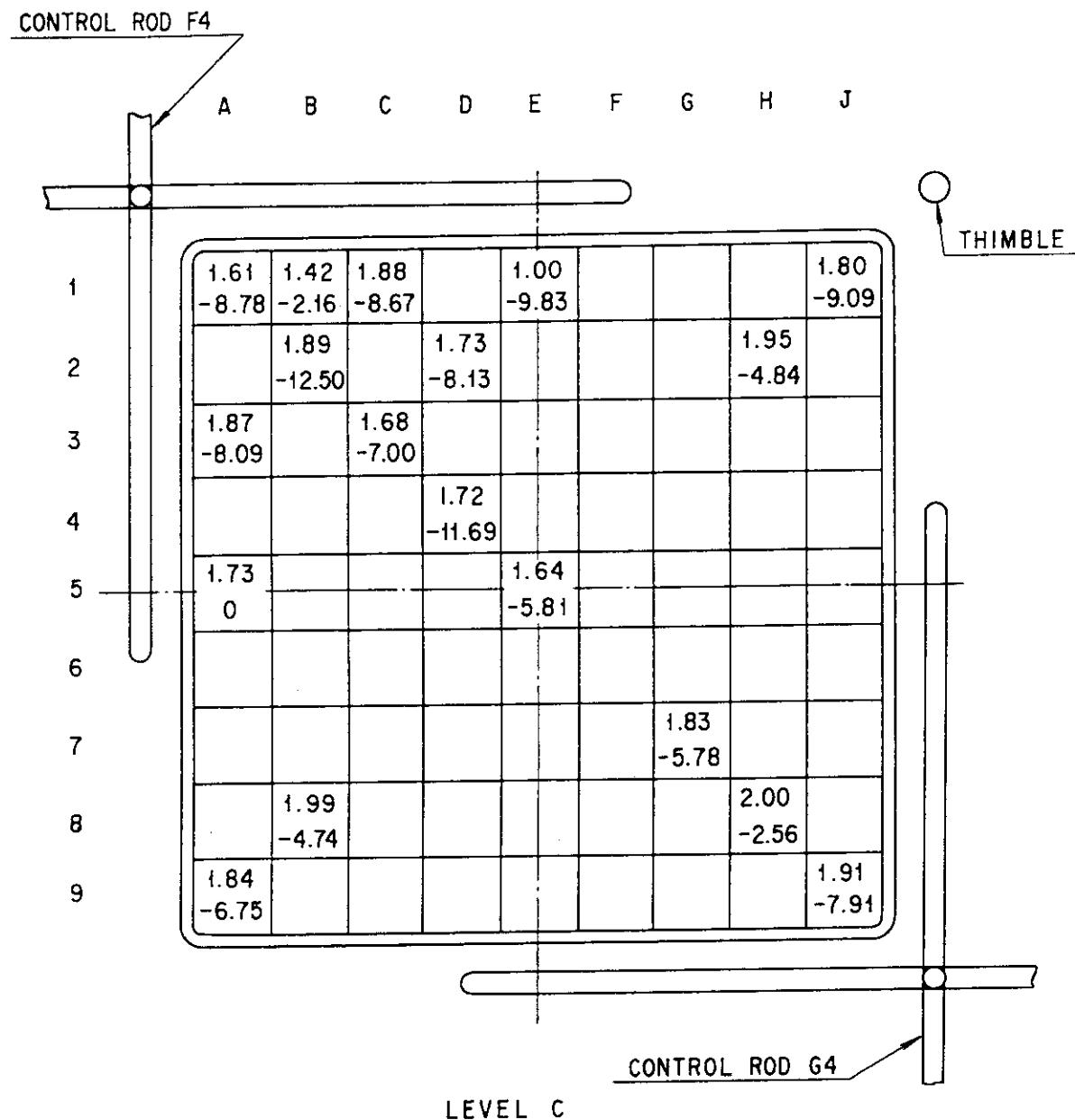


Fig. 3.4-6 Cutting positions of A-106 and SA-13



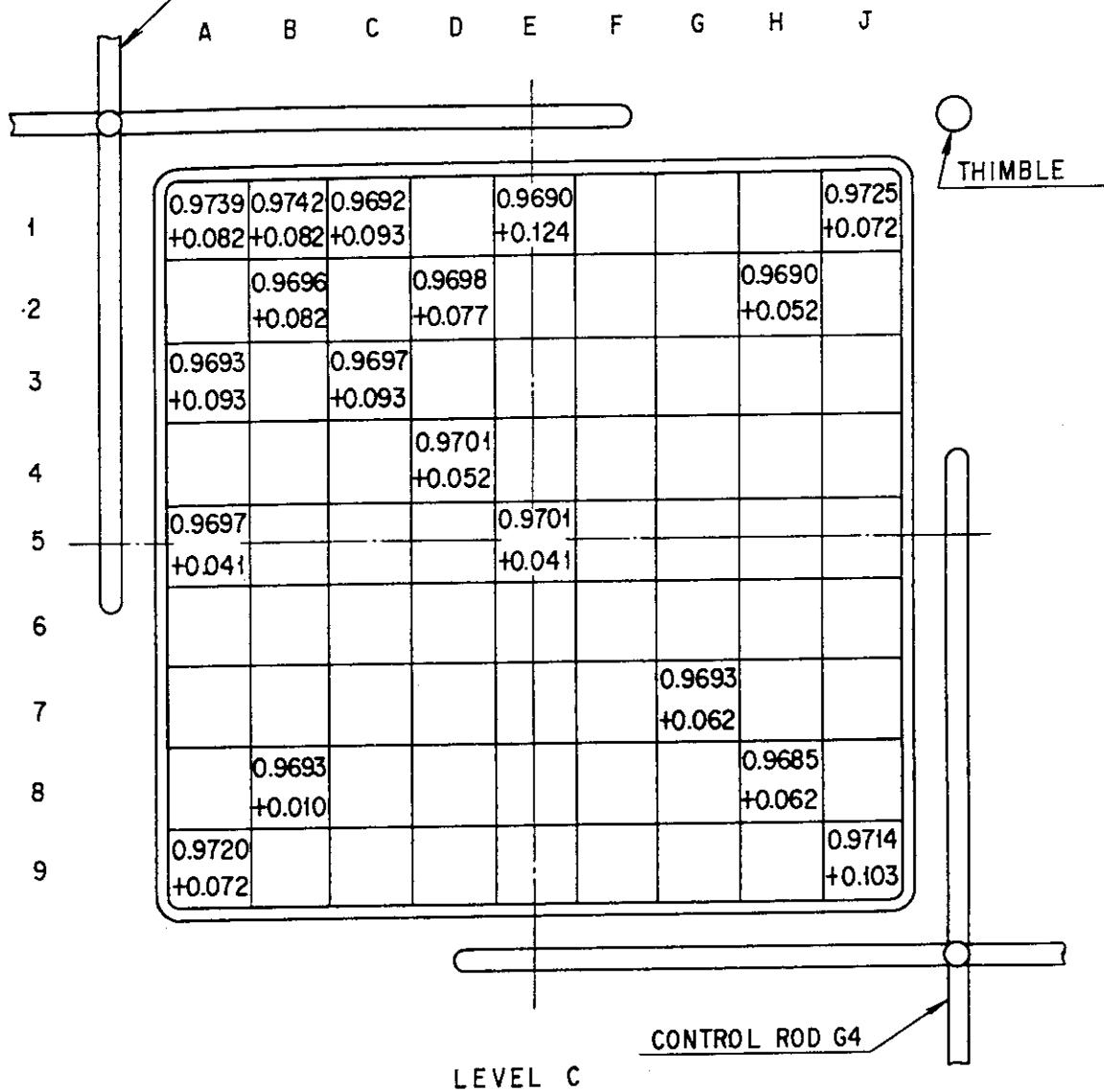
XXX VALUE OF $U_{235} \times 10^{-3}$ REFERED TO TOTAL INITIAL URANIUM
 XXX $\frac{T-E}{T} \times 100$ - 5 GROUP BURSQUID $\sigma = -3.94\%$

Fig. 3.4-7 Theoretical experimental comparison of U_{235} content



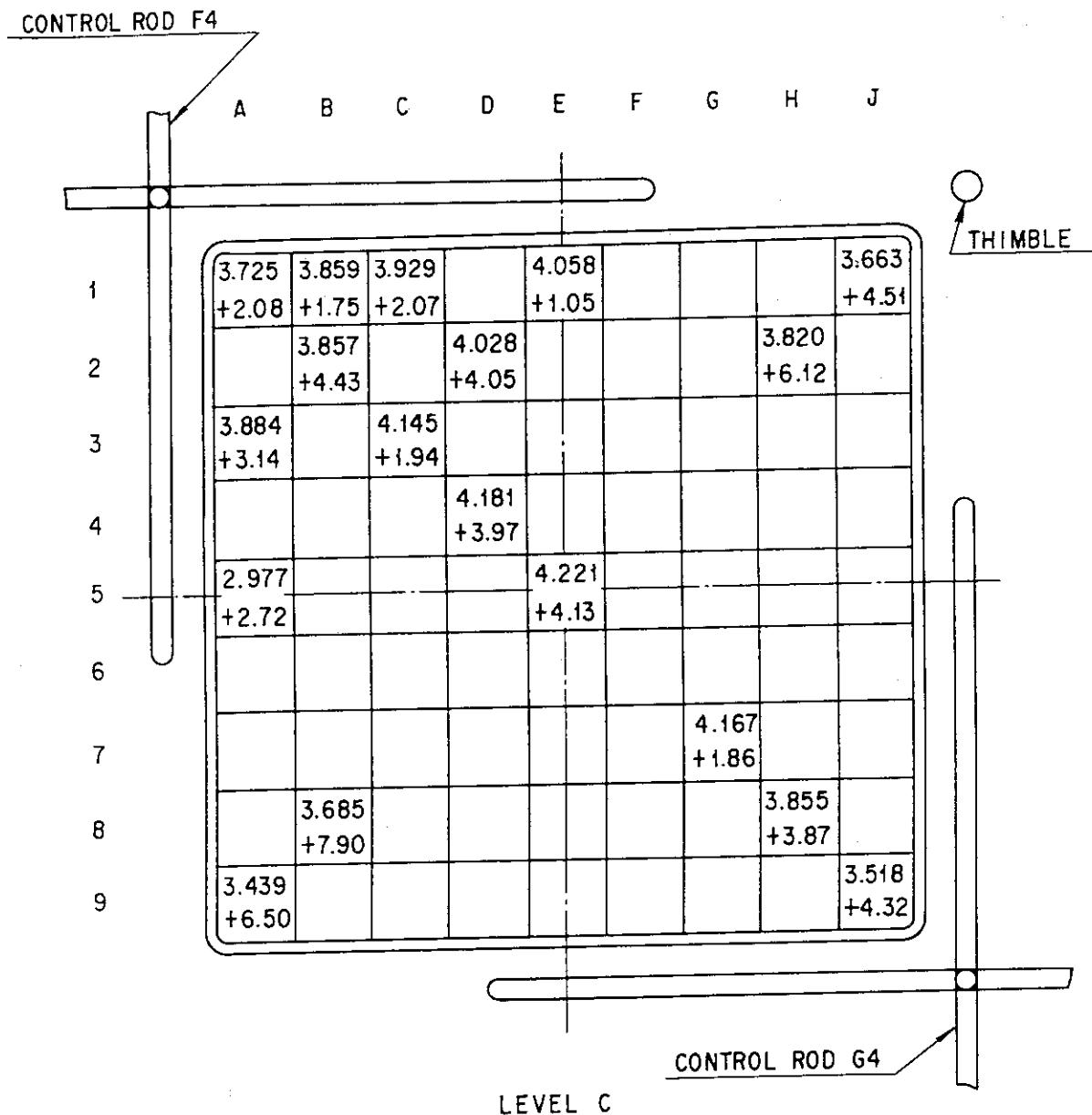
XXX → VALUE OF $U_{236} \times 10^{-3}$ REFERED TO TOTAL INITIAL URANIUM
 XXX → $\frac{T-E}{T} \times 100 - 5$ GROUP BURSQUID $\sigma = -6.85\%$

Fig. 3.4-8 Theoretical experimental comparison of U_{236} content

CONTROL ROD F4

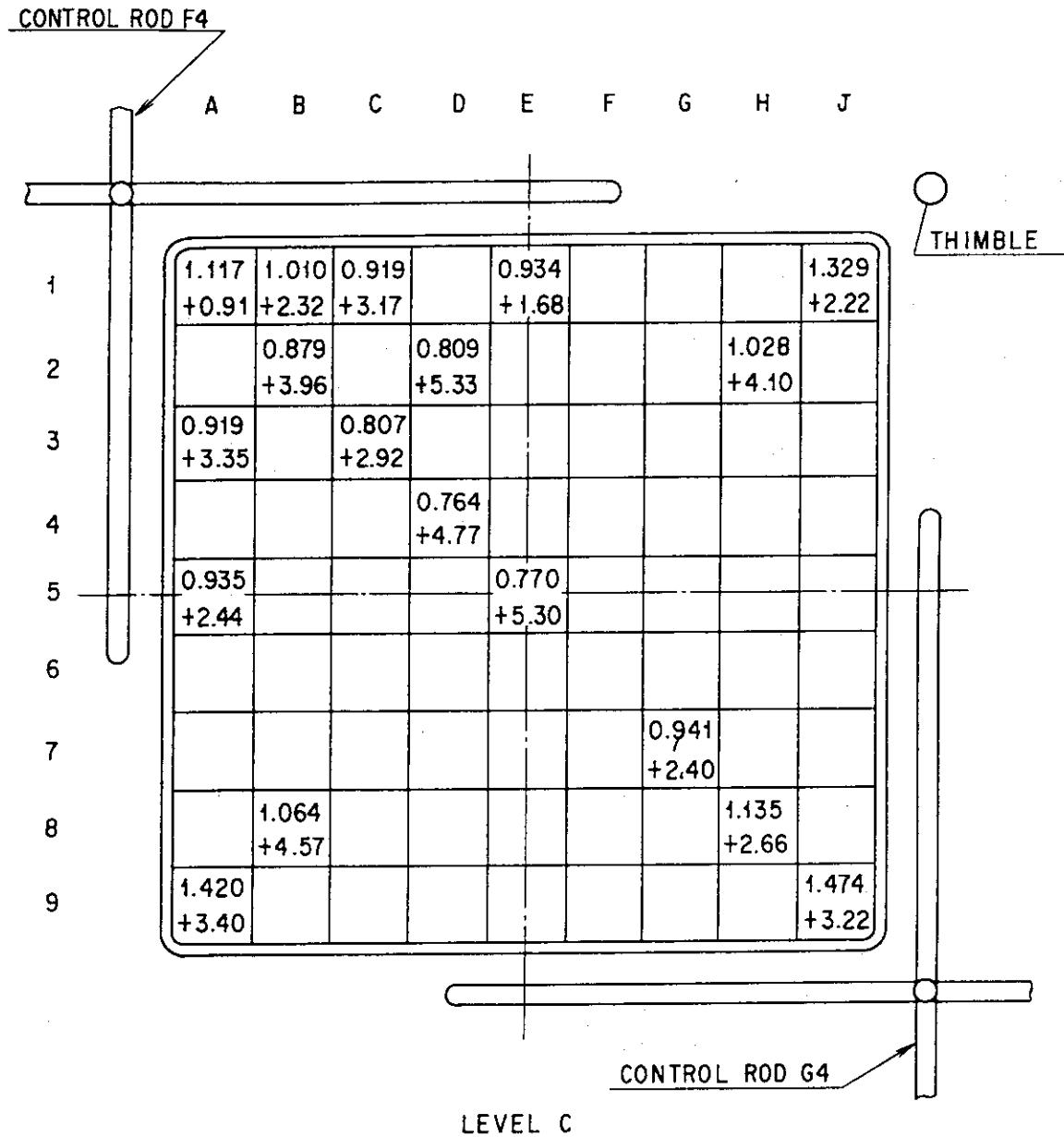
 VALUE OF $U_{238} \times 10^{-3}$ REFERED TO TOTAL INITIAL URANIUM
 $\frac{T-E}{T} \times 100$ - 5 GROUP BURSQUID $\sigma = +0.0716\%$

Fig. 3.4-9 Theoretical experimental comparison of U_{238} content



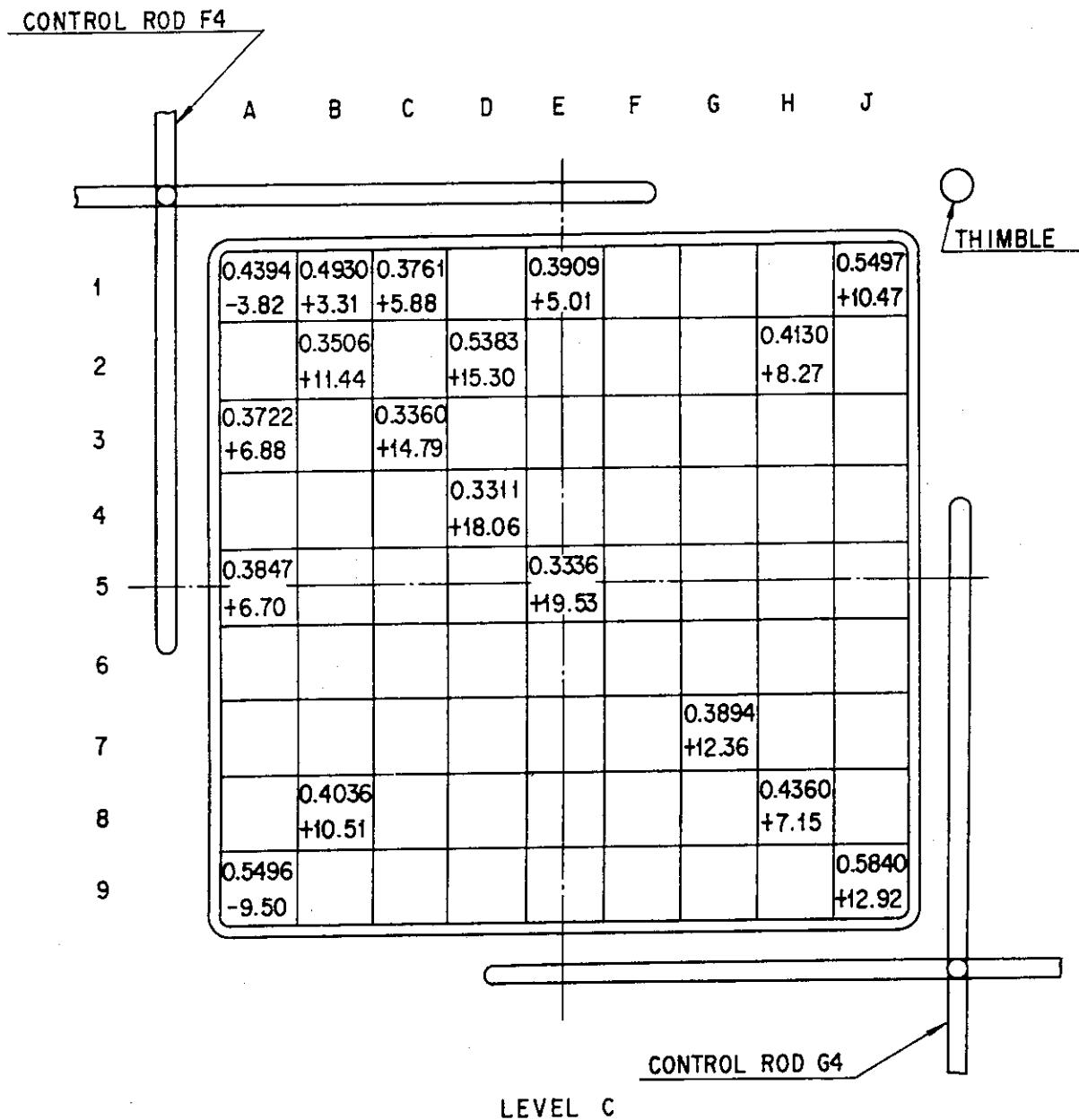
XXX → VALUE OF $Pu_{239} \times 10^{-3}$ REFERED TO TOTAL INITIAL URANIUM
 XXX → $\frac{T-E}{T} \times 100 - 5$ GROUP BURSQUID $\sigma = 3.69\%$

Fig. 3.4-10 Theoretical experimental comparison of Pu_{239} content



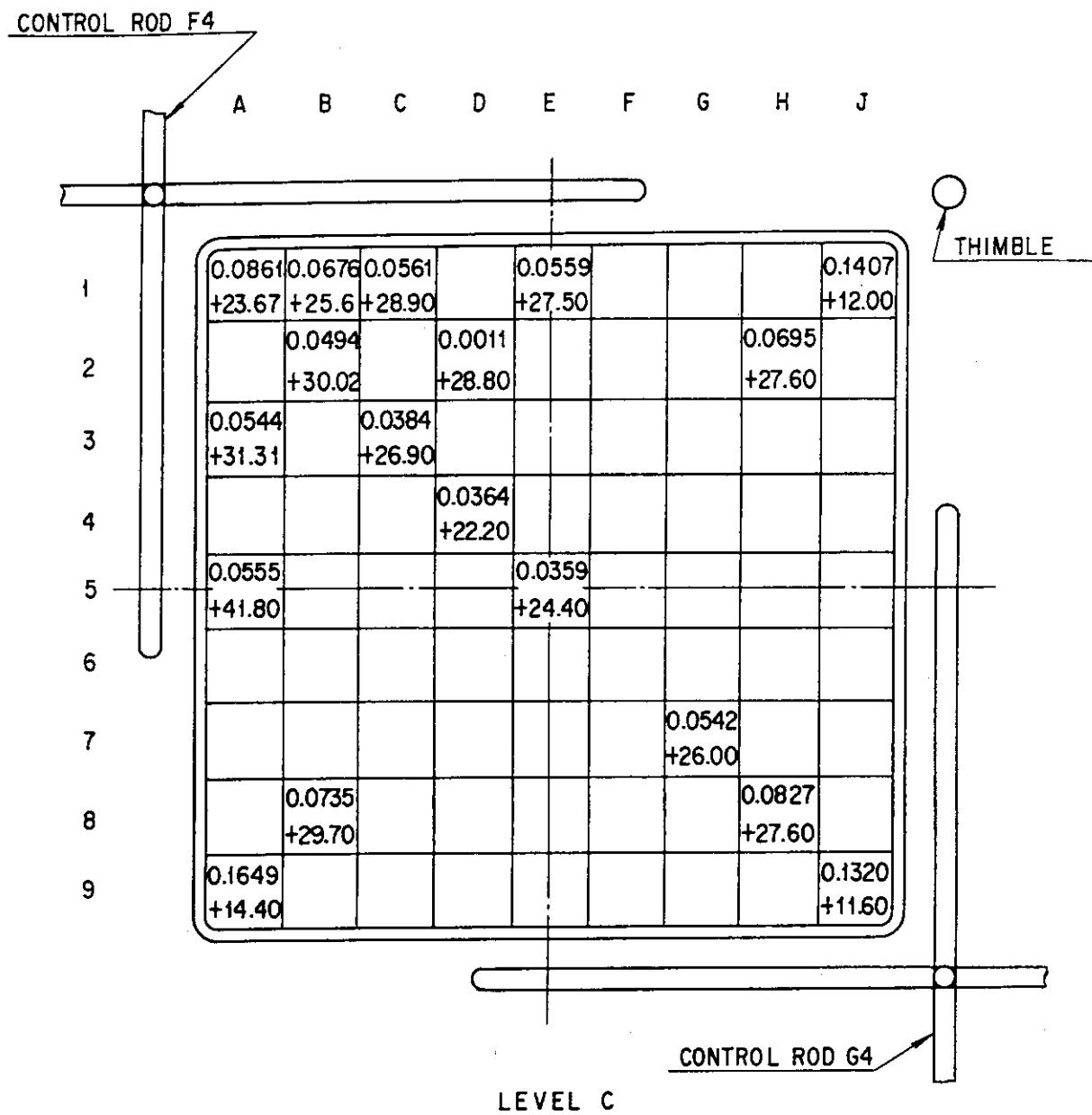
XXX → VALUE OF $Pu_{240} \times 10^{-3}$ REFERED TO TOTAL INITIAL URANIUM
 XXX → $\frac{T-E}{T} \times 100 - 5\text{GROUP BURSQUID } \sigma = +3.26\%$

Fig. 3.4-11 Theoretical experimental comparison of Pu_{240} content



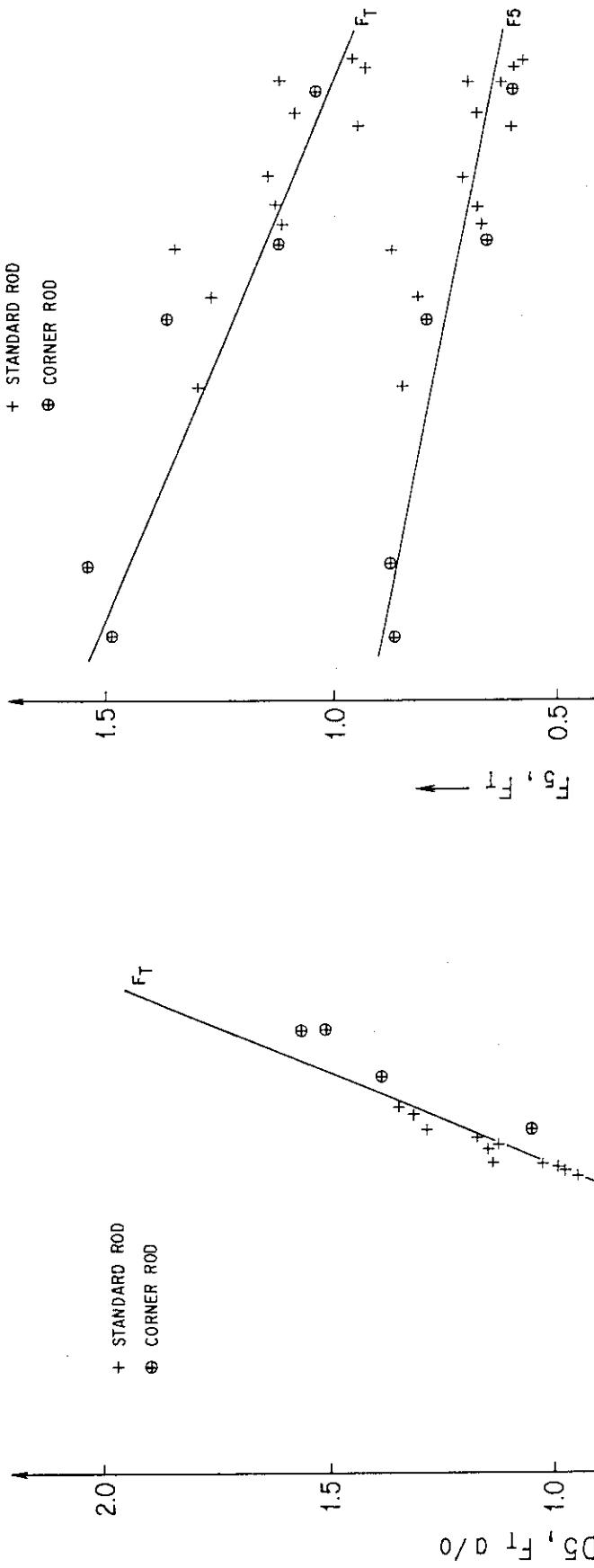
XXX → VALUE OF $Pu_{241} \times 10^{-3}$ REFERED TO TOTAL INITIAL URANIUM
 XXX → $\frac{T-E}{T} \times 100 - 5$ GROUP BURSQUID $\sigma = +10.12\%$

Fig. 3.4-12 Theoretical experimental comparison of Pu_{241} content



XXX → VALUE OF $Pu_{242} \times 10^{-3}$ REFERED TO TOTAL INITIAL URANIUM
 XXX → $\frac{I-E}{T} \times 100 - 5$ GROUP BURSQUID $\sigma = 25.50\%$

Fig. 3.4-13 Theoretical experimental comparison of Pu_{242} content

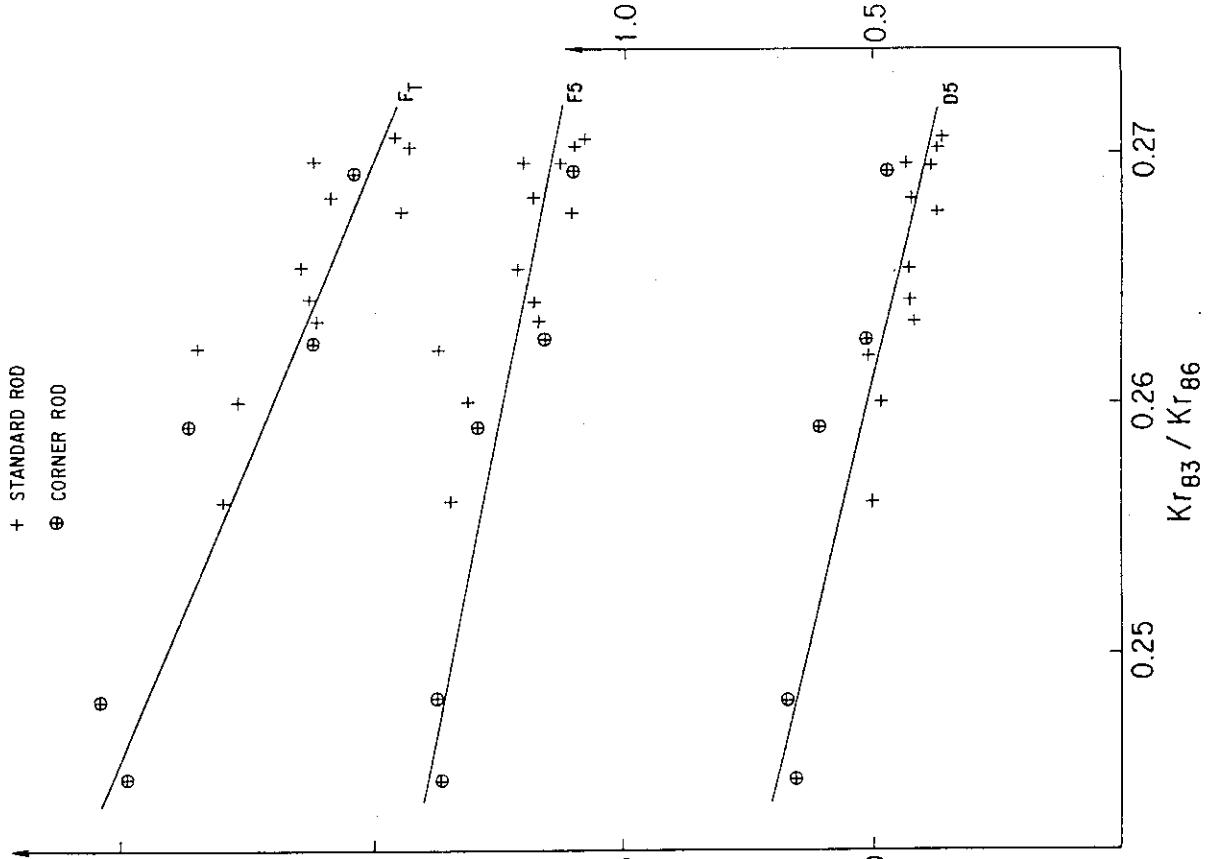
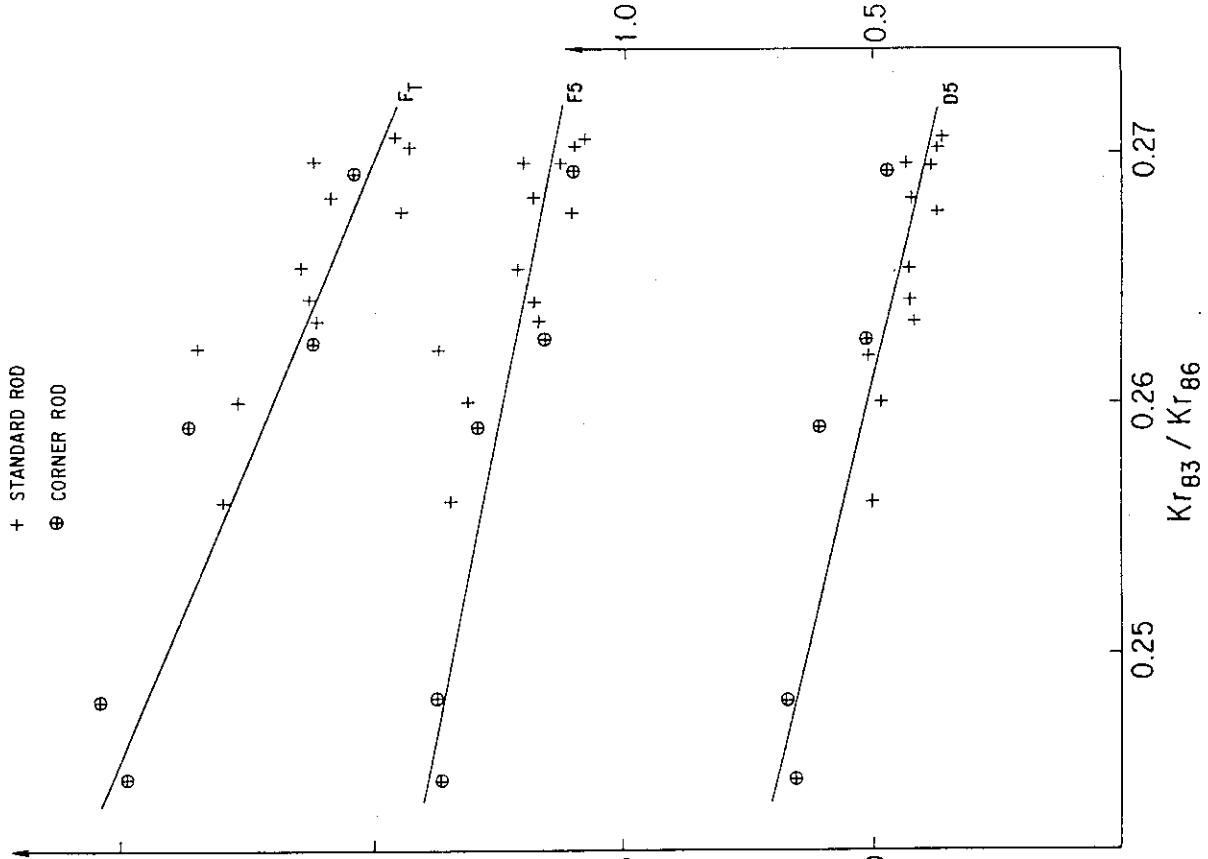
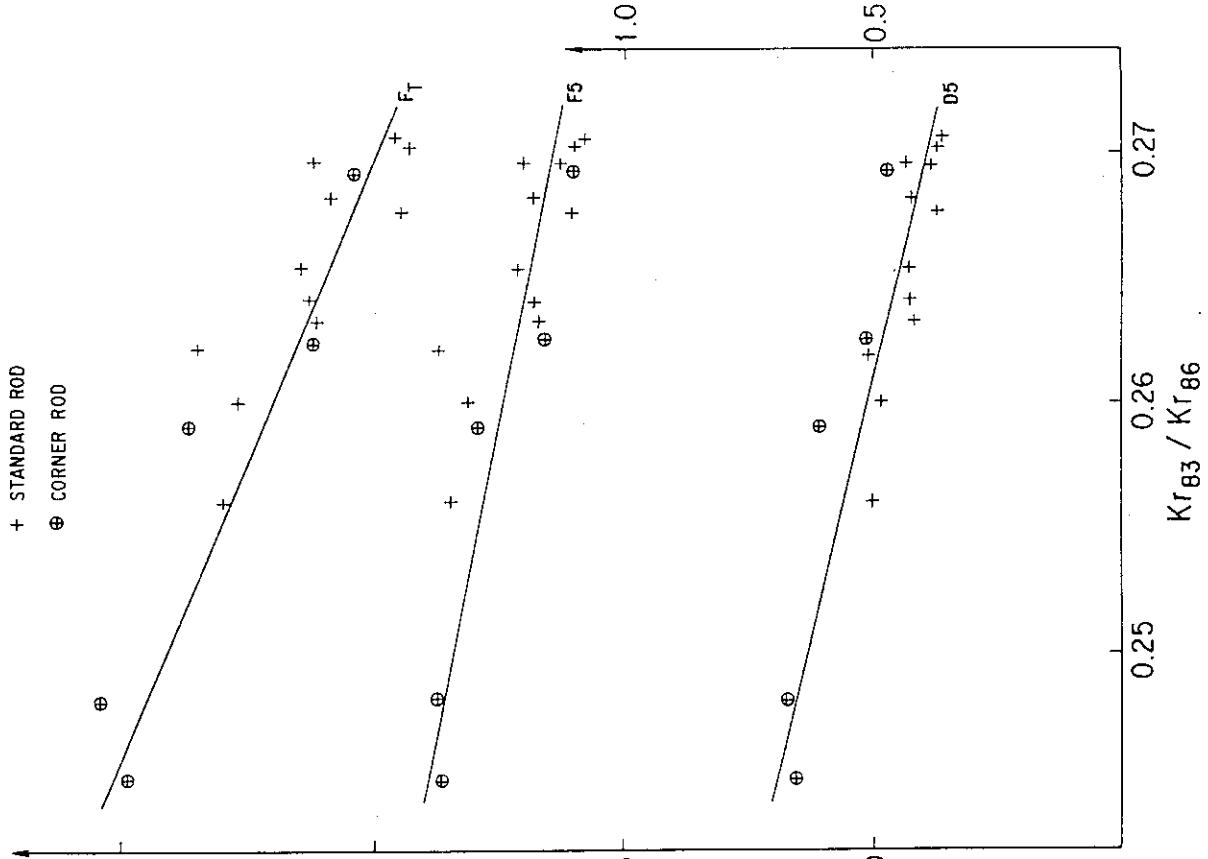
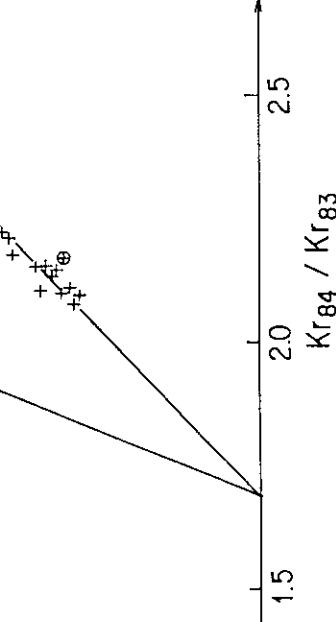


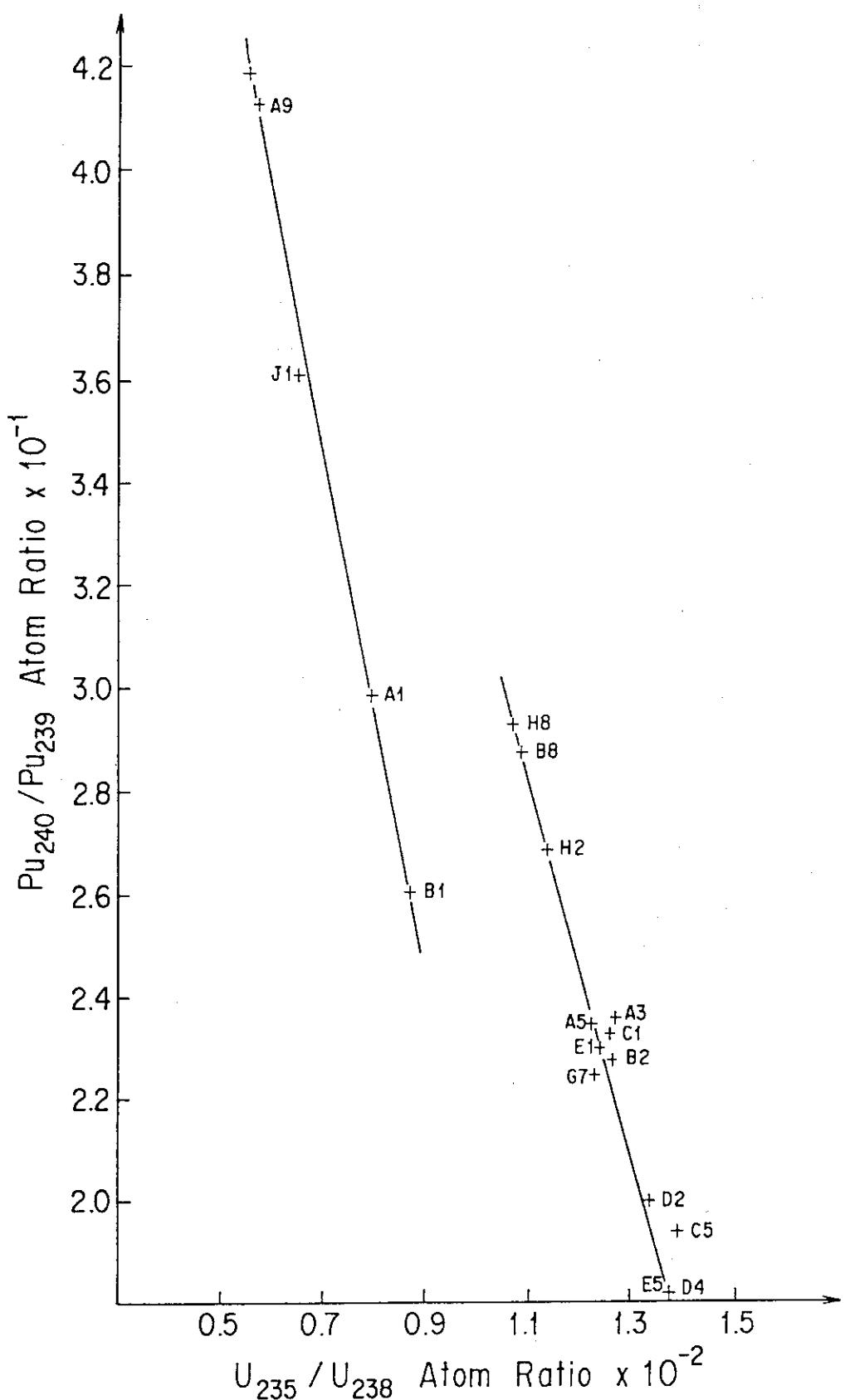
— 134 —

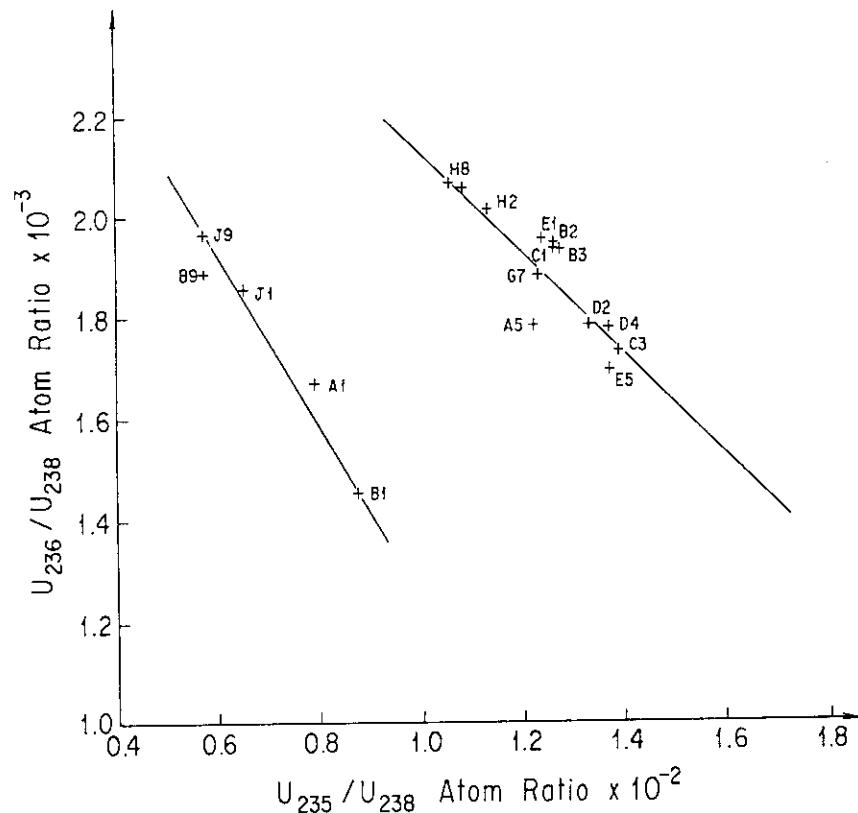
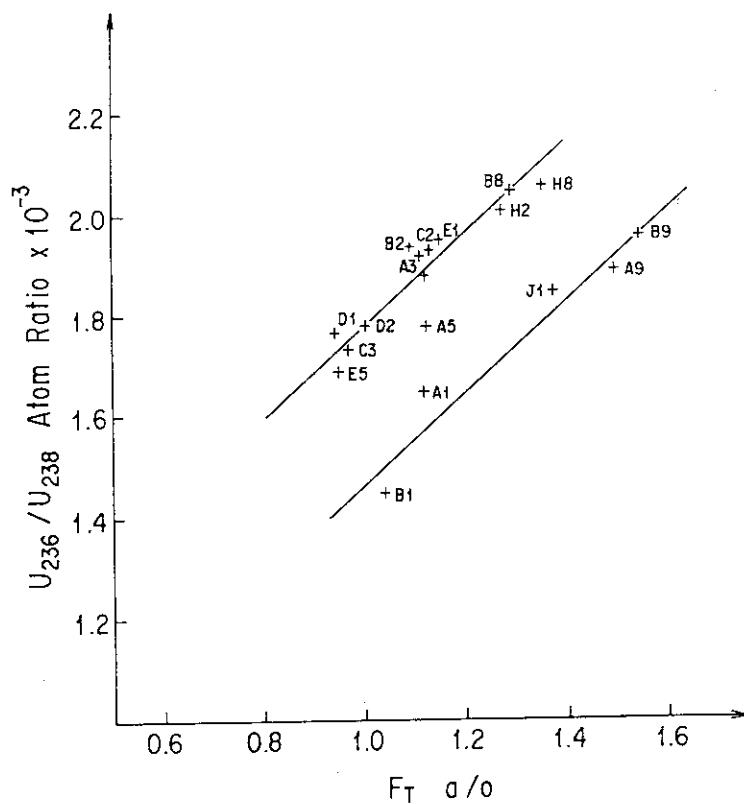
+ STANDARD ROD
⊖ CORNER ROD

1.5
1.0
0.5

F_T



Fig. 3.4-16 Correlation between $\text{Pu}_{240}/\text{Pu}_{239}$ and $\text{U}_{235}/\text{U}_{238}$

Fig. 3.4-17 Correlation between U_{236}/U_{238} and U_{235}/U_{238} Fig. 3.4-18 Correlation between U_{236}/U_{238} and burnup expressed as F_T

3.5 Gundremmingen炉(BWR)

Gundremmingen炉でのObriгheim炉などと同様、核計算手法と計算コードの検証のためデータを得る目的で、照射後試験が実施された。また、その試験方法も同様の手法が用いられた。

なお、本節で使用した図表は下記の文献から転載したものである。

- 7) P. Barbero et.al: "Post-irradiation Analysis of the Gundremmingen BWR Spent Fuel", EUR6301(1971)
- 8) S. Guardini et.al: "Benchmark Reference Data on Post-irradiation Analysis of Light Water Reactor Fuel Samples", EUR7879EN(1982).

3.5.1 炉心構成と炉心性能

Table 3.5-1に炉心構成と炉心性能を示す。また、炉心の構成図および燃料集合体図をFig. 3.5-1に示す。

3.5.2 燃焼履歴とサンプリング燃料の配置

試験燃料は平均燃焼度22,600MWD/MTUの集合体B23と平均燃焼度17,100MWD/MTUの集合体C16の2つの燃料集合体である。

その照射履歴をTable 3.5-2に示す。サンプル燃料の炉心内装荷位置をFig. 3.5-1左上図に、Table 3.5-3にサンプル燃料の炉心内装荷位置および燃焼度などを示す。

Fig. 3.5-1の左上図に燃料集合体位置に書かれた数字は該当燃料集合体がその位置で照射された原子炉運転サイクル番号を示している。また、サンプル燃料棒位置をFig. 3.5-1の下図に、サンプル燃料棒位置、軸方向サンプリング位置、その領域の中性子スペクトルの特徴およびサンプルが測定される研究所をTable 3.5-4に示す。軸方向サンプリング位置は燃料棒下端から440mmの位置および2680mmの位置であり、それぞれ(1), (2)で表す。

3.5.3 核種組成データ

測定はIspraとKarlsruheの2つの研究所で行われた。

Table 3.5-5に3種の測定法 (^{148}Nd 法、非破壊 ^{137}Cs および破壊測定 ^{137}Cs 法) による燃焼度の実測データを示す。

Table 3.5-6にU同位体の減損または蓄積量を初期U量に対する比で示す。同様にTable 3.5-7にPu同位体の蓄積量を初期U量に対する比で示す。

Table 3.5-8にAm及びCm同位体の蓄積量を初期U量に対する比で示す。

Table 3.5-9に質量分析で求めたUとPuの同位体の原子個数比を示す。

Table 3.5-10にFPガス(Kr, Xe)の放射能強度を示す。

Table 3.5-11にFPガスの同位体比を示す。

Table 3.5-12に¹⁴⁸Nd, ¹³⁷Cs及び²³⁹Puの²³⁸Uに対する原子個数比を示す。

Table 3.5-1 Core Composition and Performance (Gundremmingen)

| Fuel Pellet | | Control Rod | | B ₄ C Powder | |
|------------------------------------|----------------------|-------------|--|-------------------------|--------|
| UO ₂ density | (g/cm ³) | 10.5 | Absorbing material | | |
| Linear density | (g/cm) | 12.36 | | | |
| Diameter | (cm) | 1.224 | | | |
| Length of pellet stack in fuel rod | (cm) | 330.2 | Core | | |
| Clad-pellet clearance | (cm) | 0.013 | Equivalent diameter | (cm) | 274.8 |
| Fuel Clad | | | Active height | (cm) | 330.2 |
| Outside diameter | (cm) | 1.428 | No. of square assemblies | | 368 |
| Inside diameter | (cm) | 1.250 | No. of control rods | | 89 |
| Wall thickness | (cm) | 0.089 | UO ₂ in square assemblies(kg) | | |
| Material | Zircaloy-2 | | Total UO ₂ weight (kg) | | 52,982 |
| Square Fuel Assembly | | | Total U weight (kg) | | 46,703 |
| Rod array | | 6 × 6 | Core Thermo-hydraulic Characteristics | | |
| Number of rods | (cm) | 36 | Power (MWth) | | 250 |
| Fuel rod pitch | | 1.78 | Coolant pressure (MWth) | (kg/cm ²) | 70.35 |
| Side of square cross section | (cm) | 11.352 | Coolant temperature(ave., °C) | (inlet, °C) | 266 |
| Total length | (cm) | 386.1 | | (outlet, °C) | 286 |
| UO ₂ weight | (kg) | 144.0 | | | |
| Initial enrichment | (%) | 1.87/2.53 | | | |
| Channel material | Zircaloy-4 | | | | |
| Channel mat. thickness | (cm) | 0.15 | | | |

Table 3.5-2 Irradiation History of the Fuel Elements B23 and C16

| Cycle of operation | Periods | Days | CORE BURN-UP (MWD/MTU) | |
|--------------------|----------------------|------|------------------------|------------------|
| | | | Fuel element B23 | Fuel element C16 |
| SECOND | 25.08.69 30.05.70 | 279 | 5,839 | |
| SHUT DOWN | 31.05.70 24.07.70 | 56 | — | |
| THIRD | 25.07.70 12.06.71 | 323 | 6,131 | 5,959 |
| SHUT DOWN | 13.06.71 15.07.71 | 33 | — | — |
| FOURTH | 16.07.71 30.04.72 | 290 | 5,483 | 5,083 |
| SHUT DOWN | 01.05.72 30.06.72 | 61 | — | — |
| FIFTH | 01.07.72 05.05.73 | 309 | 5,174 | 6,026 |

Table 3.5-3 Characteristics of the Fuel Assemblies

| Fuel material | Fuel element B23 enriched UO ₂ | Fuel element C16 enriched UO ₂ |
|--|--|--|
| Initial enrichment in ²³⁵ U | 1.87 + 2.53 W% | 1.87 + 2.53 W% |
| Final burn-up | 22,627 MWD/MTU | 17,068 MWD/MTU |
| - During second cycle | 5,839 MWD/MTU | |
| - During third cycle | 6,131 MWD/MTU | 5,959 MWD/MTU |
| - During fourth cycle | 5,483 MWD/MTU | 5,083 MWD/MTU |
| - During fifth cycle | 5,174 MWD/MTU | 6,026 MWD/MTU |
| Core positions: | | |
| - Second cycle | H - 4 | |
| - Third cycle | H - 4 | J - 9 |
| - Fourth cycle | H - 4 | J - 9 |
| - Fifth cycle | J - 4 | E - 7 |
| Pellet | undished | dished |

Table 3.5-4 Selected Fuel Samples

| | | FUEL ELEMENT B23 | | | | | | | | | | | | FUEL ELEMENT C16 | | | | | | | | | | | |
|------------------|------------------------|------------------|----|----|------------|----|---|---|---|----|----------------------------------|---|---|------------------|---|---|---|---|---|---|---|---|---|---|---|
| | | I | K | I | K | I | K | I | K | I | K | I | K | I | K | I | K | I | K | I | K | I | K | I | K |
| Top | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2680 | | | | | | | | | | | | | | | | | | | | | | | | |
| | 440 | | | | | | | | | | | | | | | | | | | | | | | | |
| Bottom | | | | | | | | | | | | | | | | | | | | | | | | | |
| RODS | | A1 | B3 | B4 | | C5 | | E3 | | E5 | | | | | | | | | | | | | | | |
| NEUTRON SPECTRUM | Perturbed (corner rod) | | | | ASYMPTOTIC | | | Intermediate (near lower enrichment rods) | | | Perturbed (close to control rod) | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |

 SELECTED FUEL SAMPLES

^I SAMPLES ANALYSED AT ISPRA
^K SAMPLES ANALYSED AT KARLSRUHE

Table 3.5-5 Burn-up values (MWD/MTU) Obtained by Independent Experimental Techniques in Gundremmingen BWR

| FUEL ELEMENT | SAMPLE | LAB. | Nd-148 | Cs-137 Destructive | Cs-137 Non-destructive | Average |
|---------------------------------|--------|-----------|--------|--------------------|------------------------|---------|
| B 23 1.87 w% + 2.53 w% | A1 (1) | Ispra | 25,730 | 30,120 | 24,670 | 26,840 |
| | A1 (2) | Ispra | 27,400 | 23,830 | 27,750 | 26,327 |
| | B3 | Ispra | | 21,690 | 21,580 | 21,635 |
| | B3 | Karlsruhe | 21,240 | 22,100 | | 21,670 |
| | B4 | Ispra | 22,250 | 22,400 | 22,890 | 22,513 |
| | C5 | Karlsruhe | 22,970 | 25,330 | 23,530 | 23,943 |
| | E3 | Ispra | 23,510 | 22,130 | 23,870 | 23,170 |
| | E5 | Ispra | | 25,380 | 21,380 | 23,380 |
| | E5 | Karlsruhe | 25,190 | 25,900 | | 25,545 |
| C 16 1.87 w% + 2.53 w% | A1 (1) | Ispra | 20,300 | 21,120 | 20,250 | 20,557 |
| | A1 (2) | Ispra | 19,850 | 24,230 | | 22,040 |
| | B3 | Ispra | | 15,220 | 14,880 | 15,050 |
| | B3 | Karlsruhe | 14,390 | 15,680 | | 15,035 |
| | C5 | Karlsruhe | 15,840 | 18,200 | 15,890 | 16,643 |
| | E5 | Ispra | | 15,970 | 19,750 | 17,860 |
| | E5 | Karlsruhe | 17,490 | 19,240 | | 18,365 |

Table 3.5-6 Build-up and Depletion of U Isotopes (atoms/100 initial heavy atoms) in Gundremmingen BWR

| FUEL ELEMENT | SAMPLE | LAB. | U-235 Depletion | U-236 Build up | U-238 Depletion |
|---------------------------------|--------|-----------|-----------------|----------------|-----------------|
| B 23 1.87 w% + 2.53 w% | A1 (1) | Ispra | 1.923 | .329 | 1.828 |
| | A1 (2) | Ispra | 1.879 | .329 | 2.241 |
| | B3 | Ispra | 1.577 | .297 | 1.808 |
| | B3 | Karlsruhe | 1.557 | .298 | 1.889 |
| | B4 | Ispra | 1.656 | .302 | 1.839 |
| | C5 | Karlsruhe | 1.695 | .318 | 1.924 |
| | E3 | Ispra | 1.689 | .316 | 1.969 |
| | E5 | Ispra | 1.886 | .328 | 1.992 |
| | E5 | Karlsruhe | 1.869 | .336 | 2.057 |
| C 16 1.87 w% + 2.53 w% | A1 (1) | Ispra | 1.692 | .308 | 1.363 |
| | A1 (2) | Ispra | 1.569 | .291 | 1.523 |
| | B3 | Ispra | 1.238 | .246 | 1.196 |
| | B3 | Karlsruhe | 1.230 | .248 | 1.249 |
| | C5 | Karlsruhe | 1.305 | .252 | 1.289 |
| | E5 | Ispra | 1.516 | .273 | 1.274 |
| | E5 | Karlsruhe | 1.492 | .279 | 1.346 |

Table 3.5-7 Build-up of Plutonium Isotopes (atoms per 1000 initial heavy atoms) in Gundremmingen BWR

| FUEL ELEMENT | SAMPLE | LAB. | Pu-236 ($\times 10E-7$) | Pu-238 | Pu-239 | Pu-240 | Pu-241 | Pu-242 | Total Pu |
|---------------------------------|--------|-----------|---|--------|--------|--------|--------|--------|----------|
| B 23 1.87 w% + 2.53 w% | A1 (1) | Ispra | 10.67 15.61 12.34 .086 .092 .089 .084 .097 .099 | .068 | 3.72 | 1.80 | .782 | .325 | 6.695 |
| | A1 (2) | Ispra | | .108 | 4.78 | 2.15 | 1.128 | .442 | 8.608 |
| | B3 | Ispra | | .080 | 5.29 | 1.81 | .857 | .215 | 8.252 |
| | B3 | Karlsruhe | | .086 | 5.41 | 1.87 | .884 | .224 | 8.474 |
| | B4 | Ispra | | .092 | 5.01 | 1.84 | .859 | .232 | 8.033 |
| | C5 | Karlsruhe | | .089 | 4.91 | 1.95 | .879 | .263 | 8.091 |
| | E3 | Ispra | | .084 | 4.80 | 1.83 | .844 | .242 | 7.800 |
| | E5 | Ispra | | .097 | 4.52 | 2.09 | .898 | .331 | 7.936 |
| | E5 | Karlsruhe | | .099 | 4.45 | 2.08 | .892 | .333 | 7.854 |
| C 16 1.87 w% + 2.53 w% | A1 (1) | Ispra | 3.77 | .036 | 3.62 | 1.46 | .604 | .179 | 5.899 |
| | A1 (2) | Ispra | | .048 | 4.40 | 1.52 | .756 | .198 | 6.922 |
| | B3 | Ispra | | .033 | 4.66 | 1.15 | .536 | .087 | 6.466 |
| | B3 | Karlsruhe | | .033 | 4.69 | 1.17 | .542 | .088 | 6.523 |
| | C5 | Karlsruhe | | .035 | 4.42 | 1.23 | .537 | .098 | 6.320 |
| | E5 | Ispra | | 4.16 | .041 | 4.15 | 1.43 | .596 | .151 |
| | E5 | Karlsruhe | | | .041 | 4.13 | 1.43 | .590 | .144 |
| | | | | | | | | | 6.335 |

Table 3.5-8 Build-up of Cm and Am Isotopes in Gundremmingen BWR
(atoms/ $10E6$ initial heavy atoms)

| FUEL ELEMENT | SAMPLE | LAB. | Cm-242 | Cm-244 | Am-241 ($\times 10E-2$) |
|---------------------------------|--------|-----------|--------|--------|------------------------------|
| B 23 1.87 w% + 2.53 w% | A1 (1) | Ispra | 9.92 | 8.65 | 3.73 |
| | A1 (2) | Ispra | 14.32 | 19.28 | 6.55 |
| | B3 | Ispra | 9.37 | 8.46 | 3.10 |
| | B3 | Karlsruhe | 9.22 | 8.36 | |
| | B4 | Ispra | 9.17 | 9.16 | |
| | C5 | Karlsruhe | 9.90 | 10.58 | 1.04 |
| | E3 | Ispra | 9.46 | 8.95 | 2.19 |
| | E5 | Ispra | 11.29 | 15.24 | 2.12 |
| | E5 | Karlsruhe | 10.26 | 14.14 | 1.14 |
| C 16 1.87 w% + 2.53 w% | A1 (1) | Ispra | 5.17 | 2.55 | 2.77 |
| | A1 (2) | Ispra | 6.76 | 4.37 | 2.64 |
| | B3 | Ispra | 3.68 | 1.44 | 1.00 |
| | B3 | Karlsruhe | 3.80 | 1.62 | .94 |
| | C5 | Karlsruhe | 3.76 | 1.89 | .32 |
| | E5 | Ispra | 5.09 | 2.46 | 1.43 |
| | E5 | Karlsruhe | 4.82 | 2.99 | 1.02 |

Table 3.5-9 Atom Ratios of U and Pu from Mass Spectrometry

| FUEL ELEMENT | SAMPLE | LAB. | U ($\times 10E-2$) | | Pu ($\times 10E-1$) | | | |
|---------------------------------|--------|-----------|----------------------|---------|-----------------------|---------|---------|---------|
| | | | 235/238 | 236/238 | Date | 240/239 | 241/239 | 242/239 |
| B 23 1.87 w% + 2.53 w% | A1 (1) | Ispra | .676 | .346 | 12.03.76 | 4.883 | 1.872 | .901 |
| | A1 (2) | Ispra | .727 | .349 | 18.03.76 | 4.407 | 1.971 | .864 |
| | B3 | Ispra | 1.029 | .311 | 03.11.75 | 3.448 | 1.470 | .418 |
| | B3 | Karlsruhe | 1.049 | .312 | 18.05.76 | 3.446 | 1.430 | .414 |
| | B4 | Ispra | .960 | .319 | 05.10.76 | 3.684 | 1.459 | .466 |
| | C5 | Karlsruhe | .905 | .332 | 19.05.76 | 3.970 | 1.560 | .536 |
| | E3 | Ispra | .914 | .331 | 01.10.76 | 3.819 | 1.497 | .505 |
| | E5 | Ispra | .707 | .344 | 09.12.75 | 4.671 | 1.793 | .756 |
| | E5 | Karlsruhe | .725 | .352 | 19.05.76 | 4.667 | 1.750 | .749 |
| C 16 1.87 w% + 2.53 w% | A1 (1) | Ispra | .916 | .323 | 29.09.76 | 4.047 | 1.420 | .496 |
| | A1 (2) | Ispra | 1.048 | .305 | 01.10.76 | 3.445 | 1.459 | .450 |
| | B3 | Ispra | 1.375 | .256 | 02.03.76 | 2.501 | 1.025 | .192 |
| | B3 | Karlsruhe | 1.382 | .258 | 30.04.76 | 2.489 | 1.006 | .188 |
| | C5 | Karlsruhe | 1.306 | .262 | 30.04.76 | 2.780 | 1.059 | .222 |
| | E5 | Ispra | 1.087 | .284 | 06.11.75 | 3.492 | 1.300 | .375 |
| | E5 | Karlsruhe | 1.111 | .291 | 03.05.76 | 3.472 | 1.242 | .342 |

Table 3.5-10 Specific Activities of Fission Products and Activity Ratios (dps/g of final Uranium) at Reactor Shutdown

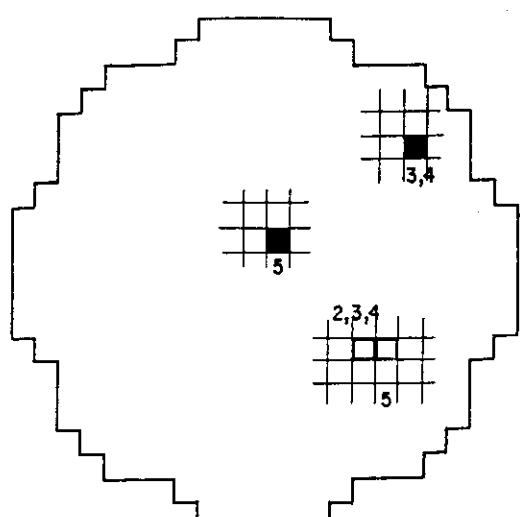
| FUEL ELEMENT | SAMPLE | LAB. | Cs-137 ($\times 10E9$) | Cs-134 ($\times 10E9$) | Eu-154 ($\times 10E8$) | Cs-134/ Cs-137 | Eu-154/ Cs-137 ($\times 10E-2$) |
|---------------------------------|--------|-----------|-----------------------------|-----------------------------|-----------------------------|-------------------|---|
| B 23 1.87 w% + 2.53 w% | A1 (1) | Ispra | 3.660 | 3.490 | 1.790 | .954 | 4.892 |
| | A1 (2) | Ispra | 2.890 | 3.280 | 1.800 | 1.133 | 6.218 |
| | B3 | Ispra | 2.610 | 2.570 | 1.550 | .984 | 5.934 |
| | B3 | Karlsruhe | 2.670 | | | | |
| | B4 | Ispra | 2.700 | 2.940 | 1.490 | 1.089 | 5.519 |
| | C5 | Karlsruhe | 3.070 | | | | |
| | E3 | Ispra | 2.750 | 3.000 | 1.530 | 1.091 | 5.564 |
| | E5 | Ispra | 3.080 | 3.250 | 1.610 | 1.055 | 5.227 |
| | E5 | Karlsruhe | 3.240 | | | | |
| C 16 1.87 w% + 2.53 w% | A1 (1) | Ispra | 2.550 | 2.260 | .890 | .887 | 3.479 |
| | A1 (2) | Ispra | 2.690 | 2.850 | 1.090 | 1.058 | 4.047 |
| | B3 | Ispra | 1.830 | 1.450 | .750 | .791 | 4.106 |
| | B3 | Karlsruhe | 1.910 | | | | |
| | C5 | Karlsruhe | 2.200 | | | | |
| | E5 | Ispra | 1.920 | 1.630 | .840 | .849 | 4.380 |
| | E5 | Karlsruhe | 2.320 | | | | |

Table 3.5-11 Isotopic Ratios of Fission Gases in Gundremmingen BWR
(Karlsruhe Laboratory)

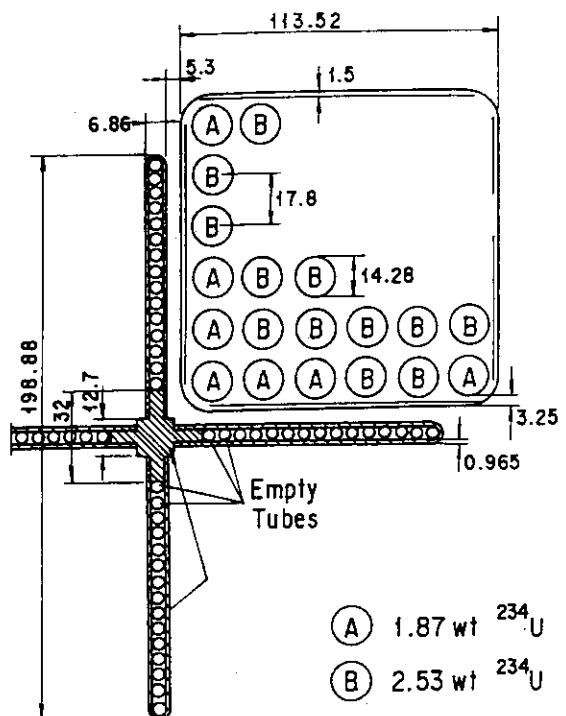
| FUEL ELEMENT | SAMPLE | Krypton | | | Xenon | | | |
|---------------------------------|--------|---------|-------|-------|---------|---------|---------|---------|
| | | 83/86 | 84/86 | 84/83 | 131/134 | 132/134 | 136/134 | 132/131 |
| B 23 1.87 w% + 2.53 w% | B3 | .245 | .588 | 2.400 | .303 | .698 | 1.424 | 2.304 |
| | C5 | .239 | .594 | 2.485 | .307 | .714 | 1.443 | 2.326 |
| | E5 | | | 2.639 | .294 | .711 | 1.510 | 2.418 |
| C 16 1.87 w% + 2.53 w% | B3 | .256 | .571 | 2.229 | .334 | .675 | 1.363 | 2.017 |
| | C5 | .254 | .573 | 2.253 | .327 | .666 | 1.404 | 2.037 |
| | E5 | .249 | .581 | 2.333 | .328 | .675 | 1.450 | 2.059 |

Table 3.5-12 Atom Ratios of Neodymium, Cesium and Plutonium
Referred to Final Uranium in Gundremmingen BWR

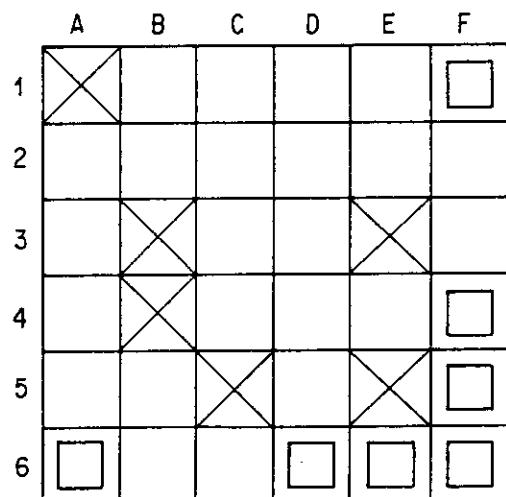
| FUEL ELEMENT | SAMPLE | LAB. | Nd-148 /U-238 ($\times 10E-4$) | Cs-137 /U-238 ($\times 10E-3$) | Pu-239 /U-238 ($\times 10E-3$) | Total Pu /U mass ($\times 10E-3$) |
|---------------------------------|--------|-----------|-------------------------------------|-------------------------------------|-------------------------------------|--|
| B 23 1.87 w% + 2.53 w% | A1 (1) | Ispra | 4.880 | 2.120 | 3.890 | 6.980 |
| | A1 (2) | Ispra | 5.220 | 1.670 | 4.990 | 9.000 |
| | B3 | Ispra | | 1.520 | 5.540 | 8.570 |
| | B3 | Karlsruhe | 4.030 | 1.550 | 5.650 | 8.800 |
| | B4 | Ispra | 4.220 | 1.570 | 5.240 | 8.350 |
| | C5 | Karlsruhe | 4.360 | 1.780 | 5.120 | 5.420 |
| | E3 | Ispra | 4.580 | 1.590 | 5.020 | 8.110 |
| | E5 | Ispra | | 1.780 | 4.730 | 8.280 |
| | E5 | Karlsruhe | 4.920 | 1.870 | 4.650 | 8.200 |
| C 16 1.87 w% + 2.53 w% | A1 (1) | Ispra | 3.800 | 1.460 | 3.770 | 6.100 |
| | A1 (2) | Ispra | 3.720 | 1.540 | 4.590 | 7.160 |
| | B3 | Ispra | | 1.056 | 4.840 | 6.650 |
| | B3 | Karlsruhe | 2.730 | 1.100 | 4.870 | 6.710 |
| | C5 | Karlsruhe | 2.960 | 1.260 | 4.590 | 6.500 |
| | E5 | Ispra | | 1.100 | 4.310 | 6.580 |
| | E5 | Karlsruhe | 3.330 | 1.330 | 4.280 | 6.540 |



- FUEL ELEMENT B23· Positions H-4 and J-4
- FUEL ELEMENT C16· Positions J-9 and F-7



ELEMENT B23



ELEMENT C16

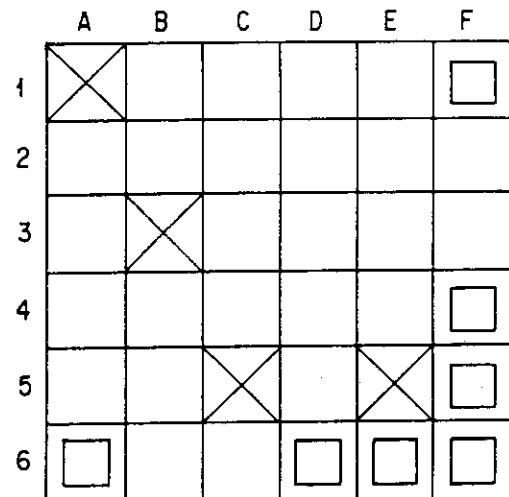
ENRICHMENT 1.87 w% ^{235}U SELECTED FUEL ROD (ENRICHMENT 2.53 w% ^{235}U)

Fig. 3.5-1 Configuration of Gundremmingen core

3.6 Monticello炉(BWR)

Monticello炉では1974年から1983年まで燃焼度増加計画を実施した。この計画のなかで集合体平均の燃焼度は45.6GWd/MTU、ピークペレット燃焼度58.7GWd/MTUに達した。この計画の一環として使用済み燃料中の核種組成の測定が行われた。実施された全体計画をFig. 3.6-1に示す。全体計画で試験された燃料集合体は4体であるが、核種組成測定された燃料集合体は1体である。

なお、本節で使用した図表は下表の文献から転載したものである。

9) J. A. Baumgartner et.al: "BWR Fuel Bundle Extended Burnup Program Final Report", GEAP-30846, DOE/ET/34031-18 UC-18(Dec, 1984)

3.6.1 炉心構成と炉心性能

炉心構成と炉心性能についてTable 3.6-1に示す。Fig. 3.6-2に炉心配置図を示す。

3.6.2 燃焼履歴とサンプリング燃料の配置

Table 3.6-2にMonticello炉の燃料集合体と燃料棒の設計値を示す。試験された燃料集合体の燃焼履歴をTable 3.6-3に示す。このうち、核種組成測定されたのは燃料集合体MTB099である。Fig. 3.6-2に燃料集合体MTB099の炉心内配置の変化を示す。

燃料集合体MTB099の中で核種測定された UO_2 燃料棒4本と $UO_2-Gd_2O_3$ 燃料棒1本の位置をFig. 3.6-3に示す。また、燃料棒の軸方向サンプル位置をFig. 3.6-4に示す。サンプル数は燃料棒当たり5個である。

3.6.3 核種組成実測データ

Table 3.6-4に試験燃料棒の設計値と照射データを示す。Table 3.6-5にサンプル位置とNdで測定した燃焼度を示す。また、Table 3.6-6に ^{242}Cm の測定結果を示す。

UとPuの濃度及び同位体組成比をTable 3.6-7に示す。

研究所間の試験及び繰り返し実験に基づき、燃焼度測定(Nd)の精度は $\pm 3\%$ (2σ)以内、 ^{242}Cm の測定不確かさは $\pm 5\%$ (2σ)と評価されている。また、測定の統計的バイアスは $\pm 5\%$ 以内と評価されている。

Table 3.6-1 Core Composition and Performance(Monticello)

| Fuel Pellet | Pellet UO_2 density Linear density Diameter | (g/cm ³) (g/cm) (cm) | Core | Control Rod Absorbing material | B_4C Powder |
|---------------------------------------|--|--|--|-----------------------------------|---------------|
| Clad-pellet clearance | 1.057 | | | | 365.76 |
| Length of pellet stack in fuel rod | (cm) | 365.76 | Equivalent diameter (cm) | | |
| Clad-pellet clearance | (cm) | 0.0114 | Active height (cm) | | |
| Fuel Clad | | | No. of square assemblies | | |
| Outside diameter | (cm) | 1.252 | No. of control rods | | |
| Inside diameter | (cm) | 1.080 | UO_2 in square assemblies(kg) | | |
| Wall thickness | (cm) | 0.086 | Total UO_2 weight (kg) | | |
| Material | Zircaloy-2 | | Total U weight (kg) | | |
| Square Fuel Assembly | | | Core Thermo-hydraulic Characteristics | | |
| Rod array | 8 × 8 | | Power (MWth) | | |
| Number of rods | 63 | | (MWe) | | |
| Fuel rod pitch | (cm) | | Coolant pressure (kg/cm ²) | | |
| Side of square cross section | (cm) | | Coolant temperature(ave., °C) (inlet, °C) (outlet, °C) | | |
| Total length | (cm) | | | | |
| UO_2 weight | (kg) | | | | |
| Initial enrichment | (%) | | | | |
| Channel material | 1.45/1.87/ 2.14/2.87 | | | | |
| Channel mat. thickness | (cm) | Zircaloy-4 | | | |

Table 3.6-2 Monticello Extended Burnup Program Fuel Bundle and Rod Design

| | |
|-----------------------|---------------------------------|
| Bundle Lattice | 8 × 8 |
| No. of Fuel Rods | 63 |
| No. of Water Rods | 1 |
| Active Fuel Length | 144.0 in. |
| Plenum Length | 11.24 in. |
| Fuel Pellet Form | Flat Ended with Chamfered Edges |
| Fuel Pellet Diameter | 0.416 in. |
| Tube Outside Diameter | 0.493 in. |
| Tube Wall Thickness | 0.034 in. |
| Nominal Diameter Gap | 0.009 in. |
| Fuel Enrichment (%) | 1.45-2.87 wt % U-235 |

| <u>Number of Rods</u> | <u>Enrichment %</u> |
|-----------------------|---------------------|
| 1 | 1.45 |
| 4 | 1.87 |
| 14 | 2.14 |
| 44 | 2.87 |

| | |
|---|------|
| Average Fuel Enrichment | 2.62 |
| Number of Gadolinia Rods | 4 |
| Percentage of Gadolinia | 1.5 |
| (Gd ₂ O ₃) in Rods | |

Table 3.6-3 Burnup History of the Full Term Extended Burnup Bundles

| Cycle No. | Bundle Average Burnup, MWd/MTU | | | | | | | |
|----------------------|--------------------------------|-------|--------|-------|--------|-------|--------|-------|
| | MTB028 | | MTB048 | | MTB084 | | MTB099 | |
| | Incre- | Cumu- | Inc. | Cum. | Inc. | Cum. | Inc. | Cum. |
| BOC 3 May 21, 1974 | | | | | | | | |
| EOC 3 Jan. 9, 1975 | 4010 | 4010 | 3900 | 3900 | 4010 | 4010 | 3900 | 3900 |
| BOC 4 Feb. 7, 1975 | | | | | | | | |
| EOC 4 Sept. 11, 1975 | 4180 | 8190 | 3940 | 7840 | 4260 | 8270 | 3950 | 7850 |
| BOC 5 Nov. 19, 1975 | | | | | | | | |
| EOC 5 Sept. 9, 1977 | 6530 | 14720 | 12700 | 20540 | 6520 | 14790 | 12690 | 20540 |
| BOC 6 Nov. 10, 1977 | | | | | | | | |
| EOC 6 Oct. 13, 1978 | 6440 | 21160 | 5520 | 26060 | 6450 | 21240 | 5520 | 26060 |
| BOC 7 Nov. 16, 1978 | | | | | | | | |
| EOC 7 Feb. 22, 1980 | 8780 | 29940 | 7730 | 33790 | 8760 | 30000 | 7740 | 33800 |
| BOC 8 Mar. 18, 1980 | | | | | | | | |
| EOC 8 Apr. 20, 1981 | 6030 | 35970 | 5830 | 39620 | 6030 | 36030 | 5830 | 39630 |
| BOC 9 May 12, 1981 | | | | | | | | |
| EOC 9 Sept. 1, 1982 | 6260 | 42230 | 6020 | 45640 | 6250 | 42280 | 6000 | 45630 |

BOC = Beginning of Cycle

EOC = End of Cycle

Table 3.6-4 Design and Exposure Data for Six Monticello High
Exposure Fuel Rods

| Rod No. | Serial Number | Cladding | | UO ₂ (2) Aver. (w/o) | Exposure Peak (GWd/MTU) | Time at Power (Days) | | | |
|------------|------------------|-----------------|----------------------|--|-------------------------------|-------------------------------|-----------------------|-----|------|
| | | OD. (Inches) | and Wall (Inches) | | | Enrich. (w/o) | Cycles at Power | | |
| A1 | BNA-0208 | 0.493 | \times 0.034 | 1 | 1.45 | 50.4 | 57.3 | 3-9 | 2650 |
| B1 | BNB-0454 | 0.493 | \times 0.034 | 1 | 1.87 | 49.8 | 54.6 | 3-9 | 2650 |
| F6 | BND-1966 | 0.493 | \times 0.034 | 1 | 2.87 | 41.4 | 48.2 | 3-9 | 2650 |
| G3 (1) | BNH-0571 | 0.493 | \times 0.034 | 1 | 2.87 | 43.4 | 51.7 | 3-9 | 2650 |
| H1 | BNB-0407 | 0.493 | \times 0.034 | 1 | 1.87 | 49.8 | 58.7 | 3-9 | 2650 |
| H8 | BNC-0976 | 0.493 | \times 0.034 | 1 | 2.14 | 46.9 | 53.9 | 3-9 | 2650 |

(1) 1.5 w/o Gd₂O₃ additive.

(2) Original pellet O.D. 0.416-inch, with 0.009-inch diametral pellet gap.

Table 3.6-5 Burnup Summary

| Rod - Section | Sample Location* | Burnup (Nd) (GWd/MTU) |
|---------------|------------------|--------------------------|
| A1 - S1 | 23.75 - 24.25 | 48.0 |
| | - S2 | 55.0 |
| | - S3 | 55.7 |
| | - S4 | <u>57.3</u> |
| | - S5 | 46.4 |
| B1 - S1 | 23.75 - 24.25 | 43.8 |
| | - S2 | 52.6 |
| | - S3 | 50.0 |
| | - S4 | <u>54.6</u> |
| | - S5 | 45.1 |
| F6 - S1 | 23.75 - 24.25 | 44.4 |
| | - S2 | <u>48.2</u> |
| | - S3 | 47.0 |
| | - S4 | 44.1 |
| | - S5 | 32.7 |
| G3 - S1 | 23.75 - 24.25 | 47.3 |
| | - S2 | <u>51.7</u> |
| | - S3 | 50.0 |
| | - S4 | 47.8 |
| | - S5 | 38.5 |
| H1 - S1 | 23.75 - 24.25 | 51.0 |
| | - S2 | 57.2 |
| | - S3 | <u>58.7</u> |
| | - S4 | 57.7 |
| | - S5 | 46.7 |
| H8 - S1 | 23.75 - 24.25 | 49.4 |
| | - S2 | <u>53.8</u> |
| | - S3 | 52.5 |
| | - S4 | 51.1 |
| | - S5 | 40.3 |

* Inches above bottom end plug tip.

Table 3.6-6 Curium-242 Results Summary

| Rod - Section | Atoms $^{242}\text{Cm}/\text{mgU}^*$ |
|---------------|--------------------------------------|
| A1 - S1 | 4.4×10^{13} |
| - S2 | 5.2 |
| - S4 | <u>6.3</u> |
| - S5 | 6.0 |
| B1 - S1 | 3.8×10^{13} |
| - S2 | 4.8 |
| - S3 | 5.9 |
| - S4 | <u>6.5</u> |
| - S5 | 6.2 |
| - S5 | 5.9 (Replicate) |
| F6 - S1 | 4.8×10^{13} |
| - S2 | 5.8 |
| - S3 | 6.9 |
| - S4 | <u>7.6</u> |
| - S5 | 5.4 |
| G3 - S1 | 4.5×10^{13} |
| - S2 | 5.1 |
| - S3 | 6.5 |
| - S4 | <u>7.1</u> |
| - S5 | 5.8 |
| H1 - S1 | 4.5×10^{13} |
| - S2 | 5.1 |
| - S2 | 5.4 (Replicate) |
| - S3 | 6.2 |
| - S4 | <u>7.2</u> |
| - S5 | 6.7 |
| H8 - S1 | 4.7×10^{13} |
| - S2 | 5.9 |
| - S3 | 7.3 |
| - S4 | <u>8.3</u> |
| - S5 | 7.2 |

* Corrected to discharge date, 9/2/82.

Table 3.6-7 Burnup Sample Isotopic Abundances (1/3)

| SAMPLE | A1-S1 | A1-S2 | A1-S3 | A1-S4 | A1-S5 |
|----------------------|-------------|-------------|-------------|-------------|-------------|
| ATM PCT U-234 | 0.32483E-02 | 0.26669E-02 | 0.30029E-02 | 0.30067E-02 | 0.39336E-02 |
| ATM PCT U-235 | 0.70607E-02 | 0.47686E-02 | 0.72730E-02 | 0.85586E-02 | 0.20125E-01 |
| ATM PCT U-236 | 0.16261E 00 | 0.18435E 00 | 0.20044E 00 | 0.19847E 00 | 0.17487E 00 |
| ATM PCT U-238 | 0.99827E 02 | 0.99808E 02 | 0.99789E 02 | 0.99790E 02 | 0.99801E 02 |
| ATM PCT PU-239 | 0.30405E 02 | 0.29758E 02 | 0.31204E 02 | 0.32473E 02 | 0.36068E 02 |
| ATM PCT PU-240 | 0.29613E 02 | 0.29692E 02 | 0.30170E 02 | 0.30050E 02 | 0.29572E 02 |
| ATM PCT PU-241 | 0.98027E 01 | 0.99555E 01 | 0.10673E 02 | 0.11342E 02 | 0.11974E 02 |
| ATM PCT PU-242 | 0.30179E 02 | 0.30595E 02 | 0.27953E 02 | 0.26134E 02 | 0.22386E 02 |
| PU239/U238 AT. RATIO | 0.29464E-02 | 0.30094E-02 | 0.32180E-02 | 0.34511E-02 | 0.37218E-02 |
| NVT EXPOSURE | 0.87871E 22 | 0.95717E 22 | 0.87028E 22 | 0.83928E 22 | 0.88911E 22 |
| ATM PCT FISS(ND-148) | 0.48504E 01 | 0.56292E 01 | 0.57161E 01 | 0.58918E 01 | 0.46895E 01 |
| ATM PCT FISS(AVG) | 0.49125E 01 | 0.56286E 01 | 0.56956E 01 | 0.58664E 01 | 0.46323E 01 |
| MWD/MT (BY ND) | 0.47975E 05 | 0.54998E 05 | 0.55651E 05 | 0.57320E 05 | 0.46360E 05 |
| SAMPLE | B1-S1 | B1-S2 | B1-S3 | B1-S4 | B1-S5 |
| ATM PCT U-234 | 0.51617E-02 | 0.43542E-02 | 0.46297E-02 | 0.48908E-02 | 0.72855E-02 |
| ATM PCT U-235 | 0.28208E-01 | 0.17189E-01 | 0.23493E-01 | 0.22412E-01 | 0.64406E-01 |
| ATM PCT U-236 | 0.28160E 00 | 0.25766E 00 | 0.27604E 00 | 0.22002E 00 | 0.26960E 00 |
| ATM PCT U-238 | 0.99685E 02 | 0.99721E 02 | 0.99696E 02 | 0.99753E 02 | 0.99659E 02 |
| ATM PCT PU-239 | 0.33194E 02 | 0.32259E 02 | 0.33301E 02 | 0.34658E 02 | 0.39593E 02 |
| ATM PCT PU-240 | 0.31172E 02 | 0.31380E 02 | 0.31197E 02 | 0.31319E 02 | 0.30690E 02 |
| ATM PCT PU-241 | 0.10577E 02 | 0.10518E 02 | 0.11272E 02 | 0.11698E 02 | 0.12558E 02 |
| ATM PCT PU-242 | 0.25057E 02 | 0.25843E 02 | 0.24230E 02 | 0.22325E 02 | 0.17160E 02 |
| PU239/U238 AT. RATIO | 0.30135E-02 | 0.31658E-02 | 0.32358E-02 | 0.36871E-02 | 0.39737E-02 |
| NVT EXPOSURE | 0.68650E 22 | 0.77238E 22 | 0.71669E 22 | 0.72504E 22 | 0.54853E 22 |
| ATM PCT FISS(ND-148) | 0.44387E 01 | 0.53741E-01 | 0.51451E 01 | 0.56090E 01 | 0.46165E 01 |
| ATM PCT FISS(AVG) | 0.44954E 01 | 0.53945E 01 | 0.51331E 01 | 0.56000E 01 | 0.46378E 01 |
| MWD/MT (BY ND) | 0.43801E 01 | 0.52584E 05 | 0.50019E 05 | 0.54578E 05 | 0.45142E 05 |

Table 3.6-7 Burnup Sample Isotopic Abundances (2/3)

| SAMPLE | F6-S1 | F6-S2 | F6-S3 | F6-S4 | F6-S5 |
|----------------------|-------------|-------------|-------------|-------------|-------------|
| ATM PCT U-234 | 0.10710E-01 | 0.98443E-02 | 0.10677E-01 | 0.11016E-01 | 0.12540E-01 |
| ATM PCT U-235 | 0.22243E 00 | 0.22252E 00 | 0.33524E 00 | 0.45882E 00 | 0.73125E 00 |
| ATM PCT U-236 | 0.45043E 00 | 0.45089E 00 | 0.45498E 00 | 0.45218E 00 | 0.42230E 00 |
| ATM PCT U-238 | 0.99316E 02 | 0.99317E 02 | 0.99199E 02 | 0.99078E 02 | 0.99834E 02 |
| ATM PCT PU-239 | 0.43998E 02 | 0.44555E 02 | 0.48728E 02 | 0.52660E 02 | 0.57802E 02 |
| ATM PCT PU-240 | 0.31213E 02 | 0.30356E 02 | 0.28079E 02 | 0.26502E 02 | 0.24765E 02 |
| ATM PCT PU-241 | 0.13092E 02 | 0.13636E 02 | 0.14172E 02 | 0.13907E 02 | 0.12700E 02 |
| ATM PCT PU-242 | 0.11698E 02 | 0.11454E 02 | 0.90205E 01 | 0.69306E 01 | 0.47334E 01 |
| PU239/U238 AT. RATIO | 0.41172E-02 | 0.47709E-02 | 0.59378E-02 | 0.70269E-02 | 0.64070E-02 |
| NVT EXPOSURE | 0.39080E 22 | 0.39115E 22 | 0.32919E 22 | 0.28194E 22 | 0.21118E 22 |
| ATM PCT FISS(ND-148) | 0.45536E 01 | 0.49865E 01 | 0.48518E 01 | 0.45539E 01 | 0.33946E 01 |
| ATM PCT FISS(AVG) | 0.45727E 01 | 0.49665E 01 | 0.48375E 01 | 0.45412E 01 | 0.33723E 01 |
| MWD/MT (BY ND) | 0.44395E 05 | 0.48238E 05 | 0.46975E 05 | 0.44083E 05 | 0.32687E 05 |
| SAMPLE | G3-S1 | G3-S2 | G3-S3 | G3-S4 | G3-S5 |
| ATM PCT U-234 | 0.11240E-01 | 0.10370E-01 | 0.10761E-01 | 0.98957E-02 | 0.12168E-01 |
| ATM PCT U-235 | 0.16202E 00 | 0.14605E 00 | 0.21146E 00 | 0.30877E 00 | 0.49244E 00 |
| ATM PCT U-236 | 0.40814E 00 | 0.38746E 00 | 0.37660E 00 | 0.41437E 00 | 0.37632E 00 |
| ATM PCT U-238 | 0.99419E 02 | 0.99456E 02 | 0.99401E 02 | 0.99267E 02 | 0.99119E 02 |
| ATM PCT PU-239 | 0.41456E 02 | 0.42082E 02 | 0.45452E 02 | 0.48300E 02 | 0.52985E 02 |
| ATM PCT PU-240 | 0.31398E 02 | 0.30979E 02 | 0.29817E 02 | 0.29078E 02 | 0.27438E 02 |
| ATM PCT PU-241 | 0.12728E 02 | 0.13217E 02 | 0.13798E 02 | 0.13742E 02 | 0.13172E 02 |
| ATM PCT PU-242 | 0.14418E 02 | 0.13721E 02 | 0.10933E 02 | 0.88799E 01 | 0.64043E 01 |
| PU239/U238 AT. RATIO | 0.39144E-02 | 0.44058E-02 | 0.52325E-02 | 0.60207E-02 | 0.60598E-02 |
| NVT EXPOSURE | 0.45731E 22 | 0.47443E 22 | 0.41556E 22 | 0.35585E 22 | 0.28191E 22 |
| ATM PCT FISS(ND-148) | 0.48383E 01 | 0.53214E 01 | 0.51681E 01 | 0.49515E 01 | 0.40025E 01 |
| ATM PCT FISS(AVG) | 0.48787E 01 | 0.53321E 01 | 0.51599E 01 | 0.49322E 01 | 0.39838E 01 |
| MWD/MT (BY ND) | 0.47342E 05 | 0.51691E 05 | 0.49987E 05 | 0.47761E 05 | 0.38529E 05 |

Table 3.6-7 Burunp Sample Isotopic Abundances (3/3)

| SAMPLE | H1-S1 | H1-S2 | H1-S3 | H1-S4 | H1-S5 |
|----------------------|-------------|-------------|-------------|-------------|-------------|
| ATM PCT U-234 | 0.48414E-02 | 0.40009E-02 | 0.47155E-02 | 0.45287E-02 | 0.58884E-02 |
| ATM PCT U-235 | 0.14048E-01 | 0.10793E-01 | 0.20418E-01 | 0.30195E-01 | 0.74633E-01 |
| ATM PCT U-236 | 0.25965E 00 | 0.24024E 00 | 0.26537E 00 | 0.26586E 00 | 0.25777E 00 |
| ATM PCT U-238 | 0.99721E 02 | 0.99745E 02 | 0.99709E 02 | 0.99699E 02 | 0.99662E 02 |
| ATM PCT PU-239 | 0.32900E 02 | 0.33585E 02 | 0.36677E 02 | 0.38777E 02 | 0.42431E 02 |
| ATM PCT PU-240 | 0.29189E 02 | 0.28546E 02 | 0.28806E 02 | 0.28720E 02 | 0.29012E 02 |
| ATM PCT PU-241 | 0.10653E 02 | 0.11084E 02 | 0.12355E 02 | 0.13112E 02 | 0.13636E 02 |
| ATM PCT PU-242 | 0.27258E 02 | 0.26785E 02 | 0.22162E 02 | 0.19391E 02 | 0.14922E 02 |
| PU239/U238 AT. RATIO | 0.32734E-02 | 0.35105E-02 | 0.40273E-02 | 0.44144E-02 | 0.45937E-02 |
| NVT EXPOSURE | 0.77710E 22 | 0.82657E 22 | 0.67916E 22 | 0.65047E 22 | 0.50400E 22 |
| ATM PCT FISS(ND-148) | 0.50816E 01 | 0.58808E 01 | 0.59384E 01 | 0.58457E 01 | 0.47518E 01 |
| ATM PCT FISS(AVG) | 0.52080E 01 | 0.58672E 01 | 0.60120E 01 | 0.59145E 01 | 0.47895E 01 |
| MWD/MT (BY ND) | 0.50985E 05 | 0.57180E 05 | 0.58681E 05 | 0.57715E 05 | 0.46650E 05 |
| SAMPLE | H8-S1 | H8-S2 | H8-S3 | H8-S4 | H8-S5 |
| ATM PCT U-234 | 0.66615E-02 | 0.62601E-02 | 0.63171E-02 | 0.68187E-02 | 0.83965E-02 |
| ATM PCT U-235 | 0.34213E-01 | 0.40845E-01 | 0.73881E-01 | 0.11846E 00 | 0.24359E 00 |
| ATM PCT U-236 | 0.28819E 00 | 0.31353E 00 | 0.32190E 00 | 0.32694E 00 | 0.32568E 00 |
| ATM PCT U-238 | 0.99673E 02 | 0.99639E 02 | 0.99598E 02 | 0.99548E 02 | 0.99422E 02 |
| ATM PCT PU-239 | 0.30568E 02 | 0.39137E 02 | 0.43271E 02 | 0.45729E 02 | 0.48786E 02 |
| ATM PCT PU-240 | 0.28968E 02 | 0.28257E 02 | 0.27736E 02 | 0.26677E 02 | 0.26759E 02 |
| ATM PCT PU-241 | 0.11811E 02 | 0.12997E 02 | 0.14258E 02 | 0.14843E 02 | 0.14751E 02 |
| ATM PCT PU-242 | 0.22653E 02 | 0.19609E 02 | 0.14735E 02 | 0.12751E 02 | 0.97040E 01 |
| PU239/U238 AT. RATIO | 0.35764E-02 | 0.42010E-02 | 0.50162E-02 | 0.57940E-02 | 0.56484E-02 |
| NVT EXPOSURE | 0.68225E 22 | 0.65109E 22 | 0.55040E 22 | 0.47288E 22 | 0.35544E 22 |
| ATM PCT FISS(ND-148) | 0.49802E 01 | 0.54860E 01 | 0.53766E 01 | 0.52306E 01 | 0.41422E 01 |
| ATM PCT FISS(AVG) | 0.50651E 01 | 0.55154E 01 | 0.53909E 01 | 0.52434E 01 | 0.41386E 01 |
| MWD/MT (BY ND) | 0.49385E 05 | 0.53783E 05 | 0.52527E 05 | 0.51090E 05 | 0.40286E 05 |

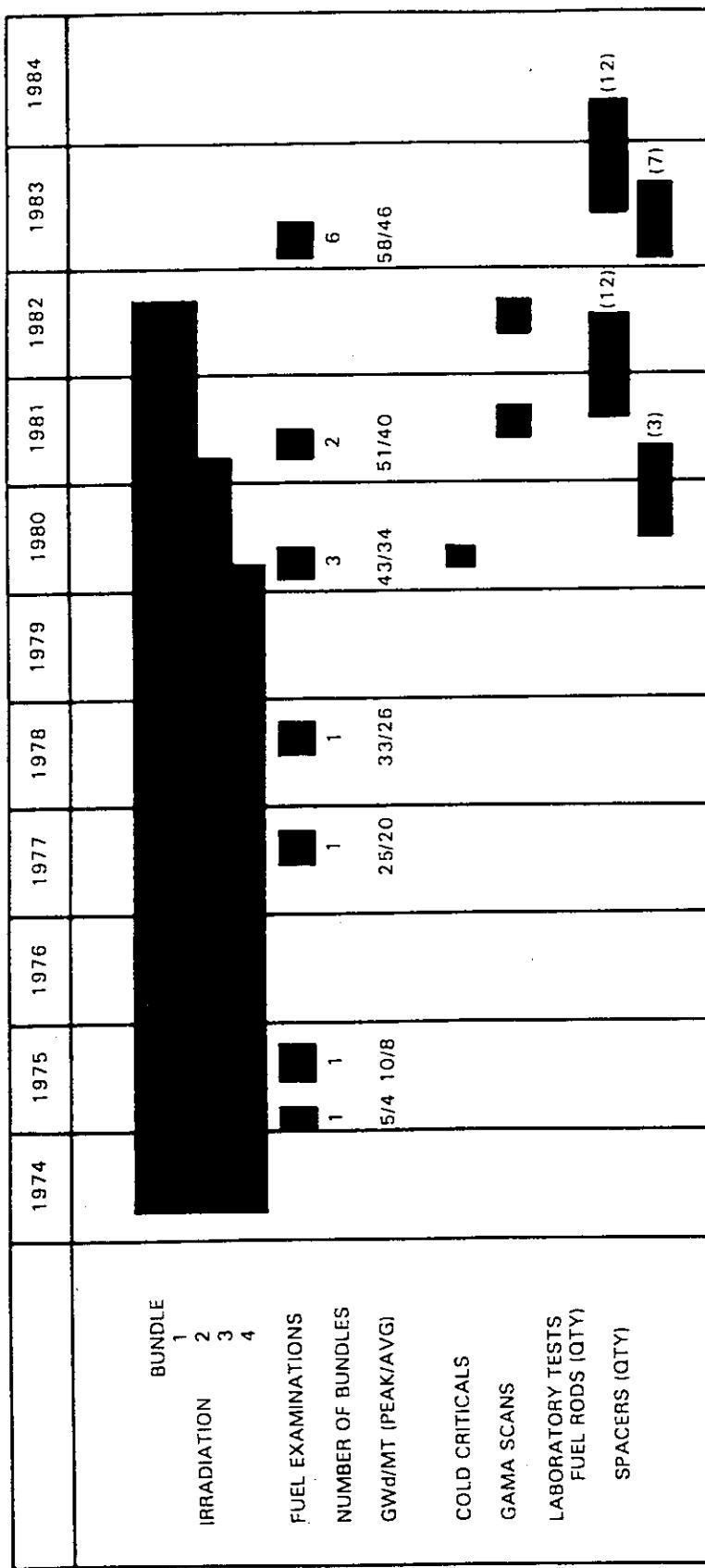
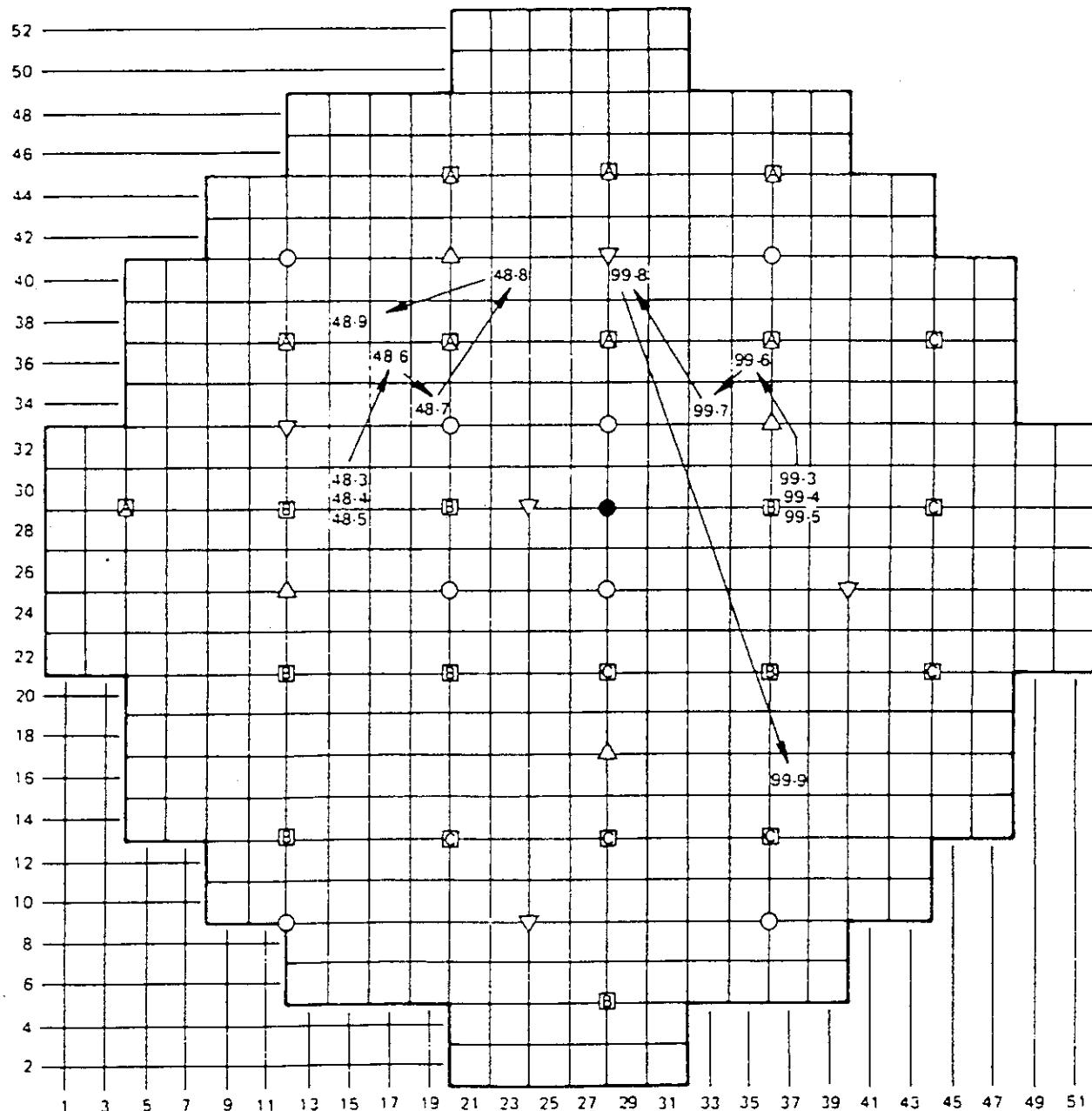


Fig. 3.6-1 Monticello extended burnup program schedule of work performed



- LOCAL POWER RANGE MONITOR (LPRM) LOCATION
[LETTER INDICATES TRAVERSING IN-CORE PROBE
(TIP) MACHINE]
- LPRM LOCATION (COMMON LOCATION FOR ALL
TIP MACHINES)
- INTERMEDIATE RANGE MONITOR (IRM) LOCATIONS
- △ SOURCE RANGE MONITOR (SRM) LOCATION
- ▽ SOURCE LOCATIONS

| BUNDLE S/N | LEGEND ON MAP |
|------------|------------------------|
| MTB048 | 48-3, 4, 5, 6, 7, 8, 9 |
| MTB099 | 99-3, 4, 5, 6, 7, 8, 9 |

Fig. 3.6-2 Monticello core map showing locations of MTB048 and MTB099 during each reactor cycle of operation

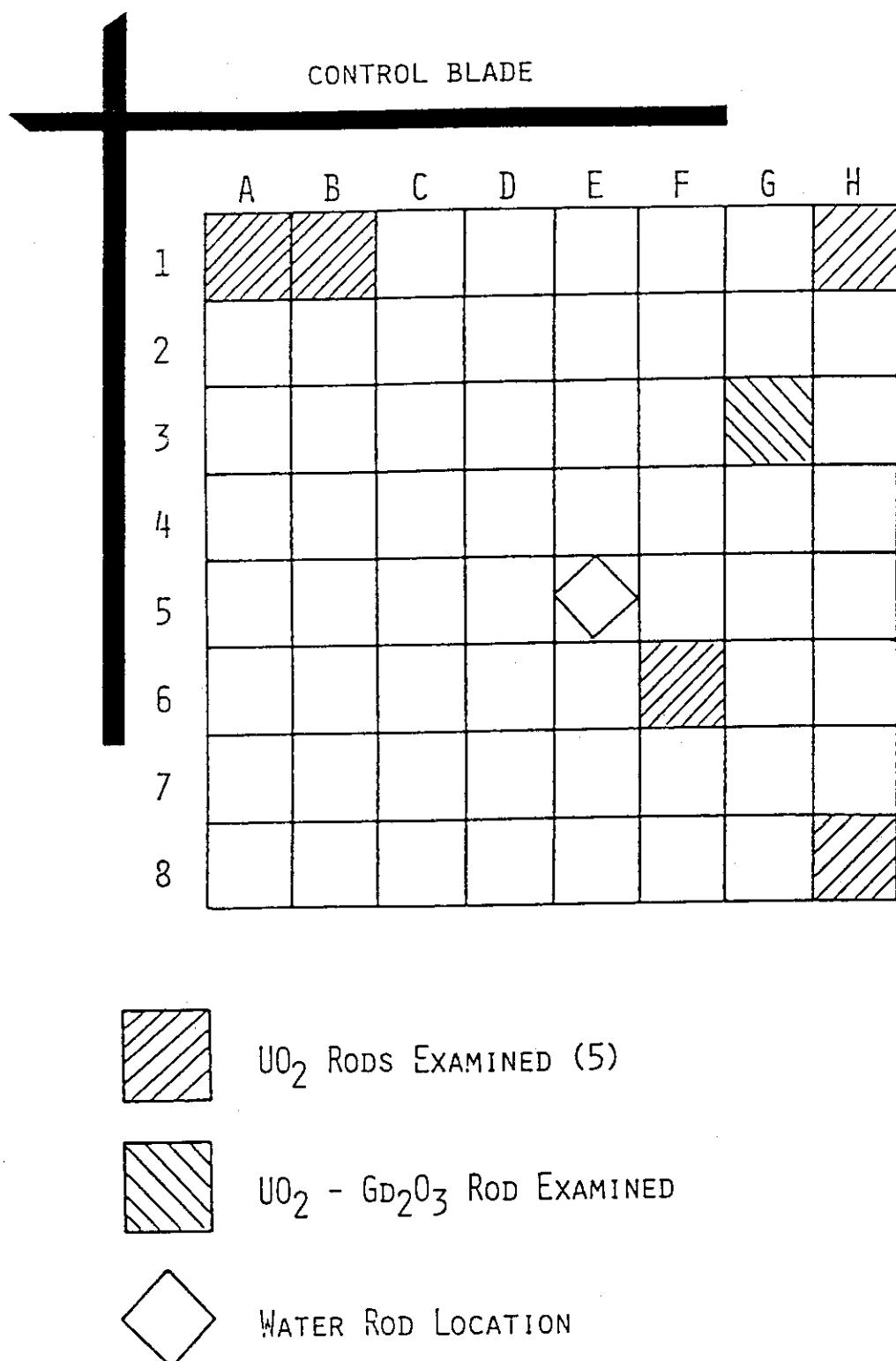


Fig. 3.6-3 Bundle locations of six Monticello fuel rods examined
(Bundle MTB099)

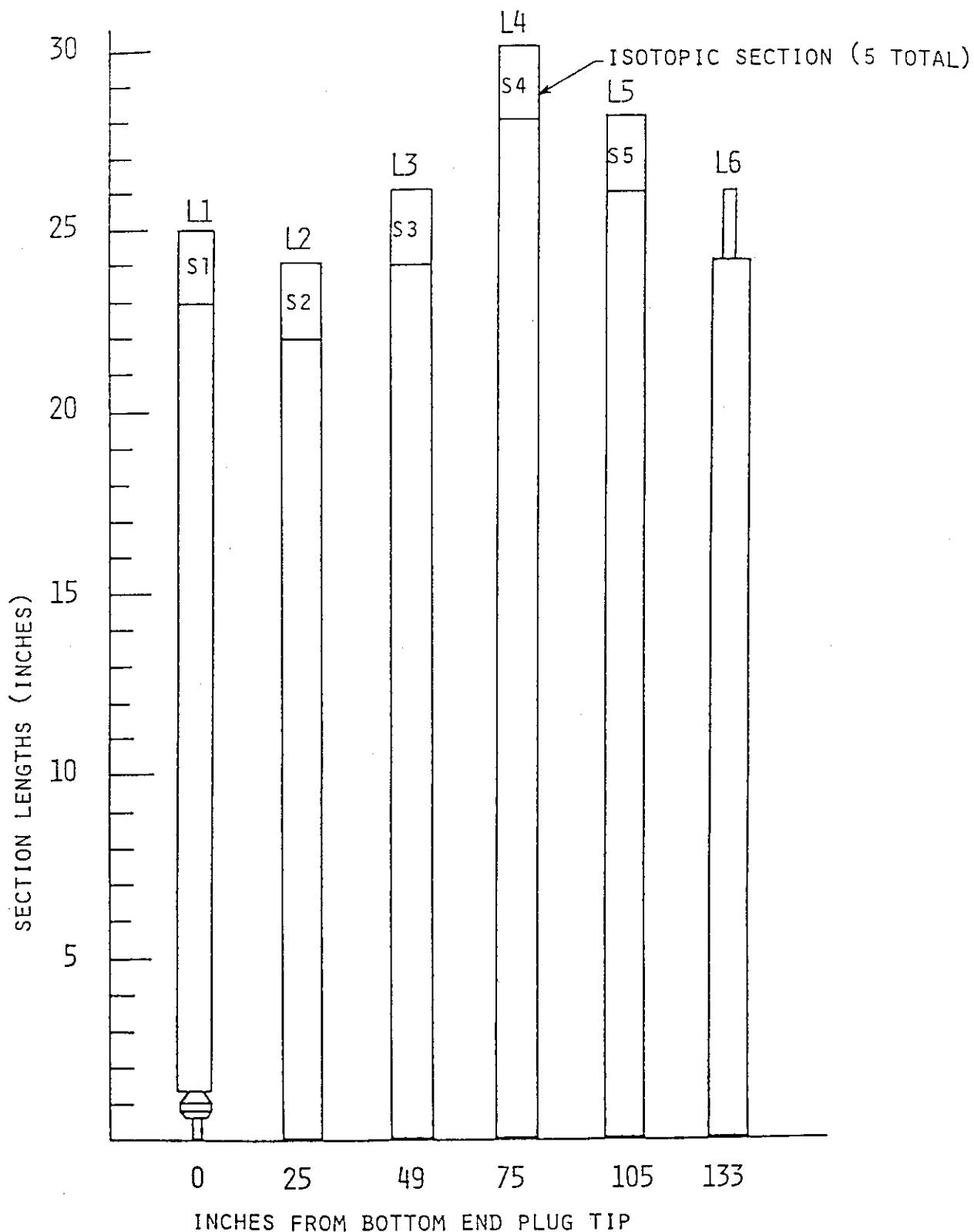


Fig. 3.6-4 Axial locations of cut sections (Battelle)

3.7 美浜3号炉及び玄海1号炉(PWR)

日本でも原子力発電所における燃料の高燃焼度化の検討が進められるなかで、高燃焼度燃料の溶解試験に関する定量的データを得るために、美浜3号炉及び玄海1号炉（PWR）の使用済燃料の溶解試験が実施された。集合体平均燃焼度8,400～36,100MWd/tのPWR使用済燃料10試料が試験された。

なお、本節に使用した図表は下記の文献から転載したものである。

- 10) 科学部溶解試験グループ：「使用済燃料の溶解試験」，JAERI-M 91-010, (1991)
- 16) 火力原子力発電技術協会：「原子力発電所運転管理年報（平成4年版）」
- 17) Y. Nakahara et al., : "Amount of Nuclides Constituting PWR Spent Fuels:Comparison of Observed with Calculated Values", Radiochim. Acta, 50, 141(1990)

3.7.1 炉心構成と炉心性能

美浜3号炉心および玄海1号炉の炉心構成と炉心性能をTable 3.7-1に示す。

また、両炉の運転履歴をそれぞれFig. 3.7-1, Fig. 3.7-2に示す。

3.7.2 燃料履歴とサンプリング燃料配置

Table 3.7-2に使用済燃料サンプルの照射履歴、サンプルペレットの質量および初期濃縮度等について示す。試験No. pre-setからNo. 8までの9試料は美浜3号炉の試料で残りの2試料が玄海1号炉のものである。Table 3.7-3にサンプル燃料の初期組成、Table 3.7-4にサンプルの照射履歴を示す。なお、Table 3.7-2の値は公称値である。

3.7.3 核種組成データ

11試料全てについて、燃焼度及びU, Pu, Ndの同位体、希ガスKr, Xeの同位体、Am, Cm同位体及びFPの量が測定された。各核種の量が試料中のU量に対する比としてTable 3.7-5に示されている。これには、各サンプル燃料の初期条件（初期U同位体比）も与えられている。また、初期U量に対する各核種の量の比をTable 3.7-6に示す。なお、これらのTableの項目の説明をTable 3.7-7に示す。

Table 3.7-1 Core Composition and Performance

| Reactor Name | Mihama-3 | Genkai-3 | Reactor Name | PWR-A | PWR-B |
|---------------------------------------|----------------------|----------|---|--------|--------|
| Fuel Pellet | | | Control Rod Absorbing material | | |
| UO ₂ density | (g/cm ³) | 95%T.D | | | |
| Linear density | (g/cm) | 0.929 | | | |
| Diameter | (cm) | 0.929 | | | |
| Length of pellet stack in fuel rod | (cm) | 366 | Core | 304 | 246 |
| Clad-pellet clearance | (cm) | 0.019 | Equivalent diameter (cm) | 366 | 366 |
| Fuel Clad | | | Active height (cm) | 157 | |
| Outside diameter | (cm) | 1.072 | No. of square assemblies | | |
| Inside diameter | (cm) | | No. of control rods | | |
| Wall thickness | (cm) | 0.0617 | UO ₂ in square assemblies(kg) | 506 | |
| Material | Zircaloy-4 | 0.062 | Total UO ₂ weight (kg) | 506 | |
| Square Fuel Assembly | Zircaloy-4 | | Total U weight (kg) | 70,000 | 48,000 |
| Rod array | 15 × 15 | 14 × 14 | | | |
| Number of rods | 204 | 179 | Core Thermo-hydraulic Characteristics | | |
| Fuel rod pitch | (cm) | 1.43 | Power (MWth) | 2,440 | 1,650 |
| Side of square cross section | (cm) | 21.4 | (MW _e) | 826 | 559 |
| Total length | (cm) | 406 | Coolant pressure (kg/cm ²) | 157 | 157 |
| UO ₂ weight | (kg) | 3.24 | Coolant temperature (ave., °C) (inlet, °C) | 287 | 288 |
| Initial enrichment | (%) | 3.42 | (outlet, °C) | 322 | 323 |

Table 3.7-2 Test Samples for Distribution Experiments of Spent Fuel

| Experiment No. Sample No. | Pre-test 86B02 | No.1 86B03 | No.2 86G05 | No.3 86G03 | No.4 86G07 |
|--|---|--|--|---|---|
| Date of experiment | 12.3.1986 | 24.6.1986 | 20.9.1986 | 13.1.1986 | 17.2.1987 |
| Irradiation history | 1.1978 ~ 9.1978 | 1.1978 ~ 9.1978 | 1.1978 ~ 9.1980 | 1.1978 ~ 9.1980 | 1.1978 ~ 9.1980 |
| Type of assembly | PWR 15×15 | PWR 15×15 | PWR 15×15 | PWR 15×15 | PWR 15×15 |
| Average assembly burnup (MWd/t) | 8400 | 8400 | 17600 | 17600 | 17600 |
| Initial U enrichment (wt%) | 3.24 | 3.24 | 3.24 | 3.24 | 3.24 |
| Weight of pellet (g) | 3.082 | 3.069 | 3.748 | 3.345 | 3.570 |
| Weight of hull (g) | 0.608 | 0.615 | 0.717 | 0.623 | 0.683 |
| State of sample | Pellet is out of cladding with 3-4 par- ticles and powder | Pellet is out of cladding with 3-4 par- ticles and powder | Pellet is al- most in clad- ding except for a slight amount of powder | Pellet is out of cladding with 10 parti- cles(Φ 2-3mm) and powder | Pellet is al- most in clad- ding no powder is seen |
| No.5 87C03 | No.6 87C04 | No.7 87C07 | No.8 87C08 | No.9 87H01 | No.10 87H05 |
| 17.6.1987 | 8.9.1987 | 22.9.1987 | 17.11.1987 | 26.1.1988 | 24.5.1988 |
| 1.1978 ~ 3.1982 | 1.1978 ~ 3.1982 | 1.1978 ~ 3.1982 | 1.1978 ~ 3.1982 | 2.1975 ~ 2.1979 | 2.1975 ~ 2.1979 |
| PWR 15×15 | PWR 15×15 | PWR 15×15 | PWR 15×15 | PWR 14×14 | PWR 14×14 |
| 31400 | 31400 | 31400 | 31400 | 36100 | 36100 |
| 3.24 | 3.24 | 3.24 | 3.24 | 3.42 | 3.42 |
| 2.330 | 2.259 | 2.163 | 2.391 | 2.287 | 2.175 |
| 0.432 | 0.420 | 0.396 | 0.440 | 0.421 | 0.412 |
| Pellet is out of cladding with 10 parti- cles(Φ 5 mm) and powder | Pellet is out of cladding with 10 parti- cles(Φ 3-4mm) and powder | Pellet is out of cladding with several particles(Φ 3mm and powder | Pellet is out of cladding with 10 parti- cles(Φ 2-3mm) and powder | Part of pellet is in cladding with several particles(3mm) and powder are out | Pellet is in cladding with trace of powder is out |

Table 3.7-3 Initial Fuel Compositions of the Samples

| Experiment No. | Fuel composition (10.2 gUO ₂ /cc) | |
|--------------------|--|-------------------------|
| | Number density ($\times 10^{24}$ /cc) | Weight percent (w/o) |
| Pre-test No.1 | U-235: 7.3910E-04 | U-235: 3.208 |
| | U-238: 2.2008E-02 | U-238: 96.742 |
| | U-234: 6.5943E-06 | U-234: 0.0285 |
| | U-236: 4.7719E-06 | U-236: 0.0208 |
| | O : 4.5517E-02 | |
| No.2 | U-235: 7.3792E-04 | U-235: 3.203 |
| | U-238: 2.2010E-02 | U-238: 96.757 |
| | U-234: 6.5940E-06 | U-234: 0.0285 |
| | U-236: 2.5006E-06 | U-236: 0.0109 |
| | O : 4.5515E-02 | |
| No.3 to No.8 | U-235: 7.3957E-04 | U-235: 3.21 |
| | U-238: 2.2005E-02 | U-238: 96.727 |
| | U-234: 6.8257E-06 | U-234: 0.0295 |
| | U-236: 7.5020E-06 | U-236: 0.0327 |
| | O : 4.5518E-02 | |

Table 3.7-4 Burnup Values and Irradiation Histories of the Samples

| Experiment No. | Burnup (MWd/MTU) | Irradiation time(days) accumulated | Power | |
|----------------|---------------------|---|--|---|
| | | | MW/MTU ^a | MW/cell ^b |
| No.1 | 6,900 | 215 | 32.20 | 1.5891E-04 |
| Pre-test | 8,300 | 215 | 38.61 | 1.9052E-04 |
| No.4 | 14,600 | 215 603 760 769 939 | 22.0 0.0 30.37 0.0 30.37 | 1.0856E-04 0.0 1.4987E-04 0.0 1.4987E-04 |
| No.2 | 15,300 | 215 603 760 769 939 | 22.99 0.0 31.87 0.0 31.87 | 1.1343E-04 0.0 1.5727E-04 0.0 1.5727E-04 |
| No.3 | 21,200 | 215 603 760 769 939 | 31.95 0.0 44.10 0.0 44.10 | 1.5766E-04 0.0 2.1762E-04 0.0 2.1762E-04 |
| No.5 | 29,400 | 215 603 760 769 939 1115 1467 1495 | 24.61 0.0 34.92 0.0 34.92 0.0 34.15 27.47 | 1.2144E-04 0.0 1.7232E-04 0.0 1.7232E-04 0.0 1.6852E-04 1.3556E-04 |
| No.6 | 32,100 | 215 603 760 769 939 1115 1467 1495 | 26.87 0.0 38.12 0.0 38.12 0.0 37.25 30.35 | 1.3260E-04 0.0 1.8811E-04 0.0 1.8811E-04 0.0 1.8382E-04 1.4977E-04 |
| No.7 | 33,600 | 215 603 760 769 939 1115 1467 1495 | 28.13 0.0 39.91 0.0 39.91 0.0 38.99 31.77 | 1.3881E-04 0.0 1.9694E-04 0.0 1.9694E-04 0.0 1.9241E-04 1.5678E-04 |
| No.8 | 34,200 | 215 603 760 769 939 1115 1467 1495 | 28.65 0.0 40.62 0.0 40.62 0.0 39.72 31.85 | 1.4138E-04 0.0 2.0042E-04 0.0 2.0042E-04 0.0 1.9599E-04 1.5718E-04 |

^a Input data for ORIGEN2.^b Input data for SRAC-FPGS.

Table 3.7-5 Measured Data Based on the Mounts of Uranium after Irradiation

| | | | | | | | | | |
|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| 86B02 00271 | 86B03 00272 | 86G05 00273 | 86G03 00274 | 86G07 00275 | 87C03 00276 | 87C04 00277 | 87C08 00279 | 87H01 00280 | 87H05 00281 |
| BURNUP_ZETIMA | 8.600E-01 | 7.210E-01 | 1.590E+00 | 2.204E+00 | 1.518E+00 | 3.067E+00 | 3.341E+00 | 3.497E+00 | 3.557E+00 |
| BURNUP_MDD/T | 8.300E+03 | 6.900E+03 | 1.530E+04 | 2.1120E+04 | 1.460E+04 | 2.944E+04 | 3.230E+04 | 3.370E+04 | 3.410E+04 |
| INIT.U-234 % | 2.900E-02 | 2.900E-02 | 2.900E-02 | 2.900E-02 | 2.900E-02 | 3.000E-02 | 3.000E-02 | 2.994E-02 | 2.948E-02 |
| INIT.U-235 % | 3.248E+00 | 3.248E+00 | 3.243E+00 | 3.243E+00 | 3.243E+00 | 3.250E+00 | 3.250E+00 | 3.250E+00 | 3.457E+00 |
| INIT.U-236 % | 2.100E-02 | 2.100E-02 | 1.100E-02 | 1.100E-02 | 1.100E-02 | 3.300E-02 | 3.300E-02 | 3.296E-02 | 2.218E-02 |
| INIT.U-238 % | 9.670E+01 | 9.670E+01 | 9.672E+01 | 9.672E+01 | 9.669E+01 | 9.669E+01 | 9.669E+01 | 9.649E+01 | 9.649E+01 |
| FINL.U-234 % | 2.300E-02 | 2.455E+00 | 2.560E+00 | 1.920E+00 | 1.518E+00 | 1.909E+00 | 1.032E+00 | 9.590E-01 | 8.350E-01 |
| FINL.U-236 % | 1.680E-01 | 1.490E-01 | 2.730E-01 | 3.400E-01 | 2.740E-01 | 4.020E-01 | 4.210E-01 | 4.410E-01 | 4.300E-01 |
| FINL.U-238 % | 9.736E+01 | 9.725E+01 | 9.779E+01 | 9.812E+01 | 9.780E+01 | 9.853E+01 | 9.861E+01 | 9.871E+01 | 9.868E+01 |
| PU-238 % | 1.270E-01 | 1.050E-01 | 4.200E-01 | 7.720E-01 | 4.270E-01 | 1.482E+00 | 1.695E+00 | 1.950E+00 | 2.430E+00 |
| PU-239 % | 8.479E+01 | 8.669E+01 | 7.519E+01 | 6.828E+01 | 7.507E+01 | 5.974E+01 | 5.806E+01 | 5.553E+01 | 5.531E+01 |
| PU-240 % | 1.179E+01 | 1.051E+01 | 1.666E+01 | 1.994E+01 | 1.670E+01 | 2.356E+01 | 2.400E+01 | 2.580E+01 | 2.454E+01 |
| PU-241 % | 3.020E+00 | 2.520E+00 | 6.540E+00 | 6.680E+00 | 6.670E+00 | 1.068E+01 | 1.111E+01 | 1.089E+01 | 1.118E+01 |
| PU-242 % | 2.630E-01 | 1.830E-01 | 1.180E+00 | 2.330E+00 | 1.175E+00 | 4.543E+00 | 5.138E+00 | 5.899E+00 | 6.463E+00 |
| PU/U | 3.593E-03 | 3.280E-03 | 6.300E-03 | 7.634E-03 | 6.423E-03 | 9.193E-03 | 9.803E-03 | 9.319E-03 | 9.960E-03 |
| ND-143 % | 2.651E+01 | 2.682E+01 | 2.475E+01 | 2.318E+01 | 2.479E+01 | 2.112E+01 | 2.069E+01 | 1.981E+01 | 1.989E+01 |
| ND-144 % | 2.773E+01 | 2.748E+01 | 2.898E+01 | 3.023E+01 | 2.896E+01 | 3.212E+01 | 3.244E+01 | 3.338E+01 | 3.305E+01 |
| ND-145 % | 1.842E+01 | 1.842E+01 | 1.796E+01 | 1.760E+01 | 1.796E+01 | 1.708E+01 | 1.690E+01 | 1.683E+01 | 1.675E+01 |
| ND-146 % | 1.512E+01 | 1.507E+01 | 1.563E+01 | 1.609E+01 | 1.563E+01 | 1.662E+01 | 1.681E+01 | 1.685E+01 | 1.663E+01 |
| ND-148 % | 8.558E+00 | 8.538E+00 | 8.754E+00 | 8.900E+00 | 8.754E+00 | 8.936E+00 | 8.974E+00 | 9.075E+00 | 9.055E+00 |
| ND-150 % | 3.614E+00 | 3.614E+00 | 3.871E+00 | 4.012E+00 | 3.905E+00 | 4.125E+00 | 4.145E+00 | 4.252E+00 | 4.304E+00 |
| ND148/I/U | 1.458E-04 | 1.221E-04 | 2.722E-04 | 3.804E-04 | 5.347E-04 | 5.347E-04 | 5.845E-04 | 6.126E-04 | 6.237E-04 |
| KR-83 % | 9.000E+00 | 9.000E+00 | 1.600E+01 | 3.100E+01 | 3.140E+01 | 3.160E+01 | 3.280E+01 | 3.240E+01 | 3.220E+01 |
| KR-84 % | 2.800E+01 | 2.900E+01 | 3.100E+01 | 3.140E+01 | 3.140E+01 | 3.1330E+00 | 5.3300E+00 | 5.2000E+00 | 4.9000E+00 |
| KR-85 % | 6.100E+01 | 6.200E+01 | 4.800E+01 | 4.920E+01 | 4.960E+01 | 4.820E+01 | 4.960E+01 | 5.110E+01 | 4.440E+01 |
| KR-86 % | 9.000E+00 | 8.800E+00 | 9.000E+00 | 9.1000E+00 | 9.1000E+00 | 9.1000E+00 | 9.0000E+00 | 9.410E+00 | 8.6000E+00 |
| XE-131 % | 1.900E+01 | 2.000E+01 | 1.800E+01 | 2.160E+01 | 2.160E+01 | 2.160E+01 | 2.140E+01 | 2.120E+01 | 2.123E+01 |
| XE-132 % | 3.000E+01 | 3.000E+01 | 2.900E+01 | 2.900E+01 | 2.840E+01 | 2.840E+01 | 2.820E+01 | 2.840E+01 | 2.850E+01 |
| XE-134 % | 3.000E+01 | 3.000E+01 | 2.840E+01 | 2.840E+01 | 2.840E+01 | 3.050E+01 | 3.050E+01 | 3.050E+01 | 3.050E+01 |
| XE-136 % | 4.300E+01 | 4.200E+01 | 4.400E+01 | 4.080E+01 | 4.060E+01 | 4.080E+01 | 3.690E+01 | 4.100E+01 | 4.100E+01 |
| U-232 G/TU | 6.900E-05 | 7.200E-05 | 3.300E-04 | 3.009E-04 | 4.306E-04 | 1.400E-03 | 1.490E-03 | 1.520E-03 | 1.490E-03 |
| NP-273 G/TU | 6.800E+01 | 5.600E+01 | 1.600E+02 | 1.600E+02 | 1.600E+02 | 4.820E+01 | 4.960E+01 | 5.110E+01 | 4.440E+01 |
| PU-236 G/TU | 1.390E+08 | 1.100E+08 | 3.0905E+08 | 4.200E+08 | 3.080E+08 | 5.880E+08 | 6.830E+08 | 6.610E+08 | 6.100E+08 |
| AM-241 G/TU | 3.025E+01 | 2.287E+01 | 1.200E+02 | 1.965E+02 | 1.193E+02 | 3.127E+02 | 3.1310E+02 | 3.351E+02 | 3.518E+02 |
| AM242M G/TU | 1.240E-02 | 8.000E-03 | 1.940E-01 | 5.200E-01 | 1.760E-01 | 7.000E-01 | 7.500E-01 | 8.400E-01 | 1.200E+00 |
| CM-243 G/TU | 3.900E-01 | 3.200E-01 | 5.900E-01 | 2.000E+01 | 6.800E+00 | 7.100E+01 | 1.100E+02 | 1.140E+02 | 9.900E+01 |
| CM-243 G/TU | 3.200E-05 | 2.000E-05 | 4.900E-04 | 1.300E-03 | 4.500E-04 | 2.900E-03 | 9.300E-03 | 8.700E-03 | 1.350E+02 |
| CM-244 G/TU | 1.730E-02 | 8.900E-03 | 6.700E-01 | 3.270E+00 | 7.400E-01 | 1.610E+01 | 2.320E+01 | 2.620E+01 | 3.110E+01 |
| RU-106 BQ/GU | 1.390E+08 | 1.100E+08 | 3.0905E+08 | 4.200E+08 | 3.080E+08 | 5.880E+08 | 6.830E+08 | 6.610E+08 | 6.100E+08 |
| SB-125 BQ/GU | 1.880E+07 | 1.576E+07 | 3.565E+07 | 5.066E+07 | 3.5336E+07 | 6.133E+07 | 7.205E+07 | 7.213E+07 | 7.870E+07 |
| CS-134 BQ/GU | 8.080E+07 | 5.830E+07 | 2.910E+08 | 5.240E+08 | 2.930E+08 | 8.900E+08 | 1.070E+09 | 1.140E+09 | 1.440E+09 |
| CS-137 BQ/GU | 8.790E+08 | 7.080E+08 | 1.620E+09 | 2.330E+09 | 1.610E+09 | 3.160E+09 | 3.550E+09 | 3.670E+09 | 3.720E+09 |
| CE-144 BQ/GU | 3.000E+08 | 2.380E+08 | 3.910E+08 | 4.890E+08 | 4.000E+08 | 4.270E+08 | 6.030E+08 | 5.710E+08 | 5.620E+08 |
| Eu-154 BQ/GU | 9.050E+06 | 6.500E+06 | 3.620E+07 | 6.730E+07 | 3.660E+07 | 1.160E+08 | 1.390E+08 | 1.400E+08 | 1.968E+08 |

Table 3.7-6 Measured Data Based on the Mounts of Uranium Before Irradiation

| | | | | | | | | | | |
|--------------|------------|-----------|-----------|-----------|-----------|------------|-----------|------------|------------|------------|
| 86B02 | 86B03 | 86G05 | 86G03 | 86G07 | 87C03 | 87C04 | 87C07 | 87C08 | 87H01 | 87H05 |
| 00271 | 00272 | 00273 | 00274 | 00275 | 00276 | 00277 | 00278 | 00279 | 00280 | 00281 |
| FT/IMA % | 8.600E-01 | 7.215E-01 | 1.590E+00 | 2.205E+00 | 1.517E+00 | 3.067E+00 | 3.341E+00 | 3.497E+00 | 3.556E+00 | 4.029E+00 |
| FT MWD/MTU | 8.3000E+03 | 6.900E+03 | 1.530E+04 | 2.120E+04 | 1.460E+04 | 2.944E+04 | 3.230E+04 | 3.370E+04 | 3.410E+04 | 3.966E+00 |
| I.U234/IMA % | 2.900E-02 | 2.900E-02 | 2.900E-02 | 2.900E-02 | 2.900E-02 | 3.000E-02 | 3.000E-02 | 3.000E-02 | 3.000E-02 | 3.810E+04 |
| I.U235/IMA % | 3.248E+00 | 3.248E+00 | 3.243E+00 | 3.243E+00 | 3.243E+00 | 3.250E+00 | 3.250E+00 | 3.250E+00 | 3.250E+00 | 2.948E-02 |
| I.U236/IMA % | 2.100E-02 | 2.100E-02 | 1.100E-02 | 1.100E-02 | 1.100E-02 | 3.300E-02 | 3.300E-02 | 3.300E-02 | 3.300E-02 | 3.457E+00 |
| I.U238/IMA % | 9.670E+01 | 9.670E+01 | 9.670E+01 | 9.670E+01 | 9.670E+01 | 9.669E+01 | 9.669E+01 | 9.669E+01 | 9.669E+01 | 2.218E-02 |
| F.U234/IMA % | 2.272E-02 | | | | | | | | | 2.18E-02 |
| F.U235/IMA % | 2.420E+00 | 2.553E+00 | 1.878E+00 | 1.473E+00 | 1.868E+00 | 9.912E-01 | 9.180E-01 | 7.984E-01 | 8.136E-01 | 7.726E-01 |
| F.U236/IMA % | 1.660E-01 | 1.474E-01 | 2.670E-01 | 3.300E-01 | 2.681E-01 | 3.861E-01 | 4.030E-01 | 4.216E-01 | 4.230E-01 | 4.660E-01 |
| F.U238/IMA % | 9.618E+01 | 9.622E+01 | 9.563E+01 | 9.523E+01 | 9.570E+01 | 9.4666E+01 | 9.439E+01 | 9.424E+01 | 9.366E+01 | 9.372E+01 |
| PU238/IMA % | 4.508E-04 | 3.408E-04 | 2.588E-03 | 5.720E-03 | 2.684E-03 | 1.309E-02 | 1.591E-02 | 1.676E-02 | 1.855E-02 | 2.372E-02 |
| PU239/IMA % | 3.009E-01 | 4.632E-01 | 5.059E-01 | 4.716E-01 | 5.275E-01 | 5.448E-01 | 4.948E-01 | 5.293E-01 | 5.836E-01 | 5.732E-01 |
| PU240/IMA % | 4.185E-02 | 3.411E-02 | 1.026E-01 | 1.477E-01 | 1.050E-01 | 2.080E-01 | 2.299E-01 | 2.408E-01 | 2.609E-01 | 2.554E-01 |
| PU241/IMA % | 1.072E-02 | 8.179E-03 | 4.029E-02 | 4.192E-02 | 9.430E-02 | 1.043E-01 | 9.703E-02 | 1.063E-01 | 1.240E-01 | 1.196E-01 |
| PU242/IMA % | 9.335E-04 | 5.940E-04 | 7.270E-03 | 1.726E-02 | 7.385E-03 | 4.011E-02 | 4.821E-02 | 5.256E-02 | 5.602E-02 | 6.450E-02 |
| PU/IMA % | 3.549E-01 | 3.246E-01 | 6.161E-01 | 7.409E-01 | 6.285E-01 | 8.830E-01 | 9.384E-01 | 8.910E-01 | 9.511E-01 | 1.063E+00 |
| ND143/IMA % | 4.462E-02 | 3.795E-02 | 7.526E-02 | 9.616E-02 | 7.196E-02 | 1.214E-01 | 1.290E-01 | 1.293E-01 | 1.308E-01 | 1.444E-01 |
| ND144/IMA % | 4.675E-02 | 3.889E-02 | 8.812E-02 | 1.254E-01 | 8.407E-02 | 1.846E-01 | 2.022E-01 | 2.178E-01 | 2.174E-01 | 2.490E-01 |
| ND145/IMA % | 3.100E-02 | 2.615E-02 | 5.461E-02 | 7.301E-02 | 5.214E-02 | 9.816E-02 | 1.054E-01 | 1.098E-01 | 1.102E-01 | 1.225E-01 |
| ND146/IMA % | 2.545E-02 | 2.133E-02 | 4.768E-02 | 6.675E-02 | 4.573E-02 | 9.552E-02 | 1.048E-01 | 1.100E-01 | 1.119E-01 | 1.274E-01 |
| ND148/IMA % | 1.440E-02 | 1.208E-02 | 2.662E-02 | 3.692E-02 | 2.541E-02 | 5.136E-02 | 5.595E-02 | 5.857E-02 | 5.857E-02 | 6.641E-02 |
| ND150/IMA % | 6.082E-03 | 5.114E-03 | 1.177E-02 | 1.664E-02 | 1.134E-02 | 2.371E-02 | 2.606E-02 | 2.705E-02 | 2.797E-02 | 3.198E-02 |
| U/UO IN ATOM | 9.879E-01 | 9.892E-01 | 9.779E-01 | 9.705E-01 | 9.785E-01 | 9.605E-01 | 9.572E-01 | 9.561E-01 | 9.549E-01 | 9.500E-01 |
| U/UO IN WEIG | 9.880E-01 | 9.897E-01 | 9.781E-01 | 9.707E-01 | 9.787E-01 | 9.607E-01 | 9.575E-01 | 9.564E-01 | 9.552E-01 | 9.502E-01 |
| F25/IMA % | 6.828E-01 | 5.685E-01 | 1.169E+00 | 1.451E+00 | 1.118E+00 | 1.906E+00 | 1.962E+00 | 2.063E+00 | 2.046E+00 | 2.227E+00 |
| D28/IMA % | 5.229E-01 | 4.673E-01 | 1.087E+00 | 1.490E+00 | 1.019E+00 | 2.032E+00 | 2.300E+00 | 2.312E+00 | 2.449E+00 | 2.835E+00 |
| (F-F5)/IMA % | 1.772E-01 | 1.522E-01 | 4.802E-01 | 7.539E-01 | 3.996E-01 | 1.161E-01 | 1.379E-01 | 1.435E-01 | 1.510E+00 | 1.739E+00 |
| PU/(F-F5) % | 2.003E+00 | 2.122E+00 | 1.283E+00 | 9.828E-01 | 1.573E+00 | 7.604E-01 | 6.805E-01 | 6.211E-01 | 6.298E-01 | 5.944E-01 |
| D25/IMA % | 8.278E-01 | 6.950E-01 | 1.365E+00 | 1.707E+00 | 2.529E+00 | 2.332E+00 | 2.453E+00 | 2.436E+00 | 2.684E+00 | 2.669E+00 |
| D26/IMA % | -1.450E-01 | 1.264E-01 | 2.560E-01 | 2.190E-01 | 2.571E-01 | -3.531E-01 | 3.700E-01 | -3.886E-01 | -4.386E-01 | -4.414E-01 |
| ALPHA-U235 | 2.123E-01 | 2.224E-01 | 2.307E-01 | 2.199E-01 | 2.300E-01 | 1.853E-01 | 1.886E-01 | 1.884E-01 | 1.906E-01 | 1.982E-01 |
| U232 G/TUO | 6.817E-05 | 7.126E-05 | 3.722E-04 | 2.921E-04 | 4.214E-04 | 1.345E-03 | 1.422E-03 | 1.454E-03 | 1.452E-03 | 1.872E-03 |
| NP273 G/TUO | 6.718E+01 | 5.542E+01 | 1.555E+02 | 1.566E+02 | 1.262E-03 | 4.404E-04 | 8.235E-03 | 8.894E-03 | 8.310E-03 | 5.796E+02 |
| PU236 G/TUO | | | | | | | | | | |
| AM241 G/TUO | 2.989E-01 | 2.263E+01 | 1.174E+02 | 1.907E+02 | 3.004E+02 | 2.998E+02 | 3.205E+02 | 3.360E+02 | 4.072E+02 | 4.371E-04 |
| AN242M G/TUO | 1.225E-02 | 7.91E-03 | 1.838E-01 | 5.048E-01 | 1.723E-01 | 6.703E-01 | 7.173E-01 | 8.023E-01 | 1.139E+00 | 9.787E-01 |
| AM243 G/TUO | 3.853E-01 | 3.167E-01 | 5.771E+00 | 1.941E+01 | 6.655E+00 | 6.821E+01 | 1.053E+02 | 1.090E+02 | 9.456E+01 | 1.282E+02 |
| CM242 G/TUO | 3.161E-05 | 1.979E-05 | 4.793E-04 | 1.262E-03 | 4.404E-04 | 8.235E-03 | 8.894E-03 | 8.310E-03 | 5.412E+02 | 5.796E+02 |
| CM243 G/TUO | | | | | | | | | | |
| CM244 G/TUO | 1.709E-02 | 8.808E-03 | 6.553E-01 | 3.174E+00 | 7.242E-01 | 1.547E+01 | 2.777E-01 | 3.252E-01 | 4.462E-01 | 5.511E-01 |
| RU106 BQ/GUO | 1.373E-08 | 1.089E-08 | 3.022E+08 | 4.077E+08 | 3.014E+08 | 5.649E+08 | 6.540E+08 | 6.322E+08 | 6.543E+08 | 4.343E+01 |
| SBL25 BQ/GUO | 1.857E-07 | 1.560E-07 | 3.482E+07 | 4.918E+07 | 3.461E+07 | 5.892E+07 | 6.899E+07 | 6.896E+07 | 7.662E+08 | 7.136E+08 |
| CS134 BQ/GUO | 7.983E-07 | 5.770E-07 | 2.846E+08 | 5.086E+08 | 8.550E+08 | 1.025E+09 | 1.033E+09 | 1.089E+09 | 1.405E+09 | 1.368E+09 |
| CS137 BQ/GUO | 8.684E-08 | 7.007E-08 | 1.583E+09 | 2.262E+09 | 1.576E+09 | 3.399E+09 | 3.510E+09 | 3.553E+09 | 4.026E+09 | 3.982E+09 |
| CE144 BQ/GUO | 2.964E+08 | 2.355E+08 | 3.824E+08 | 4.747E+08 | 3.915E+08 | 5.774E+08 | 5.461E+08 | 5.368E+08 | 3.418E+08 | 3.506E+08 |
| EU154 BQ/GUO | 8.941E+06 | 6.433E+06 | 3.541E+07 | 3.582E+07 | 1.114E+08 | 1.331E+08 | 1.329E+08 | 1.337E+08 | 1.927E+08 | 1.870E+08 |

Table 3.7-7 Explanations of Terms in Table 3.7-5 ~ Table 3.7-6

| | |
|---|--|
| BURNUP %FIMA(FT/IMA), BURNUP MWD/T(FT MWD/MTU) | Burnup(%FIMA) and Burnup(MWd/t) |
| INIT.U-234 %, INIT.U-235 %, INIT.U-236 %, INIT.U-238 % | Isotopic ratio(atom%) of initial U(before irradiation) |
| FINL.U-234 %, FINL.U-235 %, FINL.U-236 %, FINL.U-238 % | Isotopic ratio(atom%) of U after irradiation |
| PU-238 %, PU-239 %, PU-240 %, PU-241 %, PU-242 % | Isotopic ratio(atom%) of Pu after irradiation |
| ND-143 %, ND-144 %, ND-145 %, ND-146 %, ND-148 %, ND-150 % | Isotopic ratio(atom%) of Nd after irradiation |
| KR-83 %, KR-84 %, KR-85 %, KR-86 % | Isotopic ratio(atom%) of Kr after irradiation |
| XE-131 %, XE-132 %, XE-134 %, XE-136 % | Isotopic ratio(atom%) of Xe after irradiation |
| PU/U, ND-148/U | Atoms of Pu and Nd-148 per Atoms of U after irradiation |
| U-232 G/TU, NP-237 G/TU, PU-236 G/TU, AM-241 G/TU, AM-242M G/TU | Atoms of ^{232}U , ^{237}Np , ^{236}Pu , ^{241}Am , ^{242}mAm per ton U after irradi. |
| AM-243 G/TU, CM-242 G/TU, CM-243 G/TU, CM-244 G/TU | Grams of ^{243}Am , ^{242}Gm , ^{243}Cm , ^{244}Cm per ton U after irradi. |
| RU-106 BQ/GU, SB-125 BQ/GU, CS-134 BQ/GU, CS-137 BQ/GU | Grams of ^{106}Ru , ^{125}Sb , ^{134}Cs , ^{137}Cs per g U after irradi. |
| CE-144 BQ/GU, EU-154 BQ/GU | Activity(Bq) of ^{144}Ce , Activity(Bq) of ^{154}Eu per g U after irradi. |
| I.U234/IMA %, I.U235/IMA %, I.U236/IMA %, I.U238/IMA % | Atomic % of initial U isotopes per initial heavy metals(U) |
| F.U234/IMA %, F.U235/IMA %, F.U236/IMA %, F.U238/IMA % | Atomic % of U isotopes after irradi. per initial heavy metals |
| PU-238/IMA %, PU-239/IMA %, PU-240/IMA %, PU-241/IMA %, | Atomic % of Pu isotopes after irradi. per initial heavy metals(U) |
| PU-242/IMA % | Atomic % of Nd isotopes after irradi. per initial heavy metals(U) |
| ND-143/IMA %, ND-144/IMA %, ND-145/IMA %, ND-146/IMA %, | Atomic % of Pu after irrad. per initial heavy metals(U) |
| ND-148/IMA %, ND-150/IMA % | Ratio of U after irrad. per initial U in atoms and weights |
| PU/IMA % | Fission atoms(%) of ^{235}U and others per initial heavy metals |
| U/UO IN ATOM, U/UO IN WEIG | Depleted atoms(%) of ^{235}U , ^{236}U , ^{238}U per initial heavy metals |
| F25/IMA %, (F-F5)/IMA % | Atoms of Pu(%) per fission atoms other than ^{235}U |
| D25/IMA %, D26/IMA %, D28/IMA % | Alpha value(neutron capture/fission) of ^{235}U |
| PU/(F-F5) | Grams of ^{232}U , ^{237}Np , ^{236}Pu per ton initial heavy metals |
| ALPHA-U235 | Grams of ^{241}Am , ^{242}mAm , ^{243}Am per ton initial heavy metals |
| U-232 G/TUO, NP-237 G/TUO, PU-236 G/TUO | Grams of ^{242}Gm , ^{243}Cm , ^{244}Cm per ton initial heavy metals |
| AM-241,AM242M G/TUO, AM-243 G/TUO | Activity(Bq) of ^{106}Ru , ^{125}Sb , ^{134}Cs per g initial heavy metals |
| CM-242,CM-243,CM-244 G/TUO | Activity(Bq) of ^{137}Cs , ^{144}Ce , ^{154}Eu per g initial heavy metals |
| RU-106 BQ/GUO, SB-125 BQ/GUO, CS-134 BQ/GUO | |
| CS-137 BQ/GUO, CE-144 BQ/GUO, EU-154 BQ/GUO | |

Cooling times: 5 years after discharge of fuels

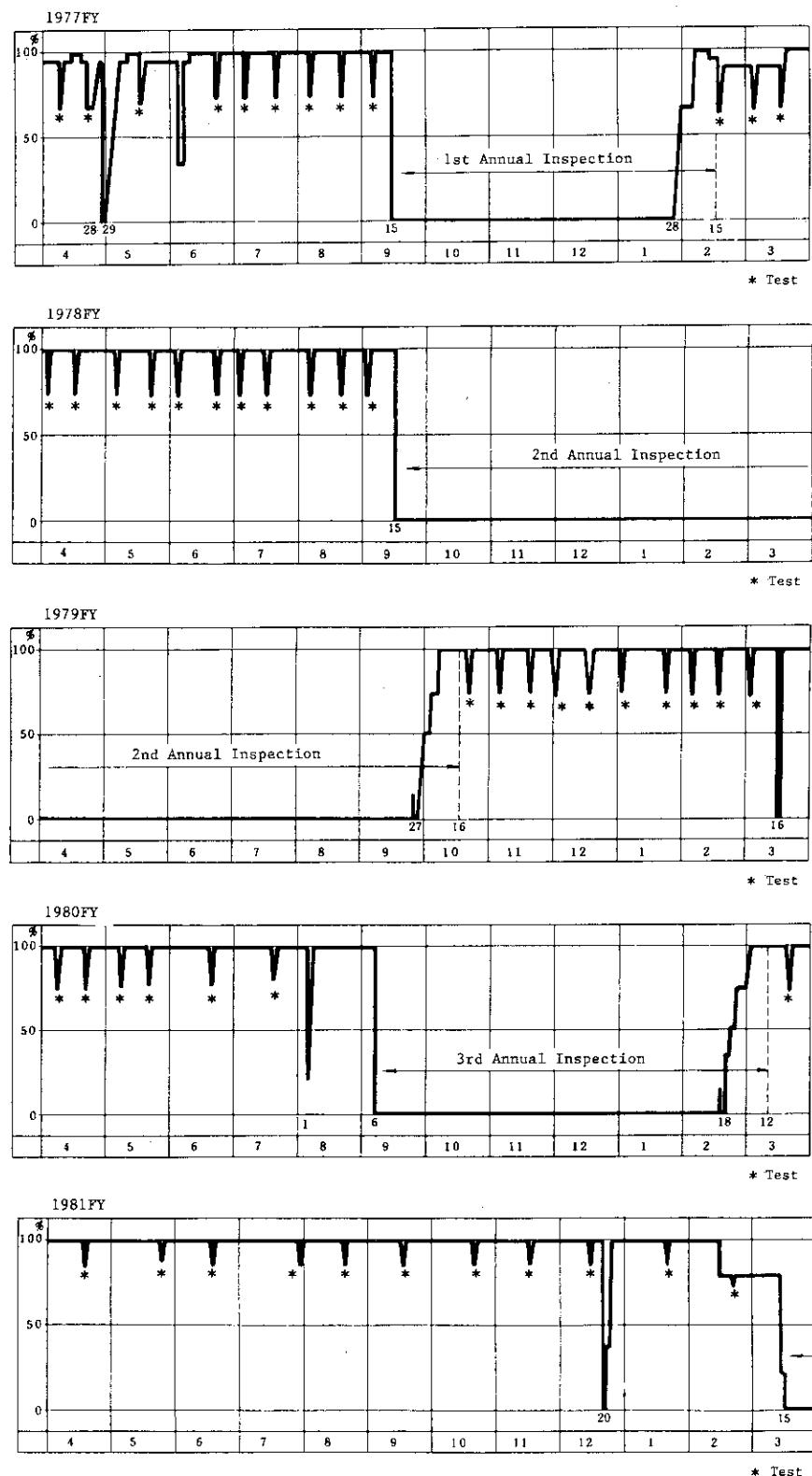


Fig. 3.7-1 Operating history of Mihama-3 reactor

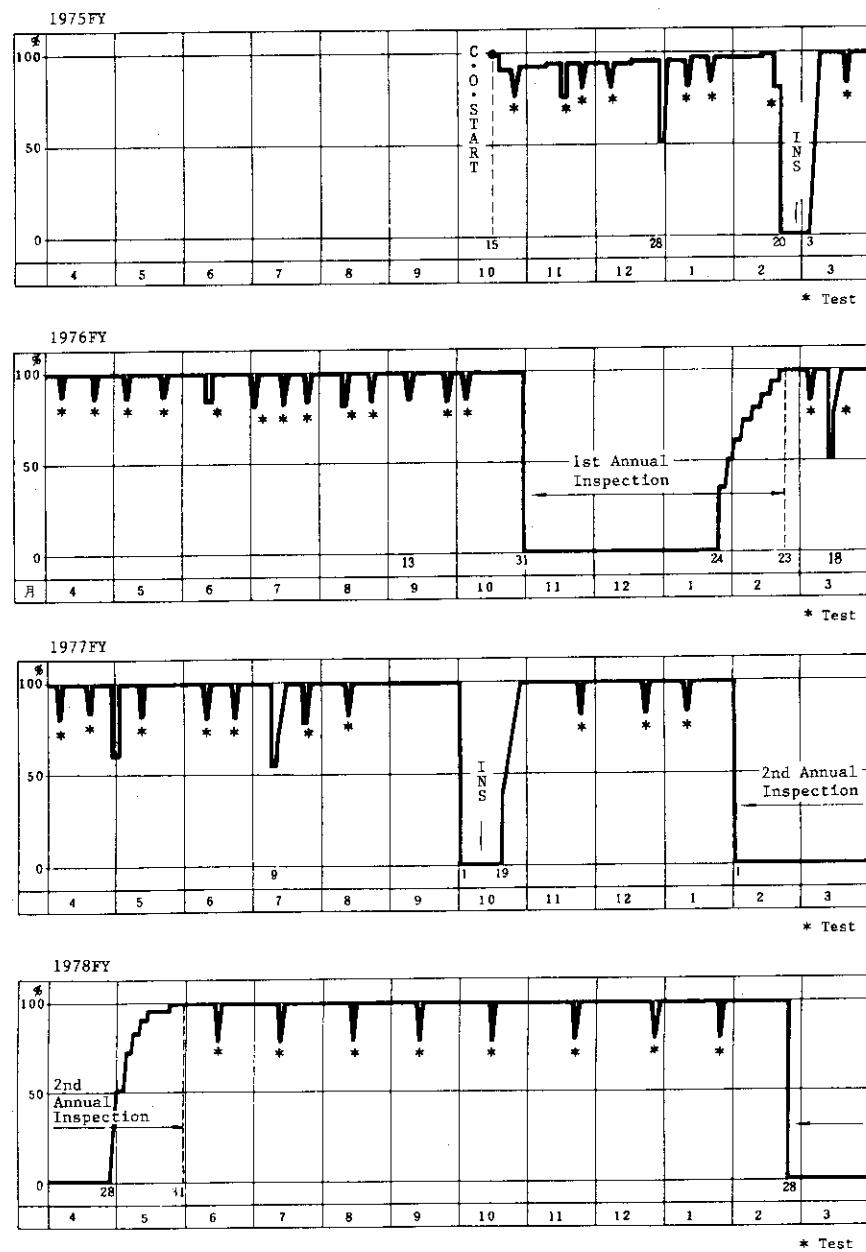


Fig. 3.7-2 Operating history of Genkai-1 reactor

3.8 敦賀1号炉(BWR)

敦賀1号炉は福井県敦賀市にある電気出力357MWeのBWRである。燃料集合体は燃料棒 7×7 で構成されている。この燃料集合体2体について照射後試験が行われ、燃焼率分析及びU, Pu同位体比の測定結果が報告されている¹¹⁾。測定は日本原子力研究所で行われた。集合体平均燃焼度は約22GWd/tであった。

なお、本節で使用した図表は下記の文献から転載したものである。

11) 土江保男他：「敦賀炉国産被覆管燃料の照射後試験」，日本原子力学会誌 Vol. 29, No. 3 (1987), pp. 219-243

3.8.1 炉心構成と炉心性能

敦賀1号炉の炉心構成と炉心性能をTable 3.8-1に示す。燃料集合体図をFig. 3.8-1に示す。

3.8.2 燃料履歴とサンプリング燃料配置

Fig. 3.8-2に敦賀1号炉の運転履歴を示す。また、燃料集合体毎の燃焼履歴をTable 3.8-2に示す。試験された使用済燃料集合体はJAB-73, JAB-74である。その燃料集合体の炉心内位置をFig. 3.8-3に示す。図内のSはJAB-73の位置を、KはJAB-74の位置を示す。また、その文字の後に続く数値はFig. 3.8-2に示したサンプル燃料の照射サイクル番号を示している。すなわち、S1は燃料集合体JAB-73が第1サイクルにあった位置を示している。

燃料集合体内サンプル燃料棒位置及び初期濃縮度をFig. 3.8-4に示す。このうち、サンプル燃料棒は、集合体JAB-73の場合A1, F4燃料棒、集合体JAB-74の場合A1, D6燃料棒である。

軸方向サンプル位置をTable 3.8-3およびFig. 3.8-5に示す。各燃料集合体毎に4試料ずつ8試料が採取され、燃焼率測定が行われた。MC1・S1はひとつの試料名を表す。各燃料集合体毎に3試料から5サンプルずつ計10サンプルがマイクロサンプリングされ、U, Pu同位体比の測定が行われた。このとき、半径方向の燃焼率分布を見るため、MC5・MS3からは3つのサンプルがマイクロサンプリングされた。

3.8.3 核種組成データ

燃焼率分析は、Cs定量分析法またはU, Pu同位体比法で行われた。結果をTable 3.8-3に示す。

燃料集合体JAB-73, JAB-74のA1燃料棒5サンプルずつ10サンプルについてU, Puの同位体組成が測定された。結果をTable 3.8-4に示す。

Table 3.8-1 Core Composition and Performance

| Reactor Name | Tsuruga-1 | Tsuruga-1 | Reactor Name | Tsuruga-1 |
|---------------------------------------|----------------------|-----------|--|------------------|
| Fuel Pellet | | | Control Rod | |
| UO ₂ density | (g/cm ³) | 94.95%T.D | Absorbing material | B ₄ C |
| Linear density | (g/cm) | | | |
| Diameter | (cm) | 1.237 | | |
| Length of pellet stack in fuel rod | (cm) | 365.7 | Core | |
| Clad-pellet clearance | (cm) | 0.031 | Equivalent diameter | (cm) |
| | | | Active height | 302 |
| Fuel Clad | (cm) | | No. of square assemblies | (cm) |
| Outside diameter | (cm) | 1.43 | No. of control rods | 365.7 |
| Inside diameter | (cm) | | UO ₂ in square assemblies(kg) | 73 |
| Wall thickness | (cm) | 0.081 | Total UO ₂ weight | (kg) |
| Material | Zircaloy-2 | | Total U weight | (kg) |
| Square Fuel Assembly | | | | 60,677 |
| Rod array | | | Core Thermo-hydraulic | |
| Number of rods | (cm) | | Characteristics | |
| Fuel rod pitch | | | Power | (MWth) |
| Side of square | | | | (MWth) |
| cross section | (cm) | 7 × 7 | | 1064 |
| Total length | (cm) | | Coolant pressure | (MWth) |
| UO ₂ weight | (kg) | 434.6 | | 357 |
| Initial enrichment | (%) | | Coolant temperature(ave., °C) | 70 |
| | | | (inlet, °C) | 286 |
| | | | (outlet, °C) | |

Table 3.8-2 Irradiation History of Fuel

| Burnup Fuel rods subjected to destructive test | | |
|---|----------------|----------------|
| Rod | Bundle | |
| | JAB-73 (GWd/t) | JAB-74 (GWd/t) |
| A1 | 25.4 | 25.7 |
| B3 | 24.2 | 24.3 |
| C3 | 20.2 | 20.3 |
| C4 | 18.4 | 18.6 |
| D6 | 16.9 | 16.3 |
| F4 | 16.9 | - |

Pellet max. ~32 GWd/t (A1)
 Fast neutron fluence ($E > 1$ MeV)
 Bundle ave. $3 \sim 4 \times 10^{21}$ n/cm²
 Max. linear heat generation rate
 Rod ave. ~ 320 W/cm (A1)
 Pellet max. ~ 470 W/cm (A1)

Table 3.8-3 Burnup of Fuel Rod Samples

| Assembly Name | Fuel Rod Name | Axial Location Distance ^{*1} (cm) | Sample Name | Burnup (FIMA%) ^{*2} |
|---------------|------------------|--|-----------------|------------------------------|
| JAB73 | A1 ^{*3} | 83.7 | MC1•MS1 | 1.18 |
| | | 183.7 | MC3•MS2 | 2.49 |
| | | 283.7 | MC5•MS3(Center) | 2.58 |
| | | | MC5•MS3(0.45r) | 2.60 |
| JAB74 | A1 ^{*3} | | MC5•MS3(0.85r) | 2.89 |
| | 245.2 | MC9 | 1.77 | |
| | A1 ^{*3} | 80.7 | MC1•MS1 | 0.90 |
| | | 180.7 | MC3•MS2 | 2.57 |
| | | 280.7 | MC5•MS3(Center) | 2.63 |
| | D6 ^{*4} | 232.2 | MC5•MS3(0.45r) | 2.57 |
| | | | MC5•MS3(0.85r) | 2.68 |
| | | | MC9 | 1.98 |

^{*1}: Distance from lower end of active fuel rod^{*2}: Fission per Intial Metal Atom^{*3}: by Method of U, Pu Isotope^{*4}: by ¹³⁷Cs Radio-chemical Analysis

Table 3.8-4 Isotope Composition of U, Pu

| ID Name | Assembly | Rod | Sampling | Position | ATOM % (INIT. U) | | | |
|---------|----------|-----|----------|----------|------------------|------|-----|--------|
| | | | | | 234 | 235 | 236 | 238 |
| 82C01 | JAB-73 | A1 | MC1,MS1 | | 0.0100 | 1.44 | 0.0 | 98.552 |
| 82C02 | JAB-73 | A1 | MC3,MS2 | | 0.0100 | 1.44 | 0.0 | 98.552 |
| 82C03 | JAB-73 | A1 | MC5,MS3 | (CENTER) | 0.0100 | 1.44 | 0.0 | 98.552 |
| 82C04 | JAB-73 | A1 | MC5,MS3 | (0.45R) | 0.0100 | 1.44 | 0.0 | 98.552 |
| 82C05 | JAB-73 | A1 | MC5,MS3 | (0.85R) | 0.0100 | 1.44 | 0.0 | 98.552 |
| 82C07 | JAB-74 | A1 | MC1,MS1 | | 0.0100 | 1.44 | 0.0 | 98.552 |
| 82C08 | JAB-74 | A1 | MC5,MS3 | (CENTER) | 0.0100 | 1.44 | 0.0 | 98.552 |
| 82C09 | JAB-74 | A1 | MC5,MS3 | (0.45R) | 0.0100 | 1.44 | 0.0 | 98.552 |
| 82C10 | JAB-74 | A1 | MC5,MS3 | (0.87R) | 0.0100 | 1.44 | 0.0 | 98.552 |
| 82C11 | JAB-74 | A1 | MC3,MS2 | | 0.0100 | 1.44 | 0.0 | 98.552 |

| ID Name | ISOTOPE COMPOSITION (Atom %) | | | | Pu/U (*E-3) | BURNUP (FIMA %) |
|---------|------------------------------|-------|-------|--------|----------------|--------------------|
| | U-234 | U-235 | U-236 | U-238 | | |
| 82C01 | 0.0085 | 0.570 | 0.148 | 99.274 | 4.42 | 1.18 |
| 82C02 | 0.0064 | 0.149 | 0.203 | 99.641 | 6.98 | 2.49 |
| 82C03 | 0.0063 | 0.164 | 0.203 | 99.628 | 7.65 | 2.58 |
| 82C04 | 0.0063 | 0.163 | 0.203 | 99.628 | 7.64 | 2.60 |
| 82C05 | 0.0061 | 0.136 | 0.203 | 99.655 | 8.49 | 2.89 |
| 82C07 | 0.0092 | 0.753 | 0.130 | 99.107 | 3.84 | 0.90 |
| 82C08 | 0.0061 | 0.152 | 0.203 | 99.639 | 7.65 | 2.63 |
| 82C09 | 0.0062 | 0.164 | 0.201 | 99.629 | 7.63 | 2.57 |
| 82C10 | 0.0062 | 0.162 | 0.202 | 99.630 | 8.06 | 2.68 |
| 82C11 | 0.0064 | 0.158 | 0.206 | 99.630 | 7.14 | 2.57 |

| ID Name | ISOTOPE COMPOSITION (Atom %) | | | | | |
|---------|------------------------------|--------|--------|--------|--------|----------------|
| | Pu-238 | Pu-239 | Pu-240 | Pu-241 | Pu-242 | |
| 82C01 | 0.54 | 64.32 | 25.21 | 7.94 | 1.99 | on May 1, 1978 |
| 82C02 | 1.71 | 44.21 | 34.49 | 11.02 | 8.56 | on May 1, 1978 |
| 82C03 | 1.78 | 45.50 | 32.65 | 11.63 | 8.44 | on May 1, 1978 |
| 82C04 | 1.81 | 45.53 | 32.16 | 11.80 | 8.69 | on May 1, 1978 |
| 82C05 | 1.83 | 45.67 | 29.63 | 12.84 | 10.03 | on May 1, 1978 |
| 82C07 | 0.47 | 69.57 | 22.06 | 6.46 | 1.45 | on May 1, 1978 |
| 82C08 | 1.80 | 44.51 | 33.43 | 11.58 | 8.67 | on May 1, 1978 |
| 82C09 | 1.79 | 45.18 | 33.34 | 11.47 | 8.23 | on May 1, 1978 |
| 82C10 | 1.79 | 45.82 | 31.53 | 12.15 | 8.71 | on May 1, 1978 |
| 82C11 | 1.75 | 43.47 | 34.34 | 11.14 | 9.30 | on May 1, 1978 |

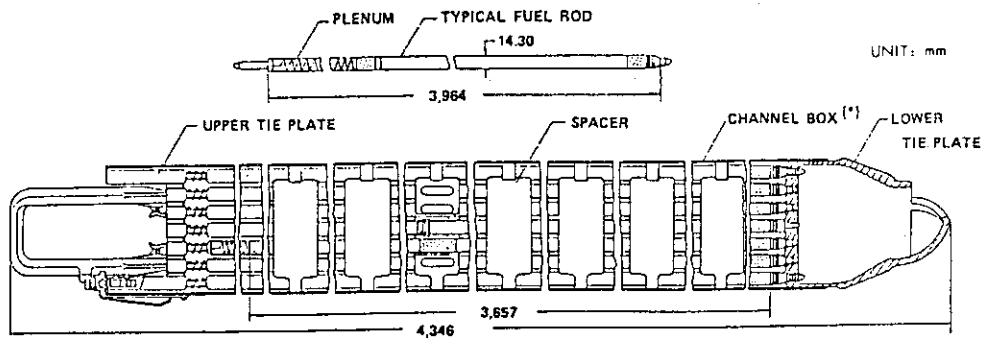


Fig. 3.8-1 Fuel bundle drawing (JAPCO Tsuruga reload batch-2)

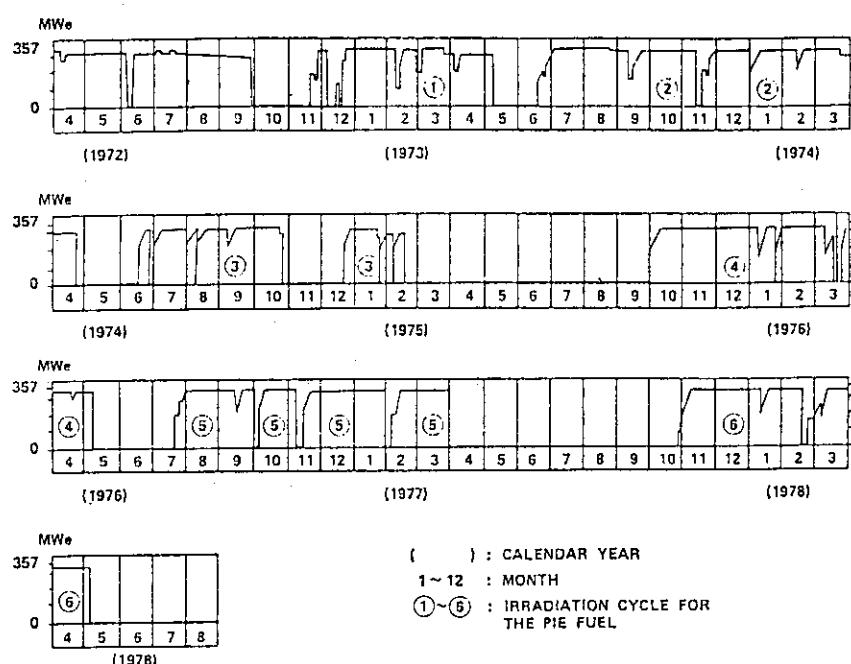


Fig. 3.8-2 Operational history of Tsuruga reactor

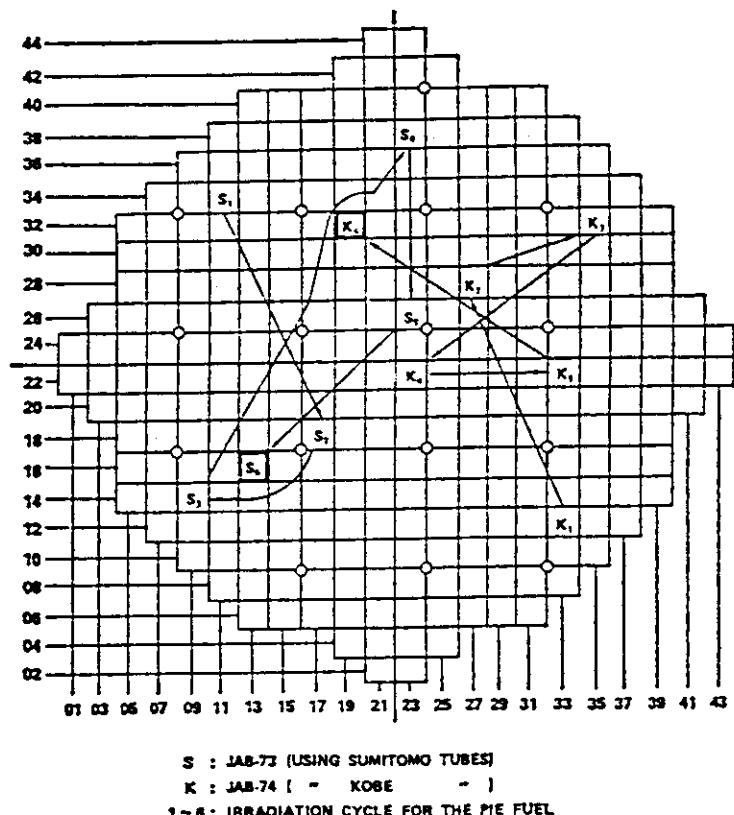
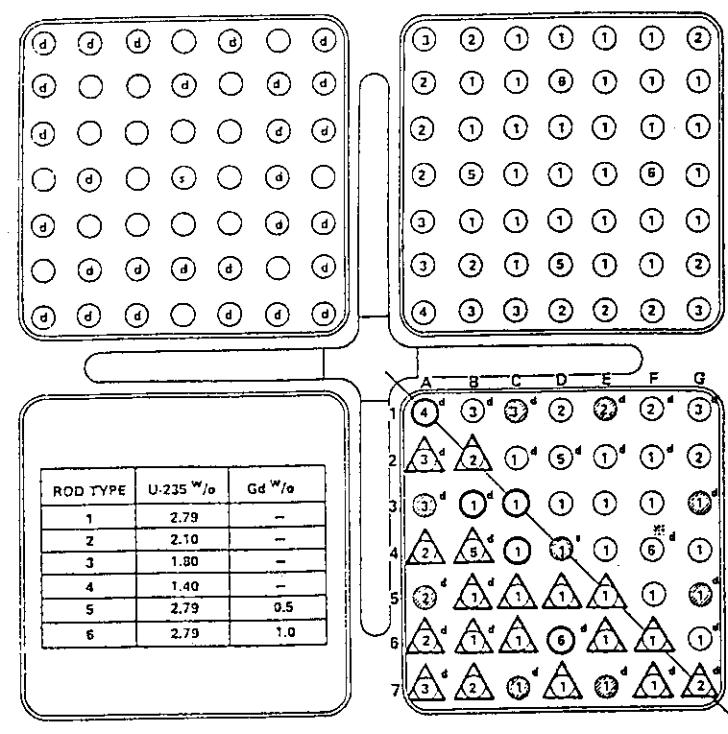


Fig. 3.8-3 Fuel locations in Tsuruga reactor



○ : CATEGORY-I (NDT+DT) : 5 RODS/B'DL ○ : TIE ROD
 △ : " II (NDT ONLY): 18 " / " ○^s : SEGMENTED ROD
 ○^d : DISHED PELLET ROD

Fig. 3.8-4 Fuel rod positions within bundle

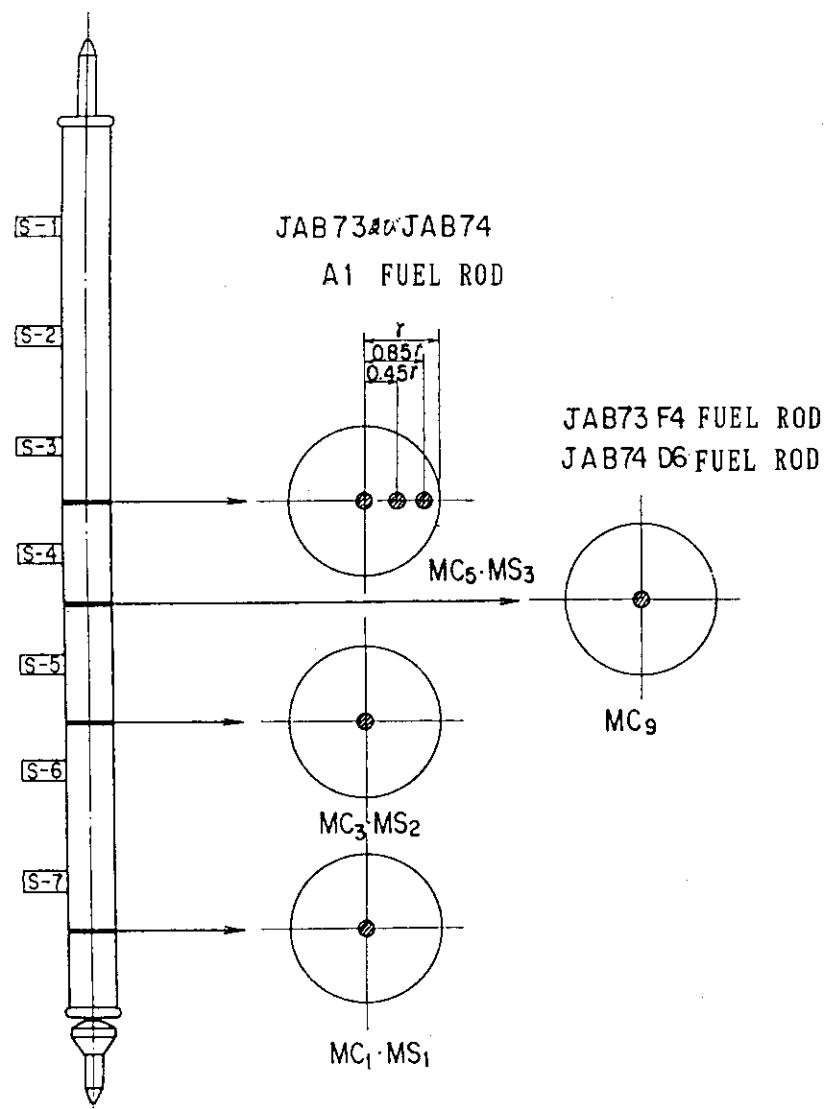


Fig. 3.8-5 Sampling position within rods

3.9 JPDR(BWR)

JPDRは茨城県東海村にある熱出力45MWthのBWRである。燃料集合体は2.6%濃縮 UO_2 燃料棒 6×6 で構成されている。この燃料集合体について照射後試験が行われ、燃焼率分析及びU, Pu同位体等の核種組成の測定がなされた。測定は燃料棒毎の測定¹²⁾（測定ステップ1），集合体毎の測定¹³⁾（測定ステップ2）の2ステップに分けて日本原子力研究所で行われた。集合体平均燃焼度は110～5,640MWd/tと評価された。

なお、本節で使用した図表は下記の文献から転載したものである。

- 12) H. Natsume et. al: "Gamma-Ray Spectrometry and Chemical Analysis Data of JPDR-I Spent Fuel", Journal of Nuclear Science and Technology, 14(10), pp. 745-761(1977).
- 13) T. Suzuki et. al: "Non-Destructive Measurements on Burnup Characteristics of Japan Power Demonstration Reactor-I Full-Core Fuel Assemblies", Journal of Nuclear Science and Technology, 23(1), pp. 53-72(1986).

3.9.1 炉心構成と炉心性能

JPDR-Iの炉心構成と炉心性能をTable 3.9-1に、炉心配置図をFig. 3.9-1に示す。炉心は72体の燃料集合体、16体の十字型制御棒及び24体のバーナブルポイズンカーテンで構成されている。燃料集合体は36本の燃料棒が 6×6 の正方格子に配列されている。燃料棒は同じ有効長さを持つ2つのセグメント（上部及び下部セグメント）で構成されている。

3.9.2 燃料履歴とサンプリング燃料配置

JPDR-Iは1963年から1969年まで運転された。原子炉出力の制御は炉心中心の4つの制御棒で行われ、他の12の周辺制御棒は1体（1965年から40%挿入を維持した4B制御棒）を除き全引き抜き状態であった。運転履歴をTable 3.9-2に示す。また、この表の意味をTable 3.9-3に示す。

燃料の炉心配置をFig. 3.9-1（測定ステップ1の説明）及びFig. 3.9-2（測定ステップ2の説明）に示す。

測定ステップ1では、燃料集合体A-14, A-18, A-20の3体が測定対象となった（Fig. 3.9-1参照）。運転データから評価された3体の燃料集合体平均燃焼度はそれぞれ5,015, 3,707及び5,570 MWd/tであった。A-20の燃料棒配置をFig. 3.9-3に示す。燃料集合体A-20からは、図中の8本の燃料棒がサンプリングされた。図中KA-376は1A燃料棒の上部セグメントのID番号であり、KC-1293は1A燃料棒の下部セグメントのID番号である。また、A-14及びA-18からは、集合体中央の4本の燃料棒の内からそれぞれ1本ずつ選ばれた。Fig. 3.9-4に燃料棒の軸方向サンプリング位置を示す。位置は燃料棒の中心をレベル0として表示している。したがって、位置が正の値をもつときは上部セグメントであり、負の値をもつときは下部セグメントであることを示す。

測定ステップ2では、炉心A-14, A-18及びA-20を除く全使用済燃料集合体72体について非破壊測定が行われた。また、A-8を除く71体が19バッチに分けて溶解され、1バッチ毎に均質化した溶液からサンプリングした試料が分析された。Table 3.9-4にバッチ毎に溶解された燃料集合体の各が示されている。左端が燃料集合体名、右端が再処理バッチ名である。燃料集合体の炉心内配置はFig. 3.9-2に示す通りである。また、Fig. 3.9-2の下図に示すPosition numberとTable 3.9-4の第2列のPosition number及び第3列の燃料の炉心装荷／取り出し日付から各燃料集合体の炉心内位置の働きが分かる。

3.9.3 核種組成データ

測定ステップ1において、ガンマ線スペクトロメトリーで測定されたFP核種の放射をdps/U atomの単位でTable 3.9-5, Table 3.9-6に示す。また、半減期とガンマ線分岐比を用いて算出した各核種の量を最終ウラン量の比としてTable 3.9-7に示す。

同位体希釈質量分析(IDMS)で求めたU及びPuの同位体組成とトータルU及びトータルPuの試料中の量をそれぞれTable 3.9-8, Table 3.9-9に示す。Table 3.9-8にはPu/U比も示してある。また、同様の方法で求められた核分裂生成物Ndの同位体組成及び¹⁴⁸Ndの試料中の量をTable 3.9-10に示す。

アルファスペクトロメトリーで求めた²³⁷Np, ²⁴¹Am, ^{242m}Am, ²⁴²Cm及び²⁴⁴Cmの試料中の量をTable 3.9-11に示す。

燃焼度は燃料集合体A-20から24試料、A-14及びA-18からそれぞれ3試料選ばれた総計30試料について測定された。測定は¹³⁷Csの量とU量から燃焼度を求めるCs法と¹⁴⁸Nd, U及びPuの量から燃焼度を求めるNd法の2つの方法で行われた。Table 3.9-12に2つの方法で求められた燃焼度を初期U原子数に対する核分裂U原子数の比(FIMA)の百分率で示す。Cs法で求めた燃焼度はNd法で求めた燃焼度より約2%ほど低くなっている。この原因は、通常、燃料中でCsが拡散したためと解釈されるが、軸方向のガスマスキャニングの結果からはこれに肯定的な証拠は見いだせなかった。

測定ステップ2では、JPDR-Iの使用済燃料集合体72体について集合体毎のガスマスキャニングが行われた。¹³⁷Cs, ¹³⁴Cs及び¹⁵⁴Euガンマ線の集合体平均の強度をTable 3.9-4に示す。集合体平均の燃焼度はBUは¹³⁷Csの放射能と燃焼度の関係を表す実験式から、集合体平均Pu/U比 R_{Pu/U}は¹³⁴Cs/¹³⁷Csの放射能比とPu/U比の関係を表す実験式から求められた¹³⁾。またU量 M_U(g)及びPu量 M_{Pu}(g)は、次式で求められた。

$$M_U = (1 - BU - R_{Pu/U})/M_{U0}$$

$$M_{Pu} = R_{Pu/U} \times C \times M_U$$

ここで M_{U0} は初期ウラン量(g), C は集合体内のPuとUの原子の平均質量比である。ここでは、近似的にC=239/238=1.0042を用いている。

使用済燃料集合体72体の内 A-8を除く71体が19バッチに分けられ、硝酸溶液の中で溶解された。燃料集合体2~4体が1バッチにまとめられ、JP-0XXと名付けられた(Table 3.9-4参照)。こ

の溶解液をサンプリングして得た試料を分析した。

ガンマスペクトロメトリーで測定されたガンマ線放出核種の量を各バッチのU量に対する原子個数比としてTable 3.9-13に示す。

U, Pu及びNdの同位体組成をそれぞれTable 3.9-14, Table 3.9-15及びTable 3.9-16に示す。

また, ^{237}Np , ^{241}Am , $^{242\text{m}}\text{Am}$ 及び ^{244}Cm の量をU量に対する原子個数比としてTable 3.9-17に示す。

Cs法とNd法で測定された燃焼度をTable 3.9-18に示す。

U, Pu及び燃焼度について整理したものをTable 3.9-19に示す。

Table 3.9-1 Core Composition and Performance

| Reactor Name | JPDR | Reactor Name | JPDR |
|------------------------------|----------------------|---------------------------------------|-----------------------|
| Fuel Pellet | | Control Rod | |
| UO ₂ density | (g/cm ³) | Absorbing material | |
| Linear density | (g/cm) | | |
| Diameter | (cm) | Core | |
| Pellet height | (cm) | Equivalent diameter | (cm) |
| Clad-pellet clearance | (cm) | Active height | (cm) |
| Fuel Clad | | No. of square assemblies | 72 |
| Outside diameter | (cm) | No. of control rods | 16 |
| Inside diameter | (cm) | UO ₂ in a segment | (g) |
| Wall thickness | (cm) | Total UO ₂ weight | (kg) |
| Material | Zircaloy-2 | Total U weight | (kg) |
| Square Fuel Assembly | | Core Thermo-hydraulic Characteristics | |
| Rod array | 6 × 6 | Power | 45 |
| Number of rods | 36 | (MWth) | |
| Fuel rod pitch | (cm) | (MW) | |
| Side of square cross section | (cm) | Coolant pressure | (kg/cm ²) |
| Total length | (cm) | Coolant temperature(ave., °C) | 61.5 |
| UO ₂ weight | (kg) | (inlet, °C) | 277 |
| Initial enrichment | (%) | (outlet, °C) | |
| | 2.6 | | |

Table 3.9-2 Numerical Data on Operation History of JPDR-1

| | | | | | | | | | | | |
|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|--------|
| 38-10-11 | A-20 | 5.9 | 235.05 | | | | | | | | |
| 9.3751 | -3 | 1.4643 | -2 | 1.9305 | -2 | 2.3158 | -2 | 2.5914 | -2 | 2.7136 | -2 |
| 2.6164 | -2 | 2.1963 | -2 | 1.2395 | -2 | 7.5166 | -3 | 4.5572 | -3 | 2.3081 | -3 |
| 1. | 1. | 1. | 0.99370. | 0.95660. | 0.91080. | 0.86730. | 0.83010. | 0.80020. | 0.77700. | 0.76010. | 0.7489 |
| 38-11-20 | A-20 | 15.8 | 160.37 | | | | | | | | |
| 1.8015 | -2 | 2.7865 | -2 | 3.6208 | -2 | 4.2568 | -2 | 4.6348 | -2 | 4.7072 | -2 |
| 4.5193 | -2 | 4.2437 | -2 | 3.8293 | -2 | 3.1218 | -2 | 1.9575 | -2 | 7.4057 | -3 |
| 1. | 1. | 0.93910. | 0.86330. | 0.79620. | 0.74040. | 0.69400. | 0.65500. | 0.62250. | 0.59630. | 0.57600. | 0.5620 |
| 38-12-06 | A-20 | 36.9 | 242.42 | | | | | | | | |
| 3.5757 | -2 | 5.3694 | -2 | 7.1338 | -2 | 8.8990 | -2 | 1.0635 | -1 | 1.2263 | -1 |
| 1.3632 | -1 | 1.4504 | -1 | 1.4587 | -1 | 1.3686 | -1 | 1.1631 | -1 | 7.7550 | -2 |
| 1. | 0.92590. | 0.83230. | 0.75770. | 0.70070. | 0.65670. | 0.62180. | 0.59380. | 0.57120. | 0.55330. | 0.53970. | 0.5300 |
| 39-03-18 | A-20 | 25.6 | 160.51 | | | | | | | | |
| 2.0458 | -2 | 3.2246 | -2 | 4.3289 | -2 | 5.3406 | -2 | 6.2166 | -2 | 6.8786 | -2 |
| 7.2181 | -2 | 7.1415 | -2 | 6.6948 | -2 | 6.0293 | -2 | 4.9601 | -2 | 3.2249 | -2 |
| 1. | 0.93660. | 0.84450. | 0.76800. | 0.70680. | 0.65740. | 0.61650. | 0.58230. | 0.55410. | 0.53120. | 0.51370. | 0.5016 |
| 39-12-11 | A-20 | 14.3 | 181.14 | | | | | | | | |
| 1.6483 | -2 | 2.5006 | -2 | 3.1494 | -2 | 3.5713 | -2 | 3.8206 | -2 | 4.0609 | -2 |
| 4.3118 | -2 | 4.5285 | -2 | 4.6236 | -2 | 4.4556 | -2 | 3.8248 | -2 | 2.5496 | -2 |
| 1. | 0.94110. | 0.85920. | 0.79160. | 0.73920. | 0.69830. | 0.66540. | 0.63790. | 0.61440. | 0.59420. | 0.57790. | 0.5663 |
| 40-01-16 | A-20 | 17.3 | 270.39 | | | | | | | | |
| 2.4757 | -2 | 3.6794 | -2 | 4.6872 | -2 | 5.4651 | -2 | 5.9960 | -2 | 6.3787 | -2 |
| 6.7835 | -2 | 7.1764 | -2 | 7.4122 | -2 | 7.2401 | -2 | 6.2951 | -2 | 4.2290 | -2 |
| 1. | 0.94350. | 0.86190. | 0.79520. | 0.74370. | 0.70380. | 0.67180. | 0.64510. | 0.62250. | 0.60370. | 0.58880. | 0.5781 |
| 40-02-11 | A-20 | 19.3 | 251.44 | | | | | | | | |
| 2.8975 | -2 | 4.5043 | -2 | 5.9045 | -2 | 7.0332 | -2 | 7.7996 | -2 | 8.1099 | -2 |
| 7.9702 | -2 | 7.6860 | -2 | 7.3320 | -2 | 6.7298 | -2 | 5.5824 | -2 | 3.6325 | -2 |
| 1. | 0.95090. | 0.86730. | 0.79600. | 0.73830. | 0.69110. | 0.65100. | 0.61640. | 0.58690. | 0.56270. | 0.54380. | 0.5306 |
| 40-03-01 | A-20 | 26.2 | 389.37 | | | | | | | | |
| 4.4077 | -2 | 6.6536 | -2 | 8.6778 | -2 | 1.0418 | -1 | 1.1748 | -1 | 1.2499 | -1 |
| 1.2542 | -1 | 1.2033 | -1 | 1.1306 | -1 | 1.0148 | -1 | 8.1944 | -2 | 5.2070 | -2 |
| 1. | 0.98520. | 0.91920. | 0.85750. | 0.80350. | 0.75760. | 0.71910. | 0.68730. | 0.66160. | 0.64150. | 0.62620. | 0.6156 |
| 40-04-01 | A-20 | 31.1 | 470.09 | | | | | | | | |
| 7.1801 | -2 | 1.0409 | -1 | 1.3328 | -1 | 1.6151 | -1 | 1.8763 | -1 | 2.0948 | -1 |
| 2.2407 | -1 | 2.2886 | -1 | 2.2530 | -1 | 2.1303 | -1 | 1.8248 | -1 | 1.2193 | -1 |
| 1. | 0.93450. | 0.84520. | 0.77310. | 0.71690. | 0.67240. | 0.63620. | 0.60660. | 0.58230. | 0.56270. | 0.54730. | 0.5361 |
| 40-05-01 | A-20 | 39.5 | 493.30 | | | | | | | | |
| 1.0492 | -1 | 1.5747 | -1 | 1.9856 | -1 | 2.3715 | -1 | 2.7546 | -1 | 3.1175 | -1 |
| 3.4123 | -1 | 3.5575 | -1 | 3.4460 | -1 | 3.0638 | -1 | 2.5342 | -1 | 1.6705 | -1 |
| 1. | 0.92320. | 0.82620. | 0.74780. | 0.68620. | 0.63770. | 0.59860. | 0.56630. | 0.53950. | 0.51780. | 0.49940. | 0.4663 |
| 40-06-01 | A-20 | 43.2 | 679.35 | | | | | | | | |
| 1.7379 | -1 | 2.6085 | -1 | 3.2524 | -1 | 3.7314 | -1 | 4.1867 | -1 | 4.6327 | -1 |
| 5.0120 | -1 | 5.2116 | -1 | 5.0646 | -1 | 4.4318 | -1 | 3.6092 | -1 | 2.3509 | -1 |
| 1. | 0.92930. | 0.83330. | 0.75380. | 0.69130. | 0.64250. | 0.60300. | 0.57010. | 0.54200. | 0.51800. | 0.49820. | 0.4836 |
| 40-07-01 | A-20 | 43.1 | 66. | | | | | | | | |
| 8.2527 | -3 | 1.2636 | -2 | 1.6313 | -2 | 1.9425 | -2 | 2.2198 | -2 | 2.4712 | -2 |
| 2.6838 | -2 | 2.8257 | -2 | 2.8479 | -2 | 2.6881 | -2 | 2.2759 | -2 | 1.5014 | -2 |
| 1. | 0.93100. | 0.83550. | 0.75590. | 0.69340. | 0.64470. | 0.60560. | 0.57290. | 0.54550. | 0.52150. | 0.50200. | 0.4876 |
| 40-09-13 | A-20 | 30.6 | 149.16 | | | | | | | | |
| 3.2007 | -2 | 4.6236 | -2 | 5.3742 | -2 | 5.9264 | -2 | 6.4671 | -2 | 6.9030 | -2 |
| 7.1037 | -2 | 6.9500 | -2 | 6.4128 | -2 | 5.6341 | -2 | 4.4998 | -2 | 2.8510 | -2 |
| 1. | 0.96850. | 0.89120. | 0.82070. | 0.76090. | 0.71180. | 0.67190. | 0.63900. | 0.61150. | 0.58810. | 0.56830. | 0.5533 |
| 40-10-01 | A-20 | 35.7 | 452.17 | | | | | | | | |
| 1.1480 | -1 | 1.6687 | -1 | 1.9515 | -1 | 2.1025 | -1 | 2.2552 | -1 | 2.3793 | -1 |
| 2.4262 | -1 | 2.3567 | -1 | 2.1738 | -1 | 1.9249 | -1 | 1.5527 | -1 | 9.9110 | -2 |
| 1. | 0.96370. | 0.88320. | 0.81130. | 0.75110. | 0.70170. | 0.66100. | 0.62720. | 0.59820. | 0.57310. | 0.55150. | 0.5351 |
| 40-11-01 | A-20 | 27.6 | 376.48 | | | | | | | | |
| 1.0005 | -1 | 1.5220 | -1 | 1.9129 | -1 | 2.1194 | -1 | 2.0850 | -1 | 1.8055 | -1 |
| 1.5012 | -1 | 1.2574 | -1 | 1.0976 | -1 | 9.2040 | -2 | 7.0613 | -2 | 4.3402 | -2 |
| 1. | 0.99830. | 0.93590. | 0.87270. | 0.81360. | 0.75920. | 0.70820. | 0.66010. | 0.61570. | 0.57950. | 0.54990. | 0.5288 |
| 40-12-01 | A-20 | 29.2 | 417.49 | | | | | | | | |
| 7.8392 | -2 | 1.1260 | -1 | 1.3224 | -1 | 1.5109 | -1 | 1.6847 | -1 | 1.8166 | -1 |
| 1.8748 | -1 | 1.8335 | -1 | 1.6989 | -1 | 1.5075 | -1 | 1.2164 | -1 | 7.7642 | -2 |
| 1. | 0.96500. | 0.88640. | 0.81580. | 0.75660. | 0.70790. | 0.66820. | 0.63570. | 0.60680. | 0.58650. | 0.56800. | 0.5539 |
| 41-01-06 | A-20 | 36.4 | 515.4 | | | | | | | | |
| 1.6712 | -1 | 2.4991 | -1 | 3.0431 | -1 | 3.2104 | -1 | 3.0290 | -1 | 2.8526 | -1 |
| 2.6321 | -1 | 2.3316 | -1 | 2.0306 | -1 | 1.7071 | -1 | 1.3100 | -1 | 8.0558 | -2 |
| 1. | 0.99620. | 0.93410. | 0.87140. | 0.81310. | 0.76060. | 0.71420. | 0.67350. | 0.63660. | 0.60370. | 0.57670. | 0.5573 |
| 41-02-06 | A-20 | 26.9 | 475.32 | | | | | | | | |
| 1.0205 | -1 | 1.5163 | -1 | 1.8549 | -1 | 2.0647 | -1 | 2.1975 | -1 | 2.2373 | -1 |
| 2.1404 | -1 | 1.8877 | -1 | 1.6665 | -1 | 1.4457 | -1 | 1.1497 | -1 | 7.2656 | -2 |
| 1. | 0.97480. | 0.90070. | 0.83160. | 0.77090. | 0.71770. | 0.67160. | 0.63230. | 0.59880. | 0.57020. | 0.54670. | 0.5294 |
| 41-03-15 | A-20 | 30.1 | 384.59 | | | | | | | | |
| 1.0080 | -1 | 1.4720 | -1 | 1.7233 | -1 | 1.7752 | -1 | 1.8276 | -1 | 1.8586 | -1 |
| 1.8271 | -1 | 1.7117 | -1 | 1.5472 | -1 | 1.3430 | -1 | 1.0603 | 01 | 6.6531 | -2 |
| 1. | 0.97940. | 0.90770. | 0.84000. | 0.78070. | 0.73030. | 0.68790. | 0.65200. | 0.62110. | 0.59350. | 0.56970. | 0.5519 |

Table 3.9-2 (Continued)

| | | |
|---------------|--|-----------|
| 41-04-01 A-20 | 38.3 | 641.22 |
| 1.9295 | -1 2.9128 | -1 3.6277 |
| 4.0650 | -1 3.7200 | -1 3.1388 |
| 1. | 0.97680.90020.82710.76150.70510.65730.61690.58120.54990.52420.5052 | 6.2613 |
| 41-05-01 A-20 | 44.6 | 210.20 |
| 6.8908 | -2 1.0474 | -1 1.3183 |
| 1.5396 | -1 1.4709 | -1 1.3295 |
| 1. | 0.96160.87500.79570.72900.67460.62910.58930.55360.52190.49580.4769 | 1.1000 |
| 41-09-21 A-20 | 23.4 | 188.02 |
| 2.5464 | -2 3.7765 | -2 4.6286 |
| 4.9421 | -2 4.3406 | -2 3.6150 |
| 1. | 0.97230.92120.86870.81820.77260.73340.70070.67410.65330.6387 | 2.8737 |
| 41-10-01 A-20 | 27.3 | 536.14 |
| 1.3922 | -1 2.1081 | -1 2.6314 |
| 2.0777 | -1 1.7386 | -1 1.4705 |
| 1. | 0.94880.88980.83250.77830.72660.67870.63620.60040.57200.5519 | 1.2110 |
| 41-11-01 A-20 | 39.5 | 555. |
| 1.6750 | -1 2.5291 | -1 3.1329 |
| 3.1475 | -1 3.0331 | -1 2.8002 |
| 1. | 0.96830.88680.81250.75020.69930.65670.61950.58550.55340.52700.5078 | 2.4206 |
| 41-12-01 A-20 | 31.1 | 447.12 |
| 1.0951 | -1 1.6600 | -1 2.0803 |
| 2.3228 | -1 2.1642 | -1 1.8889 |
| 1. | 0.97650.89880.82370.75750.70180.65530.61520.57970.54850.52290.5044 | 1.5415 |
| 42-01-05 A-20 | 19.7 | 598.30 |
| 1.1331 | -1 1.7366 | -1 2.2223 |
| 2.7985 | -1 2.4724 | -1 2.0378 |
| 1. | 0.99180.93190.86580.80080.74260.69330.65260.61910.59190.57080.5559 | 1.0901 |
| 42-02-01 A-20 | 19.2 | 18.49 |
| 3.7506 | -3 5.7277 | -3 7.3162 |
| 8.8568 | -3 7.7060 | -3 6.2386 |
| 1. | 0.99730.94080.87570.80980.74990.69880.65650.62170.59340.57130.5558 | 4.5650 |
| 42-04-01 A-20 | 21.6 | 613. |
| 5.1902 | -2 8.0004 | -2 1.0298 |
| 1.0588 | -1 9.8262 | -2 8.8580 |
| 1. | 0.97390.89340.81820.75390.70020.65380.61150.57300.53970.51310.4934 | 7.4770 |
| 42-05-01 A-20 | 35. | 336.19 |
| 9.4714 | -2 1.4305 | -1 1.7831 |
| 1.9806 | -1 1.8099 | -1 1.5272 |
| 1. | 0.97760.90200.82950.86430.70800.66050.61990.58420.55290.52730.5087 | 1.2695 |
| 42-05-23 A-20 | 40. | 216. |
| 6.9007 | -2 1.0386 | -1 1.2795 |
| 1.2628 | -1 1.1941 | -1 1.0771 |
| 1. | 0.97410.89690.82480.76300.71130.66780.63000.59530.56370.53730.5182 | 9.2823 |
| 42-06-01 A-20 | 35.7 | 494.27 |
| 1.4387 | -1 2.2021 | -1 2.7988 |
| 2.5789 | -1 2.2715 | -1 1.9483 |
| 1. | 0.99140.92300.85500.79250.73710.68810.64360.60350.56910.54170.5223 | 1.6183 |
| 42-08-29 A-20 | 9.9 | 49. |
| 4.2901 | -3 6.1716 | -3 7.8104 |
| 1.1035 | -2 1.0538 | -2 9.5615 |
| 1. | 0.99240.92460.85500.79320.74130.69890.66440.63640.61390.59640.5836 | 7.9579 |
| 42-09-01 A-20 | 37.8 | 710.30 |
| 2.4862 | -1 3.7501 | -1 4.6470 |
| 3.8295 | -1 3.2578 | -1 2.6028 |
| 1. | 0.98800.94610.80950.85170.80590.76330.72510.69320.66880.6522 | 1.9651 |
| 42-10-01 A-20 | 43.6 | 162.04 |
| 9.9070 | -2 1.4720 | -1 1.8312 |
| 2.2721 | -1 1.9975 | -1 1.7609 |
| 1. | 0.98550.92230.86020.80340.75230.70760.67020.63950.61460.59500.5809 | 1.5131 |
| 43-04-01 A-20 | 34.2 | 594.28 |
| 1.6187 | -1 2.4669 | -1 3.1206 |
| 3.4992 | -1 3.2436 | -1 2.8303 |
| 1. | 0.97780.90110.82650.76030.70460.65770.61720.58130.55030.52520.5071 | 2.2988 |
| 43-05-01 A-20 | 30.2 | 175.48 |
| 4.2119 | -2 6.3975 | -2 8.0443 |
| 9.1805 | -2 8.5934 | -2 7.5410 |
| 1. | 0.96590.88310.80670.74090.68590.63960.59940.56350.53180.50570.4868 | 6.3048 |
| 44-07-24 A-20 | 26.1 | 184.01 |
| 3.2062 | -2 4.8129 | -2 5.9844 |
| 8.2658 | -2 8.1358 | -2 7.5152 |
| 1. | 0.93540.84090.76160.69770.64570.60230.56490.53230.50400.48040.4630 | 2.9073 |
| 44-08-01 A-20 | 43.47 | 756.17 |
| 2.3060 | -1 3.5716 | -1 4.6435 |
| 5.5592 | -1 5.0817 | -1 4.4162 |
| 1. | 0.97410.89250.81360.74460.68680.63740.59400.55590.52360.49790.4797 | 3.5329 |

Table 3.9-3 Explanation of the Operation History Data

Example:

| | | | |
|---------------|---------------|--------------------|-------------------|
| [1st line] | | | |
| 38-10-11 A-20 | 5.9 | 235.05 | |
| | Assembly name | Reactor power (MW) | Running time (hr) |

Starting date of the irradiation

(year in "Showa"-month-day)

The 38th year of "Showa" corresponds to the year 1963
of the Christian Era.

[2nd and 3rd line]

| |
|---|
| 9.3751 -3 1.4643 -2 1.9305 -2 2.3158 -2 2.5914 -2 2.7136 -2 |
| 2.6164 -2 2.1963 -2 1.2395 -2 7.5166 -3 4.5572 -3 2.3081 -3 |

Node-wise burnup in 1,000 MWd/t unit.

The data are listed from Node Nos. 1 to 12.

[4th line]

| |
|--|
| 1. 1. 1. 0.9937 0.9566 0.9108 0.8673 0.8301 0.8002 |
| 0.7770 0.7601 0.7489 |

Node-wise value of (1.0-void fraction in coolant).

The data are listed from Node Nos. 12 to 1, in reverse order.

Table 3.9-4 Summary of Calculated and Non-destructively Measured Burnup and Pu Buildup on the JPDR-I Fuel Assemblies

| Ass'y Name | Pos. in *1 Core | Date of Load./Unload. (Year-Month) | Initial Wt of U (g) | FLARE Cal. | | NDA Assy's Averages *2 | | | | Estimated from NDA | | | | Reproc. Batch No. |
|------------|-----------------|------------------------------------|---------------------|----------------------|------------------------------|------------------------|-----------|--------------------------|--------------------------|--------------------|------------------------------|-----------|-------|-------------------|
| | | | | Integral BU (MWd/tU) | Pu/U *3 ($\times 10^{-3}$) | 137 (cps) | 134 (cps) | 134 ($\times 10^{-2}$) | 154 ($\times 10^{-3}$) | BU (%) | Pu/U *3 ($\times 10^{-3}$) | Pu *3 (g) | U (g) | |
| A74 | 1 | 63-9 / 64-1 | 58048 | 133 | 0.072 | 20.0 | - | - | - | 0.011 | - | - | 58042 | JP- |
| A75 | 1 | 63-9 / 64-1 | 57999 | 110 | 0.060 | 18.3 | - | - | - | 0.010 | - | - | 57993 | 001 |
| A16 | 5 | 63-9 / 65-9 | 58155 | 1282 | 0.690 | 214.1 | 0.52 | 0.225 | 0.52 | 0.113 | 0.32 | 19 | 58070 | |
| A59 | 5 | 63-9 / 65-9 | 58117 | 1240 | 0.760 | 260.6 | 1.03 | 0.363 | 0.56 | 0.138 | 0.51 | 30 | 58007 | |
| | 10 | 69-6 / 69-9 | 1469 | | | | | | | | | | | |
| A72 | 6 | 66-8 / 67-7 | 58049 | 1274 | 0.744 | 313.1 | 1.83 | 0.539 | 0.84 | 0.166 | 0.74 | 43 | 57910 | 002 |
| | 6 | 68-1 / 69-6 | 1567 | | | | | | | | | | | |
| A76 | 9 | 64-1 / 65-9 | 56364 | 802 | 0.553 | 200.4 | 0.79 | 0.366 | 0.57 | 0.106 | 0.51 | 29 | 56275 | |
| | 4 | 68-1 / 69-6 | 1130 | | | | | | | | | | | |
| A50 | 10 | 63-1 / 69-9 | 58061 | 2526 | 1.083 | 586.2 | 5.24 | 0.785 | 1.19 | 0.310 | 1.06 | 61 | 57820 | |
| A62 | 10 | " | 58116 | 2660 | 1.140 | 651.7 | 5.86 | 0.800 | 1.17 | 0.345 | 1.08 | 62 | 57853 | JP- |
| A30 | 10 | " | 57976 | 2784 | 1.187 | 619.7 | 5.81 | 0.831 | 1.17 | 0.328 | 1.11 | 65 | 57721 | 003 |
| A55 | 9 | " | 57997 | 3433 | 1.514 | 670.6 | 8.03 | 1.084 | 1.53 | 0.355 | 1.42 | 82 | 57709 | |
| A61 | 11 | 63-9 / 69-9 | 57970 | 2769 | 1.144 | 650.0 | 6.75 | 0.903 | 1.30 | 0.344 | 1.20 | 70 | 57701 | |
| A66 | 11 | " | 57985 | 2872 | 1.185 | 678.0 | 7.38 | 0.956 | 1.42 | 0.359 | 1.27 | 73 | 57704 | JP- |
| A 4 | 11 | " | 58166 | 3231 | 1.334 | 693.1 | 8.15 | 1.047 | 1.45 | 0.367 | 1.37 | 80 | 57873 | 004 |
| A 3 | 11 | " | 57933 | 3249 | 1.336 | 741.2 | 8.72 | 1.051 | 1.45 | 0.392 | 1.38 | 80 | 57626 | |
| A44 | 10 | 63-9 / 69-6 | 57888 | 2460 | 1.060 | 580.5 | 3.99 | 0.609 | 1.04 | 0.307 | 0.83 | 48 | 57662 | |
| A27 | 9 | 63-9 / 64-1 | 58015 | 104 | 1.350 | 626.2 | 7.08 | 1.040 | 1.31 | 0.331 | 1.37 | 79 | 57444 | |
| | 9 | 65-9 / 69-9 | 2957 | | | | | | | | | | | |
| A39 | 9 | 63-9 / 68-1 | 57861 | 3379 | 1.513 | 681.9 | 6.18 | 0.834 | 1.34 | 0.361 | 1.12 | 65 | 57588 | 005 |
| T1-1 | 5 | 65-9 / 68-1 | 58494 | 3175 | 1.792 | 743.3 | 12.25 | 1.477 | 1.92 | 0.393 | 1.86 | 109 | 58155 | |
| | 1 | 68-1 / 69-9 | 3811 | | | | | | | | | | | |
| A46 | 11 | 63-9 / 69-9 | 58058 | 3181 | 1.313 | 823.7 | 9.56 | 1.036 | 1.49 | 0.436 | 1.36 | 79 | 57726 | |
| A71 | 11 | " | 58041 | 3188 | 1.315 | 743.9 | 8.44 | 1.013 | 1.38 | 0.394 | 1.33 | 77 | 57735 | 006 |
| A21 | 11 | " | 57977 | 3223 | 1.326 | 755.3 | 8.88 | 1.047 | 1.47 | 0.400 | 1.37 | 80 | 57666 | |
| A73 | 9 | 63-9 / 69-9 | 58080 | 3643 | 1.608 | 817.9 | 10.82 | 1.213 | 1.68 | 0.433 | 1.57 | 91 | 57738 | |
| A35 | 9 | " | 57870 | 3769 | 1.659 | 782.1 | 10.06 | 1.183 | 1.62 | 0.414 | 1.53 | 89 | 57542 | JP- |
| A54 | 9 | " | 58330 | 3789 | 1.679 | 831.6 | 11.19 | 1.240 | 1.72 | 0.440 | 1.60 | 93 | 57980 | 007 |
| A24 | 9 | " | 58108 | 3898 | 1.718 | 826.3 | 11.06 | 1.235 | 1.71 | 0.437 | 1.59 | 92 | 57761 | |
| A47 | 1 | 63-9 / 66-8 | 57998 | 4252 | 1.878 | 855.7 | 17.44 | 1.679 | 2.26 | 0.453 | 2.07 | 120 | 57615 | |
| | 1 | 66-8 / 69-9 | | | | | | | | | | | | |
| A63 | 1 | 63-9 / 69-9 | 58073 | 4328 | 1.952 | 886.7 | 18.43 | 1.708 | 2.31 | 0.469 | 2.10 | 122 | 57679 | |
| A51 | 2 | " | 58004 | 4424 | 1.958 | 864.5 | 17.69 | 1.746 | 2.30 | 0.458 | 2.14 | 124 | 57615 | |
| A 9 | 2 | " | 58006 | 4505 | 2.008 | 867.0 | 17.59 | 1.764 | 2.33 | 0.459 | 2.16 | 125 | 57674 | |
| A11 | 8 | 63-9 / 69-9 | 58095 | 3831 | 1.650 | 848.6 | 12.87 | 1.328 | 1.86 | 0.449 | 1.70 | 98 | 57736 | |
| A29 | 8 | " | 58208 | 4390 | 1.893 | 971.2 | 15.80 | 1.475 | 2.04 | 0.514 | 1.86 | 108 | 57801 | JP- |
| A37 | 8 | " | 57918 | 4569 | 1.960 | 977.9 | 15.94 | 1.482 | 2.02 | 0.518 | 1.86 | 108 | 57510 | 009 |
| A34 | 8 | " | 57851 | 4599 | 1.971 | 964.1 | 16.17 | 1.533 | 1.99 | 0.510 | 1.92 | 111 | 57445 | |
| A65 | 2 | 63-9 / 69-9 | 58039 | 4611 | 2.047 | 952.6 | 20.17 | 1.839 | 2.36 | 0.504 | 2.23 | 129 | 57617 | |
| A 2 | 2 | " | 57934 | 4616 | 2.050 | 887.7 | 18.04 | 1.769 | 2.40 | 0.470 | 2.16 | 125 | 57537 | JP- |
| A10 | 2 | " | 58067 | 4625 | 2.074 | 938.8 | 20.05 | 1.838 | 2.37 | 0.497 | 2.23 | 129 | 57649 | 010 |
| A60 | 2 | " | 58035 | 4633 | 2.090 | 913.3 | 19.34 | 1.837 | 2.29 | 0.483 | 2.23 | 129 | 57625 | |
| A32 | 7 | 63-9 / 69-9 | 58168 | 4208 | 1.801 | 932.2 | 15.41 | 1.459 | 2.04 | 0.493 | 1.84 | 107 | 57774 | |
| A33 | 7 | " | 57821 | 4616 | 1.960 | 1008.5 | 18.21 | 1.643 | 2.20 | 0.534 | 2.03 | 117 | 57395 | JP- |
| A15 | 7 | " | 57937 | 5045 | 2.161 | 1051.2 | 19.41 | 1.697 | 2.30 | 0.556 | 2.09 | 121 | 57494 | 011 |
| A48 | 4 | " | 57933 | 4815 | 2.122 | 1053.8 | 21.30 | 1.782 | 2.32 | 0.558 | 2.18 | 126 | 57484 | |
| A64 | 6 | 63-9 / 69-9 | 58093 | 4619 | 2.101 | 942.1 | 16.87 | 1.647 | 2.22 | 0.499 | 2.04 | 118 | 57685 | |
| A 6 | 5 | " | 58133 | 4649 | 2.067 | 977.3 | 18.48 | 1.681 | 2.16 | 0.517 | 2.07 | 120 | 57112 | JP- |
| A28 | 6 | " | 58096 | 4856 | 2.209 | 966.4 | 16.88 | 1.615 | 2.18 | 0.512 | 2.00 | 116 | 57682 | 012 |
| A45 | 6 | " | 58221 | 5074 | 2.306 | 972.3 | 17.61 | 1.679 | 2.33 | 0.515 | 2.07 | 120 | 57801 | |

Table 3.9-4 (Continued)

| Ass'y Name | Pos. in*1 Core | Date of Load./Unload. (Year-Month) | Initial Wt of U (g) | FLARE Cal. | | NDA Assy's Averages *2 | | | | Estimated from NDA | | | | Reproc. Batch No. |
|---------------|----------------------|--|---------------------------|--|--------------------------------|------------------------|--------------|-----------------------------|-----------------------------|--------------------|--------------------------------|-------------|----------|-------------------------|
| | | | | Integral BU (Mwd/tU) (x10 ⁻³) | Pu/U*3 (x10 ⁻³) | 137 (cps) | 134 (cps) | 134 (x10 ⁻²) | 154 (x10 ⁻³) | BU (%) | Pu/U*3 (x10 ⁻³) | Pu*3 (g) | U (g) | |
| A42 | 7 | 63-9 / 69-9 | 57819 | 5085 | 2.159 | 1035.1 | 19.93 | 1.772 | 2.43 | 0.548 | 2.17 | 125 | 57377 | |
| A22 | 7 | " | 57986 | 5133 | 2.180 | 1059.3 | 19.45 | 1.691 | 2.55 | 0.561 | 2.08 | 120 | 57540 | JP- |
| A41 | 7 | " | 58029 | 5109 | 2.180 | 1052.0 | 19.40 | 1.699 | 2.33 | 0.557 | 2.09 | 121 | 57585 | 013 |
| A43 | 7 | " | 57875 | 5154 | 2.184 | 1048.3 | 19.52 | 1.711 | 2.36 | 0.555 | 2.10 | 121 | 57432 | |
| A13 | 5 | 63-9 / 69-9 | 57953 | 5314 | 2.367 | 1078.7 | 20.85 | 1.781 | 2.45 | 0.571 | 2.18 | 126 | 57496 | |
| A12 | 5 | " | 57982 | 5403 | 2.414 | 1067.9 | 21.43 | 1.849 | 2.54 | 0.565 | 2.24 | 130 | 57524 | JP- |
| A57 | 5 | " | 58140 | 5418 | 2.426 | 1045.8 | 20.47 | 1.801 | 2.54 | 0.554 | 2.20 | 127 | 57691 | 014 |
| A31 | 5 | " | 58132 | 5173 | 2.307 | 1047.0 | 20.37 | 1.777 | 2.46 | 0.554 | 2.17 | 126 | 57684 | |
| A23 | 5 | 63-9 / 69-9 | 58096 | 5486 | 2.442 | 1077.5 | 21.70 | 1.857 | 2.56 | 0.570 | 2.25 | 130 | 57634 | |
| A67 | 4 | " | 57922 | 5519 | 2.451 | 1069.8 | 22.04 | 1.892 | 2.75 | 0.566 | 2.29 | 132 | 57462 | JP- |
| A26 | 4 | " | 57993 | 5639 | 2.500 | 1105.4 | 23.43 | 1.951 | 2.71 | 0.585 | 2.34 | 135 | 57518 | 015 |
| A40 | 4 | " | 58043 | 5641 | 2.500 | 1175.7 | 25.98 | 2.030 | 2.74 | 0.622 | 2.42 | 140 | 57541 | |
| A56 | 3 | 63-9 / 69-9 | 57806 | 4604 | 2.049 | 961.3 | 18.14 | 1.660 | 2.13 | 0.509 | 2.05 | 118 | 57393 | |
| A53 | 3 | " | 58315 | 4600 | 2.073 | 921.2 | 18.39 | 1.711 | 2.37 | 0.488 | 2.10 | 122 | 57908 | JP- |
| A 7 | 3 | " | 58141 | 4804 | 2.180 | 911.8 | 18.45 | 1.791 | 2.49 | 0.483 | 2.19 | 127 | 57733 | 016 |
| A69 | 3 | " | 57861 | 4786 | 2.130 | 927.4 | 18.58 | 1.777 | 2.46 | 0.491 | 2.17 | 125 | 57451 | |
| A25 | 8 | 63-9 / 69-9 | 57804 | 4628 | 1.986 | 987.8 | 16.66 | 1.539 | 2.13 | 0.523 | 1.92 | 111 | 57391 | |
| A19 | 8 | " | 58147 | 4655 | 2.007 | 952.0 | 14.95 | 1.434 | 1.91 | 0.504 | 1.81 | 105 | 57749 | JP- |
| A49 | 8 | " | 57964 | 4736 | 2.025 | 959.4 | 15.82 | 1.501 | 2.04 | 0.508 | 1.88 | 109 | 57561 | 017 |
| A70 | 8 | " | 57801 | 4765 | 2.032 | 1014.3 | 17.81 | 1.604 | 2.12 | 0.537 | 1.99 | 115 | 57376 | |
| A68 | 6 | 63-9 / 66-8 | 57811 | 2587 | | | | | | | | | | |
| | 1 | 67-3 / 67-7 | | 2880 | 1.852 | 831.9 | 11.93 | 1.323 | 1.69 | 0.440 | 1.69 | 97 | 57459 | |
| | 1 | 67-7 / 68-1 | | 3453 | | | | | | | | | | |
| | 6 | 69-6 / 69-9 | | 3888 | | | | | | | | | | JP- |
| A 5 | 4 | 63-9 / 67-7 | 58098 | 3818 | | | | | | | | | | |
| | 6 | 67-7 / 68-1 | | 4392 | 2.204 | 969.5 | 18.04 | 1.691 | 2.47 | 0.513 | 2.08 | 121 | 57679 | 018 |
| | 4 | 69-6 / 69-9 | | 4882 | | | | | | | | | | |
| A36 | 4 | 63-9 / 68-1 | 57917 | 4822 | 2.377 | 1048.4 | 19.50 | 1.719 | 2.35 | 0.555 | 2.11 | 122 | 57473 | |
| A52 | 2 | 63-9 / 69-9 | 58282 | 4427 | 1.981 | 916.7 | 18.80 | 1.739 | 2.26 | 0.485 | 2.13 | 124 | 57875 | |
| | 11 | " | 57878 | 3224 | 1.332 | 827.9 | 10.05 | 1.085 | 1.59 | 0.438 | 1.42 | 82 | 57542 | JP-019 |
| A 1 | 2 | " | 57820 | 4680 | 2.101 | 927.2 | 20.01 | 1.880 | 2.45 | 0.491 | 2.27 | 131 | 57405 | |
| A 8 | 4 | 63-9 / 69-9 | 58150 | 5551 | 2.478 | 1098.2 | 23.41 | 1.961 | 2.70 | 0.581 | 2.35 | 136 | 57675 | - |
| A20 | 4 | 63-9 / 69-9 | 58067 | 5573 | 2.475 | - | - | - | - | - | - | - | - | - |

*1 Position No. in Fig. 3.9-2 *2 As of June 1, 1977. *3 As of Mar. 1, 1973.
 Symbols of 137, 134, 134/137, 154/137, Pu/U, Pu and U represent γ-ray intensities of ¹³⁷Cs and ¹³⁴Cs, intensity ratios of ¹³⁴Cs/¹³⁷Cs and ¹³⁴Eu/¹³⁷Cs, atom ratio of Pu/U, and final weights of Pu and U, respectively.
 The burnup in FIMA(%) can be converted to that in Mwd/tU with a conversion factor 9,500 Mwd/tU/%, which corresponds to the fission energy of 200 MeV.

Table 3.9-5 Gamma-ray Activities of F.P. Determined by Destructive
 γ -ray Spectrometry (γ dps/U atom, on June 1, 1972)

| Gamma-ray | | KC-1333 (Lower) | | | | | | KA-1040 (Upper) | | | |
|-----------|------|-----------------|----------|----------|----------|----------|----------|-----------------|----------|----------|----------|
| Nuclide | keV | 660 | 538 | 415 | 293 | 171 mm | 171 | 293 | 415 | 538 | 660 mm |
| Rh-106 | 512 | 2.380-15 | 5.141-15 | 7.498-15 | 9.522-15 | 1.049-14 | 1.157-14 | 1.123-14 | 9.008-15 | 6.696-15 | 3.702-15 |
| Cs-134 | 563 | 1.990-16 | 6.780-16 | 1.155-15 | 1.593-15 | 1.813-15 | 2.033-15 | 1.878-15 | 1.446-15 | 9.430-16 | 3.796-16 |
| Cs-134 | 569 | 3.741-16 | 1.240-15 | 2.158-15 | 2.960-15 | 3.372-15 | 3.702-15 | 3.531-15 | 2.714-15 | 1.731-15 | 6.812-16 |
| Cs-134 | 605 | 2.533-15 | 8.070-15 | 1.410-14 | 1.905-14 | 2.152-14 | 2.415-14 | 2.277-14 | 1.738-14 | 1.109-14 | 4.465-15 |
| Rh-106 | 622 | 1.166-15 | 2.499-15 | 3.631-15 | 4.613-15 | 5.130-15 | 5.533-15 | 5.427-15 | 4.432-15 | 3.268-15 | 1.795-15 |
| Cs-137 | 662 | 7.597-14 | 1.337-13 | 1.757-13 | 2.016-13 | 2.106-13 | 2.155-13 | 2.095-13 | 1.790-13 | 1.433-13 | 9.233-14 |
| Pr-144 | 696 | 5.662-16 | 9.580-16 | 1.254-15 | 1.453-15 | 1.587-15 | 1.687-15 | 1.673-15 | 1.398-15 | 1.134-15 | 7.899-16 |
| Cs-134 | 796 | 2.236-15 | 7.079-15 | 1.238-14 | 1.674-14 | 1.889-14 | 2.139-14 | 2.013-14 | 1.538-14 | 9.752-15 | 3.896-15 |
| Cs-134 | 802 | 2.282-16 | 7.236-16 | 1.253-15 | 1.695-15 | 1.916-15 | 2.180-15 | 2.028-15 | 1.537-15 | 9.823-16 | 4.007-16 |
| Eu-154 | *873 | 7.092-17 | 1.929-16 | 3.048-16 | 3.984-16 | 4.373-16 | 5.153-16 | 4.874-16 | 3.765-16 | 2.473-16 | 1.188-16 |
| Eu-154 | 996 | 2.689-17 | 8.958-17 | 1.654-16 | 2.083-16 | 2.218-16 | 2.761-16 | 2.457-16 | 1.934-16 | 1.211-16 | 4.444-17 |
| Eu-154 | 1005 | 4.690-17 | 1.502-16 | 2.630-16 | 3.602-16 | 4.121-16 | 4.679-16 | 4.408-16 | 3.265-16 | 2.160-16 | 7.463-17 |
| Cs-134 | 1038 | 2.279-17 | 8.482-17 | 1.500-16 | 2.039-16 | 2.355-16 | 2.482-16 | 2.440-16 | 1.992-16 | 1.075-16 | 4.465-17 |
| Rh-106 | 1050 | 1.771-16 | 3.612-16 | 5.581-16 | 6.858-16 | 7.518-16 | 8.289-16 | 8.247-16 | 6.910-16 | 4.877-16 | 2.740-16 |
| Cs-134 | 1169 | 5.288-17 | 1.565-16 | 2.748-16 | 3.769-16 | 3.966-16 | 4.504-16 | 4.291-16 | 3.307-16 | 2.052-16 | 8.000-17 |
| Co-60 | 1173 | 4.764-17 | 7.652-17 | 1.059-16 | 1.308-16 | 1.315-16 | 1.068-16 | 1.055-16 | 1.003-16 | 7.300-17 | 4.562-17 |
| Eu-154 | 1275 | 9.247-17 | 2.920-16 | 5.240-16 | 6.986-16 | 7.940-16 | 9.107-16 | 8.448-16 | 6.468-16 | 4.012-17 | 1.546-16 |
| Co-60 | 1333 | 4.506-17 | 8.579-17 | 1.023-16 | 1.244-16 | 1.337-16 | 1.078-16 | 9.249-17 | 0.991-17 | 7.304-17 | 4.818-17 |
| Cs-134 | 1365 | 6.135-17 | 2.539-16 | 4.442-16 | 6.095-16 | 6.851-16 | 7.582-16 | 6.969-16 | 5.451-16 | 3.362-16 | 1.335-16 |
| Burnup | (%) | 0.23 | 0.40 | 0.52 | 0.59 | 0.62 | 0.63 | 0.62 | 0.53 | 0.42 | 0.27 |

*: Complex photopeak with Rh-106

Table 3.9-6 Gamma-ray Activities of F.P. at Planes of +415mm and -415mm by Destructive γ -ray Spectrometry
(γ dps/U atom, on June 1, 1972)

| Nuclide | keV | KA-0376 | KA-0374 | KA-0389 | KA-1094 | KA-1094 | KA-0400 | KA-0343 | KA-1063 |
|---------|------|----------|----------|----------|----------|----------|----------|----------|----------|
| U-Xray | 98 | 6.283-16 | 6.069-16 | 6.660-16 | 5.886-16 | 4.119-16 | 4.650-16 | 7.058-16 | 6.086-16 |
| Eu-155 | 105 | 1.038-15 | 9.461-16 | 9.732-16 | 8.865-16 | 8.964-16 | 1.067-15 | 8.670-16 | 8.403-16 |
| Eu-154 | 123 | 1.179-15 | 1.021-15 | 1.122-15 | 9.569-16 | 9.322-16 | 1.267-15 | 8.380-16 | 8.819-16 |
| Ce-144 | 134 | 1.754-14 | 1.590-14 | 1.673-14 | 1.523-14 | 1.517-14 | 1.852-14 | 1.390-14 | 1.459-14 |
| Sb-125 | 428 | 1.889-15 | 1.593-15 | 1.744-15 | 1.511-15 | 1.581-15 | 1.915-15 | 1.434-15 | 1.532-15 |
| Rh-106 | 512 | 1.284-14 | 1.140-14 | 1.267-14 | 1.081-14 | 1.067-14 | 1.364-14 | 9.989-15 | 1.027-14 |
| Cs-134 | 563 | 2.321-15 | 2.033-15 | 2.272-15 | 1.869-15 | 1.843-15 | 2.471-15 | 1.676-15 | 1.762-15 |
| Cs-134 | 569 | 4.352-15 | 3.723-15 | 4.142-15 | 3.420-15 | 3.419-15 | 4.580-15 | 3.075-15 | 3.251-15 |
| Cs-134 | 605 | 2.756-14 | 2.369-14 | 2.653-14 | 2.214-14 | 2.203-14 | 2.933-14 | 1.986-14 | 2.047-14 |
| Rh-106 | 622 | 6.249-15 | 5.525-15 | 6.143-15 | 5.327-15 | 5.143-15 | 6.645-15 | 4.893-15 | 4.940-15 |
| Cs-137 | 662 | 2.510-13 | 2.238-13 | 2.325-13 | 2.083-13 | 2.072-13 | 2.513-13 | 1.993-13 | 2.004-13 |
| Pr-144 | 696 | 1.921-15 | 1.795-15 | 1.889-15 | 1.644-15 | 1.687-15 | 2.033-15 | 1.574-15 | 1.645-15 |
| Eu-154 | 723 | 6.002-16 | 4.963-16 | 5.361-16 | 4.544-16 | 4.315-16 | 5.827-16 | 4.199-16 | 3.938-16 |
| Cs-134 | 796 | 2.456-14 | 2.102-14 | 2.353-14 | 1.958-14 | 1.954-14 | 2.608-14 | 1.764-14 | 1.820-14 |
| Cs-134 | 802 | 2.504-15 | 2.128-15 | 2.412-15 | 1.989-15 | 1.996-15 | 2.640-15 | 1.795-15 | 1.854-15 |
| Eu-154 | 873 | 4.974-16 | 4.505-16 | 4.969-16 | 4.128-16 | 4.168-16 | 5.579-16 | 3.978-16 | 4.144-16 |
| Eu-154 | 996 | 2.977-16 | 2.391-16 | 2.777-16 | 2.274-16 | 2.479-16 | 3.008-16 | 2.127-16 | 2.232-16 |
| Eu-154 | 1005 | 5.125-16 | 4.370-16 | 4.921-16 | 4.115-16 | 4.111-16 | 5.351-16 | 3.647-16 | 3.767-16 |
| Cs-134 | 1038 | 2.929-16 | 2.467-16 | 2.724-16 | 2.272-16 | 2.339-16 | 2.928-16 | 2.041-16 | 2.095-16 |
| Rh-106 | 1050 | 9.364-16 | 8.549-16 | 8.969-16 | 8.039-16 | 7.763-16 | 1.006-15 | 7.519-16 | 7.493-16 |
| Ch-134 | 1169 | 5.154-16 | 4.375-16 | 5.052-16 | 4.393-16 | 4.044-16 | 5.497-16 | 3.892-16 | 3.938-16 |
| Eu-154 | 1275 | 9.714-16 | 8.537-16 | 9.194-16 | 7.824-16 | 7.650-16 | 1.028-15 | 7.382-16 | 7.132-16 |
| Cs-134 | 1365 | 8.947-16 | 7.337-16 | 8.298-16 | 6.862-16 | 6.732-16 | 9.391-16 | 6.345-16 | 6.451-16 |
| Pr-144 | 1488 | 3.954-16 | 3.606-16 | 3.753-16 | 3.486-16 | 3.329-16 | 4.065-16 | 3.278-16 | 2.878-16 |
| Burnup | (%) | 0.74 | 0.66 | 0.68 | 0.61 | 0.61 | 0.74 | 0.59 | 0.59 |

| Nuclide | keV | KC-1295 | KC-1301 | KC-1352 | KC-1334* | KC-1304 | KC-1293 | KC-1290 |
|---------|------|----------|----------|----------|----------|----------|----------|----------|
| U-Xray | 98 | 5.799-16 | 4.597-16 | 4.146-16 | 6.485-16 | 5.438-16 | 6.537-16 | 5.639-16 |
| Eu-155 | 105 | 7.263-16 | 8.041-16 | 8.199-16 | 9.851-16 | 7.947-16 | 9.545-16 | 8.684-16 |
| Eu-154 | 123 | 5.553-15 | 6.659-16 | 7.022-16 | 9.749-16 | 6.675-16 | 9.020-16 | 8.439-16 |
| Ce-144 | 134 | 1.129-14 | 1.239-14 | 1.255-14 | 1.542-14 | 1.231-14 | 1.495-14 | 1.403-14 |
| Sb-125 | 428 | 1.142-15 | 1.277-15 | 1.321-15 | 1.658-15 | 1.262-15 | 1.701-15 | 1.515-15 |
| Rh-106 | 512 | 7.133-15 | 8.127-15 | 8.384-15 | 1.076-14 | 8.140-15 | 1.026-14 | 9.517-15 |
| Cs-134 | 563 | 1.125-15 | 1.269-15 | 1.363-15 | 1.898-15 | 1.266-15 | 1.762-15 | 1.685-15 |
| Cs-134 | 569 | 2.070-15 | 2.355-15 | 2.479-15 | 3.568-15 | 2.396-15 | 3.269-15 | 2.908-15 |
| Cs-134 | 605 | 1.330-14 | 1.522-14 | 1.576-14 | 2.253-14 | 1.550-14 | 2.113-14 | 1.891-14 |
| Rh-106 | 622 | 3.486-15 | 3.926-15 | 3.978-15 | 5.206-15 | 3.951-15 | 5.023-15 | 4.628-15 |
| Cs-137 | 662 | 1.744-13 | 1.892-13 | 1.914-13 | 2.321-13 | 1.913-13 | 2.362-13 | 2.173-13 |
| Pr-144 | 696 | 1.252-15 | 1.339-15 | 1.402-15 | 1.722-15 | 1.381-15 | 1.711-15 | 1.618-15 |
| Eu-154 | 723 | 2.808-16 | 3.112-16 | 3.352-16 | 4.698-16 | 3.180-16 | 4.462-16 | 4.087-16 |
| Cs-134 | 796 | 1.176-14 | 1.352-14 | 1.407-14 | 2.001-14 | 1.382-14 | 1.885-14 | 1.676-14 |
| Cs-134 | 802 | 1.214-15 | 1.385-15 | 1.420-15 | 2.018-15 | 1.396-15 | 1.896-15 | 1.721-15 |
| Eu-154 | 873 | 2.654-16 | 3.060-16 | 3.207-16 | 4.287-16 | 3.049-16 | 4.094-16 | 3.763-16 |
| Eu-154 | 996 | 1.397-16 | 1.593-16 | 1.632-16 | 2.459-16 | 1.715-16 | 2.373-16 | 2.105-16 |
| Eu-154 | 1005 | 2.410-16 | 2.906-16 | 2.989-16 | 4.222-16 | 2.846-16 | 4.054-16 | 3.548-16 |
| Cs-134 | 1038 | 1.376-16 | 1.559-16 | 1.686-16 | 2.205-16 | 1.627-16 | 2.247-16 | 2.034-16 |
| Rh-106 | 1050 | 5.397-16 | 5.714-16 | 5.994-16 | 7.912-16 | 5.979-16 | 7.239-16 | 6.908-16 |
| Cs-134 | 1169 | 2.569-16 | 2.829-16 | 3.067-16 | 4.236-16 | 2.761-16 | 3.864-16 | 3.618-16 |
| Eu-154 | 1275 | 4.790-16 | 5.546-16 | 5.860-16 | 8.040-16 | 5.634-16 | 7.932-16 | 6.985-16 |
| Cs-134 | 1365 | 4.202-16 | 4.801-16 | 5.032-16 | 7.114-16 | 4.808-16 | 6.972-16 | 5.874-16 |
| Pr-144 | 1488 | 2.499-16 | 2.571-16 | 2.676-16 | 3.136-16 | 2.713-16 | 3.479-16 | 2.961-16 |
| Burnup | (%) | 0.51 | 0.56 | 0.56 | 0.68 | 0.56 | 0.70 | 0.64 |

*: Taken of -293 plane

Table 3.9-7 Atomic Ratios of Fission-product Nuclides to Final U Atoms on June 1, 1972

| Nuclide | ^{106}Ru | ^{134}Cs | ^{137}Cs | ^{144}Ce | ^{154}Eu | ^{155}Eu |
|-------------------------------|-------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| Half-life | 368d | 2.06y | 30.1y | 284.8d | 8.5y | 4.96y |
| $E\gamma$ (keV) | 622 | 796 | 662 | 696 | 1275 | 105 |
| $\gamma\text{s}/\text{decay}$ | 0.0985 | 0.8508 | 0.852 | 0.015 | 0.336 | 0.20 |
| Assembly | Position of measurement | | | | | |
| A-20 | KA-0376 +415 | 2.910-6 | 2.707-6 | 4.037-4 | 4.546-6 | 1.119-6 |
| | KC-1293 -415 | 2.339-6 | 2.078-6 | 3.799-4 | 4.049-6 | 9.136-7 |
| | KA-0374 +415 | 2.573-6 | 2.317-6 | 3.600-4 | 4.248-6 | 9.832-7 |
| | KC-1290 -415 | 2.155-6 | 1.848-6 | 3.495-4 | 3.829-6 | 8.045-7 |
| | KA-0400 +415 | 3.094-6 | 2.875-6 | 4.042-4 | 4.811-6 | 1.184-6 |
| | KC-1334 -293 | 2.424-6 | 2.206-6 | 3.733-4 | 4.075-6 | 9.260-7 |
| | KA-1063 +415 | 2.301-6 | 2.006-6 | 3.223-4 | 3.893-6 | 8.214-7 |
| | KC-1301 -415 | 1.828-6 | 1.493-6 | 3.043-4 | 3.169-6 | 6.388-7 |
| | KA-1040 +660 | 8.359-7 | 4.294-7 | 1.485-4 | 1.869-6 | 1.781-7 |
| | +538 | 1.522-6 | 1.075-6 | 2.305-4 | 2.684-6 | 4.621-7 |
| | +415 | 2.064-6 | 1.695-6 | 2.879-4 | 3.309-6 | 7.450-7 |
| | +293 | 2.527-6 | 2.219-6 | 3.370-4 | 3.959-6 | 9.730-7 |
| | +171 | 2.577-6 | 2.358-6 | 3.466-4 | 3.993-6 | 1.049-6 |
| | KC-1333 -171 | 2.389-6 | 2.082-6 | 3.387-4 | 3.756-6 | 9.145-7 |
| | -293 | 2.148-6 | 1.845-6 | 3.243-4 | 3.439-6 | 8.046-7 |
| | -415 | 1.691-6 | 1.364-6 | 2.826-4 | 2.968-6 | 6.035-7 |
| | -538 | 1.164-6 | 7.804-7 | 2.150-4 | 2.267-6 | 3.363-7 |
| | -660 | 5.430-7 | 2.464-7 | 1.222-4 | 1.340-6 | 1.065-7 |
| | KA-1094 +415 | 2.438-6 | 2.156-6 | 3.342-4 | 3.942-6 | 8.911-7 |
| | KC-1295 -415 | 1.623-6 | 1.296-6 | 2.805-4 | 2.963-6 | 5.517-7 |
| | KA-0343 +415 | 2.279-6 | 1.944-6 | 3.206-4 | 3.725-6 | 8.502-7 |
| | KC-1352 -415 | 1.853-6 | 1.551-6 | 3.079-4 | 3.318-6 | 6.749-7 |
| | KA-0389 +415 | 2.861-6 | 2.594-6 | 3.740-4 | 4.471-6 | 1.059-6 |
| | KC-1304 -415 | 1.840-6 | 1.523-6 | 3.077-4 | 3.268-6 | 6.489-7 |
| A-18 | +538 | | | 1.679-4 | | |
| | + 49 | | | 2.659-4 | | |
| | -293 | | | 1.845-4 | | |
| A-14 | +538 | | | 2.134-4 | | |
| | + 49 | | | 3.402-4 | | |
| | -293 | | | 2.612-4 | | |

Table 3.9-8 Content and Isotopic Composition of U

| Assembly | Position of measurement | Atom percent | | | | Total U ×10 ²² atoms | Atom ratio of Pu/U × 10 ⁻³ |
|---------------------|-------------------------|--------------|-------|--------|--------|------------------------------------|--|
| | | U-234 | U-235 | U-236 | U-238 | | |
| A-20 | KA-0376 +415 | 0.0139 | 1.931 | 0.1416 | 97.914 | 1.280 | 2.813 |
| | KC-1293 -415 | 0.0141 | 1.921 | 0.1368 | 97.929 | 1.305 | 2.406 |
| | KA-0374 +415 | 0.0145 | 1.998 | 0.1304 | 97.857 | 1.308 | 2.722 |
| | KC-1290 -415 | 0.0147 | 1.933 | 0.1232 | 97.929 | 1.395 | 2.351 |
| | KA-0400 +415 | 0.0138 | 1.918 | 0.1401 | 97.928 | 1.214 | 2.900 |
| | KC-1334 -293 | 0.0140 | 1.951 | 0.1337 | 97.901 | 1.144 | 2.561 |
| | KA-1063 +415 | 0.0144 | 2.060 | 0.1210 | 97.805 | 1.423 | 2.593 |
| | KC-1301 -415 | 0.0149 | 2.071 | 0.1140 | 97.800 | 1.262 | 2.219 |
| | KA-1040 +660 | 0.0149 | 2.357 | 0.0699 | 97.558 | 1.165 | 1.348 |
| | +538 | 0.0149 | 2.219 | 0.0949 | 97.671 | 1.047 | 2.015 |
| | +415 | 0.0140 | 2.112 | 0.1115 | 97.762 | 1.010 | 2.544 |
| | +293 | 0.0145 | 2.041 | 0.1242 | 97.820 | 0.939 | 2.843 |
| | +171 | 0.0137 | 2.032 | 0.1288 | 97.826 | 0.882 | 2.880 |
| | KC-1333 -171 | 0.0148 | 2.004 | 0.1282 | 97.853 | 1.338 | 2.743 |
| | -293 | 0.0143 | 2.044 | 0.1214 | 97.821 | 1.404 | 2.557 |
| | -415 | 0.0149 | 2.096 | 0.1111 | 97.777 | 1.429 | 2.218 |
| | -538 | 0.0148 | 2.218 | 0.0906 | 97.676 | 1.291 | 1.743 |
| | -660 | 0.0154 | 2.391 | 0.0591 | 97.534 | 1.332 | 1.008 |
| A-18 | KA-1094 +415 | 0.0143 | 2.039 | 0.1226 | 97.824 | 1.076 | 2.788 |
| | KC-1295 -415 | 0.0150 | 2.119 | 0.1062 | 97.760 | 1.646 | 2.090 |
| | KA-0343 +415 | 0.0144 | 2.062 | 0.1197 | 97.804 | 1.727 | 2.594 |
| | KC-1352 -415 | 0.0145 | 2.056 | 0.1181 | 97.811 | 0.945 | 2.254 |
| | KA-0389 +415 | 0.0143 | 1.976 | 0.1334 | 97.876 | 1.244 | 2.846 |
| | KC-1304 -415 | 0.0145 | 2.055 | 0.1147 | 97.816 | 1.344 | 2.232 |
| A-14 | +538 | 0.0150 | 2.334 | 0.0699 | 97.581 | 1.477 | 1.313 |
| | + 49 | 0.0149 | 2.194 | 0.0940 | 97.697 | 1.365 | 1.890 |
| | -293 | 0.0141 | 2.333 | 0.0725 | 97.580 | 1.626 | 1.322 |
| Initial composition | | 0.0156 | 2.629 | 0.0162 | 97.339 | | |

Table 3.9-9 Content and Isotopic Composition of Pu

| Assembly | Position of measurement | Atom percent | | | | | Total Pu x10 ¹⁹ atoms | Date of measurement |
|----------|-------------------------|--------------|--------|--------|--------|--------|-------------------------------------|---------------------|
| | | Pu-238 | Pu-239 | Pu-240 | Pu-241 | Pu-242 | | |
| A-20 | KA-0376 +415 | 0.128 | 84.39 | 12.53 | 2.71 | 0.238 | 3.60 | 73/ 3/20 |
| | KC-1293 -415 | 0.111 | 84.76 | 12.68 | 2.25 | 0.201 | 3.14 | 73/ 6/18 |
| | KA-0374 +415 | 0.119 | 86.19 | 11.19 | 2.32 | 0.182 | 3.56 | 73/ 3/27 |
| | KC-1290 -415 | 0.103 | 86.11 | 11.58 | 2.05 | 0.164 | 3.28 | 73/ 6/19 |
| | KA-0400 +415 | 0.135 | 84.37 | 12.41 | 2.84 | 0.246 | 3.52 | 73/ 3/30 |
| | KC-1334 -293 | 0.117 | 85.28 | 12.06 | 2.34 | 0.201 | 2.93 | 73/ 6/12 |
| | KA-1063 +415 | 0.112 | 87.12 | 10.37 | 2.25 | 0.150 | 3.69 | 73/ 4/17 |
| | KC-1301 -415 | 0.088 | 87.73 | 10.21 | 1.85 | 0.125 | 2.80 | 73/ 4/20 |
| | KA-1040 +660 | 0.039 | 93.51 | 5.76 | 0.67 | 0.020 | 1.570 | 72/11/30 |
| | +538 | 0.071 | 90.46 | 7.99 | 1.42 | 0.064 | 2.11 | 72/12/14 |
| | +415 | 0.101 | 88.34 | 9.44 | 2.00 | 0.120 | 2.57 | 72/12/ 4 |
| | +293 | 0.122 | 86.78 | 10.52 | 2.41 | 0.164 | 2.67 | 72/12/ 5 |
| | +171 | 0.130 | 86.24 | 10.92 | 2.53 | 0.183 | 2.54 | 72/12/ 6 |
| | KC-1333 -171 | 0.121 | 86.20 | 11.08 | 2.42 | 0.180 | 3.67 | 72/12/20 |
| | -293 | 0.108 | 86.70 | 10.80 | 2.24 | 0.155 | 3.59 | 72/12/18 |
| | -415 | 0.086 | 88.22 | 9.80 | 1.78 | 0.109 | 3.17 | 72/12/11 |
| | -538 | 0.056 | 90.80 | 7.96 | 1.13 | 0.050 | 2.25 | 72/12/13 |
| | -660 | 0.025 | 94.71 | 4.85 | 0.40 | 0.010 | 1.342 | 72/12/ 1 |
| A-18 | KA-1094 +415 | 0.111 | 86.83 | 10.53 | 2.37 | 0.160 | 3.00 | 73/ 3/29 |
| | KC-1295 -415 | 0.079 | 88.54 | 9.61 | 1.67 | 0.099 | 3.44 | 73/ 4/19 |
| | KA-0343 +415 | 0.108 | 87.36 | 10.19 | 2.19 | 0.145 | 4.48 | 73/ 4/13 |
| | KC-1352 -415 | 0.094 | 87.45 | 10.43 | 1.90 | 0.126 | 2.13 | 73/ 4/24 |
| | KA-0389 +415 | 0.124 | 85.46 | 11.52 | 2.69 | 0.207 | 3.54 | 73/ 3/28 |
| | KC-1304 -415 | 0.086 | 87.47 | 10.50 | 1.82 | 0.124 | 3.00 | 73/ 6/13 |
| A-14 | +538 | 0.023 | 93.54 | 5.78 | 0.64 | 0.0145 | 1.94 | 72/ 8/25 |
| | + 49 | 0.066 | 90.16 | 8.44 | 1.27 | 0.063 | 2.58 | 72/ 7/ 5 |
| | -293 | 0.035 | 93.13 | 6.17 | 0.64 | 0.0216 | 2.15 | 72/ 7/ |

Table 3.9-10 Isotopic Composition of Nd and Amount of ^{148}Nd

| Assembly | Position of measurement | Atom percent | | | | | | No. of ^{148}Nd $\times 10^{18}$ atoms |
|----------|-------------------------|--------------|--------|--------|--------|--------|--------|--|
| | | Nd-143 | Nd-144 | Nd-145 | Nd-146 | Nd-148 | Nd-150 | |
| A-20 | KA-0376 +415 | 26.29 | 28.16 | 18.47 | 15.08 | 8.43 | 3.57 | 1.634 |
| | KC-1293 -415 | 26.34 | 28.23 | 18.65 | 14.95 | 8.35 | 3.49 | 1.590 |
| | KA-0374 +415 | 26.58 | 27.81 | 18.57 | 15.03 | 8.42 | 3.60 | 1.501 |
| | KC-1290 -415 | 26.60 | 27.98 | 18.59 | 14.95 | 8.37 | 3.51 | 1.559 |
| | KA-0400 +415 | 26.34 | 28.11 | 18.52 | 15.04 | 8.45 | 3.55 | 1.537 |
| | KC-1334 -293 | 26.52 | 28.10 | 18.55 | 14.96 | 8.36 | 3.53 | 1.356 |
| | KA-1063 +415 | 26.82 | 27.65 | 18.53 | 14.99 | 8.42 | 3.60 | 1.455 |
| | KC-1301 -415 | 26.90 | 27.68 | 18.57 | 14.95 | 8.37 | 3.54 | 1.198 |
| | KA-1040 +660 | 27.72 | 26.82 | 18.81 | 14.81 | 8.33 | 3.50 | 0.557 |
| | +538 | 27.20 | 27.15 | 18.64 | 14.99 | 8.44 | 3.61 | 0.771 |
| A-20 | +415 | 26.95 | 27.37 | 18.60 | 15.03 | 8.42 | 3.63 | 0.933 |
| | +293 | 26.67 | 27.58 | 18.54 | 15.12 | 8.45 | 3.64 | 0.998 |
| | +171 | 26.59 | 27.61 | 18.58 | 15.10 | 8.46 | 3.65 | 0.976 |
| | KC-1333 -171 | 26.63 | 27.71 | 18.58 | 15.05 | 8.41 | 3.61 | 1.471 |
| | -293 | 26.70 | 27.63 | 18.61 | 15.04 | 8.42 | 3.60 | 1.466 |
| A-20 | -415 | 26.94 | 27.52 | 18.68 | 14.94 | 8.39 | 3.54 | 1.314 |
| | -538 | 27.34 | 27.25 | 18.75 | 14.84 | 8.32 | 3.51 | 0.902 |
| | -660 | 27.93 | 26.82 | 18.89 | 14.66 | 8.28 | 3.42 | 0.520 |
| | KA-1094 +415 | 26.73 | 27.65 | 18.54 | 15.06 | 8.43 | 3.59 | 1.145 |
| | KC-1295 -415 | 27.01 | 27.48 | 18.66 | 14.97 | 8.39 | 3.51 | 1.472 |
| | KA-0343 +415 | 26.75 | 27.57 | 18.57 | 15.03 | 8.42 | 3.60 | 1.758 |
| A-18 | KC-1352 -415 | 26.85 | 27.77 | 18.57 | 14.92 | 8.36 | 3.53 | 0.924 |
| | KA-0389 +415 | 26.52 | 27.87 | 18.52 | 15.06 | 8.42 | 3.61 | 1.476 |
| | KC-1304 -415 | 26.93 | 27.72 | 18.59 | 14.92 | 8.33 | 3.51 | 1.298 |
| | +538 | 27.67 | 26.82 | 18.82 | 14.83 | 8.34 | 3.52 | 0.716 |
| | + 49 | 27.24 | 27.25 | 18.74 | 14.90 | 8.34 | 3.52 | 1.046 |
| | -293 | 27.65 | 26.96 | 18.86 | 14.75 | 8.31 | 3.46 | 0.842 |
| A-14 | +538 | 27.50 | 26.94 | 18.78 | 14.87 | 8.37 | 3.54 | 0.909 |
| | + 49 | 26.86 | 27.52 | 18.67 | 15.01 | 8.39 | 3.56 | 1.511 |
| | -293 | 27.29 | 27.28 | 18.74 | 14.85 | 8.33 | 3.52 | 1.005 |

Table 3.9-11 Amounts of ^{237}Np , ^{241}Am , ^{242m}Am , ^{242}Cm and ^{244}Cm

| Assembly | Position of measurement | Np-237 [#] ($\times 10^{17}$ at) | Am-241 ($\times 10^{17}$ at) | Am-242m ($\times 10^{14}$ at) | Cm-242 ($\times 10^{12}$ at) | Cm-244 ($\times 10^{13}$ at) |
|----------|-------------------------|---|----------------------------------|-----------------------------------|----------------------------------|----------------------------------|
| A-20* | KA-0376 +415 | 5.12±0.09 | 2.33 | 9.5 | 11.4 | 9.9 |
| | KC-1293 -415 | 4.28±0.04 | 1.923 | 5.3 | 8.8 | 5.1 |
| | KA-0374 +415 | 5.05±0.05 | 2.21 | 6.5 | 10.0 | 8.0 |
| | KC-1290 -415 | 4.34±0.07 | 1.822 | 6.5 | 7.8 | 4.1 |
| | KA-0400 +415 | 5.10±0.06 | 2.56 | 12.1 | 13.2 | 11.9 |
| | KC-1334 -293 | 4.09±0.03 | 1.835 | 7.9 | 8.6 | 5.9 |
| | KA-1063 +415 | 5.35±0.04 | 2.07 | 7.8 | 9.0 | 5.7 |
| | KC-1301 -415 | 3.61±0.05 | 1.330 | 2.5 | 5.1 | 2.3 |
| | KA-1040 +660 | 1.68±0.05 | 0.259 | 0.61 | 0.55 | 0.088 |
| | +538 | 2.67±0.11 | 0.751 | 2.4 | 2.4 | 0.92 |
| | +415 | 3.56±0.04 | 1.276 | 2.0 | 5.1 | 3.4 |
| | +293 | 3.76±0.06 | 1.571 | 5.1 | 7.2 | 5.6 |
| | +171 | 3.67±0.04 | 1.608 | 5.6 | 7.7 | 6.3 |
| | KC-1333 -171 | 5.15±0.09 | 2.19 | 10.4 | 10.1 | 7.1 |
| | -293 | 4.96±0.10 | 1.984 | 5.3 | 8.7 | 5.0 |
| | -415 | 3.97±0.04 | 1.440 | 3.5 | 5.5 | 2.3 |
| | -538 | 2.44±0.03 | 0.638 | 1.60 | 1.80 | 0.45 |
| | -660 | 1.29±0.02 | 0.135 | 0.34 | 0.21 | 0.025 |
| A-18** | KA-1094 +415 | 4.20±0.03 | 1.753 | 4.6 | 7.9 | 5.4 |
| | KC-1295 -415 | 4.49±0.05 | 1.538 | 2.5 | 5.3 | 2.2 |
| | KA-0343 +415 | 6.26±0.07 | 2.45 | 6.3 | 10.2 | 6.9 |
| | KC-1352 -415 | 2.89±0.03 | 1.057 | 3.1 | 4.1 | 2.1 |
| | KA-0389 +415 | 5.09±0.04 | 2.42 | 8.3 | 11.7 | 10.2 |
| | KC-1304 -415 | 3.82±0.05 | 1.473 | 1.9 | 5.4 | 2.6 |
| A-14** | +538 | | 0.266 | | 1.65 | 0.084 |
| | + 49 | | 0.806 | | 7.32 | 0.85 |
| | -293 | | 0.237 | | 1.34 | 0.065 |
| A-14** | +538 | | 0.509 | | 3.95 | 0.33 |
| | + 49 | | 1.993 | | 23.8 | 4.49 |
| | -293 | | 0.677 | | 5.45 | 0.59 |

* The results of assembly A-20 are represented on Aug. 1, 1973.

** The results of assemblies A-18 and A-14 are represented on Sep. 20, 1972⁽⁶⁾.

Errors quoted are the greater of either $\sqrt{\sum(x_i - \bar{x})^2/n(n-1)}$ or $\sqrt{\sum\sigma_i^2/n}$, where x_i is the results of i-th measurement and σ_i its standard deviation estimated by considering counting statistics, errors in measuring aliquot and the uncrentainty in a standard samples used.

Table 3.9-12 Burnup Values Evaluated by
 ^{148}Nd and ^{137}Cs Methods

| Assembly | Position of measurement | Burnup (FIMA) | | |
|----------|--------------------------------|----------------------|----------------------|-------|
| | | $^{148}\text{Nd(A)}$ | $^{137}\text{Cs(B)}$ | A/B |
| A-20 | KA-0376 +415 | 0.747 | 0.74 | 1.010 |
| | KC-1293 -415 | 0.714 | 0.70 | 1.020 |
| | KA-0374 +415 | 0.672 | 0.66 | 1.018 |
| | KC-1290 -415 | 0.655 | 0.64 | 1.023 |
| | KA-0400 +415 | 0.741 | 0.74 | 1.001 |
| | KC-1334 -293 | 0.694 | 0.68 | 1.021 |
| | KA-1063 +415 | 0.600 | 0.59 | 1.017 |
| | KC-1301 -415 | 0.557 | 0.56 | 0.995 |
| | KA-1040 +660 | 0.282 | 0.27 | 1.044 |
| | +538 | 0.433 | 0.42 | 1.031 |
| | +415 | 0.542 | 0.53 | 1.023 |
| | +293 | 0.623 | 0.62 | 1.005 |
| | +171 | 0.648 | 0.63 | 1.029 |
| | KC-1333 -171 | 0.644 | 0.62 | 1.039 |
| | -293 | 0.612 | 0.59 | 1.037 |
| | -415 | 0.539 | 0.52 | 1.037 |
| | -538 | 0.411 | 0.40 | 1.028 |
| | -660 | 0.230 | 0.23 | 1.000 |
| | KA-1094 +415 | 0.624 | 0.61 | 1.023 |
| | KC-1295 -415 | 0.525 | 0.51 | 1.029 |
| | KA-0343 +415 | 0.597 | 0.59 | 1.012 |
| | KC-1352 -415 | 0.573 | 0.56 | 1.023 |
| | KA-0389 +415 | 0.694 | 0.68 | 1.021 |
| | KC-1304 -415 | 0.567 | 0.56 | 1.013 |
| | A-18 | +538 | 0.289 | 0.27 |
| | +49 | 0.453 | 0.43 | 1.053 |
| | -293 | 0.306 | 0.30 | 1.020 |
| | A-14 | +538 | 0.352 | 0.34 |
| | +49 | 0.577 | 0.54 | 1.068 |
| | -293 | 0.430 | 0.42 | 1.024 |
| | Average (n=30) = 1.025 ± 0.018 | | | |

Table 3.9-13 Atom Ratios of γ -ray Emitting Nuclides to U
as of April, 1982

| Nuclide | ^{137}Cs | ^{134}Cs | ^{154}Eu | ^{155}Eu | ^{125}Sb | ^{60}Co | ^{106}Ru |
|----------------------|-------------------|-------------------|-------------------|-------------------|-------------------|------------------|-------------------|
| Half-life | 30.17 yr | 2.06 yr | 8.8 yr | 4.96 yr | 2.77 yr | 5.27 yr | 368 d |
| E _γ (keV) | 661.7 | 795.8 | 1274 | 105.3 | 428 | 1173 | 621.9 |
| γs/decay | 0.8518 | 0.8552 | 0.3525 | 0.23 | 0.297 | 1.0 | 0.0995 |
| Reproc. batch No. | $\times 10^{-4}$ | $\times 10^{-8}$ | $\times 10^{-7}$ | $\times 10^{-7}$ | $\times 10^{-8}$ | $\times 10^{-9}$ | $\times 10^{-7}$ |
| JP-001 | 0.043 | 8.2-4+ | 6.4-4+ | 0.023 | 0.0 | 0.074 | 0.0 |
| JP-002 | 0.586 | 0.302 | 0.180 | 0.368 | 0.92 | 1.54 | 0.0 |
| JP-003 | 1.26 | 1.42 | 0.756 | 0.702 | 2.11 | 4.27 | 0.0 |
| JP-004 | 1.51 | 2.14 | 1.12 | 0.813 | 2.28 | 4.98 | 0.0 |
| JP-005 | 1.40 | 1.96 | 1.06 | 0.739 | 2.47 | 4.21 | 0.0 |
| JP-006 | 1.55 | 2.22 | 1.21 | 0.862 | 2.43 | 4.38 | 0.0 |
| JP-007 | 1.63 | 2.58 | 1.40 | 0.878 | 2.90 | 4.86 | 0.0 |
| JP-008 | 2.04 | 5.11 | 2.55 | 1.14 | 3.86 | 8.24 | 0.0 |
| JP-009 | 1.93 | 3.73 | 2.02 | 1.00 | 3.38 | 7.89 | 0.0 |
| JP-010 | 2.04 | 5.19 | 2.69 | 1.22 | 3.98 | 7.50 | 0.0 |
| JP-011 | 1.96 | 4.40 | 2.24 | 1.06 | 3.22 | 7.59 | 0.0 |
| JP-012 | 2.00 | 4.45 | 2.32 | 1.14 | 3.90 | 7.42 | 0.0 |
| JP-013 | 2.26 | 5.07 | 2.74 | 1.28 | 4.08 | 8.34 | 0.0 |
| JP-014 | 2.24 | 5.49 | 2.96 | 1.22 | 3.96 | 9.31 | 0.0 |
| JP-015 | 2.36 | 6.12 | 3.23 | 1.25 | 4.71 | 9.04 | 0.0 |
| JP-016 | 2.14 | 16.0 | 3.44 | 1.42 | 4.78 | 23.6 | 3.66 |
| JP-017 | 2.16 | 10.9 | 2.81 | 1.25 | 7.72 | 21.7 | 0.40 |
| JP-018 | 2.06 | 8.08 | 2.64 | 1.15 | 18.6 | 13.3 | 1.07 |
| JP-019 | 1.95 | 8.13 | 2.55 | 1.20 | 6.10 | 9.66 | 0.22 |

+ To be read as 8.2×10^{-4} and 6.4×10^{-4}

Table 3.9-14 Isotopic Composition of U

| Reproc. batch No. | Atompercent | | | |
|----------------------|------------------|------------------|------------------|------------------|
| | ^{234}U | ^{235}U | ^{236}U | ^{238}U |
| JP-001 | 0.0156 | 2.600 | 0.0187 | 97.36 |
| JP-002 | 0.0153 | 2.481 | 0.0434 | 97.46 |
| JP-003 | 0.0153 | 2.319 | 0.0697 | 97.59 |
| JP-004 | 0.0152 | 2.264 | 0.0813 | 97.64 |
| JP-005 | 0.0153 | 2.280 | 0.0776 | 97.63 |
| JP-006 | 0.0152 | 2.239 | 0.0842 | 97.66 |
| JP-007 | 0.0151 | 2.226 | 0.0881 | 97.67 |
| JP-008 | 0.0149 | 2.176 | 0.1005 | 97.71 |
| JP-009 | 0.0149 | 2.165 | 0.0982 | 97.72 |
| JP-010 | 0.0148 | 2.163 | 0.1030 | 97.72 |
| JP-011 | 0.0148 | 2.146 | 0.1029 | 97.74 |
| JP-012 | 0.0148 | 2.166 | 0.1010 | 97.72 |
| JP-013 | 0.0147 | 2.102 | 0.1092 | 97.77 |
| JP-014 | 0.0147 | 2.099 | 0.1110 | 97.77 |
| JP-015 | 0.0148 | 2.082 | 0.1156 | 97.79 |
| JP-016 | 0.0149 | 2.160 | 0.1043 | 97.72 |
| JP-017 | 0.0149 | 2.127 | 0.1038 | 97.75 |
| JP-018 | 0.0149 | 2.158 | 0.1023 | 97.73 |
| JP-019 | 0.0148 | 2.174 | 0.0965 | 97.71 |

Table 3.9-15 Isotopic Composition of Pu and Atom Ratio of Pu to U
as of March 10, 1982

| Reproc. batch No. | Atompercent | | | | | Pu/U ($\times 10^{-3}$) |
|----------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--|
| | ^{238}Pu | ^{239}Pu | ^{240}Pu | ^{241}Pu | ^{242}Pu | |
| JP-001 | 0.0005 | 99.75 | 0.248 | 0.0017 | 0.0006 | 0.0057 |
| JP-002 | 0.0014 | 96.44 | 3.42 | 0.131 | 0.0041 | 0.638 |
| JP-003 | 0.0346 | 92.72 | 6.78 | 0.433 | 0.0303 | 1.052 |
| JP-004 | 0.0466 | 91.40 | 7.88 | 0.613 | 0.0499 | 1.289 |
| JP-005 | 0.0454 | 91.89 | 7.40 | 0.608 | 0.0459 | 1.280 |
| JP-006 | 0.0484 | 91.10 | 8.15 | 0.635 | 0.0539 | 1.355 |
| JP-007 | 0.0547 | 90.72 | 8.44 | 0.714 | 0.0674 | 1.486 |
| JP-008 | 0.0884 | 88.96 | 9.60 | 1.218 | 0.131 | 2.031 |
| JP-009 | 0.0712 | 89.21 | 9.63 | 0.975 | 0.106 | 1.710 |
| JP-010 | 0.0908 | 88.83 | 9.71 | 1.236 | 0.134 | 2.090 |
| JP-011 | 0.0849 | 88.70 | 9.92 | 1.157 | 0.133 | 1.704 |
| JP-012 | 0.0793 | 89.24 | 9.47 | 1.099 | 0.114 | 1.935 |
| JP-013 | 0.0889 | 88.20 | 10.37 | 1.205 | 0.140 | 2.045 |
| JP-014 | 0.0947 | 88.04 | 10.42 | 1.295 | 0.151 | 2.159 |
| JP-015 | 0.103 | 87.55 | 10.78 | 1.399 | 0.172 | 2.217 |
| JP-016 | 0.150 | 87.55 | 10.34 | 1.622 | 0.334 | 2.174 |
| JP-017 | 0.101 | 88.23 | 10.26 | 1.211 | 0.199 | 1.854 |
| JP-018 | 0.0975 | 88.60 | 9.88 | 1.236 | 0.189 | 1.975 |
| JP-019 | 0.0943 | 88.91 | 9.61 | 1.204 | 0.171 | 1.828 |

Table 3.9-16 Isotopic Composition of Nd and Atom Ratio of ^{148}Nd to U

| Reproc. batch No. | Atompercent | | | | | | $^{148}\text{Nd}/\text{U}$ ($\times 10^{-5}$) |
|----------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--|
| | ^{143}Nd | ^{144}Nd | ^{145}Nd | ^{146}Nd | ^{148}Nd | ^{150}Nd | |
| JP-001 | 28.38 | 26.34 | 18.93 | 14.57 | 8.25 | 3.52 | 0.182 |
| JP-002 | 27.93 | 26.65 | 18.85 | 14.66 | 8.29 | 3.62 | 2.36 |
| JP-003 | 27.44 | 27.27 | 18.76 | 14.68 | 8.30 | 3.59 | 4.95 |
| JP-004 | 27.19 | 27.40 | 18.73 | 14.76 | 8.32 | 3.60 | 6.09 |
| JP-005 | 27.30 | 27.28 | 18.73 | 14.76 | 8.32 | 3.61 | 5.57 |
| JP-006 | 27.15 | 27.46 | 18.72 | 14.74 | 8.31 | 3.61 | 6.36 |
| JP-007 | 27.08 | 27.48 | 18.69 | 14.77 | 8.32 | 3.66 | 6.68 |
| JP-008 | 26.74 | 27.56 | 18.59 | 14.93 | 8.44 | 3.73 | 7.89 |
| JP-009 | 26.81 | 27.67 | 18.63 | 14.84 | 8.36 | 3.69 | 7.76 |
| JP-010 | 26.74 | 27.56 | 18.58 | 14.94 | 8.43 | 3.75 | 8.13 |
| JP-011 | 26.72 | 27.68 | 18.59 | 14.89 | 8.38 | 3.73 | 7.40 |
| JP-012 | 26.81 | 27.57 | 18.60 | 14.88 | 8.38 | 3.75 | 7.98 |
| JP-013 | 26.61 | 27.73 | 18.58 | 14.91 | 8.41 | 3.76 | 8.95 |
| JP-014 | 26.55 | 27.71 | 18.58 | 14.95 | 8.45 | 3.76 | 8.86 |
| JP-015 | 26.51 | 27.82 | 18.56 | 14.96 | 8.42 | 3.71 | 9.43 |
| JP-016 | 26.58 | 27.65 | 18.56 | 14.98 | 8.45 | 3.79 | 8.35 |
| JP-017 | 26.64 | 27.81 | 18.60 | 14.89 | 8.38 | 3.69 | 8.43 |
| JP-018 | 26.71 | 27.64 | 18.60 | 14.91 | 8.42 | 3.71 | 8.11 |
| JP-019 | 26.75 | 27.61 | 18.60 | 14.90 | 8.42 | 3.71 | 7.67 |

Table 3.9-17 Atom Ratios of ^{237}Np , ^{241}Am , ^{242m}Am and ^{244}Cm to U as of March 10, 1982

| Reproc. batch No. | ^{237}Np ($\times 10^{-5}$) | ^{241}Am ($\times 10^{-5}$) | ^{242m}Am ($\times 10^{-8}$) | ^{244}Cm ($\times 10^{-9}$) |
|----------------------|---|---|--|---|
| JP-001 | 0.043 | 0.00016 | 0.00012 | 0.0021 |
| JP-002 | 0.539 | 0.094 | 0.031 | 0.0074 |
| JP-003 | 1.04 | 0.506 | 0.42 | 0.0727 |
| JP-004 | 1.44 | 0.896 | 0.86 | 0.208 |
| JP-005 | 1.41 | 0.840 | 0.63 | 0.249 |
| JP-006 | 1.46 | 0.990 | 0.99 | 0.201 |
| JP-007 | 1.63 | 1.08 | 1.09 | 0.313 |
| JP-008 | 2.57 | 2.66 | 3.39 | 2.26 |
| JP-009 | 2.12 | 1.84 | 2.15 | 1.29 |
| JP-010 | 2.86 | 2.52 | 3.44 | 2.22 |
| JP-011 | 2.33 | 2.05 | 2.61 | 1.71 |
| JP-012 | 2.49 | 2.39 | 2.95 | 1.64 |
| JP-013 | 2.72 | 2.67 | 3.38 | 2.10 |
| JP-014 | 2.96 | 3.06 | 4.06 | 2.88 |
| JP-015 | 3.06 | 3.41 | 4.38 | 3.48 |
| JP-016 | 2.92 | 2.88 | 4.54 | 85.8 |
| JP-017 | 2.25 | 2.28 | 3.15 | 58.0 |
| JP-018 | 2.61 | 2.45 | 3.26 | 32.1 |
| JP-019 | 2.43 | 2.04 | 2.17 | 34.5 |

Table 3.9-18 Burnups Evaluated by ^{148}Nd - and ^{137}Cs - methods

| Reproc. batch No. | Burnup (%FIMA) | | A/B |
|----------------------|----------------------|----------------------|-------|
| | $^{148}\text{Nd(A)}$ | $^{137}\text{Cs(B)}$ | |
| JP-001 | 0.011 | 0.01 | 1.100 |
| JP-002 | 0.140 | 0.14 | 1.000 |
| JP-003 | 0.295 | 0.29 | 1.017 |
| JP-004 | 0.362 | 0.35 | 1.034 |
| JP-005 | 0.331 | 0.32 | 1.034 |
| JP-006 | 0.378 | 0.36 | 1.050 |
| JP-007 | 0.397 | 0.38 | 1.045 |
| JP-008 | 0.468 | 0.47 | 0.996 |
| JP-009 | 0.461 | 0.45 | 1.024 |
| JP-010 | 0.482 | 0.47 | 1.026 |
| JP-011 | 0.440 | 0.45 | 0.978 |
| JP-012 | 0.473 | 0.46 | 1.028 |
| JP-013 | 0.532 | 0.52 | 1.021 |
| JP-014 | 0.525 | 0.52 | 1.010 |
| JP-015 | 0.559 | 0.54 | 1.035 |
| JP-016 | 0.495 | 0.49 | 1.010 |
| JP-017 | 0.500 | 0.50 | 1.000 |
| JP-018 | 0.481 | 0.47 | 1.023 |
| JP-019 | 0.455 | 0.45 | 1.011 |

Average of A/B = 1.023 ± 0.025

Table 3.9-19 Summary of Destructive and Non-destructive Analyses on 19 Reprocessing Batches

| Reproc. batch No. | Init.U (kg) | Destructive analysis | | | | | Non-destructive analysis | | | | | |
|-------------------------|----------------|---|-----------|--|----------------------|-----------|---|---|-----------|--|----------------------|-----------|
| | | $\frac{^{134}\text{Cs}+1}{^{137}\text{Cs}}$ | BU (%) | $\text{Pu}/\text{U}+2$ ($\times 10^{-3}$) | $\text{Pu}+2$ (g) | U (kg) | $\frac{^{137}\text{Cs}+3}{^{137}\text{Cs}}$ | $\frac{^{134}\text{Cs}+3}{^{137}\text{Cs}}$ | BU (%) | $\text{Pu}/\text{U}+4$ ($\times 10^{-3}$) | $\text{Pu}+4$ (g) | U (kg) |
| | | ($\times 10^{-4}$) | | | | | (cps) | ($\times 10^{-3}$) | | | | |
| JP-001 | 116.05 | 0.019 | 0.011 | 0.057 | 6.7 | 116.03 | 19.2 | - | 0.011 | - | - | 116.04 |
| JP-002 | 230.69 | 0.516 | 0.140 | 0.638 | 147.6 | 230.22 | 247.1 | 3.73 | 0.131 | 0.52 | 120 | 230.26 |
| JP-003 | 232.15 | 1.13 | 0.295 | 1.052 | 244.4 | 231.23 | 632.1 | 8.75 | 0.335 | 1.17 | 270 | 231.10 |
| JP-004 | 232.05 | 1.41 | 0.362 | 1.289 | 299.1 | 230.93 | 690.6 | 9.89 | 0.366 | 1.30 | 303 | 230.90 |
| JP-005 | 232.26 | 1.39 | 0.331 | 1.280 | 297.4 | 231.20 | 658.0 | 9.90 | 0.348 | 1.30 | 301 | 231.15 |
| JP-006 | 174.08 | 1.39 | 0.378 | 1.355 | 235.8 | 173.19 | 774.3 | 10.32 | 0.410 | 1.36 | 236 | 173.13 |
| JP-007 | 232.39 | 1.59 | 0.397 | 1.486 | 345.2 | 231.13 | 814.5 | 12.18 | 0.431 | 1.57 | 365 | 231.02 |
| JP-008 | 232.14 | 2.50 | 0.468 | 2.031 | 470.7 | 230.60 | 868.5 | 17.24 | 0.460 | 2.12 | 490 | 230.58 |
| JP-009 | 232.07 | 1.93 | 0.461 | 1.710 | 396.3 | 230.62 | 940.5 | 14.55 | 0.498 | 1.83 | 424 | 230.49 |
| JP-010 | 232.08 | 2.54 | 0.482 | 2.090 | 484.1 | 230.49 | 923.1 | 18.21 | 0.489 | 2.21 | 513 | 230.43 |
| JP-011 | 231.86 | 2.25 | 0.440 | 1.704 | 394.7 | 230.46 | 1,011.4 | 16.45 | 0.535 | 2.04 | 470 | 230.15 |
| JP-012 | 232.54 | 2.22 | 0.473 | 1.935 | 449.2 | 231.01 | 964.5 | 16.56 | 0.511 | 2.05 | 475 | 230.88 |
| JP-013 | 231.71 | 2.24 | 0.531 | 2.045 | 472.8 | 230.02 | 1,048.7 | 17.18 | 0.555 | 2.11 | 487 | 229.93 |
| JP-014 | 232.21 | 2.45 | 0.525 | 2.159 | 500.2 | 230.50 | 1,059.9 | 18.02 | 0.561 | 2.20 | 508 | 230.40 |
| JP-015 | 232.05 | 2.59 | 0.559 | 2.217 | 513.1 | 230.26 | 1,107.1 | 19.33 | 0.586 | 2.32 | 537 | 230.16 |
| JP-016 | 232.12 | - | 0.495 | 2.174 | 503.6 | 230.49 | 930.4 | 17.35 | 0.492 | 2.13 | 493 | 230.49 |
| JP-017 | 231.72 | - | 0.500 | 1.854 | 428.8 | 230.14 | 978.4 | 15.20 | 0.518 | 1.90 | 440 | 230.08 |
| JP-018 | 173.83 | - | 0.481 | 1.975 | 342.7 | 172.66 | 949.9 | 15.78 | 0.503 | 1.96 | 340 | 172.61 |
| JP-019 | 173.98 | - | 0.455 | 1.828 | 317.6 | 172.88 | 890.6 | 15.68 | 0.471 | 1.94 | 337 | 172.82 |

⁺¹ Atom ratio as of Apr. 1, 1982. ⁺² As of Mar. 10, 1982.⁺³ Activity or activity ratio as of June 1, 1977. ⁺⁴ As of Mar. 1, 1973.

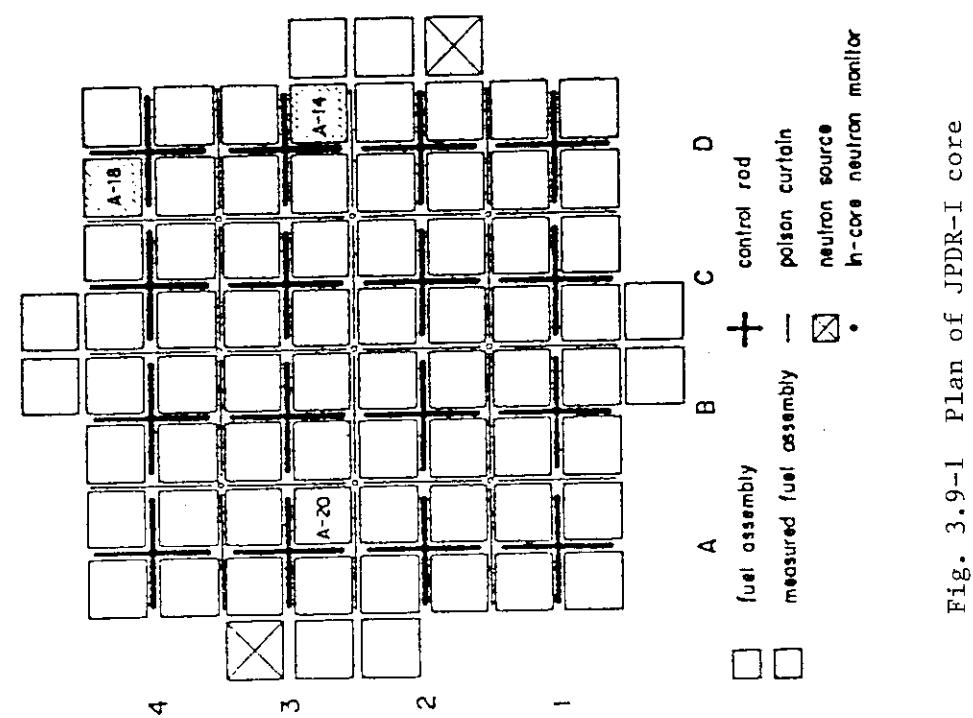


Fig. 3.9-1 Plan of JPDR-I core

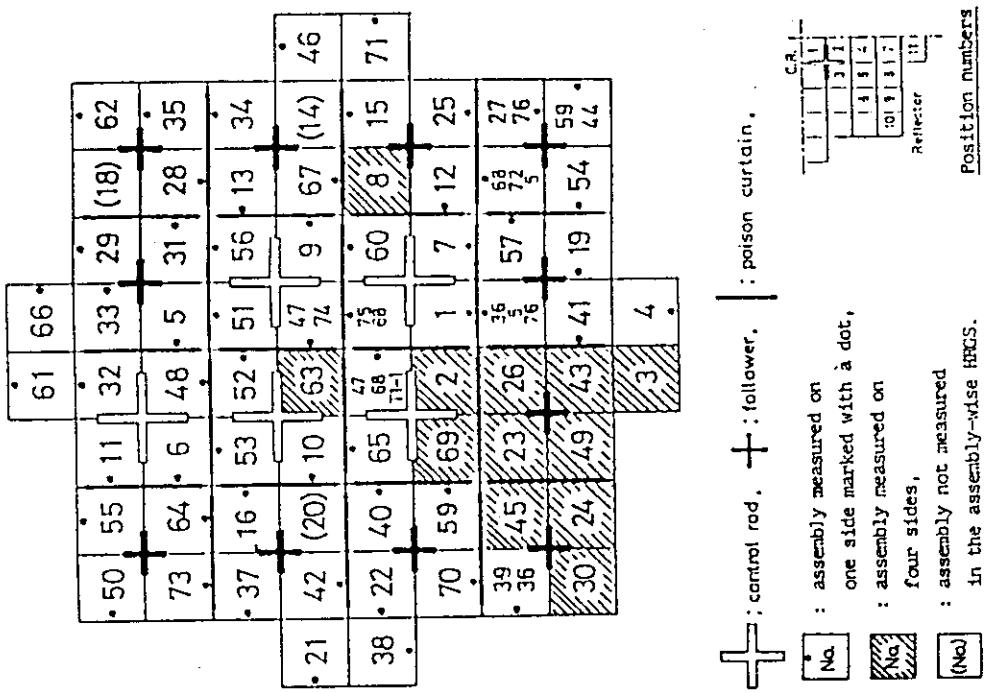


Fig. 3.9-2 Plan of JPDR-I core and identification numbers of assemblies

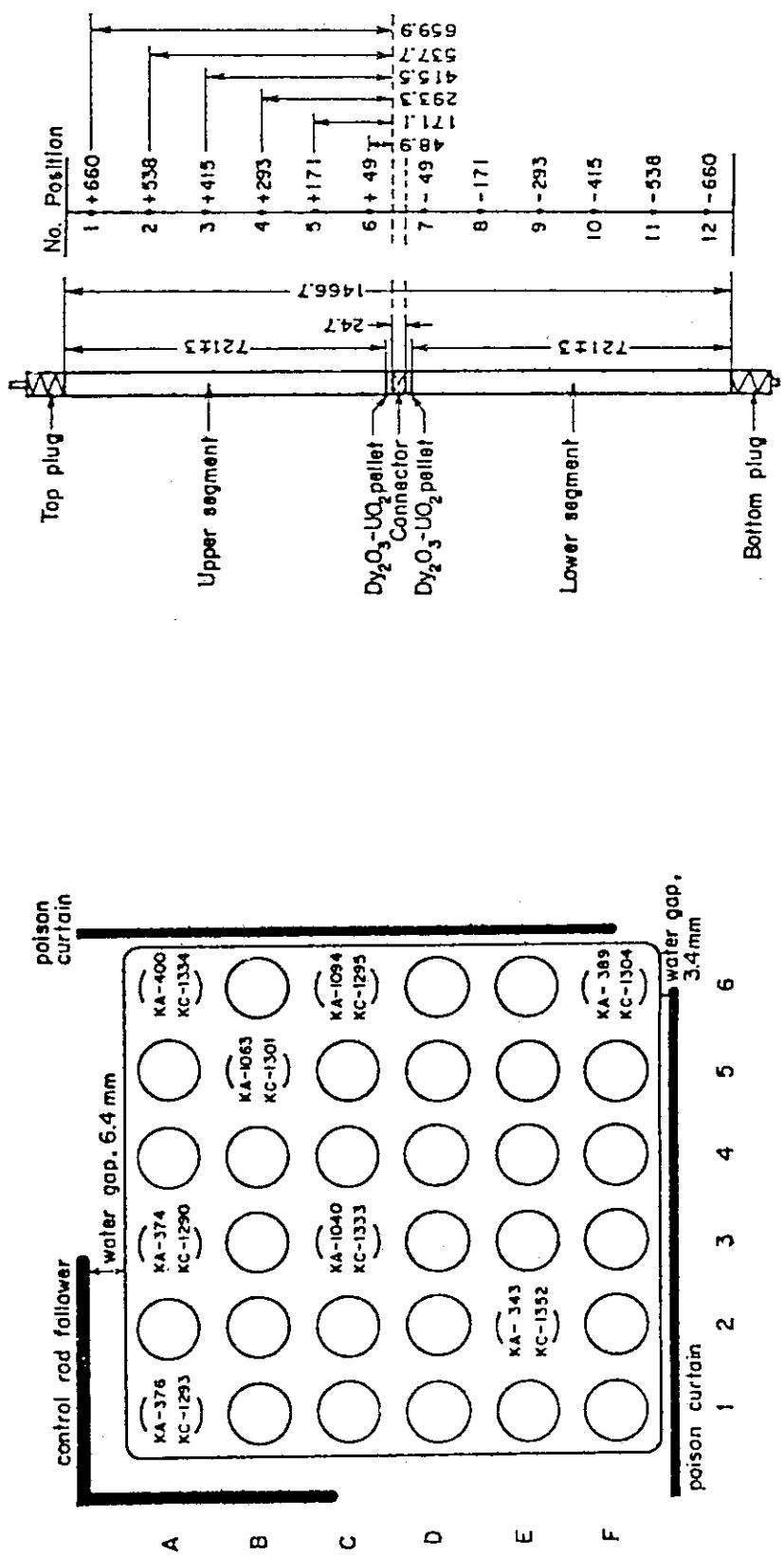


Fig. 3.9-3 Locations of fuel rods chosen for measurement in assembly A-20

Fig. 3.9-4 Composition of a fuel rod and measured positions

4. W. B. WilsonらによるLWR燃料インベントリベンチマークデータ

W. B. Wilsonらは、ベンチマーク用の核種組成データを調査、検討した結果、TMI-2炉、H. B. Robinson-2炉、Quad Cities-1炉及びCalvert Cliffs-1炉の4つの測定データを選び、EPPRI-CELL/CINDER-2コードによる計算値と測定値の比較を行い、コードとライブラリーの精度評価を行っている。

ここでは、報告された4原子炉のうち実測値が公開されていないCalvert Cliffs-1炉を除く3原子炉のデータについて記す。

なお、本章で使用した図表は下記の文献から転載したものである。

15) W. B. Wilson et. al: "Spent LWR Fuel Inventory Benchmarks", Applied Nuclear Data Research and Development, LA-9647-PR, pp. 75-88(1982).

4.1 TMI-2炉(PWR)

スリーマイル島原発2号炉(TMI-2)は熱出力2772MWthのPWRである。炉心構成と炉心性能をTable 4.1-1に示す。また、出力履歴と燃料の初期条件をTable 4.1-2に示す。TMI-2は1979年3月28日に事故を起こし、燃料からFPの一部が放出された。3月31日午前7:00に原子炉建屋内環境から空気サンプルが取られ、同日午後8:00にBettis Atomic Power Laboratory(BAPL)でIとXeの放射能が測定された。このときの空気サンプルのI及びXeの同位体の放射能濃度、 $^{133m}\text{Xe}/^{133}\text{Xe}$, $^{135}\text{Xe}/^{133}\text{Xe}$, $^{135}\text{Xe}/^{133m}\text{Xe}$ および $^{133}\text{I}/^{131}\text{I}$ の放射能比をTable 4.1-3に示す。

4.2 H. B. Robinson-2炉(PWR)

H. B. Robinson-2炉(HBR-2)は熱出力2200MWthのPWRである。燃料集合体は15×15である。炉心構成と炉心性能をTable 4.2-1に示す。燃料集合体B05は、1975年5月5日に炉心から取り出された。この燃料集合体のP8燃料棒から3つの燃料サンプルが取られ、 Battelle Columbus Laboratories (BCL) で1975年9月24日に破壊分析が行われた。3つのサンプルのうちひとつはスペーサグリッドに近接していた部分の燃料であり、代表的燃料として不適と考えられた。残りの2つのサンプルは、燃料の下端から12インチのものがP8A, 68インチのものがP8Bと名付けられた。さらに、E14燃料棒下端から 112インチの部分のサンプリングでもうひとつ追加サンプルが取られた。このサンプルはロスアラモスで分析された。これらのサンプルの出力履歴と燃料の初期条件をTable 4.1-2に示す。

測定されたB05燃料棒P8A及びP8BのサンプルのU, Pu同位体組成及び $^{239}\text{Pu}/^{238}\text{U}$, $^{148}\text{Nd}/^{238}\text{U}$ の原子個数比をTable 4.2-2に示す。

また, E14燃料棒のサンプルのU, Puの同位体, FP核種及びアクチナイドの量をatom/g-oxideの単位でTable 4.2-3に示す。

4.3 Quad Cities-1炉(BWR)

Quad Cities-1 炉の炉心構成と炉心性能についてTable 4.3-1に示す。選ばれたサンプルの出力履歴と燃料の初期条件をTable 4.1-2に示す。この出力履歴のヒストグラムは原子炉の総出力履歴のグラフと半月毎のTransverse irradiation probe(TIP) のデータから作られた。

U, Pu, Am, Cmの同位体組成及び ^{148}Nd , ^{237}Np , ^{239}Pu , $^{241\text{m}}\text{Am}$, ^{242}Cm の ^{238}U に対する比をTable 4.3-2に示す。

Table 4.1-1 Core Composition and Performance(TMI-2)

| Fuel Pellet | | Control Rod Absorbing material | |
|---|------------|---|--------|
| UO ₂ density (g/cm ³) | (g/cm) | | |
| Linear density (g/cm) | (cm) | | |
| Diameter (cm) | 0.94 | | |
| Length of pellet stack in fuel rod (cm) | | Core | |
| Clad-pellet clearance (cm) | | Equivalent diameter (cm) | 328 |
| Fuel Clad | | Active height (cm) | 366 |
| Outside diameter (cm) | | No. of square assemblies | 177 |
| Inside diameter (cm) | | No. of control rods | |
| Wall thickness (cm) | 0.067 | UO ₂ in square assemblies(kg) | 83,000 |
| Material | Zircaloy-4 | Total UO ₂ weight (kg) | |
| | | Total U weight (kg) | |
| Core Thermo-hydraulic Characteristics | | | |
| Square Fuel Assembly | | Power (MWth) | 2772 |
| Rod array | | (MWe) | 907 |
| Number of rods | 208 | Coolant pressure (kg/cm ²) | 154.5 |
| Fuel rod pitch (cm) | 1.36 | Coolant temperature(ave., °C) | 306 |
| Side of square cross section (cm) | 21.65 | (inlet, °C) | 290 |
| Total length (cm) | | (outlet, °C) | 318 |
| UO ₂ weight (kg) | 2.29/2.64/ | | |
| Initial enrichment (%) | 2.90 | | |

Table 4.1-2 Power Histories Used for Spent-fuel Calculations

| QUANTITY | TIME STEP | TMI-2 | | H. B. ROBINSON-2 | | H. B. ROBINSON-2 | | QUAD CITIES-1 | | CALVERT CLIFFS-1 | |
|-----------------|---------------|----------------|---------------------|-------------------|-------------------|------------------|------------------|------------------|-------------------|------------------|--------------------|
| | | CY1: CORE TYP. | CY1: ROD P8, 12"ABF | CY1, 2; ASSY, B05 | CY1, 2; ASSY, B05 | ROD P8, 68"ABF | ROD E14, 112"ABF | ROD E14, 112"ABF | ROD BSG56, 72"ABF | CY1-4; ASSY, B05 | CY2: ASSY, GEB-161 |
| INITIAL U234/CC | <4, 39033+18> | | | 4.44528+18 | 4.44528+18 | | 4.44528+18 | 4.40031+18 | | 4.20591+18 | |
| INITIAL U235/CC | <5, 82902+20> | | | 5.66790+20 | 5.66790+20 | | 5.66790+20 | 5.90354+20 | | 5.70028+20 | |
| INITIAL U236/CC | <3, 67315+18> | | | 3.52605+18 | 3.52605+18 | | 3.52605+18 | 3.67408+18 | | 3.70686+18 | |
| INITIAL U238/CC | <2, 17845+22> | | | 2.12845+22 | 2.12845+22 | | 2.12845+22 | 2.21783+22 | | 2.24019+22 | |
| POWER HISTORY: | | TIME | AVG. | TIME | AVG. | TIME | AVG. | TIME | AVG. | TIME | AVG. |
| | HRS. | W/CC | HRS. | W/CC | HRS. | W/CC | HRS. | W/CC | HRS. | W/CC | HRS. |
| 1 | 62.00 | 66.68 | 88.53 | 233.37 | 70.35 | 295.11 | 70.35 | 278.33 | 40.00 | 295.61 | 40.00 |
| 2 | 3531.50 | 0.00 | 354.11 | 237.80 | 281.39 | 300.53 | 281.39 | 283.47 | 152.00 | 302.40 | 200.00 |
| 3 | 315.50 | 57.19 | 663.95 | 237.96 | 527.60 | 300.49 | 527.60 | 283.44 | 360.00 | 228.25 | 475.00 |
| 4 | 110.00 | 120.91 | 663.95 | 237.80 | 527.60 | 300.43 | 527.60 | 283.41 | 384.00 | 306.00 | 92.00 |
| 5 | 178.00 | 0.00 | 892.53 | 237.79 | 703.46 | 300.44 | 703.46 | 283.42 | 288.00 | 233.62 | 807.00 |
| 6 | 365.00 | 162.33 | 892.53 | 237.69 | 703.46 | 300.34 | 703.46 | 283.33 | 480.00 | 272.53 | 692.00 |
| 7 | 105.0 | 0.00 | 744.00 | 280.89 | 741.78 | 300.22 | 741.78 | 283.23 | 360.00 | 129.13 | 1500.00 |
| 8 | 58.00 | 261.42 | 744.00 | 259.98 | 744.00 | 354.67 | 744.00 | 334.64 | 336.00 | 254.38 | 1500.00 |
| 9 | 26.50 | 0.00 | 696.00 | 283.91 | 744.00 | 328.31 | 744.00 | 309.75 | 408.00 | 210.49 | 1500.00 |
| 10 | 51.00 | 221.77 | 744.00 | 285.25 | 696.00 | 358.53 | 696.00 | 338.27 | 240.00 | 263.29 | 1500.00 |
| 11 | 636.50 | 0.00 | 853.30 | 289.73 | 744.00 | 360.15 | 744.00 | 339.83 | 360.00 | 209.91 | 252.76 |
| 12 | 296.00 | 229.40 | 725.20 | 0.00 | 853.30 | 365.70 | 853.30 | 345.08 | 96.00 | 0.00 | 1497.00 |
| 13 | 149.00 | 0.00 | 455.99 | 219.33 | 725.20 | 0.00 | 725.20 | 0.00 | 528.00 | 243.61 | 738.00 |
| 14 | 233.00 | 269.00 | 893.51 | 218.20 | 455.99 | 278.17 | 455.99 | 262.28 | 1104.00 | 0.00 | 1500.00 |
| 15 | 320.00 | 248.77 | 744.00 | 270.15 | 893.51 | 275.00 | 893.51 | 259.49 | 384.00 | 122.23 | 1500.00 |
| 16 | 414.67 | 0.00 | 720.00 | 271.23 | 744.00 | 341.31 | 744.00 | 322.04 | 360.00 | 211.31 | 1798.00 |
| 17 | 9.33 | 3.64 | 744.00 | 279.46 | 720.00 | 342.56 | 720.00 | 323.21 | 360.00 | 190.26 | 270.00 |
| 18 | 672.00 | 268.43 | 720.00 | 244.14 | 744.00 | 352.89 | 744.00 | 332.98 | 504.00 | 211.22 | 392.00 |
| 19 | 135.75 | 299.11 | 744.00 | 192.19 | 720.00 | 308.36 | 720.00 | 290.94 | 96.00 | 0.00 | 192.00 |
| 20 | 16.50 | 0.00 | 744.00 | 156.45 | 744.00 | 241.80 | 744.00 | 228.09 | 624.00 | 127.22 | 484.00 |
| 21 | 15.75 | 185.08 | 634.22 | 160.61 | 744.00 | 197.84 | 744.00 | 186.60 | 384.00 | 215.00 | 1730.00 |
| 22 | 484.00 | 294.33 | 542.89 | 160.77 | 634.22 | 203.22 | 634.22 | 191.66 | 336.00 | 306.61 | 251.55 |
| 23 | 92.00 | COOLING | 145.30 | 0.00 | 542.89 | 203.19 | 542.89 | 191.64 | 552.00 | 245.04 | 923.00 |
| 24 | | | 967.60 | 147.18 | 1455.30 | 0.00 | 1455.30 | 0.00 | 96.00 | 0.00 | 260.51 |
| 25 | | | 744.00 | 249.23 | 967.60 | 186.30 | 967.60 | 175.66 | 528.00 | 195.89 | 2076.00 |
| 26 | | | 744.00 | 215.40 | 744.00 | 314.53 | 744.00 | 296.80 | 72.00 | 0.00 | 346.00 |
| 27 | | | 720.00 | 224.45 | 744.00 | 272.34 | 744.00 | 256.66 | 240.00 | 183.08 | 261.34 |
| 28 | | | 744.00 | 214.17 | 720.00 | 283.57 | 720.00 | 267.53 | 480.00 | 259.69 | 122.00 |
| 29 | | | 720.00 | 162.81 | 744.00 | 270.58 | 744.00 | 253.25 | 480.00 | 272.17 | 753.00 |
| 30 | | | 744.00 | 197.93 | 720.00 | 205.83 | 720.00 | 194.14 | 504.00 | 272.14 | 1460.00 |
| 31 | | | 744.00 | 214.16 | 744.00 | 250.31 | 744.00 | 236.08 | 504.00 | 254.09 | 1800.00 |
| 32 | | | 672.00 | 220.58 | 744.00 | 270.60 | 744.00 | 255.27 | 480.00 | 254.18 | 1460.00 |
| 33 | | | 744.00 | 226.81 | 672.00 | 278.73 | 672.00 | 262.90 | 504.00 | 254.10 | 1588.00 |
| 34 | | | 833.80 | 224.99 | 744.00 | 286.59 | 744.00 | 270.34 | 204.00 | 108.21 | 1642.00 |
| 35 | | | 12162.00 | COOLING | 833.80 | 284.29 | 833.80 | 268.15 | 1120.00 | 262.81 | 1292.00 |
| 36 | | | 12162.00 | COOLING | 42569.00 | COOLING | 42569.00 | COOLING | 2064.00 | 0.00 | 255.41 |
| 37 | | | | | | | | | | | 1369.00 |
| 38 | | | | | | | | | | | 152.47 |
| 39 | | | | | | | | | | | 152.93 |
| 40 | | | | | | | | | | | 219.00 |
| 41 | | | | | | | | | | | 76.77 |
| 42 | | | | | | | | | | | 1139.00 |
| 43 | | | | | | | | | | | 229.32 |
| 44 | | | | | | | | | | | 1642.00 |
| 45 | | | | | | | | | | | 265.07 |
| 46 | | | | | | | | | | | 1642.00 |
| 47 | | | | | | | | | | | 265.67 |
| 48 | | | | | | | | | | | 548.00 |
| 49 | | | | | | | | | | | 229.17 |
| | | | | | | | | | | | 11232.00 |
| | | | | | | | | | | | COOLING |
| | | | | | | | | | | | 312.00 |
| | | | | | | | | | | | 264.00 |
| | | | | | | | | | | | COOLING |

Table 4.1-3 Comparison of Measured and Calculated TMI-2 Containment Building Air Sample Activity Ratios

| QUANTITY | MEASURED VALUE | CALCULATED VALUES | | | | | | CORE AVERAGE VALUE | %DIFF. |
|---------------------------|-------------------|---------------------|--------|---------------------|--------|---------------------|--------|-----------------------|--------|
| | | 2.01% FUEL VALUE | %DIFF. | 2.67% FUEL VALUE | %DIFF. | 3.00% FUEL VALUE | %DIFF. | | |
| BURNUP. ATOM%FISSION | 0.337 | | | 0.338 | | 0.339 | | 0.338 | |
| EXPOSURE, MWD/T | 3265 | | | 3263 | | 3261 | | 3263 | |
| SAMPLE ACTIVITIES: | | | | | | | | | |
| CURIES/LITER | | | | | | | | | |
| I131 | 6.0 -5 | | | | | | | | |
| I133 | < 1.9 -5 | | | | | | | | |
| XE133 | 6.29-1 | | | | | | | | |
| XE133M | 1.35-2 | | | | | | | | |
| XE135 | 3.00-3 | | | | | | | | |
| FUEL INVENTORY: | | | | | | | | | |
| CURIES/CC | | | | | | | | | |
| I131 | 5.281+0 | | | 5.223+0 | | 5.205+0 | | 5.235+0 | |
| I133 | 8.510-1 | | | 8.537-1 | | 8.548-1 | | 8.532-1 | |
| XE133 | 1.155+1 | | | 1.159+1 | | 1.161+1 | | 1.158+1 | |
| XE133M | 2.284-1 | | | 2.279-1 | | 2.278-1 | | 2.280-1 | |
| XE135 | 4.925-1 | | | 5.030-2 | | 5.079-2 | | 5.014-2 | |
| ACTIVITY RATIOS: | | | | | | | | | |
| XE133M:XE133 | 0.0214 | 0.01977 | -8 | 0.01966 | -8 | 0.01962 | -8 | 0.01968 | -8 |
| XE135:XE133 | 0.0048 | 0.00426 | -11 | 0.00434 | -9 | 0.00437 | -8 | 0.00433 | -9 |
| XE135:XE133M | 0.2230 | 0.21564 | -3 | 0.22072 | -1 | 0.22300 | 0 | 0.21988 | -1 |
| I133:I131 | < 0.3235 | 0.16116 | -50 | 0.16345 | -49 | 0.16423 | -49 | 0.16298 | -50 |

AIR SAMPLES TAKEN AT 7:00 AM MARCH 31, 1979: MEASUREMENTS MADE AT BAPL AT 8:00 PM OF THE SAME DAY. REPORTED ACTIVITIES WERE DECAY CORRECTED TO THE TIME SAMPLES WERE TAKEN. VALUES QUOTED AS MEASURED ABOVE HAVE BEEN DECAY CORRECTED BACK TO THE TIME OF MEASUREMENT

CALCULATED VALUES GIVEN FOR THE CORRESPONDING 88 HOURS COOLING.

Table 4.2-1 Core Composition and Performance(Robinson--2)

| Fuel Pellet UO ₂ density Linear density Diameter Length of pellet stack in fuel rod Clad-pellet clearance | (g/cm ³) (g/cm) (cm) | 0.93 386.1 (cm) | Core Equivalent diameter Active height No. of square assemblies No. of control rods UO ₂ in square assemblies(kg) Total UO ₂ weight (kg) Total U weight (kg) | 304 366 157 70,100 |
|--|--|-----------------------|---|---------------------------------------|
| Fuel Clad Outside diameter Inside diameter Wall thickness Material | (cm) | 1.07 0.062 (cm) | Zircaloy-4 | |
| Square Fuel Assembly | | | | Core Thermo-hydraulic Characteristics |
| Rod array | 15 × 15 | 15 × 15 | Power (MWth) | 2200 |
| Number of rods | 204 | 204 | (MW _e) | 700 |
| Fuel rod pitch | (cm) | | Coolant pressure (kg/cm ²) | 155.5 |
| Side of square cross section | (cm) | 21.4 | Coolant temperature(ave., °C) (inlet, °C) | 302 285 |
| Total length | (cm) | 414 | (outlet, °C) | 317 |
| UO ₂ weight | (kg) | | | |
| Initial enrichment | (%) | 1.85/2.55/ 3.10 | | |

Table 4.2-2 Comparison of Measured and Calculated H.B. Robinson-2
2.56% PWR Spent-fuel Inventory, Cycles 1-2, Assembly B05
Rod P8, Samples 12 in. and 68 in. Above Bottom of Fuel

| QUANTITY | SAMPLE P8A, 12 IN. ABF | | | SAMPLE P8B, 68 IN. ABF | | |
|----------------------------------|------------------------|----------------|--------|------------------------|----------------|--------|
| | MEASURED VALUE | CALC. VALUE | %DIFF. | MEASURED VALU | CALC. VALUE | %DIFF. |
| BURNUP. | | | | | | |
| ATOM%FISSION | 2.559 | 2.525 | -1.30 | 3.221 | 3.173 | -1.48 |
| EXPOSURE, MWD/T | | | | | | |
| | 24570 | 24935 | +1.48 | 30920 | 31494 | +1.86 |
| ATOM FRACTIONS: | | | | | | |
| U234/U | 0.00016 | 0.00014 | -13.53 | 0.00014 | 0.00012 | -12.03 |
| U235/U | 0.00816 | 0.00843 | +3.27 | 0.00612 | 0.00604 | -1.34 |
| U236/U | 0.00326 | 0.00320 | -1.74 | 0.00352 | 0.00354 | +0.58 |
| U238/U | 0.98842 | 0.98823 | -0.02 | 0.99022 | 0.99030 | +0.01 |
| PU238/PU | 0.01143 | 0.00952 | -16.75 | 0.01676 | 0.01407 | -16.07 |
| PU239/PU | 0.59557 | 0.59686 | +0.22 | 0.54261 | 0.54319 | +0.11 |
| PU240/PU | 0.23290 | 0.22679 | -2.63 | 0.25101 | 0.23943 | -4.61 |
| PU241/PU | 0.11842 | 0.12291 | +3.79 | 0.12998 | 0.13697 | +5.38 |
| PU242/PU | 0.04168 | 0.04393 | +5.39 | 0.05964 | 0.06635 | +11.24 |
| ATOM RATIOS: | | | | | | |
| PU239/U238 | 0.00494 | 0.00485 | -1.79 | 0.00518 | 0.00496 | -4.33 |
| ND148/U238 | 0.000450 | 0.000450 | -0.01 | 0.000570 | 0.000570 | +0.03 |

MEASURED VALUES REPORTED IN BATTELLE COLUMBUS LABORATORIES
REPORT BMI-1938.P16.(1975). CALCULATED VALUES FROM THE USE OF
A DETAILED POWER HISTORY, A 506.75 DAY COOLING PERIOD,
AND ENDF/B-V DATA IN ITERATIVE TANDEM EPRI-CELL/CINDER-2
CALCULATIONS TO CONVERGE UPON THE MEASURED ND148/U238 ATOM RATIO.

Table 4.2-3 Comparison of Measured and Calculated H.B. Robinson-2
 2.56% PWR Spent-fuel Inventory, Cycles 1-2, Assembly B05
 Rod E14, Sample 112 in. Above Bottom of Fuel

| QUANTITY | MEASURED VALUE | CALCULATED VALUE | %DIFF. |
|--|-------------------|---------------------|--------|
| BURNUP. | | | |
| ATOM%FISSION | | 2.998 | |
| EXPOSURE, | | | |
| MWD/T | | 29711 | |
| ATOM RATIO: | | | |
| CS137/U238 | 0.00174 | 0.00174 | -0.08 |
| NUCLIDE DENSITIES, ATOMS/GM OXIDE AT 4.86 YEARS COOLING | | | |
| SR 90 | 2.73+18 | 2.37+18 | -13.17 |
| RU106 | >1.71+16 | 2.54+16 | |
| SB125 | 7.45+15 | 8.39+15 | +12.59 |
| CS134 | 7.61+16 | 6.92+16 | -9.01 |
| CS137 | 3.75+18 | 3.64+18 | -2.88 |
| CE144 | 1.41+16 | 1.38+16 | -1.89 |
| EU154 | 3.92+16 | 6.59+16 | +67.99 |
| EU155 | 1.28+16 | 1.83+16 | +43.16 |
| U234 | 3.24+17 | 2.71+17 | -16.24 |
| U235 | 1.34+19 | 1.40+19 | +4.38 |
| U236 | 7.68+18 | 7.31+18 | -4.82 |
| U238 | 2.15+21 | 2.09+21 | -2.80 |
| NP237 | 8.19+17 | 7.64+17 | -6.69 |
| PU238 | 3.25+17 | 2.34+17 | -28.00 |
| PU239 | 1.08+19 | 1.03+19 | -4.41 |
| PU240 | 5.23+18 | 4.39+18 | -16.01 |
| PU241 | 2.18+18 | 2.11+18 | -3.23 |
| PU242 | 1.29+18 | 1.11+18 | -13.57 |
| AM241 | 6.55+17 | 6.23+17 | -4.84 |
| AM243 | 2.2 +17±20% | 2.07+17 | -6.11 |
| CM242 | 1.8 +12 | 1.76+13 | -2.23 |
| CM244 | 5.1 +16±20% | 4.21+16 | -17.54 |

MEASUREMENTS BY LOS ALAMOS GROUP CNC-11: EXPERIMENTAL
 UNCERTAINTY ±5% UNLESS OTHERWISE INDICATED.

CALCULATED VALUES FROM THE USE OF A DETAILED POWER
 HISTORY, A 4.86-YEAR COOLING PERIOD, AND ENDF/B-V DATA
 IN ITERATIVE TANDEM EPRI-CELL/CINDER-2 CALCULATIONS
 TO CONVERGE UPON THE MEASURED CS137/U238 ATOM RATIO.
 CALCULATED ATOMS-PER-GRAM-OXIDE QUANTITIES FROM
 CALCULATED ATOMS-PER-CM³-OXIDE VALUES /9.95G/CM³.

Table 4.3-1 Core Composition and Performance(Quad-Cities-1)

| Fuel Pellet | | | | | Control Rod Absorbing material | |
|--|-----------------------|--------------------|--|--|-----------------------------------|--|
| UO ₂ density | (g/cm ³) | | | | | |
| Linear density | (g/cm) | | | | | |
| Diameter | (cm) | 1.24 | | | | |
| Length of pellet stack in fuel rod | (cm) | | | | | |
| Clad-pellet clearance | (cm) | | | | | |
| Fuel Clad | | | | | | |
| Outside diameter | (cm) | | | | | |
| Inside diameter | (cm) | | | | | |
| Wall thickness | (cm) | | | | | |
| Material | | | | | | |
| Zircaloy-2 | | | | | | |
| Square Fuel Assembly | | | | | | |
| Rod array | | | | | | |
| Number of rods | | | | | | |
| Fuel rod pitch | (cm) | | | | | |
| Side of square cross section | (cm) | | | | | |
| Total length | (cm) | | | | | |
| UO ₂ weight | (kg) | | | | | |
| Initial enrichment | (%) | | | | | |
| | | 1.20/1.69/ 2.44 | | | | |
| Core | | | | | | |
| Equivalent diameter | (cm) | | | | | |
| Active height | (cm) | | | | | |
| No. of square assemblies | | | | | | |
| No. of control rods | | | | | | |
| UO ₂ in square assemblies(kg) | | | | | | |
| Total UO ₂ weight | (kg) | | | | | |
| Total U weight | (kg) | | | | | |
| Core Thermo-hydraulic Characteristics | | | | | | |
| Power | (MWth) | | | | | |
| | (MW) | | | | | |
| 7 × 7 | | | | | | |
| 49 | | | | | | |
| Coolant pressure | (kg/cm ²) | | | | | |
| Coolant temperature(ave., °C) | | | | | | |
| (inlet, °C) | | | | | | |
| (outlet, °C) | | | | | | |
| | | 2511 | | | | |
| | | 809 | | | | |
| | | 71.4 | | | | |
| | | 286 | | | | |

Table 4.3-2 Comparison of Measured and Calculated Quad Cities-1
2.56% BWR Spent-fuel Inventory, Cycle 2, Assembly GEB-161
Rod BSG0856, Sample 21.5 in. Above Bottom of Fuel

| QUANTITY | MEASURED VALUE | CALCULATED VALUE | %DIFF. |
|------------------------|-------------------|---------------------|--------|
| BURNUP. | | | |
| ATOM%FISSION | 1.193 | 1.215 | +1.8 |
| EXPOSURE, | | | |
| MWD/T | 11450 | 11837 | +3.4 |
| ATOM FRACTIONS: | | | |
| U234/U | 1.776-4 ± 1.0% | 1.638-4 | -7.8 |
| U235/U | 1.512-2 ± 0.6% | 1.505-2 | -0.5 |
| U236/U | 2.063-3 ± 0.5% | 2.061-3 | -0.1 |
| U238/U | 9.861-1 ± 0.5% | 9.827-1 | +0.01 |
| PU239/PU | 7.469-1 ± 0.1% | 7.428-1 | -0.5 |
| PU240/PU | 1.810-1 ± 0.3% | 1.901-1 | +5.0 |
| PU241/PU | 6.342-2 ± 0.5% | 5.894-2 | -7.1 |
| PU242/PU | 8.694-3 ± 1.3% | 8.154-3 | -6.2 |
| AM241/AM | 7.75 -1 ± 68.0% | 6.52 -1 | -15.9 |
| AM242/AM | 6.42 -3 ± 68.0% | 6.88 -3 | +7.5 |
| AM243/AM | 2.18 -1 ± 68.0% | 3.41 -1 | +56.4 |
| CM242/CM | 8.08 -1 ± 0.9% | 8.05 -1 | -0.4 |
| CM243+244/CM | 1.92 -1 ± 6.0% | 1.95 -1 | +1.6 |
| ATOM RATIOS: | | | |
| ND148/U238 | 2.123-4 ± 0.67% | 2.129-4 | +0.3 |
| NP237/U238 | 8.33 -5 ± 18.0% | 8.89 -5 | +6.7 |
| PU239/U238 | 3.354-3 ± 0.10% | 3.224-3 | -3.9 |
| AM241/U238 | 8.98 -6 ± 890.0% | 3.785-6 | -57.9 |
| CM242/U238 | 8.86 -7 ± 12.9% | 5.819-7 | -34.4 |

MEASUREMENTS BY G.E., RESULTS DECAY CORRECTED TO SHUTDOWN.

CALCULATED VALUES FROM THE USE OF A DETAILED POWER HISTORY
AND ENDF/B-V DATA IN ITERATIVE TANDEM EPRI-CELL/CINDER-2
CALCULATIONS TO CONVERGE UPON THE MEASURED ND148/U238 ATOM RATIO.

5. U, Pu同位体の燃焼特性の検討

いくつかの軽水炉の核種組成データを選び、U, Pu同位体の燃焼による変化を燃焼度依存のパラメータ flux time の関数として整理することにより、U, Pu同位体組成の燃焼特性を示す。

5.1 検討対象データ

本報告にまとめたデータの中から比較的新しい軽水炉の4炉心を選び、データ整理の検討対象とした。これらのデータを、燃焼特性が異なる要因と考えられる燃料の初期濃縮度および炉心位置に応じて、さらに次のような6ケースに分類して整理した。

- | | | |
|------------------|-----|--------------------|
| 1) Obribeim | PWR | 初期濃縮度3.00wt% |
| 2) Obribeim | PWR | 初期濃縮度2.83wt% |
| 3) Gundremmingen | BWR | 初期濃縮度2.53wt% 軸方向下部 |
| 4) Gundremmingen | BWR | 初期濃縮度2.53wt% 軸方向上部 |
| 5) 美浜3号炉 (Japan) | PWR | 初期濃縮度3.24wt% |
| 6) 玄海1号炉 (Japan) | PWR | 初期濃縮度3.42wt% |

5.2 核種組成比率に基づく存在量の算出

測定された核種組成比率から、核種毎の存在量を算出する。算出にあたって次の前提をおく。

- 1) ^{234}U および ^{236}U は無視する。
- 2) 核種の存在比率や生成消滅割合などが flux time x の関数 $f(x)$ として与えられると仮定する。

このとき、初期濃縮度および着目時点での flux time x が与えられたとすると、各核種の存在量は次のように表される。

初期 U の組成は、初期濃縮度 ε を用いて

$$^{238}\text{U}_{\text{init}} = (1 - \varepsilon)^{\text{total}} \text{U}_{\text{init}} \quad (1)$$

$$^{235}\text{U}_{\text{init}} = \varepsilon^{\text{total}} \text{U}_{\text{init}} \quad (2)$$

と書ける。ここで、 $^{235}\text{U}_{\text{init}}$, $^{238}\text{U}_{\text{init}}$ および $^{\text{total}}\text{U}_{\text{init}}$ は、それぞれ ^{235}U , ^{238}U および $^{\text{total}}\text{U}$ の初期存在量を示す。以下、同様に表現する。

着目時点での ^{238}U の消滅量 $\Delta^{238}\text{U}$ が、そのときの flux time x を用いて

$$\Delta^{238}\text{U}/^{238}\text{U}_{\text{init}} = f_1(x) \quad (3)$$

と表されると、 ^{238}U の存在量は

$$\begin{aligned} {}^{238}\text{U} &= {}^{238}\text{U}_{\text{init}} - \Delta {}^{238}\text{U} \\ &= {}^{238}\text{U}_{\text{init}} - (1 - f_1(x)) \end{aligned} \quad (4)$$

初期濃縮度と残留濃縮度の比を

$$({}^{235}\text{U}/{}^{\text{total}}\text{U})/\varepsilon = f_2(x) \quad (5)$$

とすると、着目時点での ${}^{\text{total}}\text{U}$ 量は、 ${}^{\text{total}}\text{U} = {}^{235}\text{U} + {}^{238}\text{U}$ より

$$\begin{aligned} {}^{\text{total}}\text{U} &= {}^{238}\text{U}/(1 - {}^{235}\text{U}/{}^{\text{total}}\text{U}) \\ &= ({}^{238}\text{U}_{\text{init}} - (1 - f_1(x)))/(1 - f_2(x)\varepsilon) \end{aligned} \quad (6)$$

着目時点での ${}^{235}\text{U}$ の存在量は

$${}^{235}\text{U} = f_2(x) \varepsilon {}^{\text{total}}\text{U} \quad (7)$$

となる。

また、着目時点での ${}^{\text{total}}\text{Pu}/{}^{\text{total}}\text{U} = f_3(x)$ とすると、

$${}^{\text{total}}\text{Pu} = f_3(x) {}^{\text{total}}\text{U} \quad (8)$$

着目時点での ${}^{239}\text{Pu}/{}^{\text{total}}\text{Pu} = f_4(x)$ とすると、

$${}^{239}\text{Pu} = f_4(x) {}^{\text{total}}\text{Pu} \quad (9)$$

着目時点での ${}^{240}\text{Pu}/{}^{\text{total}}\text{Pu} = f_5(x)$ とすると、

$${}^{240}\text{Pu} = f_5(x) {}^{\text{total}}\text{Pu} \quad (10)$$

着目時点での ${}^{241}\text{Pu}/{}^{\text{total}}\text{Pu} = f_6(x)$ とすると、

$${}^{241}\text{Pu} = f_6(x) {}^{\text{total}}\text{Pu} \quad (11)$$

着目時点での ${}^{242}\text{Pu}/{}^{\text{total}}\text{Pu} = f_7(x)$ とすると、

$${}^{242}\text{Pu} = f_7(x) {}^{\text{total}}\text{Pu} \quad (12)$$

と表せる。

したがって、

$$\begin{aligned} \Delta {}^{238}\text{U}/{}^{238}\text{U}_{\text{init}} &= f_1(x) \\ ({}^{235}\text{U}/{}^{\text{total}}\text{U})/\varepsilon &= f_2(x) \\ {}^{\text{total}}\text{Pu}/{}^{\text{total}}\text{U} &= f_3(x) \\ {}^{239}\text{Pu}/{}^{\text{total}}\text{U} &= f_4(x) \end{aligned}$$

$$^{240}\text{Pu}/\text{total Pu} = f_5(x)$$

$$^{241}\text{Pu}/\text{total Pu} = f_6(x)$$

$$^{242}\text{Pu}/\text{total Pu} = f_7(x)$$

の7つの関数形を決定できれば、 ^{235}U , ^{238}U , ^{239}Pu , ^{240}Pu , ^{241}Pu 及び ^{242}Pu の7核種の存在量が算出できる。

5.3 flux timeの算出

flux time $x = \phi t$ と燃焼度Bの関係は、次式で与えられる。

$$B = (\sigma_{f}^{235}N^{235}/A^{235} + \sigma_{f}^{239}N^{239}/A^{239} + \sigma_{f}^{241}N^{241}/A^{241}) \phi t$$

ここで、Nは初期ウラン1トン当たりの各核種の重量(kg), σ_f は微視的核分裂断面積(barn), Aは原子量である。また、添え字235, 239, 241は、それぞれ ^{235}U , ^{239}Pu , ^{241}Pu を示す。ここでは、各核種の微視的核分裂断面積として2200m値である次の値を用いた。

$$\sigma_f^{235} = 584, \quad \sigma_f^{239} = 746.7, \quad \sigma_f^{241} = 1015$$

このとき、5.1節で示した6ケースのデータを用いて燃焼度とflux timeの関係を示したのがFig. 5.1である。また、典型的なPWRの燃焼度21GWd/tにおける微視的核分裂断面積を用いて算出したflux timeと2200m値を用いた場合の比較をFig. 5.2に示す。このときの断面積は次の値である。

$$\sigma_f^{235} = 40.27, \quad \sigma_f^{239} = 92.88, \quad \sigma_f^{241} = 102.57$$

この図から、いずれの値を用いてもファクターの違いだけであることが分る。

5.4 関数形の決定

測定値を最小2乗フィッティングして、 $f_1(x) \sim f_7(x)$ の関数形を定めた。

$$\Delta^{238}\text{U}/^{238}\text{U}_{init} = f_1(x) = C_1x - C_2x^2$$

$$(^{235}\text{U}/\text{total U})/\varepsilon = f_2(x) = \exp(C_1x - C_2x^2)$$

$$\text{total Pu}/\text{total U} = f_3(x) = C_2x/(C_1 + x)$$

$$^{239}\text{Pu}/\text{total U} = f_4(x) = 1/(1 + C_1x) + C_2x$$

$$^{240}\text{Pu}/\text{total U} = f_5(x) = C_2x/(1 + C_1x) + C_3x + C_4x^2$$

$$^{241}\text{Pu}/\text{total U} = f_6(x) = C_2x/(1 + C_1x) + C_3x$$

$$^{242}\text{Pu}/\text{total U} = f_7(x) = C_2x/(1 + C_1x) + C_3x + C_4x^2 + C_5x^3 + C_6x^4$$

結果をそれぞれFig. 5.3 ~ 5.9に示す。

5.5 燃焼度で整理した場合との比較

燃焼度で整理した場合の核種組成の変化をそれぞれFig. 5.10～5.16に示す。両者を比較すると、flux time で整理した方がデータのバラツキが少なくなっているものが多い。特に、Fig. 5.4 に示す $(^{235}\text{U}/\text{total U})/\epsilon$ および Fig. 5.6 に示す $^{235}\text{U}/\text{total U}$ の変化は著しく改善されており、flux time で整理するとその燃焼特性が良く表現できる。

○ Obnigheim 3.0wt%
 □ Obnigheim 2.83wt%
 ◇ Gundremmingen (下部)
 × Gundremmingen (上部)
 + Japan 3.24wt%
 Δ Japan 3.42wt%

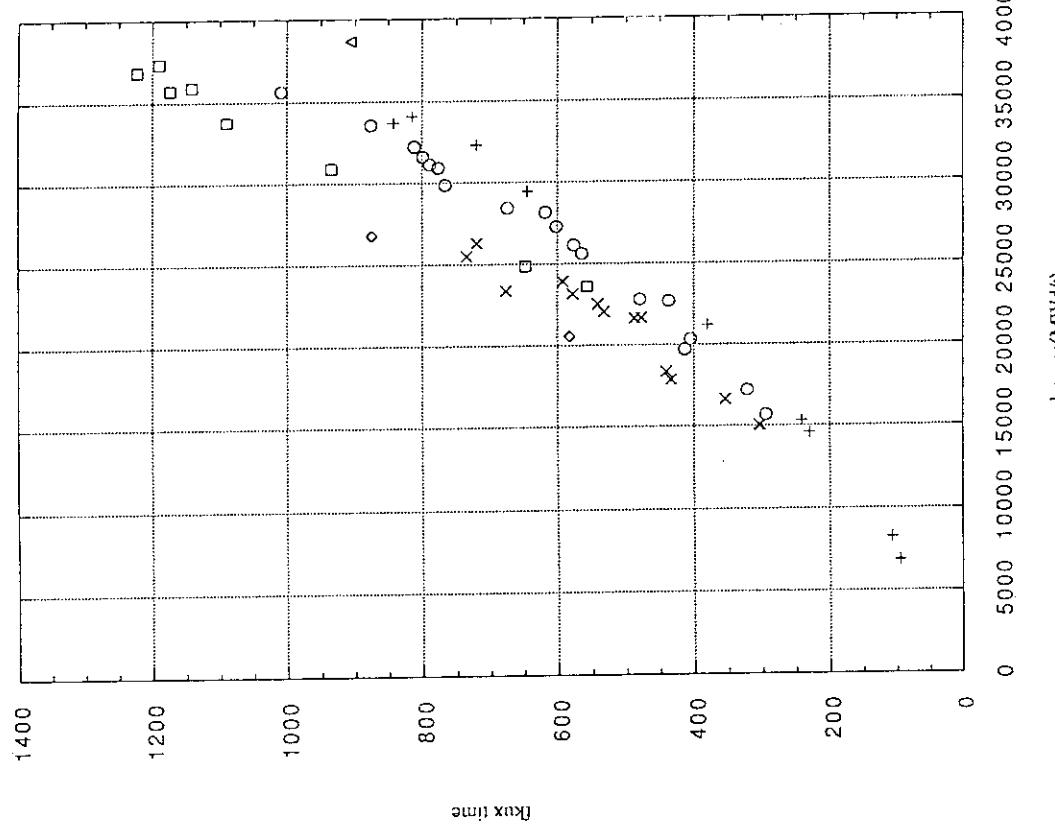


Fig. 5.1 Burnup vs flux time

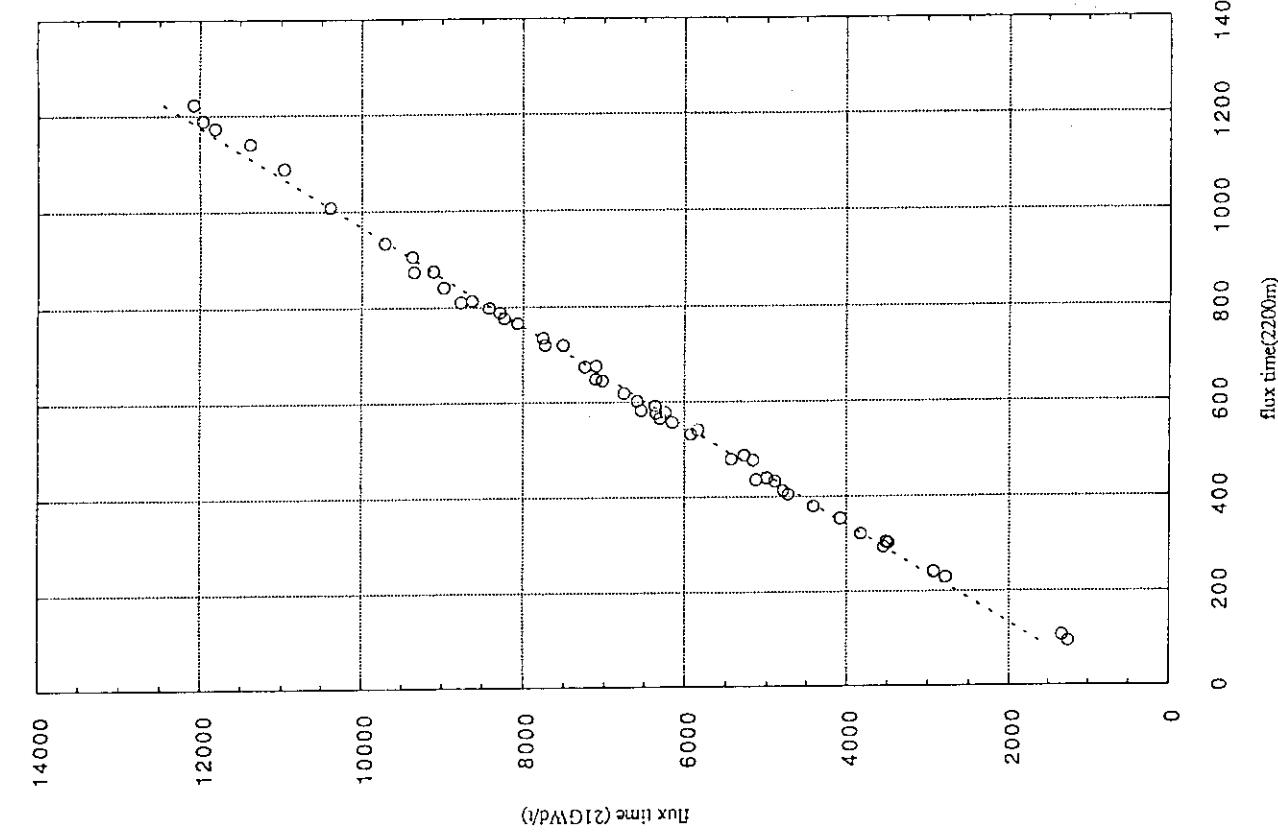


Fig. 5.2 Flux time (2200m) vs. flux time (21GWd/t)

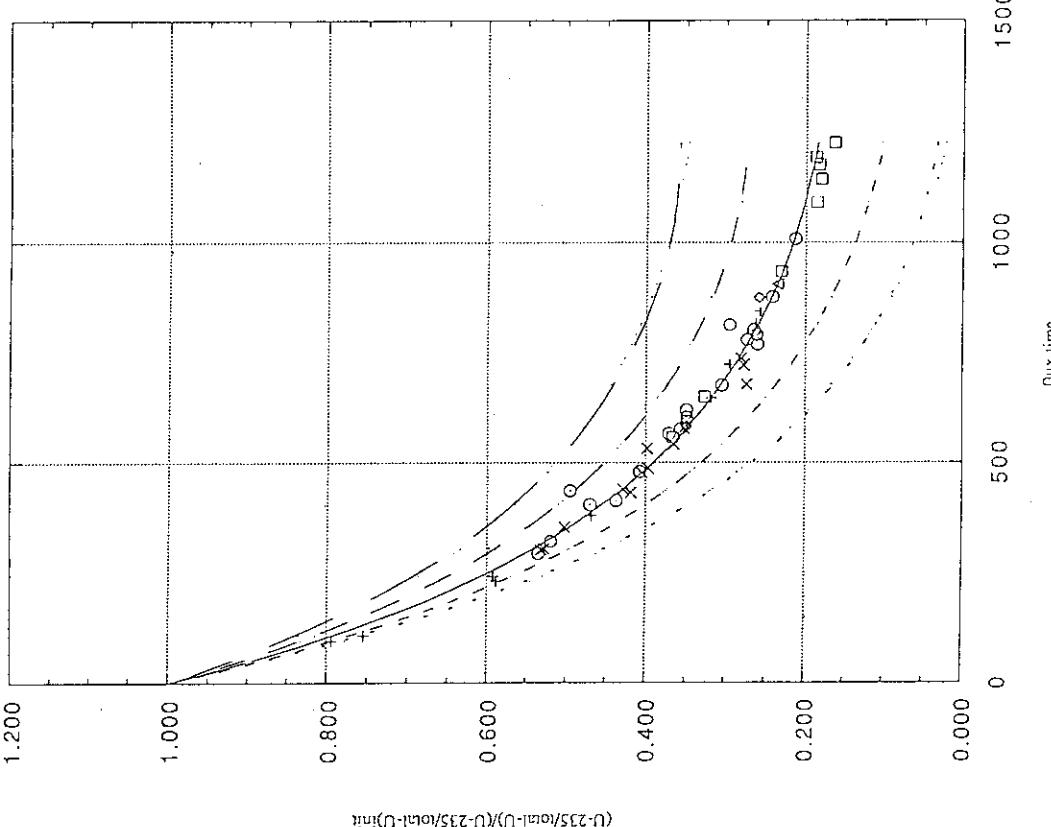
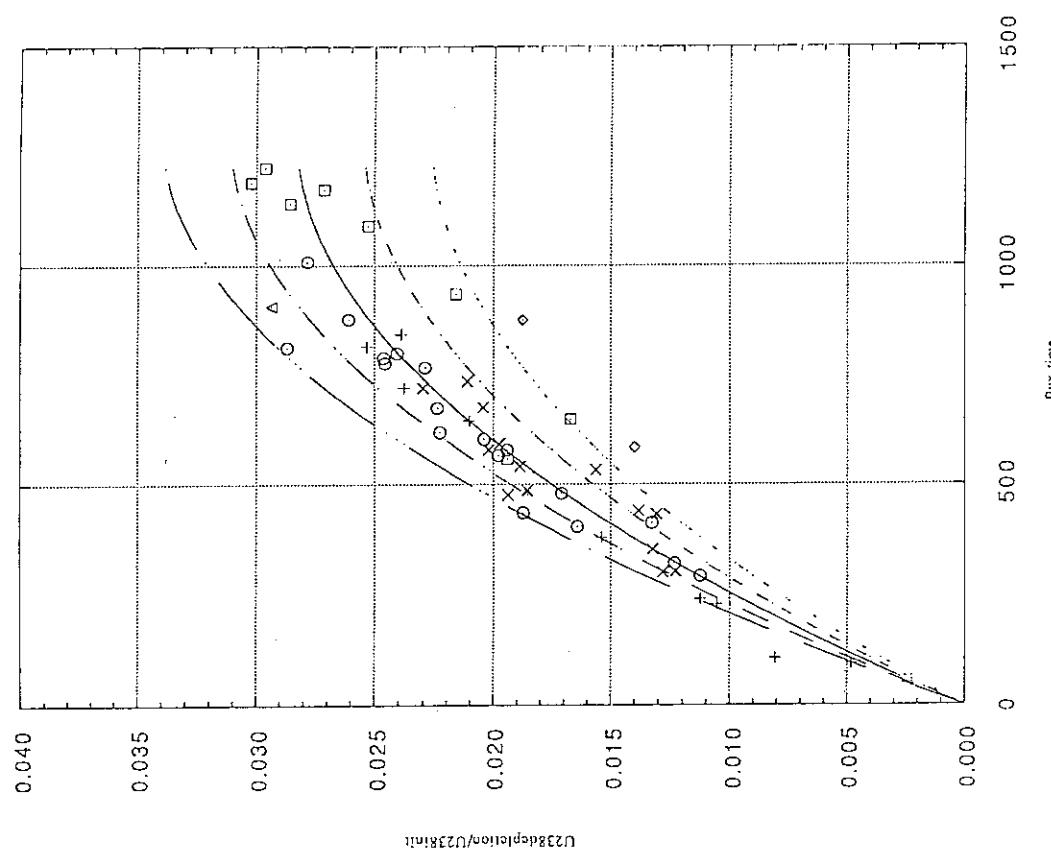
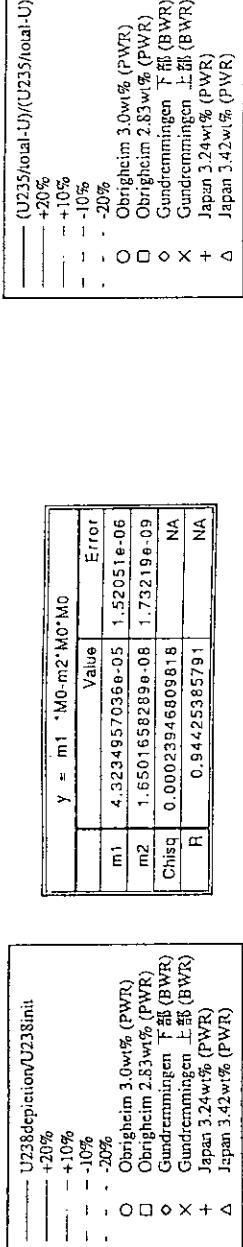
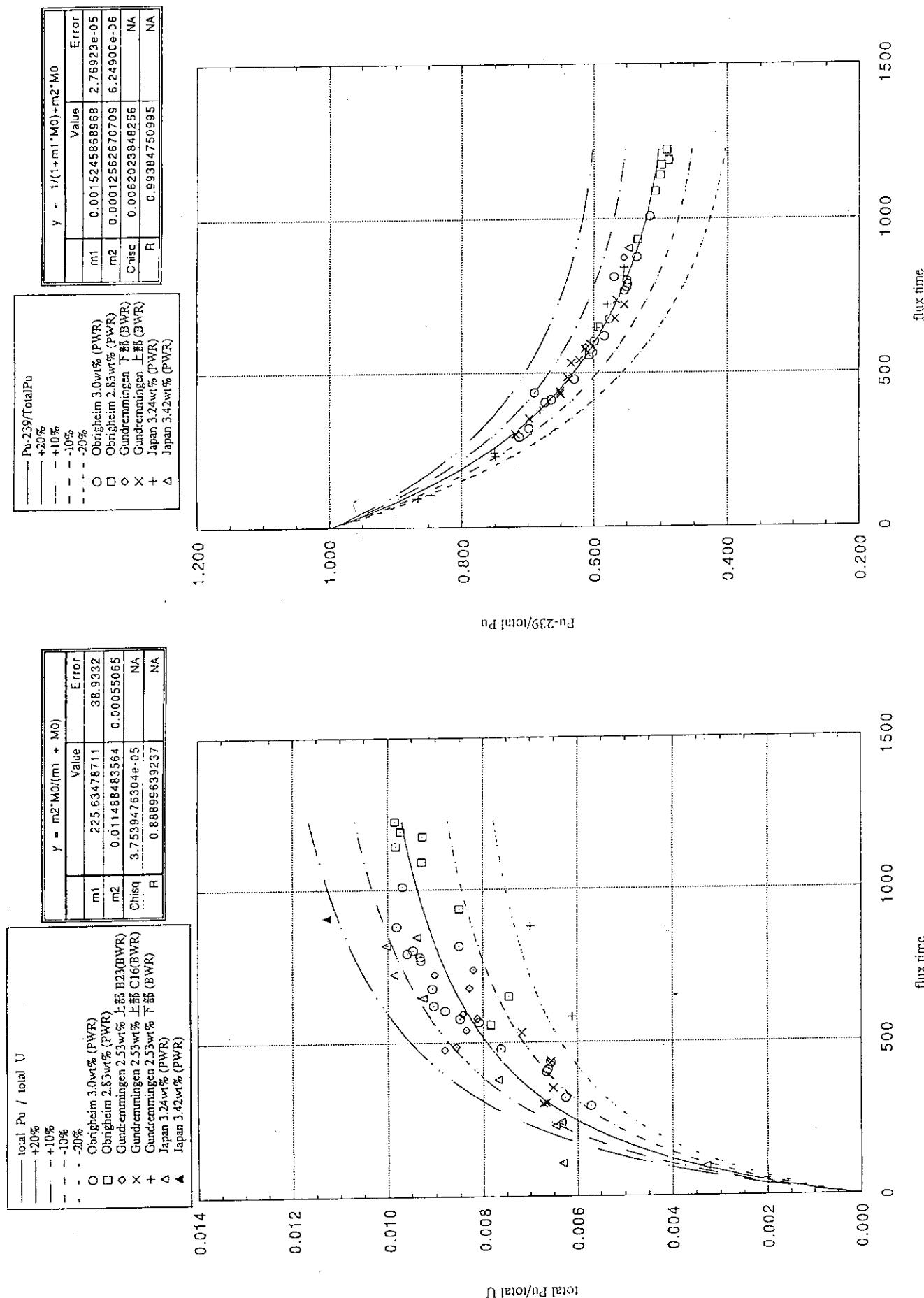


Fig. 5.3 U-238 depletion/U-238 init vs. flux time

Fig. 5.4 $(U-235/\text{total-U}) / (U-235/\text{total-U})_\text{init}$ vs. flux time



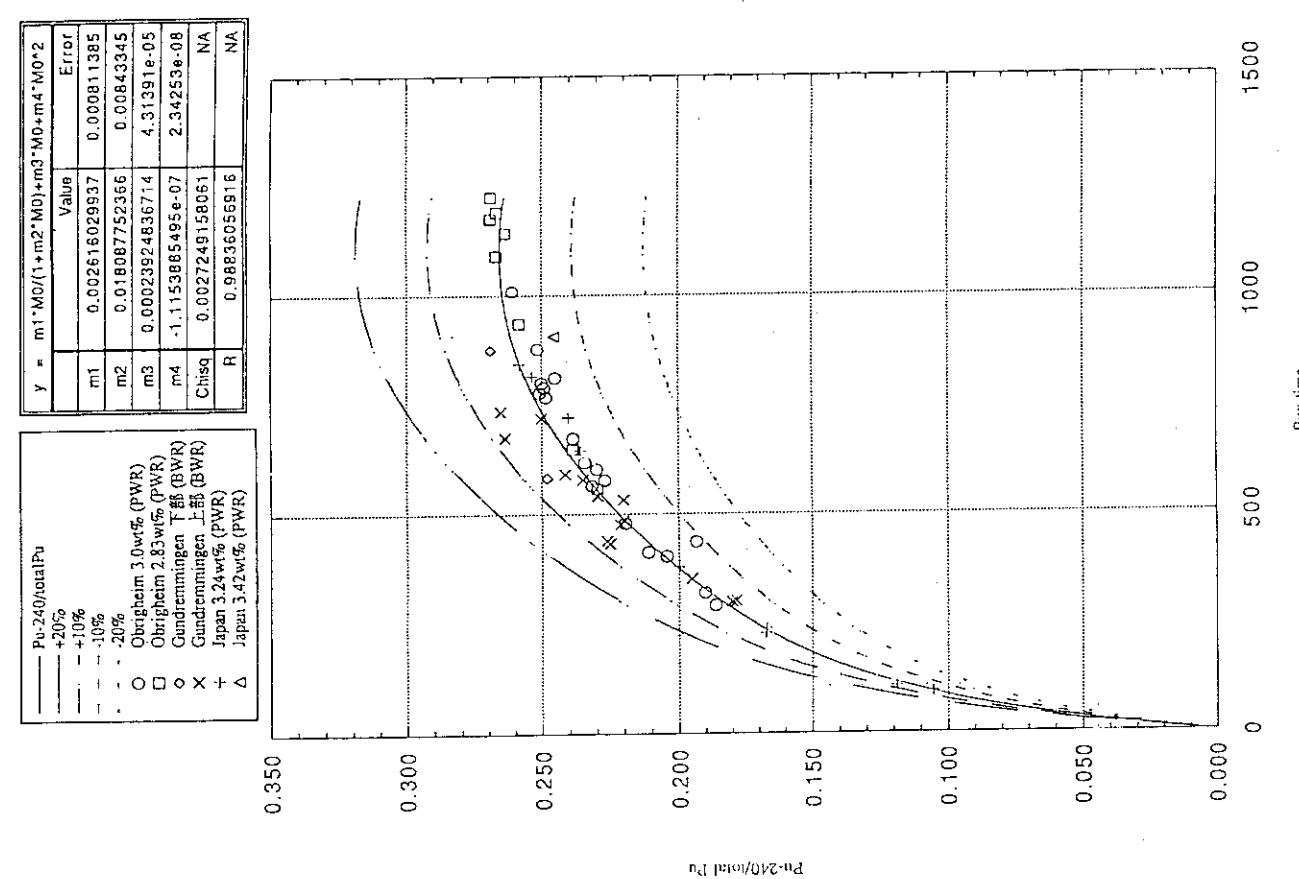


Fig. 5.7 Pu-240/total Pu vs. flux time

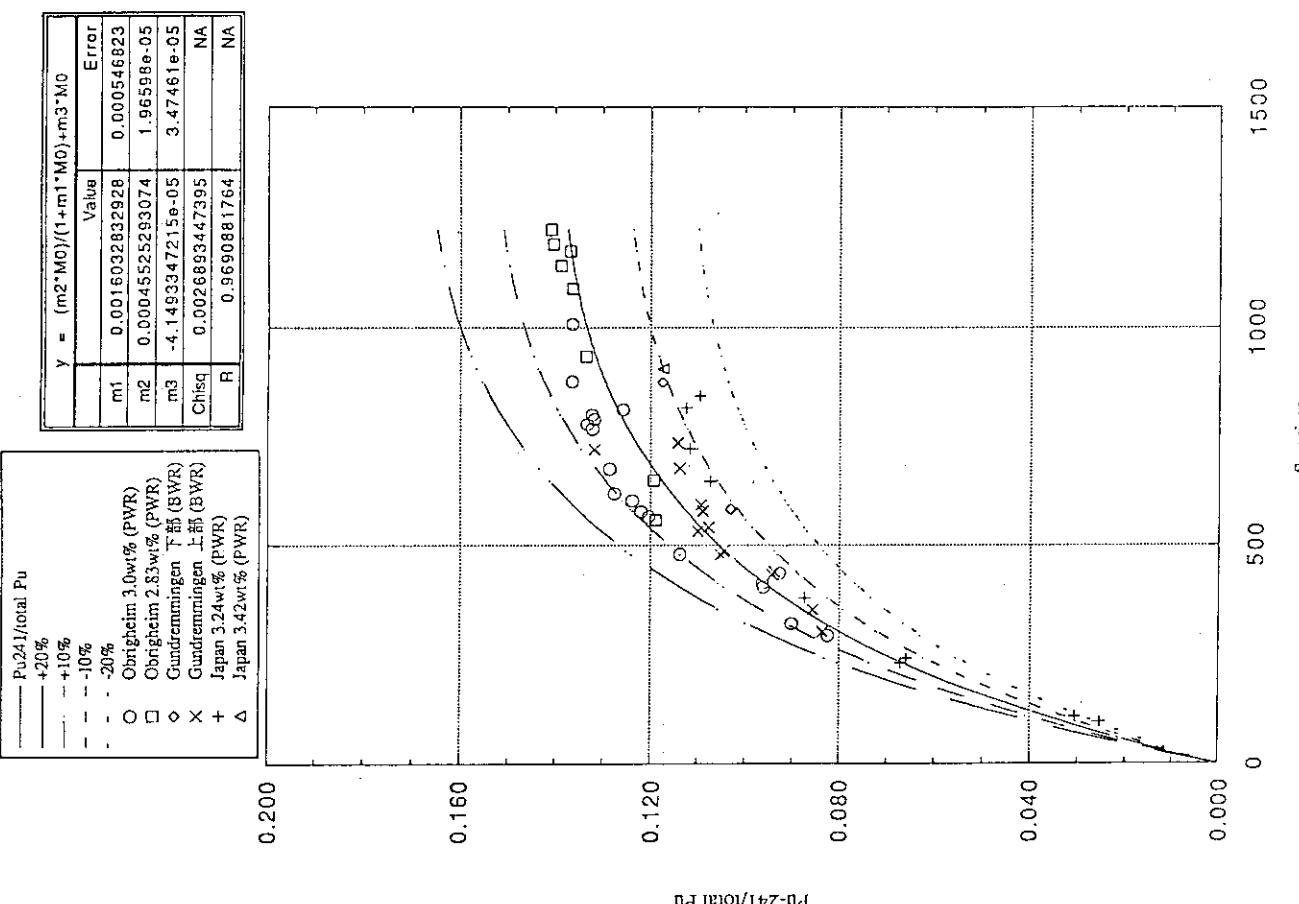


Fig. 5.8 Pu-241/total Pu vs. flux time

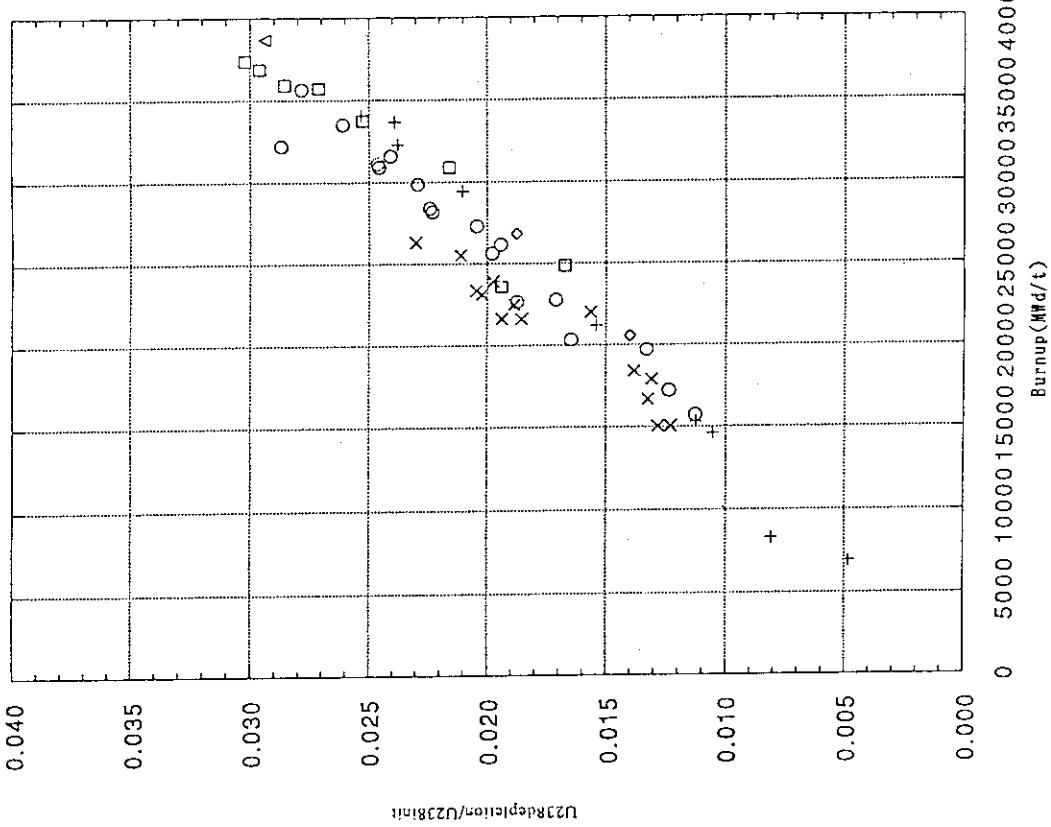
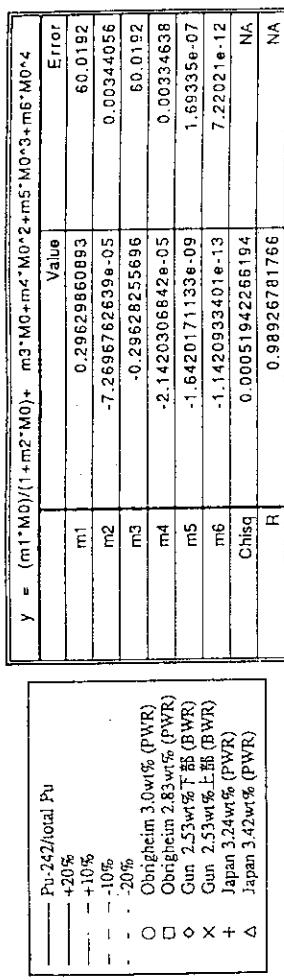


Fig. 5.9 Pu-242/total Pu vs. flux time

Fig. 5.10 U-238 depletion/U-238 init vs. burnup

| | |
|---|--------------------------|
| ○ | Obriegheim 3.0wt% (PWR) |
| □ | Obriegheim 2.83wt% (PWR) |
| ◊ | Gundremmingen 下部 (BWR) |
| × | Gundremmingen 上部 (BWR) |
| + | Japan 3.24wt% (PWR) |
| △ | Japan 3.42wt% (PWR) |

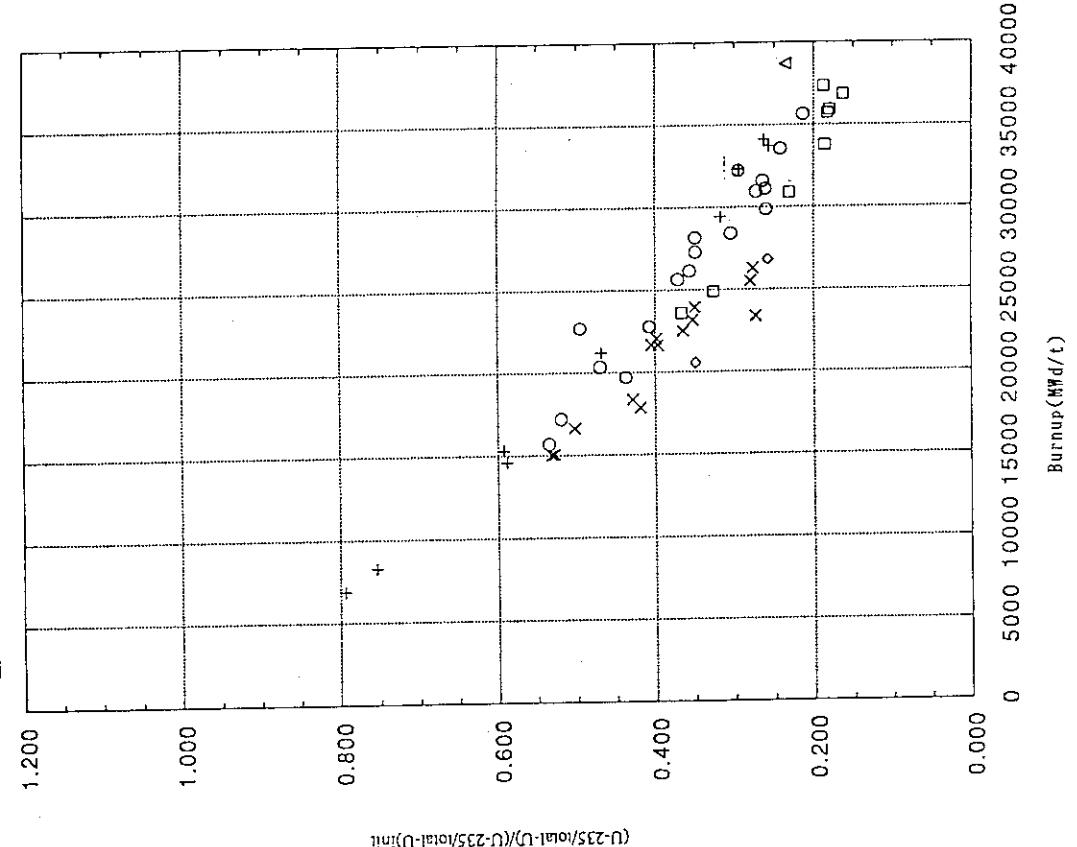


Fig. 5.11 $(U-235/\text{total}-U)/(U-235/\text{total}-U) \text{ init}$ vs. burnup

| | |
|---|--------------------------|
| ○ | Obriegheim 3.0wt% (PWR) |
| □ | Obriegheim 2.83wt% (PWR) |
| ◊ | Gundremmingen 下部 (BWR) |
| × | Gundremmingen 上部 (BWR) |
| + | Japan 3.24wt% (PWR) |
| △ | Japan 3.42wt% (PWR) |

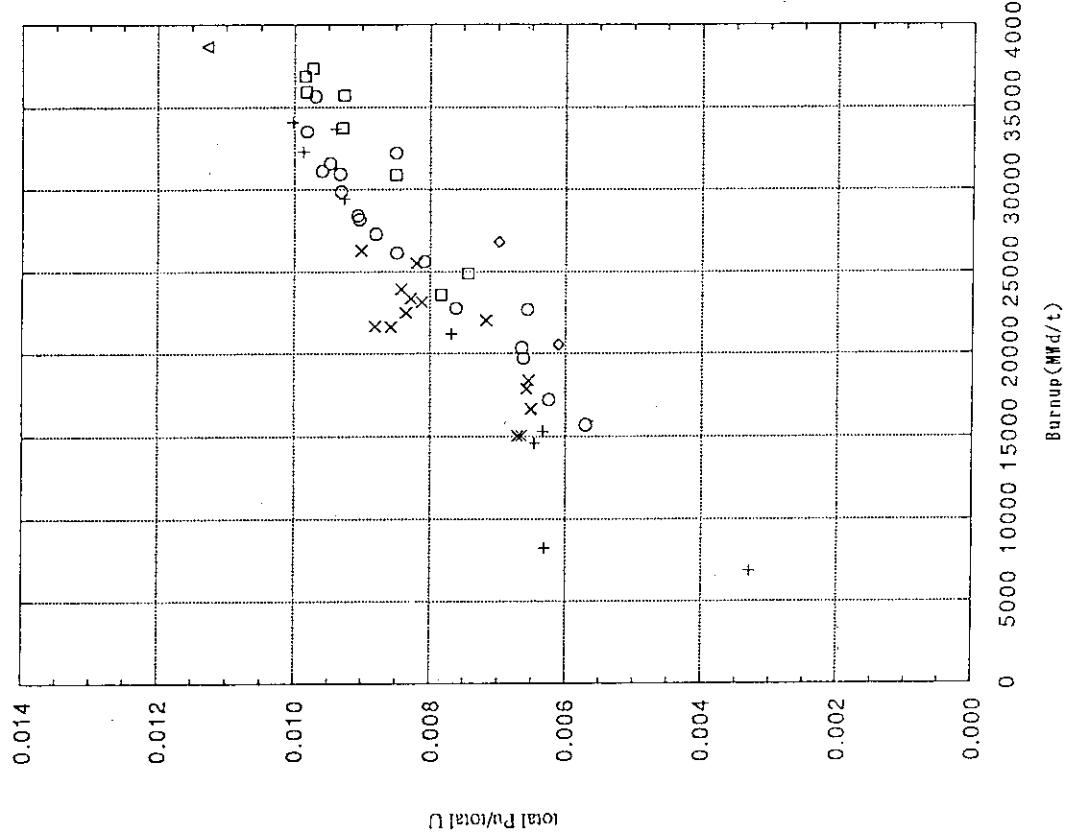


Fig. 5.12 Total Pu/total U vs. burnup

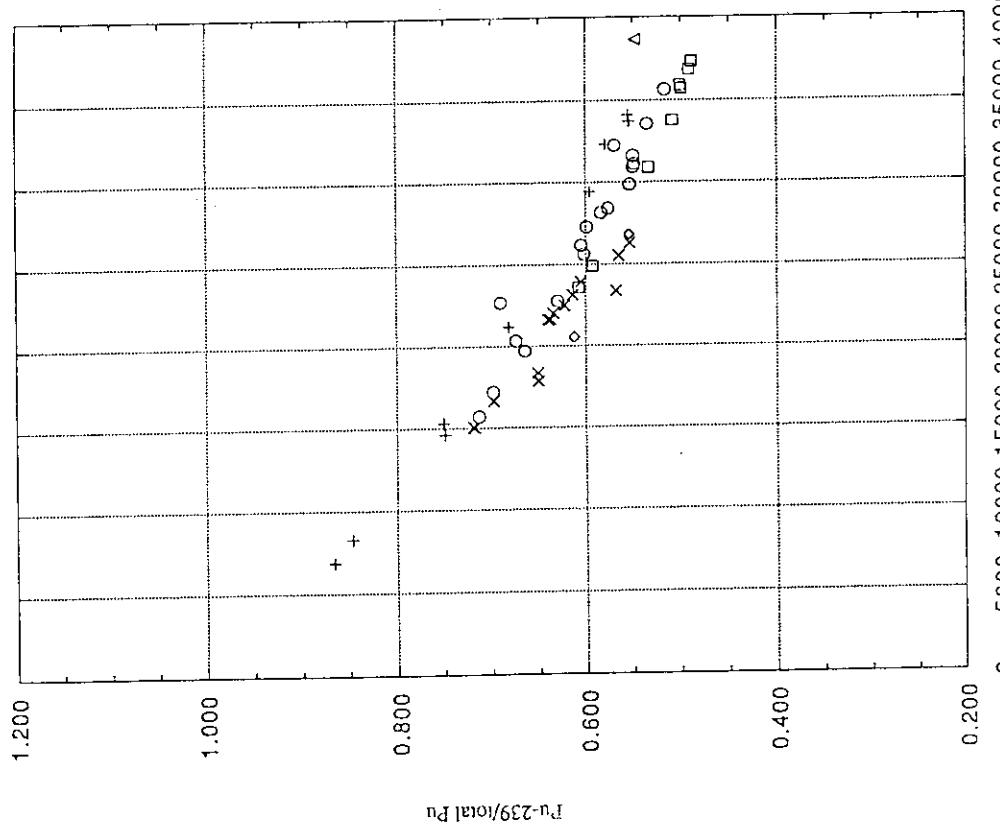


Fig. 5.13 Pu-239/total Pu vs. burnup

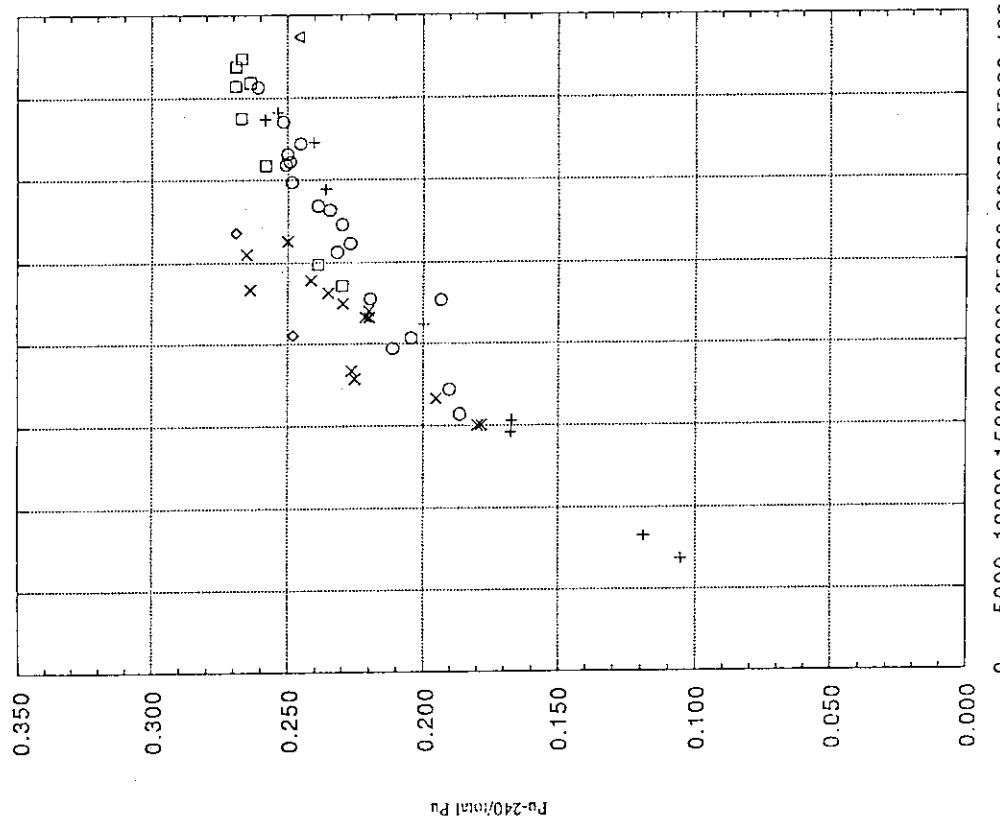


Fig. 5.14 Pu-240/total Pu vs. burnup

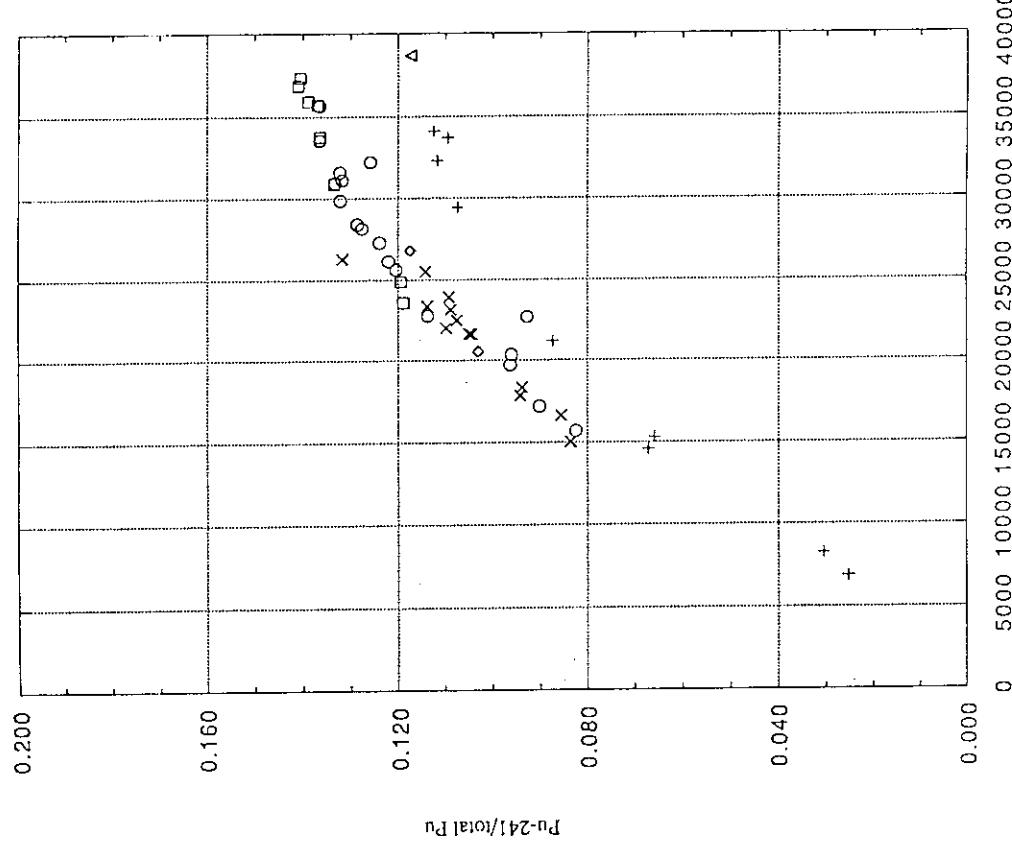


Fig. 5.15 Pu-241/total Pu vs. burnup

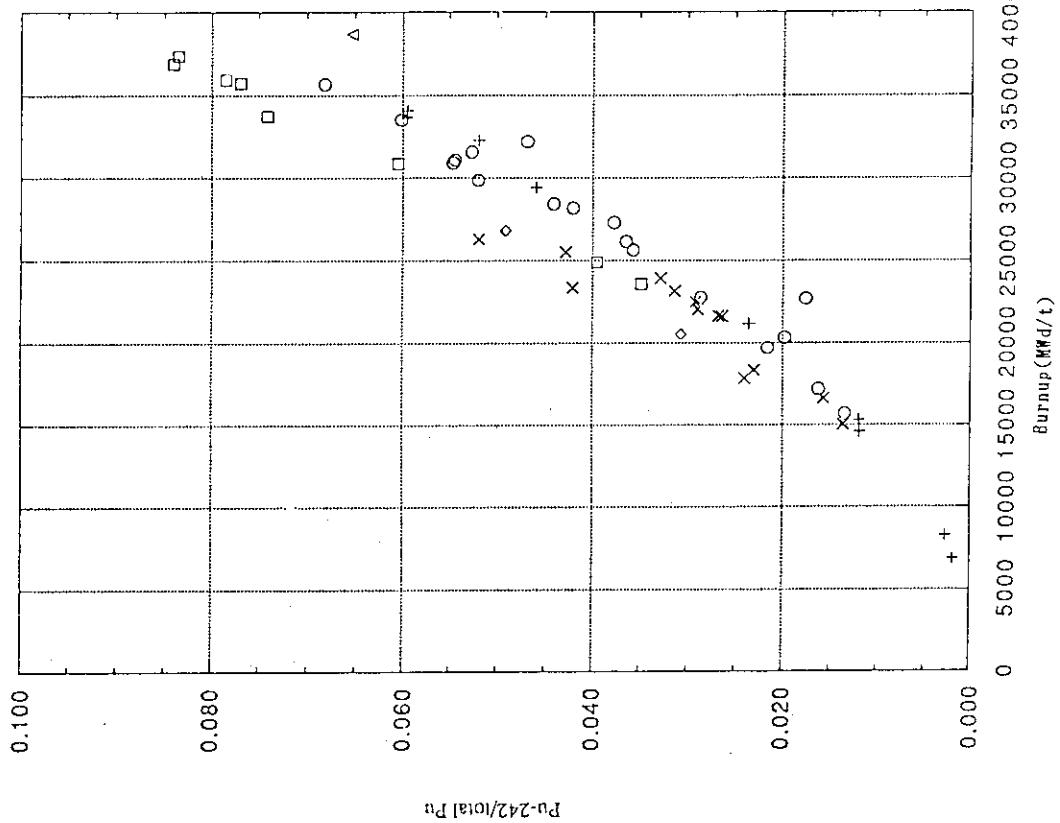


Fig. 5.16 Pu-242/total Pu vs. burnup

6. おわりに

本報告で発電用軽水炉の燃焼計算コードの精度を検証するために必要なベンチマークデータがまとめられた。

燃焼計算コードの精度検証のため軽水炉使用済燃料中の核種組成実測データを調査してきた結果、海外の原子炉 9 基、日本の原子炉 4 基の計 13 基（内 PWR 7 基、BWR 6 基）の測定データを各原子炉の運転情報などとともに、ここに収録することができた。特許等により情報公開の制限があるなどデータ収録にあたっていくつかの制約があったが、関係機関の協力を得て、できる限り多くの情報を掲載するようにした。しかし、収録された各データ間にはデータの質や量に関して大きな差がある。また、測定データの精度や信頼性に関する記述もあるが、個々の調査文献の記述をそのまま採録したもので、新たな系統的検討を加えたものではない。

今後、更に多くのデータの収集と未公開情報の公開努力を続けるとともに、ベンチマークデータとしてより利用し易い整理形式の検討や収録した測定データの系統的精度評価および信頼性評価を行い、ベンチマークデータ集としての充実を図っていく考えである。

謝 辞

日本シグマ研究委員会の下に設置されている核種生成量評価WGでは、燃焼解析に必要な計算コードを整備するとともにその検証のためのデータの収集を行ってきた。ここに報告するデータ集はWGの活動の一環として収集してきたデータを計算コードの精度検証に便利なように編集したものである。データの収集にあたっては下記に示すWGの人々の助力を受けた。ここに、深く謝意を表します。また、日本のデータの掲載にあたっては、日本原子力発電(株)発電技術部長山崎亮吉氏、関西電力(株)原子燃料部長横手光洋氏、九州電力(株)原子力管理部長児玉英男氏、日本原子力研究所ホット試験室長石本 清氏等の支援をいただいた。また、文献の転載にあたって日本原子力研究所須崎武則氏、化学部溶解試験グループには快諾をいただいた。ここに記して深く謝意を表します。最後に、報告書の作成にあたって助言をいただいた化学部分析センター鈴木敏夫氏、本データ集の重要性を認められ支持して下さいました燃料安全工学部長小林岩夫氏に感謝致します。

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